Title
Downhole catching apparatus

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Related Art
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Title: DOWNHOLE CATCHING APPARATUS

Abstract: A downhole catching apparatus (20) comprises a plurality of radially moveable seat members (26) arranged circumferentially around a longitudinal axis, wherein the seat members are moveable between a radially extended configuration which permits passage of an object (64) therethrough and a radially retracted configuration which permits an object (64) to be caught by the apparatus. A releasable lock arrangement (44) is provided for releasably retaining the seat members in the radially extended configuration.
CATCHING APPARATUS

FIELD OF INVENTION

The present invention relates to a catching apparatus for use in catching an object, such as within a downhole flow path.

BACKGROUND TO INVENTION

In the oil and gas industry many downhole operations rely on objects dropped from surface to be caught at some point along a downhole system to perform a desired function, such as mechanical actuation, flow diversion or the like. For example, WO 2011/117601 and WO 2011/117602 each disclose downhole apparatus which catch objects for use in actuation of a downhole tool and flow diversion within the tool, for example for use in fracturing operations.

A collet type catching apparatus includes a number of collet fingers each carrying a collet or seat member. In use, the collet fingers are capable of being deflected radially inwards to move the seat members between the radially extended configuration and a radially retracted configuration which permits an object to be caught.

In some circumstances, however, it is possible for the collet fingers to inadvertently move to the radially retracted configuration, impairing the passage of an object or tool through the downhole system.

Inadvertent movement of the collet fingers to the radially retracted configuration may occur, for example, where residual stresses retained in the apparatus from its manufacture are released when the apparatus is subject to repeated impact events during its operational life, such as from the impact of an object or objects to be caught by the apparatus.

OBJECT OF INVENTION

It is an object of the present invention to substantially overcome or at least ameliorate one or more of the abovementioned disadvantages.
SUMMARY OF INVENTION

According to a first aspect of the present invention there is provided a downhole catching apparatus for catching an object, comprising:

- a plurality of radially moveable seat members arranged circumferentially around a longitudinal axis, wherein the seat members are moveable between a radially extended configuration and a radially retracted configuration; and
- a releasable lock arrangement for releasably radially restraining the seat members in the radially extended configuration and against radial movement towards the radially retracted configuration.

The radially extended configuration may permit passage of an object through the seat members and the radially retracted configuration may permit an object to be caught by the apparatus/seat members.

Providing a lock arrangement may permit the seat members to be retained in the radially extended configuration and so prevent inadvertent movement or collapse of the seat members towards a radially retracted configuration, for example as a result of impact of an object on the seat members. Providing a lock arrangement may permit the seat members to be retained in the radially extended configuration without reliance on equalised stresses in the apparatus to keep them in position.

The apparatus may be configured to be retained in the radially extended configuration until acted on by an actuation event. Retaining the apparatus in the radially extended configuration until acted on by an actuation event may ensure that the apparatus is not collapsed until an operator wishes to actuate the tool.

The lock arrangement may define a locked condition and an unlocked condition.

The lock arrangement may be biased towards the locked condition. The lock arrangement may be biased towards the locked condition by a biasing member, such as a spring or the like.

The lock arrangement may be configured to move from the locked condition to the unlocked condition. The lock arrangement may be configured to move from the locked condition to the unlocked condition to permit movement of the seat members towards the
retracted configuration. Thus, the apparatus may be retained until it is desired to release the lock arrangement.

The lock arrangement may be configured to move from the locked condition to the unlocked condition by axial movement. The actuation event may comprise the axial movement.

The lock arrangement may be configured to move from the unlocked condition to the locked condition. The lock arrangement may be configured to move from the unlocked condition to the locked condition to permit the seat members to again be retained in the extended configuration. Thus, the lock arrangement may be re-useable, being moveable between the locked condition and the unlocked condition a plurality of times. The lock arrangement may be configured to move from the locked condition to the unlocked condition by axial movement.
At least part of the lock arrangement may be defined by a seat member.

At least part of the lock arrangement may be defined by a housing. The apparatus may comprise the housing or the housing may be operably associated with the catching apparatus.

