CLAIMS

~~1. A method of severing a drill string formed from drill string sections including pin connections having a neck between a threaded portion and a shoulder, the method comprising reducing the loadbearing cross-sectional area of the neck of a connection.~~

~~2. The method of claim 1, wherein reducing the loadbearing cross-sectional area of the neck comprises forming a circumferential cut.~~

~~3. The method of claim 2, wherein the cut is circumferentially continuous.~~

~~4. The method of claim 2, wherein the cut is circumferentially discontinuous.~~

~~5. The method of any of claims 1 to 4, comprising applying or winding in torque to the drill string.~~

~~6. The method of any of claims 1 to 5, comprising applying tension to the drill string.~~

~~7. The method of any preceding claim, comprising reducing the loadbearing cross-sectional area of the neck to zero.~~

~~8. The method of any preceding claim, comprising reducing the loadbearing cross-sectional area by eroding or removing metal from the inside of the connection.~~

~~9. The method of any preceding claim, comprising reducing the loadbearing cross-sectional area by operating a cutter.~~

~~10. The method of claim 9, wherein the cutter operates by at least one of mechanical cutting, material removal, material displacement, fluid erosion, or chemical erosion.~~

~~11. The method of any preceding claim, comprising directing cutting fluid towards the neck surface through a fluid cutter.~~

~~12. The method of claim 11, comprising forming the cutting fluid into a high speed jet.~~

~~13. The method of claim 11 or 12, comprising pumping the cutting fluid through a flow constriction or nozzle.~~

~~14. The method of claim 11, 12 or 13, wherein the cutting fluid speed is at least 100 feet/sec.~~

~~15. The method of any of claims 11 to 14, comprising forming the cutting fluid into a circumferentially continuous cutting stream.~~

~~16. The method of any of claims 11 to 15, comprising forming the cutting fluid into a series of discrete jets or streams.~~

~~17. The method of any of claims 11 to 16, comprising rotating a flow constriction or nozzle around a main axis of the string.~~

~~18. The method of any of claims 11 to 17, comprising pumping the cutting fluid down the drill string bore.~~

~~19. The method of any of claims 11 to 18, comprising providing a fluid cutter having a fluid inlet in association with a seal located between the cutter and the drill string wall such that the fluid pumped down the string is directed into the cutter.~~

~~20. The method of any of claims 11 to 19, comprising pumping cutting fluid down the string through an intermediate conduit.~~

~~21. The method of any of claims 11 to 20, comprising adding an abrasive material to a cutting fluid.~~

~~22. The method of any of claims 11 to 21, comprising providing a filter in a cutting fluid circulation path.~~

~~23. The method of any preceding claim, comprising rotating and radially extending a cutting member.~~

~~24. The method of any preceding claim, comprising driving a reciprocating cutting member into a surface of the neck.~~

~~25. The method of claim 23 or 24, comprising powering the cutting member using a power fluid.~~

~~26. The method of claim 25, comprising powering the cutting member via a mud motor or a turbine.~~

~~27. The method of claim 25 or 26, comprising pumping the power fluid down the drill string.~~

~~28. The method of claim 25 or 26, comprising pumping the power fluid through an intermediate conduit.~~

~~29. The method of claim 23 or 24, comprising electrically powering the cutting member.~~

~~30. The method of claim 29, comprising supplying the power from a local source.~~

~~31. The method of claim 30, comprising supplying the power from a battery pack.~~

~~32. The method of claim 29, comprising delivering the power from surface.~~

~~33. The method of claim 32, comprising delivering the power via electric wireline.~~

~~34. The method of claim 23 or 24, comprising mechanical driving the cutting member.~~

~~35. The method of any of claims 23 to 34, comprising controlling or monitoring the cutting member using signals transmitted from or to surface.~~

~~36. The method of claim 35, wherein transmitting the signals through at least one of the fluid in the drill string or a signal carrier.~~

~~37. The method of any preceding claim, comprising running a cutter into the drill string on a support member.~~

~~38. The method of any preceding claim, comprising pumping or dropping a cutter into the drill string.~~

~~39. The method of claim 37 or 38, comprising providing a cutter locator for locating the cutter accurately in the string.~~

~~40. The method of any of claim 37 to 39, comprising providing a catcher ring in the string.~~

~~41. The method of claim 40, comprising providing the catcher ring in an upper part or a lower part of a cutter locating sub.~~

~~42. The method of any of claims 37 to 41, comprising providing a cutter-locating seat in the string, for cooperation with a cutter locator.~~

~~43. The method of claim 42, comprising providing a plurality of cutter-locating seats in the string for cooperation with respective cutter locators.~~

