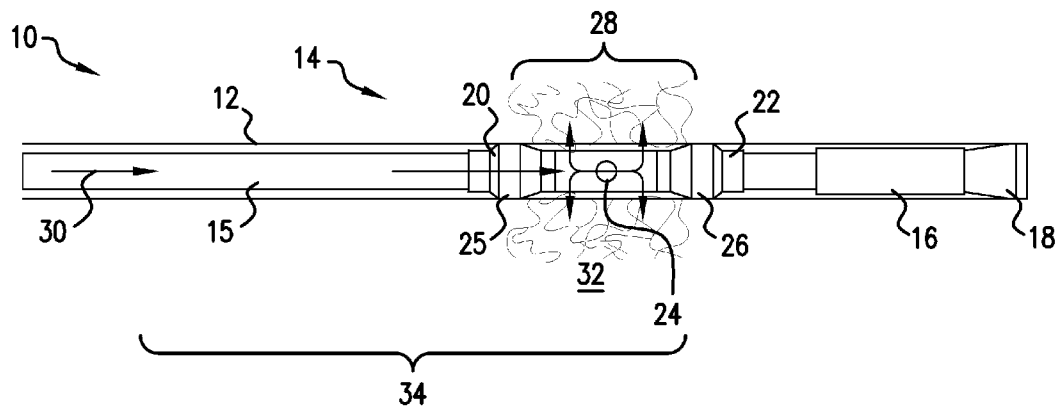


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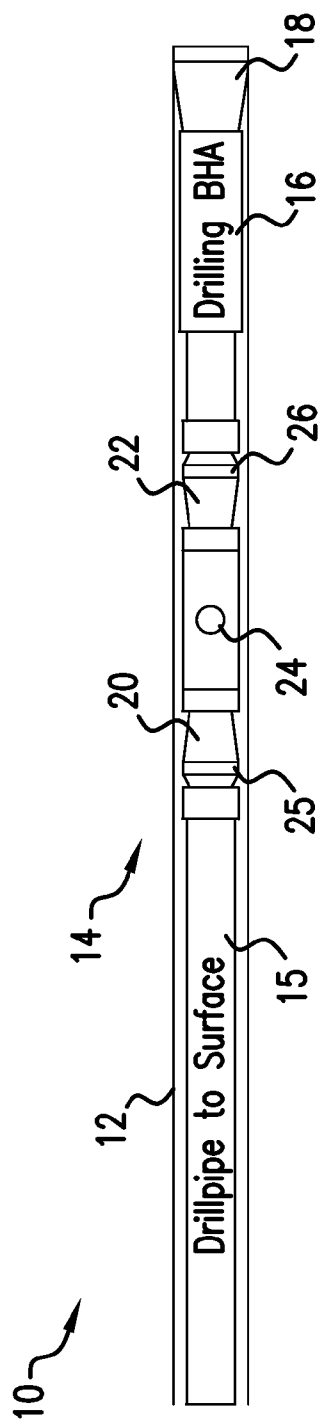