At least part of the lock arrangement may be defined by a tool. The apparatus may comprise the tool or the tool may be operably associated with the catching apparatus. The tool may be disposed about the seat members. The tool may be disposed between the housing and the seat members.

The tool may comprise an annular member. The tool may comprise a ring, a washer or the like.

The tool may comprise a sleeve, such as an insert sleeve, disposed within the housing. The insert sleeve may be secured to the housing. Providing an insert sleeve may assist in manufacture of the lock arrangement.

In particular embodiments, the lock arrangement may be defined by the seat members, the annular member, such as the ring, and the housing/insert sleeve.

The lock arrangement may comprise a lock profile.

The lock profile may comprise an external profile. For example, the lock profile may comprise an external profile formed or otherwise provided on one or more of the seat members.

The lock profile may comprise an internal profile. For example, the lock profile may comprise an internal profile formed or otherwise provided on the annular member, such as the ring. Alternatively, or additionally, the lock profile may comprise an internal profile formed or otherwise provided on the housing or insert sleeve.

In particular embodiments, the lock profile may be defined by an external profile on the seat members, and internal profiles on the ring and insert sleeve. The internal profiles may be axially spaced.

In use, the lock profiles may cooperate to retain the lock arrangement in the locked condition.

The apparatus may be configured to define multiple locked configurations. For example, in a first locked configuration the seat member lock profile may be arranged to cooperate with the annular member lock profile. In a second locked configuration the seat member lock profile may be arranged to cooperate with the housing or insert sleeve lock profile.
The, or at least one, lock profile may comprise a hook profile, a barb, or the like.

The, or at least one, lock profile may comprise an acute angle. In particular embodiments, the, or at least one, lock profile may comprise an angle of 50 degrees. The angle may alternatively be, for example, 30 degrees, 45 degrees, 60 degrees, 70 degrees, or any other suitable angle.

The lock arrangement, more particularly the lock profile or profiles, may assist in providing erosion protection. This may be achieved since the profile, or profiles, define more material to be eroded should erosion occur. Thus the profile, or profiles, may be at least partially sacrificial.

At least one of the apparatus, the seat members, housing, annular member, sleeve, ring may be provided with or comprise an erosion resistant coating. Providing an erosion resistant coating may assist in providing erosion protection.

The catching apparatus may be configured to catch an object such as a ball, dart, plug, tool or the like.

The catching apparatus may be for use in catching an object passing along any flow path, such as in a pipeline environment, downhole environment or the like.

The catching apparatus may be configured to catch an object travelling in a downhole environment, for example travelling through a tubular structure positioned within a wellbore, such as a tubing string, completion string, tool string, production string, injection string, fracturing string or the like. The catching apparatus may be configured to be located within a tubular structure. For example, the catching apparatus may be configured to be mounted within a housing of a downhole tool.

The catching apparatus may define a catching sleeve. In such an arrangement the apparatus may be provided in the form of a sleeve.

The catching apparatus may be configured to function as a flow diverter when an object is caught.

The catching apparatus may be configured to function as an actuator when an object is caught. For example, the catching apparatus may be configured to actuate another component, structure, apparatus, tool or the like. For example, when an object is caught by the catching apparatus, the object may facilitate movement of the catching apparatus, for example by impact of the object against the apparatus, by a pressure differential established across the object/catching apparatus, or the like.

The catching apparatus may be provided in combination with a j-slot actuator arrangement.
The catching apparatus may be configured to function as a bore plug when an object is caught, for example to isolate a region within a tubing structure. Such an arrangement may facilitate pressure to be controlled, for example elevated, in a section of a tubing structure. Such an arrangement may facilitate pressure actuation of a further component, structure, apparatus, tool or the like, such as packers, slips, rupture disks and the like.

The catching apparatus may be configured to function as a flow restrictor when an object is caught. For example, the catching apparatus may be configured to function as a choke.

The catching apparatus may be configured for use within a fracturing system or operation. For example, the catching apparatus may be configured to actuate or open one or more fracturing valves to permit a fracturing fluid to be delivered into a surrounding formation. Alternatively, or additionally, the catching apparatus may be configured to function as a flow diverter when an object is caught to divert flow of fracturing fluid outwardly through opened ports and into a surrounding formation.