~~44. The method of claim 42, wherein the seats are of progressively smaller diameters.~~

~~45. The method of claim 42, 43 or 44, comprising forming a seal between the locator and seat.~~

~~46. The method of any of claims 42 to 45, comprising locating the seat in a conventional drill string element.~~

~~47. The method of any of claims 42 to 46, comprising locating the seat in a specially adapted cutter locating sub.~~

~~48. The method of any of claims 1 to 47, comprising: pumping fluid from surface down through an internal bore defined by the drill string and through a fluid cutter to remove material from the wall of the drill string; directing the fluid that has passed through the cutter from the drill string bore into an annulus between the drill string and a surrounding bore wall, and returning the fluid to surface.~~

~~49. The method of any preceding claim, comprising providing a fluid bypass device in the drill string.~~

~~50. The method of 49, comprising activating the fluid bypass device to bypass fluid pressure loss-inducing drill string elements below the bypass device.~~

~~51. The method of 49, comprising activating the fluid bypass device to bypass a packed-off section of annulus between the drill string and a surrounding bore wall.~~

~~52. The method of claim 49, comprising activating the fluid bypass device to facilitate fluid circulation through the string.~~

~~53. The method of claim 52, comprising activating the bypass device with a ball or dart.~~

~~54. The method of claim 53, comprising subsequently retrieving the dart from the string.~~

~~55. The method of any of claims 49 to 54, where a bypass device is provided below the intended severing location.~~

~~56. The method of any of claims 49 to 55, where a bypass device is provided above the intended severing location.~~

~~57. The method of any of claims 49 to 56, comprising providing a plurality of bypass devices in the drill string, each associated with a particular severing location.~~

~~58. The method of any preceding claim, comprising severing a conventional connection.~~

~~59. The method of any preceding claim, comprising severing a connection configured to facilitate severing.~~

~~60. The method of any preceding claim, comprising severing a single-shouldered connection.~~

~~61. The method of any preceding claim, comprising severing a double-shouldered connection.~~

~~62. The method of claim 61, comprising severing a connection in a sub adapted to receive and locate a cutter.~~

~~63. Downhole apparatus comprising a cutter configured for reducing the loadbearing cross-sectional area of a neck of a pin connection of a drill string section.~~

~~64. The apparatus of claim 63, wherein the cutter is configured to reduce the loadbearing cross-sectional area of the neck by forming a circumferential cut.~~

~~65. The apparatus of claim 64, wherein the cutter is configured to form a circumferentially continuous cut.~~

~~66. The apparatus of claim 64, wherein the cutter is configured to form a circumferentially discontinuous cut.~~

~~67. The apparatus of claim 63, comprising a fluid cutter configured to direct fluid towards the neck surface.~~

~~68. The apparatus of claim 67, wherein the fluid cutter comprises a flow constriction or nozzle.~~

~~69. The apparatus of claim 67 or 68, wherein the fluid cutter is configured to provide a fluid output in the form of a circumferentially-continuous stream.~~

~~70. The apparatus of claim 67 or 68, wherein the fluid cutter is configured to provide a fluid output in the form of a series of discrete jets or streams.~~

~~71. The apparatus of any of claims 67 to 70, wherein a flow constriction or nozzle is configured to rotate around the axis of the string.~~

~~72. The apparatus of claim 67, wherein the cutter is configured to utilise fluid pumped down the drill string as the cutting fluid.~~

~~73. The apparatus of any of claims 67 to 71, wherein the cutter is associated with a seal configured for engaging a drill string wall such that the all of the fluid pumped down the string is directed into the cutter.~~

~~74. The apparatus of any of claims 67 to 73, comprising a filter in a cutting fluid circulation path.~~

~~75. The apparatus of claim 74, wherein the filter is located in the drill string at surface.~~

~~76. The apparatus of any of claims 63 to 75, including a rotatable mechanical cutter.~~

~~77. The apparatus of claim 76, wherein the cutter includes a radially extendable cutting member.~~

~~78. The apparatus of any of claims 63 to 77, including an impact cutter having a reciprocating cutting member.~~

~~79. The apparatus of any of claims 63 to 78, comprising a fluid powered cutter.~~

~~80. The apparatus of any of claims 63 to 79, comprising an electrically powered cutter.~~

~~81. The apparatus of claim 80, including a local source power source for the cutter.~~

~~82. The apparatus of any of claims 63 to 81, wherein the cutter is configured to be pumped or dropped into the drill string.~~

~~83. The apparatus of any of claims 63 to 82, including a cutter locator configured to ensure the accurate location of the cutter relative to the neck to be cut.~~