FIG. 1

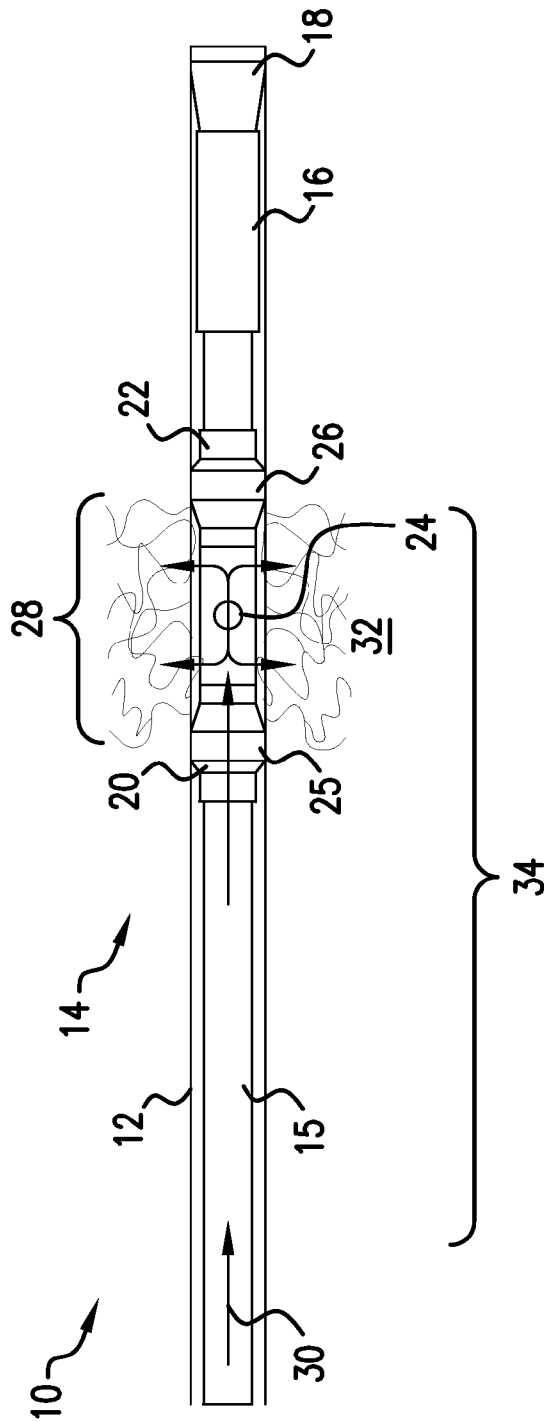
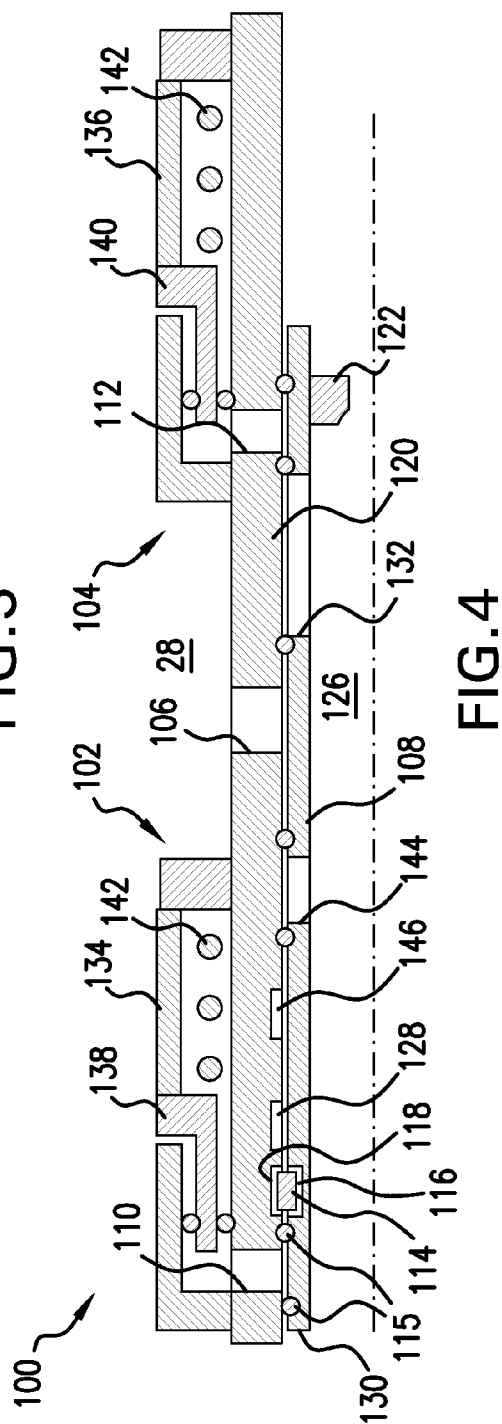