The seat members may be radially moveable to be radially extended and retracted relative to a central bore of the catching apparatus. That is, the seat members may be moveable radially inwardly to be retracted into the central bore to define a reduced effective inner diameter. The seat members may be moveable radially outwardly to be radially extended from the central bore to define an increased effective inner diameter. When the seat members are positioned radially inwardly and retracted into the central bore said members may be positioned into the path of an object passing through the catching apparatus. When in such a configuration the seat members may be engaged by an object. When the seat members are positioned radially outwardly and extended from the central bore said members may be outside the path of an object passing through the catching apparatus.

The catching apparatus may be configurable from a free configuration in which the seat members permit an object to pass the catching apparatus, to a catching configuration in which the seat members catch an object.

The catching apparatus may be reconfigured to or in its catching configuration by radially supporting the seat members in a radially inward position such that outward radial movement is prevented. In such a configuration an object passing through the catching apparatus may become seated against the radially supported seat members.
The catching apparatus may be configurable between its free and catching configurations by an actuator. Any suitable actuator may be used to actuate and reconfigure the catching apparatus. For example, a valve member, such as a valve sleeve, arranged in proximity to the catching apparatus may function to reconfigure the catching apparatus. For example, opening and/or closing of a valve member may also reconfigure the catching apparatus.

An indexing sleeve, such as a collet sleeve disclosed in WO 2011/117601 and/or WO 2011/117602 may be used to reconfigure the catching apparatus. The disclosure of WO 2011/117601 and WO 2011/117602 is incorporated herein by reference.

A piston assembly may be used to reconfigure the catching apparatus. A shifting tool, such as a coiled tubing or wireline deployed shifting tool may be used to reconfigure the catching apparatus.

The seat members may be biased in a radial direction.

In one embodiment the seat members may be biased radially outwardly. In such an arrangement the seat members may require to be positively moved against this bias to be moved radially inwardly and be retracted into the central bore to be engaged by an object. Thus, when the catching apparatus is in its free configuration an object may freely pass through the catching apparatus without or with minimal engagement with the seat members. The catching apparatus may be reconfigured into its catching configuration by positively moving the seat members radially inwardly into the central bore against the bias to catch an object.

In one embodiment the seat members may be biased radially inwardly. In such an arrangement the seat members may be required to be positively moved against this bias to be moved radially outwardly and be extended from the central bore to allow passage of an object, when required. Such outward radial movement of the seat members may be caused by an object acting against the seat members during passage of the object through the catching apparatus when the catching apparatus is configured in its free configuration.

The catching apparatus may be axially moveable to be configured between its free and catching configurations.

The catching apparatus may be held stationary and a support arrangement, such as a sleeve, may be moved axially relative to said catching apparatus to selectively support the seat members in a radially inward position.
The catching apparatus may be configurable from the catching configuration to a release configuration in which the seat members permit release of a previously caught object.

In one embodiment the catching apparatus may be configurable to the release configuration by de-supporting the seat members. When the seat members are de-supported a bias force may act to move the seat members radially outwardly and extend the seat members from the central bore. Alternatively, or additionally, when the seat members are de-supported displacement of an object, for example by fluid pressure, may deflect the seat members radially outwardly, thus allowing the object to pass.

The catching apparatus may be axially moveable to permit said catching apparatus to be reconfigured to the release configuration. Such axial movement may be achieved by action of an object seated against the seat members, for example by action of a differential pressure permitted to be established across the interface between the object and the seat members.

The catching apparatus may be axially moveable to align the seat members with a region of increased inner diameter, thus permitting the seat members to be moved radially outwardly.

The catching apparatus may be provided in combination with a release arrangement. The catching apparatus and the release apparatus may form part of a catching system according to an alternative aspect of the present invention. The release arrangement may be actuated by axial movement of the catching apparatus. The release arrangement may be configured to facilitate de-supporting of the seat members to permit the catching apparatus to be configured in its release configuration.

The release arrangement may comprise a release sleeve. The release sleeve may be moveable between a supporting position in which the release sleeve may radially support the seat members in the radially inward or retracted position, towards a de-supporting position in which the release sleeve removes the radial support to the seat members, allowing the seat members to be moved radially outwardly.