~~84. The apparatus of claim 83, wherein the cutter includes a profile dimensioned to engage a seat provided in the drill string.~~

~~85. The apparatus of claim 84, wherein the seat is provided by a catcher ring.~~

~~86. The apparatus of claim 85, wherein the ring has external seals.~~

~~87. The apparatus of claim 85 or 86, wherein the ring is adapted for location in an upper part of a locating sub.~~

~~88. The apparatus of claim 85 or 86, wherein the ring is adapted for location in a lower part of a locating sub.~~

~~89. The apparatus of any of claims 84 to 88, comprising a plurality of seats each for cooperation with a respective cutter locater.~~

~~90. The apparatus of claim 89, wherein the seats are of progressively smaller diameters.~~

~~91. The apparatus of any of claims 84 to 90, wherein the locator and seat are configured to form a seal therebetween.~~

~~92. The apparatus of any of claims 84 to 91, wherein the seat is configured for location in a conventional drill string element.~~

~~93. The apparatus of any of claims 84 to 91, wherein the seat is configured for location in a cutter locating sub.~~

~~94. The apparatus of any of claims 63 to 93 to wherein the cutter is mounted on an elongate support.~~

~~95. The apparatus of claim 94, wherein the cutter is mounted on a reelable support.~~

~~96. The apparatus of claim 94, wherein the cutter is mounted on electric wireline.~~

~~97. The apparatus of any one of claims 63 to 96, wherein the cutter includes extendable locating members for engaging and locating the cutter in the drill string.~~

~~98. The apparatus of any of claims 63 to 97, comprising a fluid bypass device for location in the drill string.~~

~~99. The apparatus of claim 98, comprising a plurality of bypass devices.~~

1~~100~~. A method of severing a drill pipe string, the method including: dropping or pumping a flow-actuated cutter (36;72) into a drill pipe string (10,16) provided with a fluid bypass device (24a); activating the fluid bypass device (24a) to facilitate fluid circulation through the string (10,16); landing the cutter (36,72) at a predetermined location in the string (22;70); and pumping fluid down through the drill string (10,16) and through the cutter (36;72) to actuate the cutter and remove material from a selected portion of the drill string.

2~~101~~. The method of claim 1~~100~~, comprising applying torque or tension to the string.

3~~102~~. The method of claim 1 or 2~~100 or 101~~, wherein, once the drill string has been severed, delivering cement through the string to form a kick-off plug.

4~~103~~. The method of claim 1, 2 or 3~~100~~, wherein the selected portion is the neck of a drill pipe connection and wherein removing material comprises reducing the loadbearing cross-sectional area of the neck by forming a circumferential cut.

5~~104~~. The method of claim 4~~103~~, wherein the cut is circumferentially continuous.

6~~105~~. The method of claim 4~~103~~, wherein the cut is circumferentially discontinuous.

7~~106~~. The method of any of claims 1 to 6~~100 to 105~~, wherein the flow-actuated cutter is a fluid cutter and utilises fluid pumped from surface as a cutting fluid.

8~~107~~. The method of any of claims 1 to 7~~100 to 106~~, comprising directing fluid from the cutter in a high velocity stream towards an inner surface of the string.

9~~108~~. The method of any of claims 1 to 8~~100 to 107~~, comprising locating a fluid outlet from the cutter directly adjacent an inner surface of the drill string.

10~~109~~. The method of any of claims 1 to 9~~100 to 108~~, comprising directing fluid from the cutter at a transverse angle to the string axis.

11~~110~~. The method of any of claims 1 to 10~~100 to 109~~, comprising directing fluid from the cutter at an incline relative to the string axis.

12~~111~~. The method of any of claims 1 to 11~~100 to 110~~, comprising creating eddies or vortices in the fluid exiting the cutter.

13~~112~~. The method of any of claims 1 to 12~~100 to 111~~, comprising directing fluid from the cutter in a continuous circumferential stream.

14~~113~~. The method of any of claims 1 to 13~~100 to 112~~, comprising directing fluid from the cutter in discrete jets.

15~~114~~. The method of any of claims 1 to 14~~100 to 113~~, comprising rotating a fluid outlet around the axis of the string.

16~~115~~. The method of any of claims 1 to 15~~100 to 114~~, comprising sealing a body of the cutter to a wall of the string and directing all of the fluid pumped down the string into the cutter.

17~~116~~. The method of any of claims 1 to 16~~100 to 115~~, comprising adding an abrasive material to cutting fluid directed from the cutter to increase the cutting effect.

18~~117~~. The method of any of claims 1 to 17~~100 to 116~~, comprising filtering the cutting fluid to avoid larger particles reaching the cutter.