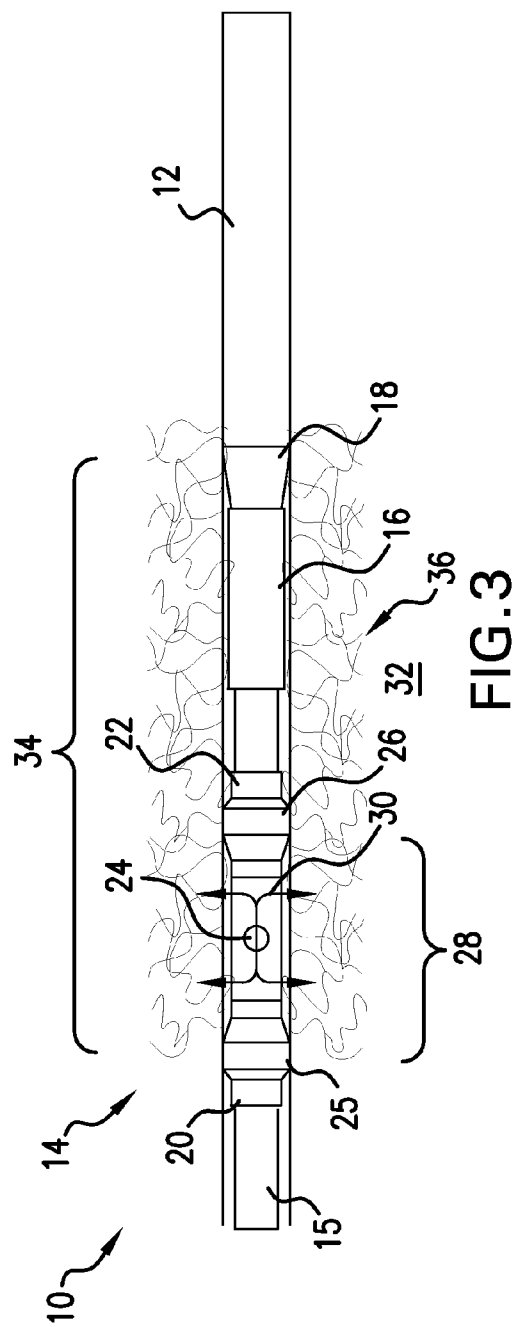
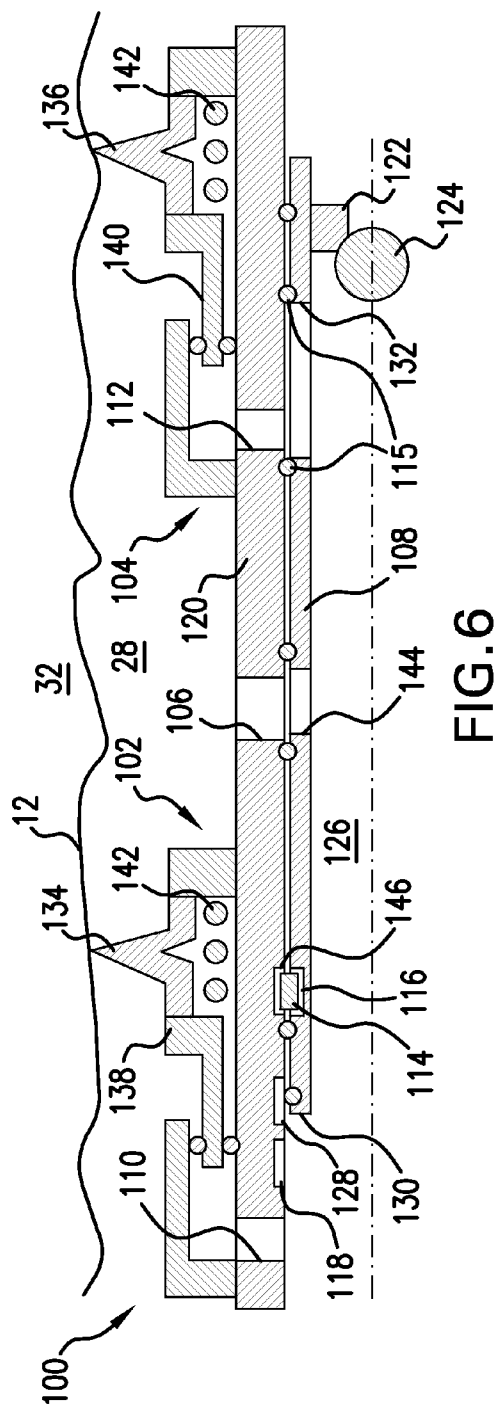
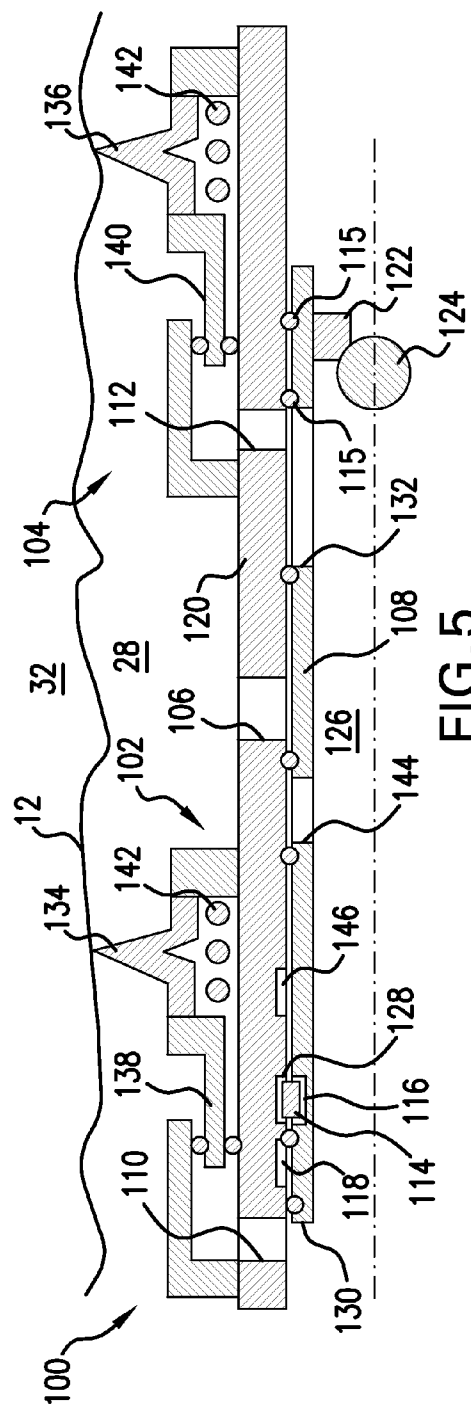