The release sleeve may cover a release recess, for example formed within a tubing structure, when said release sleeve is located within its supporting position. The release sleeve may be moved axially towards its release position to uncover the
release recess and permit the seat members to be moved radially outwardly and received within the release recess to permit release of an object.

The release sleeve may be moved axially by an actuator.

The release sleeve may be moved axially by the catching apparatus,

The release sleeve may define a load profile, such as a load shoulder, configured to be engaged by the catching apparatus.

The catching apparatus may define a load profile configured to engage a load profile on the release sleeve to permit the catching apparatus to apply a force on the release sleeve.

One or more seat members may comprise a load profile, such as a notch, configured to engage a load profile on the release sleeve to permit the release sleeve to be moved by the catching apparatus. One or more seat members may comprise a load profile on a radially outer surface thereof and configured to engage a corresponding load profile, such as an annular shoulder, on a radially inner surface thereof.

Each seat member may comprise a load profile, wherein when said seat members are moved radially inwardly the individual load profiles define a substantially circumferentially continuous load profile.

The catching apparatus may be biased in a preferred axial direction. Such bias may be provided by a spring, for example. In some embodiments such bias may be provided in a direction to permit the catching apparatus to be configured in its free configuration. In one embodiment the catching apparatus may be biased in a direction opposite to the direction in which a release sleeve is moved to be positioned within a release position. Such an arrangement may permit the catching apparatus to be axially returned, following actuation of the release sleeve, to a position at which the seat members may be aligned with an uncovered release recess.

The seat members may collectively define a substantially complete annular structure when positioned radially inwardly, for example when the catching apparatus is configured within its catching configuration. In such an arrangement each seat member may be engaged or be brought into very close proximity with circumferentially adjacent seat members when positioned radially inwardly.

The ability to provide a substantially complete annular structure may permit a high degree of sealing to be achieved between the seat members and an object when seated against the seat members. The ability to provide a substantially complete annular structure may permit a more robust structure to be formed, which
may facilitate improved mechanical response to the operational forces, such as impact forces upon engagement by an object, actuation forces by an object seated against the seat members, resistance to extrusion forces and the like.

One or more seat members may define a seat surface on one axial side thereof. Such a seat surface may be configured to be engaged by an object.

The seat surface of a seat member may be arranged to provide a substantially continuous or complete engagement with an object. Such an arrangement may permit sealing engagement to be achieved between the seat surface and an object. In one embodiment the seat surface may define a circumferential profile which corresponds to a circumferential profile of an object.

One or more seat members may define a curved seat surface. One or more seat members may define a convex seat surface. Such an arrangement may be provided in combination with use of an object having a curved, such as convex, surface.

One or more seat members may be configured to be engaged by an object from opposing axial directions. Such an arrangement may permit an object to be caught or arrested when passing in either axial direction. For example, in some embodiments reverse flow through the catching apparatus may cause an object which has previously passed in a forward direction to be engaged or seated against the seat members. Further, such an arrangement may permit the catching apparatus to be actuated to move in opposing axial directions in response to engagement by an object in either axial direction.

One or more seat members may comprise a first seat surface on one axial side thereof, and a second seat surface on an opposing axial side thereof.

The catching apparatus may comprise or define a collet sleeve.

The catching apparatus may comprise a tubular portion and a plurality of fingers extending longitudinally from the tubular portion. Each finger may support a respective seat member. A distal end of each finger may support a respective seat member. Each finger may be radially deformable, for example by longitudinal bending, to permit the respective seat
members to be moved radially outwardly and inwardly. The fingers may be elastically
deformable to provide a desired radial bias.

In another aspect, there is disclosed a method for catching an object, comprising:
arranging a catching apparatus according to any other aspect within a path of travel of an
object;
retaining the catching apparatus in a radially extended configuration by a releasable lock
arrangement;
releasing the lock arrangement;
configuring the catching apparatus into a catching configuration; and
catching the object.