19~~118~~. The method of any of claims 1 to 18~~100 to 117~~, comprising mechanically cutting the drill string.

20~~119~~. The method of claim 19~~118~~, comprising rotating a cutting member.

21~~120~~. The method of claim 19 or 20~~118 or 119~~, comprising radially extending a cutting member.

22~~121~~. The method of any of claims 1 to 21~~100 to 120~~, comprising driving a cutting member using a mud motor or turbine.

23~~122~~. The method of any of claims 1 to 22~~100 to 121~~, comprising landing the cutter in a cutter seat.

24~~123~~. The method of any of claims 1 to 23~~100 to 122~~, comprising: pumping the fluid from surface down through an internal bore defined by the drill string and through the cutter to actuate the cutter and remove material from the selected portion of a wall of the drill string; directing the fluid from the drill string bore and through the open fluid bypass device into an annulus between the drill string and a surrounding bore wall, and returning the fluid to surface.

~~124. The method of any of claims 100 to 123, comprising providing a fluid bypass device in the string and activating the device to facilitate fluid circulation through the string.~~

25~~125~~. The method of any of claim 1 to 24~~claim 124~~, comprising activating the fluid bypass device to bypass fluid pressure loss-inducing drill string elements below the bypass device.

26~~126~~. The method of any of claims 1 to 24~~claim 124~~, comprising activating the fluid bypass device to bypass a packed-off section of annulus between the drill string and a surrounding bore wall.

27~~127~~. The method of any of claims 25 to 26~~124 to 126~~, comprising activating a fluid bypass device before activating the cutter.

28~~128~~. The method of any of claims 1 to 27~~124 to 127~~, comprising activating a further fluid bypass device after the drill string has been severed and then pumping cement through the string and through the open bypass device to form a kick-off plug.

29~~129~~. The method of any of claims 1 to 28~~100 to 129~~, comprising reconfiguring the cutter to allow the cutter to drop out of the severed string or open a less restricted flow path through the string.

30. The method of any of claims 1 to 29, wherein the fluid is drilling mud.

31~~130~~. Apparatus for severing a drill pipe string (10, 16), the apparatus comprising a flow-actuated cutter (36; 72) configured to be dropped or pumped into a drill pipe string (10, 16) and to land at a predetermined location in the string (22; 70), and a fluid bypass device (24a) for location in the string to facilitate fluid circulation in the string, whereby circulating fluid down through the drill string actuates the cutter (36; 72) to remove material from a selected portion of the drill string.

32~~131~~. The apparatus of claim 32~~130~~, wherein the cutter (36; 72) is configured such that the fluid exits the cutter in a high velocity stream directed towards an inner surface of the string.

33~~132~~. The apparatus of claim 32~~131~~, wherein the cutter defines a flow passage (44,46,50:138,136,142,146) and the flow passage defines a constriction or nozzle (50;148) to provide the high velocity outlet stream.

34~~133~~. The apparatus of claim 33~~132~~, wherein portions of the flow passage are formed of an erosion resistant material.

35~~134~~. The apparatus of claim 34~~133~~, wherein portions of the flow passage are coated with a hard facing material.

36~~135~~. The apparatus of any of claims 32~~130~~ to 36~~134~~, wherein a fluid outlet is configured to be directly adjacent an inner surface of the drill string.

37~~136~~. The apparatus of any of claims 31~~130~~ to 36~~135~~, wherein the cutter is configured such that fluid exits the cutter at a transverse angle to the string axis.

38~~137~~. The apparatus of any of claims 31 to 37~~any of claims 130 to 135~~, wherein the cutter (36;72) is configured such that the fluid exits the cutter in a continuous circumferential stream.

39~~138~~. The apparatus of claims 31 to 37~~130 to 136~~, wherein the cutter is configured such that the fluid exits the cutter in discrete jets.

40~~139~~. The apparatus of any of claims 31 to 39~~130 to 138~~, wherein a cutter fluid outlet is rotatable around the axis of the string.~~,~~

41~~140~~. The apparatus of any of claims 31 to 40~~130 to 139~~, in combination with a seal bore (106) provided in the string and wherein an external seal (108) is provided on a cutter body (93,112,110) between a flow passage inlet and a flow passage outlet for cooperation with the seal bore (106) such that all of the fluid pumped down the string is directed into the cutter (72).

42~~141~~. The apparatus of any of claims 31 to 41~~130 to 140~~, including a filter in a fluid circulation path to avoid larger particles reaching the cutter and potentially blocking the cutter.

43~~142~~. The apparatus of any of claims 31 to 42~~130 to 141~~, wherein the cutter includes a mechanical cutting member.