FIG. 2





## METHOD AND SYSTEM FOR TREATING A BOREHOLE

### BACKGROUND

**[0001]** In industries that practice in the subsurface environment, such as hydrocarbon recovery, carbon dioxide sequestration, etc., it is often desirable to treat the subsurface formation to affect various physical or chemical attributes thereof. One specific example of affecting physical attributes of the formation is fracturing (fracing) procedures that help to increase permeability of a formation.

**[0002]** While such procedures are commonly undertaken, they often require extended periods of time to complete and multiple runs in the borehole, both of which increase costs associated with the completion operation being undertaken. Since the art well appreciates new methods that improve efficiency and reduce costs, new methods for doing so with respect to fracturing and treating boreholes are always in demand.

### SUMMARY

**[0003]** A method for treating an open borehole including running a tool having axially spaced isolation band assemblies disposed thereon; pressuring on the tool resulting in deployment of the isolation band assemblies; applying fluid to the open borehole between the isolation band assemblies; and continuously moving the tool through the borehole along a length of the borehole while treating.

**[0004]** A method for drilling and fracing a borehole in a single trip including drilling with a bottom hole assembly (BHA) at a first end of a string, the string including a fracing tool upstring of the BHA, to form a borehole; deploying axially spaced isolation band assemblies into contact with a wall of the borehole; applying frac pressure to the wall between the isolation band assemblies; and continuously drawing the fracing tool in an uphole direction at a frac progression rate while applying the frac pressure.

**[0005]** A method for fracturing a borehole including running a tool having axially spaced isolation band assemblies disposed thereon; pressuring on the tool resulting in deployment of the isolation band assemblies; applying fluid to the borehole in a zone between the isolation band assemblies; and continuously moving the tool through the borehole while fracturing the borehole with the fluid.

**[0006]** A system for fracturing a borehole including a tool body; two or more isolation band assemblies spaced axially apart on the tool body; and one or more fluid openings in the tool body between the isolation band assemblies.

**[0007]** A method for fracturing a borehole including running a tool having axially spaced isolation band assemblies disposed thereon; pressuring on the tool resulting in deployment of the isolation band assemblies; applying fluid to the borehole between the isolation band assemblies for fracturing a downhole formation adjacent the borehole; moving the tool along a length of the borehole; and forming a continuous fracture pattern in the downhole formation along the length of the borehole.

**[0008]** A method for fracturing a borehole including forming an isolation zone in the borehole having a first length; and fracturing a downhole formation adjacent the isolation zone, wherein a fracture pattern of the fracturing is continuous over a second length longer than the first length.

### BRIEF DESCRIPTION OF THE DRAWINGS

**[0009]** The following descriptions should not be considered limiting in any way. With reference to the accompanying drawings, like elements are numbered alike:

**[0010]** FIG. 1 is a schematic view of a system for performing a borehole treatment operation according to one embodiment disclosed herein;

**[0011]** FIG. 2 is a schematic view of the system of FIG. 1 having a pair of isolation bands in a set configuration for treating a section of the borehole;

**[0012]** FIG. 3 is a schematic view of the system of FIG. 2 after the system has been moved without unsettling the isolation bands or ceasing treatment;

**[0013]** FIG. 4 is a cross-sectional view of a tool in an initial configuration according to one embodiment disclosed herein;

**[0014]** FIG. 5 illustrates the tool of FIG. 4 in an intermediate open configuration in which isolation bands of the tool are open to fluid pressure; and

**[0015]** FIG. 6 illustrates the tool of FIG. 4 in a fully open configuration in which fluid communication through the tool for treating a borehole is established.

### DETAILED DESCRIPTION

**[0016]** A detailed description of one or more embodiments of the disclosed apparatus and method are presented herein by way of exemplification and not limitation with reference to the Figures.

**[0017]** Referring now to FIG. 1, a system 10 is illustrated for treating a borehole 12. In one embodiment, the borehole 12 is an open borehole, while in other embodiments it could be cased, lined, cemented, etc. The system includes a tool 14 run in on a tubular string 15. In the illustrated embodiment, the string 15 is a drillstring having a bottom hole assembly (BHA) 16, which includes a drill bit 18. Advantageously, the method of the present invention facilitates borehole treatment such as fracing in a single run (i.e., fracturing can be immediately undertaken following drilling with the same string that delivered the BHA into the borehole, the fracing being done while withdrawing the BHA) or a separate run, as desired. Drilling of a borehole in a formation followed by fracturing of the same borehole while the drilling BHA is being tripped out of the borehole improves efficiency and reduces cost. In non-illustrated embodiments, the tubular string 15 could be a work string or other string run into the borehole 12 after a drill string is pulled out.

**[0018]** The tool 14 includes a pair of isolation band assemblies 20 and 22 that can be radially expanded, enlarged, or otherwise deployed or set in order to sufficiently engage with or against the borehole 12 that fracture pressure will be contained in the target annulus axially bounded by the isolation bands. This may in some cases be a commonly understood seal or in other cases may be a condition that retards leakoff to a point sufficient to enable fracturing prior to bleed off of pressure past the isolation band assemblies. The isolation band assemblies 20 and 22 are initially unset or undeployed, as illustrated in FIG. 1, in order to promote the ability to run the tool 14 in the hole to perform drilling or other operations. The tool 14 includes one or more ports 24 or other fluid opening that is initially closed, as shown in FIG. 1, to enable the string 15 to be used normally, e.g., for typical drilling, circulation, or other operations. The assemblies 20 and 22 are shown in a set or expanded configuration in FIGS. 2 and 3 in which isolation bands 25 and 26 of the isolation band assem-

blies 20 and 22 are engaged against a wall of the borehole 12. The isolation band assemblies 20 and 22 are transitioned between the set and unset configurations via pressure, spring force, mechanical coupling, etc., or combinations thereof.