According to a second aspect of the present invention, there is provided a method for
catching an object downhole, comprising:
arranging a downhole catching apparatus within a path of an object travelling downhole,
wherein the catching apparatus includes a plurality of seat members which are moveable
between a radially extended configuration and a radially retracted configuration;
radially restraining the seat members in the radially extended configuration and against
radial movement towards the radially retracted configuration by a releasable lock arrangement;
releasing the lock arrangement;
causing the seat members to be radially retracted; and
catching the object.

The method may comprise configuring the catching apparatus into a release configuration
to permit the object to be released.

The method may comprise reconfiguring the catching apparatus to the radially extended
configuration after the object has been released.

In another aspect, there is disclosed a method for manufacturing a catching apparatus,
such as a catching apparatus according to any other aspect.

The method may comprise deforming the individual collet fingers radially outwardly.

The method may comprise forming the lock arrangement on the catching apparatus.
The method may comprise forming a lock profile on the catching apparatus.

In another aspect, there is disclosed a downhole tool comprising a catching apparatus according to any other aspect.

According to a third aspect of the present invention, there is provided a downhole tool comprising a catching apparatus, wherein the catching apparatus comprises:

- a plurality of radially moveable seat members arranged circumferentially around a longitudinal axis, wherein the seat members are moveable between a radially extended configuration and a radially retracted configuration; and
- a releasable lock arrangement for releasably radially restraining the seat members in the radially extended configuration and against radial movement towards the radially retracted configuration.

The downhole tool may comprise a tool housing defining a central bore and including a fluid port. The fluid port may be configured to permit fluid communication between the central bore and a location external to the housing. The fluid port may extend in any suitable direction. The fluid port may extend generally perpendicularly relative to the central bore. In some embodiments the fluid port may extend generally obliquely relative to the central bore. The fluid port may extend in varying directions, for example portions of the fluid port may extend at least one of perpendicularly, parallel and obliquely relative to the central bore.

A valve member, such as a valve sleeve may be mounted within the housing. The valve member may be moveable, for example axially moveable, from a closed position in which the fluid port is blocked to an open position in which the fluid port is opened. The fluid port may be opened to provide fluid communication between the central bore of the tool and an external downhole location, such as an annulus, a surrounding formation or the like. The fluid port may be arranged to accommodate one or both of outflow and inflow.
The downhole tool may comprise a catching apparatus, such as provided in accordance with any other aspect. The catching apparatus may be mounted within the housing, for example on a downhole side of the valve member.

The downhole tool may comprise an indexing mechanism mounted within the housing. The indexing mechanism may be located on an uphole side of the valve member. The indexing mechanism may be arranged to be moved axially along the housing towards an actuation site. Upon reaching the actuation site the indexing mechanism may initiate actuation, for example movement, of at least one of the valve member and the catching apparatus.

The downhole tool may define a downhole fracturing tool.

**BRIEF DESCRIPTION OF DRAWINGS**

These and other aspects of the present invention will now be described, by way of example only, with reference to the accompanying drawings, in which:

- **Figure 1** a longitudinal sectional view of a downhole tool which includes a catching apparatus according to an embodiment of the present invention, shown in a radially extended configuration;
- **Figure 2** the downhole tool of Figure 1, reconfigured to a catching configuration prior to receiving an object to be caught;
- **Figure 3** the downhole tool of Figures 1 and 2 in the catching configuration, after the object has been received;
- **Figure 4** the downhole tool of Figures 1, 2 and 3, reconfigured to a release configuration, after the object has been released;
- **Figure 5** an enlarged view of a region of the downhole tool shown in Figure 1, showing the catching apparatus.
- **Figure 6** an enlarged view of a region of Figure 5, showing the lock arrangement;
- **Figure 7** an enlarged view of a region of the downhole tool shown in Figure 2, showing the catching apparatus.
- **Figure 8** an enlarged view of a region of Figure 7, showing the lock arrangement;
- **Figure 9** an enlarged view of a region of the downhole tool shown in Figure 3, showing the catching apparatus.
Figure 10  an enlarged view of a region of Figure 9, showing the lock arrangement;
Figure 11  an enlarged view of a region of the downhole tool shown in Figure 4, showing the catching apparatus.
Figure 12  an enlarged view of a region of Figure 11, showing the lock arrangement;
Figure 13  a longitudinal section view of a collet sleeve of the catching apparatus;
Figure 14  a longitudinal section view of an insert sleeve of the catching apparatus; and
Figure 15  a longitudinal section view of an annular ring of the catching apparatus.