44~~143~~. The apparatus of claim 43~~142~~, including a mud motor or turbine for driving the cutting member.

45~~144~~. The apparatus of any of claims 31 to 44~~130 to 143~~, in combination with a seat (34;90) provided in the drill string and including a cutter locator~~, to ensure the accurate location of the cutter relative to portion of the drill string to be cut.~~

~~145. The apparatus of claim 144, wherein the cutter locator includes~~including a profile (38;91) dimensioned to engage thea seat ~~provided in the drill string~~.

46~~146~~. The apparatus of claim 45~~145~~, wherein the seat is provided by a catcher ring.

47~~147~~. The apparatus of claim 46~~146~~, wherein the ring includes external seals.

48~~148~~. The apparatus of claim 46 or 47~~146 or 147~~, wherein the ring is adapted for location in an upper part of a locating sub.

49~~149~~. The apparatus of any of claims 31 to 48~~144 to 148~~, wherein a plurality of seats is provided for cooperation with a respective cutter locator, and ~~.~~

~~150. The apparatus of claim 149,~~ wherein the seats are of progressively smaller diameters.

50~~151~~. The apparatus of any of claims 45 to 49~~145 to 150~~, wherein a cutter locator and a seat are configured to engage and form a seal therebetween.

51~~152~~. The apparatus of any of claims 45 to 50~~145 to 151~~, wherein the seat is configured for location in a conventional drill string element.

52~~153~~. The apparatus of any of claims 45 to 50~~145 to 151~~, wherein the seat is configured for location in a cutter locating sub.

~~154. The apparatus of any of claims 145 to 153, including a fluid bypass device for location in the string.~~

53~~155~~. The apparatus of any of claims 31 to 52~~claim 154~~, wherein the bypass device is adapted for location below the intended severing location.

54~~156~~. The apparatus of any of claims 311 to 52~~claim 154~~, wherein the bypass device is adapted for location above the intended severing location.

55~~157~~. The apparatus of any of claims 31 to 54~~154 to 156~~, wherein a plurality of bypass devices are provided for location in the drill string, each to be associated with a particular severing location.

56~~158~~. The apparatus of any of claims 31~~130~~ to 55~~157~~, wherein the cutter is reconfigurable to allow the cutter to drop out of the severed string or open a less restricted flow path through the string.

57~~159~~. A method of severing a drill string, the method comprising: opening a bypass valve in a stuck string; locating a flow-actuated cutter in the drill string; and circulating fluid through the drill string to actuate the cutter and remove material from a selected portion of the drill string.

58~~160~~. The method of claim 57~~159~~ comprising: pumping the fluid from surface down through an internal bore defined by the drill string and through the cutter to actuate the cutter and remove material from the selected portion of a wall of the drill string; directing the fluid from the drill string bore and through the open bypass valve into an annulus between the drill string and a surrounding bore wall, and returning the fluid to surface.

59~~161~~. The method of claim 57 or 58~~159 or 160~~, comprising activating the fluid bypass valve to bypass fluid pressure loss-inducing drill string elements below the bypass valve.

60~~162~~. The method of claim 57 or 58~~159 or 160~~, comprising activating the fluid bypass valve to bypass a packed-off section of annulus between the drill string and a surrounding bore wall.

61~~163~~. The method of any of claims 57 to 60~~159 to 162~~, wherein the drill string is severed into an upper portion and a lower portion.

62~~164~~. The method of claim 61~~163~~, wherein once the pipe string has been severed, delivering cement into the bore through the upper portion of the string to form a kick-off plug above the lower portion of the string that remains in the bore.

63~~165~~. The method of claim 61 or 62~~163 or 164~~, wherein once the pipe string has been severed, removing the lower portion of the string from the bore.

64~~166~~. The method of any of claims 61 to 63~~163 to 165~~, comprising removing one of more devices from the lower portion of the string.

65~~167~~. The method of any of claims 61 to 63~~163 to 165~~, comprising removing the upper portion of the string from the bore and running a further string run into the bore to engage or mate with the top of the lower section of the string that remains in the hole.

66~~168~~. The method of any of claims 1~~61 to 65~~~~63 to 167~~, comprising passing wireline equipped with a fishing tool through the further string and into the lower section of the tool.

67~~169~~. Apparatus for severing a drill string, the apparatus comprising: a bypass valve configured for location in a drill string; and a flow-actuated cutter configured to be run into the drill string and positioned above the bypass valve, whereby, in use, the bypass valve is opened and fluid circulated through the drill string to actuate the cutter and remove material from a selected portion of the drill string.