[0019] By deploying the assemblies 20 and 22, isolation of a zone 28 between the assemblies 20 and 22 is achieved. The act of deploying the assemblies 20 and 22, discussed in more detail below, may result in the port(s) 24 becoming opened, or the port(s) 24 may be opened subsequent to deployment of the assemblies 20 and 22. Once the one or more ports 24 is/are opened, as shown in FIG. 2, a fluid or media 30 (e.g., borehole fluid, a slurry, with or without proppant, etc.), indicated by a set of arrows (labeled 30), may be pumped or delivered through the string 15 to the isolated zone 28 via the port(s) 24. This enables the portion of a downhole formation 32 contiguous to the zone 28 to be treated, e.g., fractured, by the media 30. Of course, it is again noted that while hydraulic fracturing operations are particularly benefitted by the illustrated embodiment, any other fluid or media treatment operation could be performed by the system 10.

[0020] Currently known fracing systems rely on packers that split the borehole into a plurality of separate isolated zones that are fractured individually (e.g., via frac sleeves, plug and perf operations, etc.). Disadvantageously, these known fracturing operations may lead to the downhole formation not being fully fractured, i.e., in the areas proximate to the packers between zones.

[0021] Instead of creating a plurality of separate isolated zones that are individually fractured, as in the aforementioned previously known systems, the system 10 is arranged to continuously treat or fracture the formation 32 along an extended length 34 that is larger than that of the zone 28. In order to facilitate the continuous treating operation, the assemblies 20 and 22 of the tool 14 remain deployed against the borehole 12 during movement of the tool. For example, as noted above, the tool 14 directs fracture fluid under pressure to the formation 32 within zone 28 as it is pulled out of the hole or moved in the uphole direction. In this way, the assemblies 20 and 22 can be said to be “dragged” along the borehole 12 while the tool 14 is moved by the string 15 along the length 34. The assemblies 20 and 22 can be initially deployed and the zone 28 initially fractured, as shown in FIG. 2, and then the tool 14 moved along the length 34 without retracting the assemblies 20 and 22 and while applying a pressurized fluid via the port(s) 24 to continuously fracture the entirety of the length 34 as shown in FIG. 3. At any instantaneous moment along the length 34, only the formation contiguous to the zone 28 is being treated. However, as the location of the zone 28 is constantly moving due to the movement of the tool 14 (and “dragging” of the assemblies 20 and 22), the entire length 34 of the formation 32 is treated over the time it takes tool 14 to traverse length 34.

[0022] In one embodiment, the spacing between the assemblies 20 and 22, and thus the size of the zone 28, is considerably smaller than the distance between the aforementioned statically positioned packers of known systems. Advantageously, this reduces the horsepower required to pump the media 30 downhole for treating or fracturing the formation 32. The use of smaller zones is infeasible in known systems, as the number of packer systems, and thus the expense of completing a borehole, would increase drastically as the distance between the systems is decreased. It is also noted that a fracture pattern 36 of the formation 32 is advantageously formed as a continuous or uniform pattern (generally, a “con-

tinuous pattern”). For example, as illustrated in FIG. 3, there are no regular gaps or breaks in the fracture pattern 36 along the length 34. In contrast, currently known system employing statically positioned packers result in areas adjacent to the packers that are not fully fractured or treated, thus forming discontinuous fracture or treatment patterns. A continuous fracture pattern, e.g., the pattern 36, enables the more complete extraction of hydrocarbons or the like from the downhole formation 32. For this reason, the system 10 or other systems according to the current invention can also be used, as discussed in more detail below, to fracture or re-fracture existing wells that have already been fractured and/or produced, and/or which may be considered dry or depleted.

[0023] The speed or progression rate at which the tool 14 is moved can be set in response to the particular conditions under which the system 10 is utilized, e.g., porosity of the formation 32, depth, temperature, materials used for the media 30, pressure of the media 30, frac pressure required to fracture the formation 32, etc. For example, the progression rate should not be so high that the media 30 does not have sufficient time to fully penetrate, fracture, or treat a portion of the formation 32 before the zone 28 is moved out of range of that portion. However, higher rates of speed will reduce the potential of the tool 14 becoming stuck. For example, proppant, sand, or solids in the media 30 can settle and become wedged between the borehole 12 and the isolation bands 25 and/or 26. Accordingly, it may be desirable to determine a proper progression rate based on these and other conditions and parameters that are determined or measured with respect to the media 30, the borehole 12, the tool 14, the formation 32, etc. prior to setting a speed or while the operation is proceeding for real time adjustment of the process.