DETAILED DESCRIPTION OF DRAWINGS

Referring initially to Figures 1 and 5, there is shown a downhole tool, generally identified by reference number 10, according to an embodiment of the present invention. In the illustrated embodiment, the downhole tool 10 is for use in treating, for example fracturing, a subterranean formation 11. The downhole tool 10 comprises a housing 12 which defines a plurality of ports 14 (one port is visible in Figure 1). A valve sleeve 16 is mounted within the housing 12 and is shown in a closed position in Figure 1, in which the ports 14 are closed and sealed via o-rings 18. When in this initial closed position the valve sleeve 16 is pinned to the housing 12 via a shear pin 19.

A catching apparatus 20, according to an embodiment of the present invention, is mounted within the housing 12 on a downhole side of the valve sleeve 16. The catching apparatus 20 is provided, generally, in the form of a collet-type sleeve, and comprises a tubular body 22 and a plurality of collet fingers 24 which extend axially from the tubular body 22. Each finger 24 carries at a distal end thereof a respective seat member 26. The catching apparatus 20 defines a longitudinal axis 28, which is coincident with the longitudinal axis 29 of the tool 10, and the fingers 24 and seat members 26 are circumferentially distributed around this axis 28. The fingers 24 are deformable by bending in a longitudinal direction to permit the seat members 26 to be selectively moved radially into and out of a central bore or passage 30 defined by the catching apparatus 20.

In the configuration shown in Figures 1 and 5, the seat members 26 are positioned in a biased radially outward position, received within a recess 32 provided
in an insert sleeve 33 disposed within the housing 12, and thus removed from the central bore 30. Accordingly, any object passing through the tool 10 will not be caught by the catching apparatus 20. For example, a passing object may continue past the tool 10 to perform some operation further downhole, for example within a deeper tool. In this respect, the catching apparatus 20 may be considered to be presented in a free configuration in Figures 1 and 5.

An activator sleeve 34 is located downhole of the catching apparatus 20, wherein said sleeve 34 defines an activation surface 36 and a step profile 38. In the configuration shown in Figure 1 the activator sleeve 34 is secured to the insert sleeve 33 via a number of shear screws 40, and covers an annular recess 42.

Referring now also to Figure 6, which shows an enlarged view of a region of Figure 5, a lock arrangement 44 is provided for retaining the catching apparatus 20 in the radially extended free configuration.

In the illustrated embodiment, the lock arrangement 44 comprises a barb 46 formed on an external surface 48 of the collet fingers 26 and a corresponding barb 50 formed on an internal surface 52 of a washer ring 54 disposed within the housing 12. A corresponding barb 56 is also formed on an internal surface 58 of the insert sleeve 33, as will be described further below.

As can be seen, in the configuration shown in Figures 1, 5 and 6 the lock arrangement 44 is in a locked condition, in which the barbs 46, 50 cooperate to radially restrain movement of the collet fingers 26 and so retain the catching apparatus 20 in the radially extended free configuration.

The washer ring 54 engages a no-go shoulder 60 on the insert sleeve 33 and a spring 62 biases at least one, and in the illustrated embodiment both, of the washer ring 54 and the collet fingers 26 to the engaged position.

The catching apparatus 20 is configured such that erosion of the seat members 26 is minimised when said members 26 are positioned radially outwardly and the apparatus 20 configured in its free configuration, and the larger surfaces defined by at least one of the barbs may assist in preventing erosion.

Referring now to Figures 2, 7 and 8, the downhole tool 10 is shown in an initial activated configuration. Specifically, the shear screw 19 has been sheared and the valve sleeve 16 has been axially moved in a downhole direction to open the ports 14 and permit fluid communication outwardly from the tool 10. The valve sleeve 16 may be moved by any suitable actuator, such as via a piston. In some embodiments
the valve sleeve may be moved or actuated by an indexing sleeve, such as a collet sleeve disclosed in WO 2011/117601 and/or WO 2011/117602.