[0024] If the isolation bands become stuck e.g., on a protuberance, projection, or radially restricted area of the borehole 12, and/or by proppant or other solids becoming wedged or lodged between the isolation bands and the wall of the borehole 12, several actions can be taken alone or in combination to free the tool. For example, the isolation bands can be retracted, e.g., by reducing the pressure internal to the string 15 used to actuate the isolation band assemblies, in order to permit circulation past the fractures bands in order to clear out settled or lodged particles and then pressure reapplied to redeploy the isolation bands, the string 15 can be forced or bumped in an opposite direction and then continued along its path in the desired direction, etc.

[0025] It is to be appreciated that movement of the tool 14 can be halted and resumed any number of times for continuously treating any number of lengths of the borehole 12, with the length 34 designating one such length. That is, the length 34 may correspond to the entirety of an interval of the borehole 12 that is desired to be treated or fractured by the system 10, or the length 34 may be some portion of a desired interval (e.g., determined on-the-fly during the treatment operation, or portions of the borehole between joints, etc.). For example, if the tool 14 becomes stuck, as noted above (e.g., the tool 14 needs to be bumped, the assemblies 20 and 22 retracted and redeployed, fluid circulated past the assemblies 20 and/or 22, etc.), the length 34 may correspond to a distance along the borehole 12 up to the point at which movement of the tool 14 is halted and corrective action to free the tool 14 occurs. As another example, movement of the tool 14 may be paused or halted if it is measured or determined that the pressure and/or flow rate of the media 30 is too low (e.g., relatively high fluid loss occurs through a particularly soft or porous portion of the

formation 32), if the progression rate is determined during treating to be too fast, or to otherwise ensure a complete and effective treatment or fracture of the formation 32. In any such case, the length 34 again corresponds to the portion of the borehole 12 up to the point at which movement of the tool 14 is paused or halted.

[0026] In one embodiment, the isolation bands 25 and 26 also exert a sufficient force against the wall of the borehole 12 to induce stress therein that will help the fracture process. More particularly, the contact stress imparted to the formation 32 is substantially equal to or greater than the strength of the formation thus promoting sealing against the formation while inducing mechanical failure of the formation either alone or in combination with the hydraulic failure induced by pressure of the media 30 supplied by the port(s) 24 as discussed above.

[0027] Whether the isolation bands are arranged only to retard fluid pressure escape from zone 28 or to induce stress, or both, the material of the isolation bands 25 and 26 is in some embodiments selected to be resistant to disintegration or wear during movement along the formation while in loaded contact with the borehole 12. Exemplary materials include various metals, ceramics, and composites, which exhibit good strength properties in downhole conditions.

[0028] A tool 100 suitable for the above-discussed continuous treatment operation is illustrated in FIGS. 4-6. The tool 100 includes a pair of isolation band assemblies 102 and 104, similar to the assemblies 20 and 22, i.e., to engage a wall of the borehole 12 in order to form the zone 28 therebetween. The tool 100 also includes one or more ports 106 arranged similarly to the port(s) 24, i.e., to provide fluid to the zone 28, e.g., for fracturing or treating the formation 32 contiguous to the zone 28. In this way, the tool 100 can be generally used in the above-described manner as tool 14.

[0029] The tool 100 is shown in an initially closed configuration in FIG. 4. In this configuration, a sleeve 108 blocks fluid flow through the port(s) 106. The isolation band assemblies 102 and 104 respectively have one or more ports 110 and 112, which ports 110 and 112 are also initially closed by the sleeve 108. A plurality of seal elements 115, such as O-rings, are included throughout the tool 100 to seal off unintended fluid pathways throughout the tool 100. The sleeve 108 can initially be held in the closed configuration by a release mechanism, such as a shear screw or ring, ratchet profile, magnetic coupling, collet, spring-loaded dog, etc., such that the sleeve 108 will not open the ports 106, 110, or 112 until suitable force is applied to the sleeve 108. In the illustrated embodiment, the release mechanism takes the form of a resilient member 114, e.g., a split or expandable ring, disposed in both a groove or slot 116 of the sleeve 108 and a groove or slot 118 of a body or mandrel 120 (e.g., part of the string 15 in FIGS. 1-3). A seat 122 is included by the sleeve 108 and receptive of a ball, dart, plug, or other object (collectively "plug") to enable the aforementioned application of force for releasing the resilient member 114 or other release mechanism.

[0030] The tool 100 is shown in an intermediate open configuration in FIG. 5. Specifically, the sleeve 108 can be shifted by landing a plug 124 at the seat 122 and pressurizing an internal passageway 126 of the body 120 against the plug 124. The plug 124 can be dropped from surface and/or from a designated tool along the length of the body 120 and/or string 15. When sufficiently pressurized, the member 114 will release from the groove 116 and enable movement of the sleeve 108 relative to the body 120. The sleeve 108 is held in

the intermediate configuration by the resilient member 114 springing into or resiliently engaging with an intermediate groove or slot 128 of the body 120. When the sleeve 108 is shifted to the intermediate configuration, the ports 110 and 112 become opened, i.e., in fluid communication with the interior passageway 126 of the body 120, by movement of an end 130 of the sleeve 108 beyond the port 110 and alignment of a port 132 in the sleeve 108 with the port 112.

[0031] The port 106 remains closed or blocked by the sleeve 108 in the intermediate configuration. To this end, a pair of isolation bands 134 and 136 corresponding respectively to the isolation band assemblies 102 and 104 can be deployed before the port 106 is opened. Deployment of the isolation bands 134 and 136 is achieved in the illustrated embodiment by pressurizing a pair of pistons 138 and 140 corresponding respectively to the isolation band assemblies 102 and 104 with fluid from the passageway 126 provided to the pistons 138 and 140 respectively via the ports 110 and 112. The pistons 138 and 140 axially compress the isolation bands 134 and 136, which causes the isolation bands 134 and 136 to extend radially outwardly to engage the borehole 12 as shown. A spring 142 or other resilient member can be included to initially maintain each of the isolation band assemblies 102 and 104 in their undeployed or retracted configuration of FIG. 4, and/or to urge the isolation bands 132 and 134 to at least partially retract when the pressure in the passageway 126 is reduced.

[0032] Similar to the isolation bands 25 and 26 discussed above, the isolation bands 134 and 136 can be arranged to retard fluid escape, seal against the borehole, and/or exert a fracture force or pressure mechanically on the formation 32. The isolation bands 134 and 136 are made of, include, or are coated by a metal, ceramic, composite, or some other material or combination of materials resistant to damage, wear, or disintegration of the isolation bands 134 and 136 as they are dragged along the borehole 12 in the manner discussed above with respect to FIGS. 2 and 3. In one embodiment, the isolation bands 134 and 136 include an elastomeric material covered by a metal or other hard material, such that the elastomeric material helps support the metal from buckling when highly pressured or mechanically forced against the borehole 12. In one embodiment, the borehole 12 is cased or lined with relatively smooth walled structures, and an elastomeric material, metal, or any other suitable material is used alone or in combination for the isolation bands. In one embodiment, the borehole 12 has already been completed, fractured and/or produced, and may include a cased, lined, and/or cemented borehole, packers, frac sleeves, perforations, cementation, or any other currently used fracturing device or component, and a system according to the current invention is utilized to re-fracture the borehole. In this way, seemingly depleted or dry wells can be revitalized for additional production. The isolation bands 134 and 136 may be scored or include slots, slits, or notches in order to ensure or encourage the isolation bands 134 and 136 to extend in the desired direction and/or create the desired sealing profile. For example, a plurality of different borehole engagement profiles for the isolation bands (e.g., pointed as shown in FIGS. 5 and 6, rounded, squared off, etc.) is taught in U.S. Pat. No. 6,896,049 to Moyes, which patent is hereby incorporated by reference in its entirety, and the teachings of which are generally applicable to the operation and/or structure of isolation band assemblies according to various embodiments.

[0033] In lieu of the axially compressible members shown, one of ordinary skill in the art will appreciate that radial deployment of isolation band assemblies could be accomplished in other ways. For example, the deployment could be the result of radially expanding an isolation band, plastically and/or elastically, e.g., with a wedge or cone, inflating a chamber at least partially defined by the isolation bands with a pressurized fluid, etc. It is also noted that the pertinent parameters of the release mechanism can be set to resist further actuation of the sleeve 108 until the pressure to fully set or deploy the isolation band assemblies 102 and 104 is reached. For example, with respect to the groove 128, the depth of the groove 128, the angle of the edge of the groove 128, etc., can be set to resist a selected threshold pressure. For example, a higher pressure must be provided to release the resilient member 114 from a relatively deeper groove and/or a groove having walls at angles approaching perpendicularity with the direction of movement of the sleeve 108 than if the groove 128 were shallower or had a more gently tapered edge.

[0034] Once a suitable pressure is reached to release the member 114 from the groove 128, the sleeve 108 is further actuated to open the port(s) 106 by aligning the port(s) 106 with one or more ports 144 in the sleeve 108. The sleeve 108 is held in the fully open configuration of FIG. 6 by way of the resilient member 114 engaging with a groove or slot 146 in the body 120 or some other manner such as a stop. Once the port(s) 106 is opened, the passageway 126 is in fluid communication with the zone 28 between the assemblies 102 and 104. If the tool 100 is used in a fracturing operation, a proppant slurry can then be communicated to the zone 28 for fracturing the formation 32. Other fluids can be similarly communicated for treating the formation 32 contiguous to the zone 28.