During actuation, the valve sleeve 16 acts upon the catching apparatus 20, causing this apparatus 20 to also move axially downhole within the housing 12, moving the barbs 46, 50 out of engagement and driving the seat members 26 out of the recess 32 and onto the activation surface 36 of the activator sleeve 34. Relative movement of the catching apparatus 20 and activator sleeve 34 is arrested upon engagement of the seat members 26 against the step profile 38. Thus, the seat members 26 are positioned radially inwardly and into the central bore 30 of the apparatus 20. Such a configuration of the apparatus 20 may be considered a catching configuration. That is, any object, such as a ball 64 of appropriate dimension passing through the tool 10 will engage and seat against the seat members 26, thus becoming caught, as shown in Figures 3, 9 and 10.

In the exemplary embodiment shown in Figures 3, 9 and 10, the ball 64 may function to block the tool 10 and establish a flow diversion such that substantially all fluid may be diverted outwardly through the ports 14, for example to fracture a surrounding formation. Further, in some embodiments the ball 64 may have previously operated a system, such as an indexing system, to initially move the valve sleeve 16 and/or catching apparatus 20.

Referring now also to Figures 4, 11 and 12, when the ball 64 is to be released the catching apparatus 20 may be reconfigured into a release configuration. Pressure may be elevated uphole of the ball 64, increasing the force being applied axially on the catching apparatus 20, and also on the activator sleeve 34 via the engagement of the seat members 26 with the step profile 38. Upon reaching a predetermined axial force the shear screws 40 will shear, permitting the catching apparatus 20 and activator sleeve 34 to move axially downhole. As such, the annular recess 42 may become uncovered, and upon relief of fluid pressure the spring 62 may move the catching apparatus 20 in an uphole direction (left as shown in the Figures) to permit the seat members 26 to become located within the annular recess 42, and allowing the ball 64 to be released. By such use, the activator sleeve 34 may function as a release sleeve.

As shown, the barb 46 engages the barb 56 on the insert sleeve 33, such that in the configuration shown in Figures 4, 11 and 12 the lock arrangement 44 defines a second locked condition retaining the apparatus 20 in a radially extended
configuration which permits passage of an object, such as another ball or a tool, such as a shifting tool, or the like.

Referring now to Figures 13, 14 and 15, there is shown longitudinal section views, respectively, of the catching apparatus 20 showing the barb 46, the insert sleeve 33 showing the barb 56 and washer ring 54 showing barb 50.

It should be understood that the embodiments described herein are merely exemplary and that various modifications may be made thereto without departing from the scope of the present invention.

For example, any suitable lock arrangement may be provided. The lock arrangement may alternatively or additionally comprise a mechanical retainer, such as a shear pin or the like.

In the exemplary embodiments described the catching apparatus is utilised within a tool which is used for fracturing operations. However, generally, the catching apparatus may be utilised in any situation where an object must be caught. For example, the catching apparatus may function as an actuator, wherein movement of the apparatus to actuate a further apparatus or process may be achieved upon or subsequent to catching an object.

In this specification, the terms “comprise”, “comprises”, “comprising” or similar terms are intended to mean a non-exclusive inclusion, such that a system, method or apparatus that comprises a list of elements does not include those elements solely, but may well include other elements not listed.

The reference to any prior art in this specification is not, and should not be taken as, an acknowledgement or any form of suggestion that the prior art forms part of the common general knowledge.
CLAIMS

1. A downhole catching apparatus for catching an object, comprising:
   a plurality of radially moveable seat members arranged circumferentially around a longitudinal axis, wherein the seat members are moveable between a radially extended configuration and a radially retracted configuration; and
   a releasable lock arrangement for releasably radially restraining the seat members in the radially extended configuration and against radial movement towards the radially retracted configuration.

2. The downhole catching apparatus according to claim 1, wherein the radially extended configuration permits passage of an object past the seat members, and the radially retracted configuration permits an object to be caught by the seat members.

3. The downhole catching apparatus according to claim 1 or 2, wherein the releasable lock arrangement restrains the seat members in the radially extended configuration until the occurrence of an actuation event.