[0035] While the invention has been described with reference to an exemplary embodiment or embodiments, it will be understood by those skilled in the art that various changes may be made and equivalents may be substituted for elements thereof without departing from the scope of the invention. In addition, many modifications may be made to adapt a particular situation or material to the teachings of the invention without departing from the essential scope thereof. Therefore, it is intended that the invention not be limited to the particular embodiment disclosed as the best mode contemplated for carrying out this invention, but that the invention will include all embodiments falling within the scope of the claims. Also, in the drawings and the description, there have been disclosed exemplary embodiments of the invention and, although specific terms may have been employed, they are unless otherwise stated used in a generic and descriptive sense only and not for purposes of limitation, the scope of the invention therefore not being so limited. Moreover, the use of the terms first, second, etc. do not denote any order or importance, but rather the terms first, second, etc. are used to distinguish one element from another. Furthermore, the use of the terms a, an, etc. do not denote a limitation of quantity, but rather denote the presence of at least one of the referenced item.

What is claimed is:

1. A method for treating an open borehole comprising:
  - running a tool having axially spaced isolation band assemblies disposed thereon;
  - pressuring on the tool resulting in deployment of the isolation band assemblies;

- applying fluid to the open borehole between the isolation band assemblies; and
- continuously moving the tool through the borehole along a length of the borehole while treating.

2. The method of claim 1, wherein the pressuring is subsequent to seating a plug in the tool.

3. The method of claim 2, wherein seating the plug includes landing the plug at a seat of a sleeve of the tool, the pressuring includes shifting a sleeve in order to open a port, and the applying includes flowing fluid through the port.

4. The method of claim 2, further comprising dropping the plug from surface.

5. The method of claim 1, wherein the applying is applying fracture pressure.

6. The method of claim 1, wherein the continuously moving is at a progression rate related to a particular formation in which the method is being employed.

7. The method of claim 1, wherein the pressuring includes shifting a sleeve.

8. The method of claim 1, wherein the deployment of the isolation band assemblies includes axially compressing isolation bands of the isolation band assemblies, resulting in radial extension of the isolation bands.

9. A method for drilling and fracing a borehole in a single trip comprising:

- drilling with a bottom hole assembly (BHA) at a first end of a string, the string including a fracing tool upstring of the BHA, to form a borehole;

- deploying axially spaced isolation band assemblies into contact with a wall of the borehole;

- applying frac pressure to the wall between the isolation band assemblies; and

- continuously drawing the fracing tool in an uphole direction at a frac progression rate while applying the frac pressure.

10. The method of claim 9, wherein the drilling includes circulation.

11. The method of claim 9, wherein the deploying includes seating a plug in a seat of the fracing tool.

12. The method of claim 11, wherein the method includes shifting a sleeve that is operatively connected to the seat to open a port to the wall of the borehole between the isolation band assemblies.

13. The method of claim 9, wherein the deploying includes imposing hoop stress in the borehole.

14. The method of claim 9, wherein pressure is relieved to at least partially retract the isolation band assemblies.

15. The method of claim 14, further comprising circulating.

16. A method for fracturing a borehole comprising:

- running a tool having axially spaced isolation band assemblies disposed thereon;

- pressuring on the tool resulting in deployment of the isolation band assemblies;

- applying fluid to the borehole in a zone between the isolation band assemblies; and

- continuously moving the tool through the borehole while fracturing the borehole with the fluid.

17. The method of claim 16, wherein the borehole has been fractured or produced prior to performing the method.

18. A system for fracturing a borehole comprising:

- a tool body;

- two or more isolation band assemblies spaced axially apart on the tool body; and



one or more fluid openings in the tool body between the isolation band assemblies.

**19.** The system of claim **18**, wherein the two or more isolation band assemblies are operatively arranged to extend radially outwardly against a borehole wall in order to isolate a zone therebetween.

**20.** The system of claim **19**, wherein the tool body is operatively arranged to be moved a desired length along the borehole while maintaining engagement of the two or more isolation band assemblies with the borehole.

**21.** The system of claim **19**, wherein each of the two or more isolation band assemblies includes an isolation band that is operatively arranged to be axially compressed and radially extended via pressure within the tool body.

**22.** The system of claim **22** further comprising a sleeve having a seat receptive of a plug, the sleeve movable between an initial configuration in which the one or more openings are closed and fluid communication is blocked between the two or more isolation band assemblies and the pressure in the tool body, an intermediate configuration in which the two or more isolation band assemblies become in fluid communication

with the pressure in the tool body, and a fully open configuration in which the one or more openings are also in flow communication with the pressure in the tool body.

**23.** A method for fracturing a borehole comprising:

running a tool having axially spaced isolation band assemblies disposed thereon;

pressuring on the tool resulting in deployment of the isolation band assemblies;

applying fluid to the borehole between the isolation band assemblies for fracturing a downhole formation adjacent the borehole;

moving the tool along a length of the borehole; and

forming a continuous fracture pattern in the downhole formation along the length of the borehole.

**24.** A method for fracturing a borehole comprising:

forming an isolation zone in the borehole having a first length; and

fracturing a downhole formation adjacent the isolation zone, wherein a fracture pattern of the fracturing is continuous over a second length longer than the first length.

\* \* \* \* \*