4. The downhole catching apparatus according to any preceding claim, wherein the lock arrangement defines a locked condition and an unlocked condition, and wherein the lock arrangement is moveable from the locked condition to the unlocked condition to permit movement of the seat members towards the retracted configuration.

5. The downhole catching apparatus according to claim 4, wherein the lock arrangement is biased towards the locked condition.

6. The downhole catching apparatus according to claim 4 or 5, wherein the lock arrangement is biased towards the locked condition by a biasing member.

7. The downhole catching apparatus according to any one of claims 4, 5 or 6, wherein the lock arrangement is moveable from the locked condition to the unlocked condition by axial movement.
8. The downhole catching apparatus according to any one of claims 4 to 7, wherein the lock arrangement is moveable from the unlocked condition to the locked condition to permit the seat members to again be retained in the extended configuration.

9. The downhole catching apparatus according to any one of claims 4 to 8, wherein the lock arrangement is moveable between the locked condition and the unlocked condition a plurality of times.

10. The downhole catching apparatus according to any preceding claim, wherein at least part of the lock arrangement is defined by a seat member, and/or wherein at least part of the lock arrangement is defined by a structure at least partially surrounding the seat members.

11. The downhole catching apparatus according to any preceding claim, wherein the lock arrangement comprises a lock profile.

12. The downhole catching apparatus according to claim 11, wherein the lock profile comprises an external profile formed or otherwise provided on one or more of the seat members.

13. The downhole catching apparatus according to claim 12, wherein the lock profile comprises an internal profile formed or otherwise provided on a structure at least partially surrounding the seat members, wherein the internal and external profiles are configured to cooperate with each other to selectively provide locking.

14. The downhole catching apparatus according to claim 13, wherein the internal and external profiles are axially moveable relative to each other, wherein in a first relative axial position the internal and external profiles are engaged to provide locking, and in a second relative axial position the internal and external profiles are not engaged to provide unlocking.

15. The downhole catching apparatus according to any one of claims 12 or 14, wherein the downhole catching apparatus comprises a first internal profile and a second internal profile, wherein the external profile is configured to engage the first internal profile to provide a first locked configuration, and to engage the second internal profile to provide a second locked configuration.
16. The downhole catching apparatus according to any one of claims 11 to 15, wherein the, or at least one, lock profile comprises at least one of a hook profile and a barb, and/or wherein the, or at least one, lock profile comprises or defines a geometry with an acute angle.

17. The catching apparatus according to any preceding claim, comprising a housing, wherein the seat members are located within said housing.

18. The catching apparatus according to claim 17, wherein at least a portion of the locking arrangement is defined by the housing.

19. The catching apparatus according to claim 17 or 18, wherein at least a portion of the locking arrangement is provided on a locking structure which is mounted within the housing.

20. The catching apparatus according to claim 19, wherein the locking structure comprises a ring member mounted within the housing.

21. The downhole catching apparatus according to any preceding claim, wherein at least a portion of the lock arrangement is sacrificial to provide erosion protection, and/or wherein the downhole catching apparatus comprises an erosion resistant coating.

22. The downhole catching apparatus according to any preceding claim, for use within a fracturing system or operation.

23. The downhole catching apparatus according to any preceding claim, wherein the catching apparatus is reconfigured to or in its catching configuration by radially supporting the seat members in a radially inward position such that outward radial movement is prevented.

24. A method for catching an object downhole, comprising:
   arranging a downhole catching apparatus within a path of an object travelling downhole, wherein the catching apparatus includes a plurality of seat members which are moveable between a radially extended configuration and a radially retracted configuration;
   radially restraining the seat members in the radially extended configuration and against radial movement towards the radially retracted configuration by a releasable lock arrangement;
   releasing the lock arrangement;
causing the seat members to be radially retracted; and
catching the object.

25. A downhole tool comprising a catching apparatus, wherein the catching apparatus comprises:
   a plurality of radially moveable seat members arranged circumferentially around a longitudinal axis, wherein the seat members are moveable between a radially extended configuration and a radially retracted configuration; and
   a releasable lock arrangement for releasably radially restraining the seat members in the radially extended configuration and against radial movement towards the radially retracted configuration.

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