CLAIMS

1. A method of drilling a subterranean bore hole comprising:

a) pumping a drilling fluid down a drill string, the drill string having a drill bit at an end thereof,

b) rotating the drill string about its longitudinal axis to that the bit forms bore hole in the ground,

the method further comprising the steps of:

c) changing the rate of pumping of the drilling fluid into the drill string in response to a change in the speed of rotation of the drill string, and / or changing the speed of rotation of the drill string in response to a change in the rate of pumping of the drilling fluid into the drill string.

2. The method of claim 1 wherein the rate of pumping of the drilling fluid is increased as the speed of rotation of the drill string is decreased, and the rate of pumping of the drilling fluid is decreased as the speed of rotation of the drill string is increased, and / or the speed of rotation of the drill string is increased as the rate of pumping of the drilling fluid is decreased and the speed of rotation of the drill string is decreased as the rate of pumping of the drilling fluid is increased.

3. The method of claim 1 or 2 further including the steps of:

d) stopping the rotation of the drill string,

e) pumping drilling fluid into a side port adjacent the uppermost end of the drill string,

f) ceasing pumping of drilling fluid into the uppermost end of the drill string,

g) connecting a new section of drill pipe to the uppermost end of the drill string,

h) commencing pumping of drilling fluid into the uppermost end of the new section of drill pipe,

i) ceasing pumping of drilling fluid into the side port, and

j) recommencing rotation of the drill string.

4. The method of claim 3 wherein the rate of pumping of fluid into the drill string is increased as the speed of rotation of the drill string is decreased in step d, and the rate of pumping of fluid into the drill string is decreased as the speed of rotation of the drill string is increased in step j.

5. The method of any preceding claim further comprising directing drilling fluid leaving the bore hole along an annulus return line, and varying the fluid pressure in the well bore by varying the degree of restriction of fluid flow along the annulus return line.

6. The method according to any preceding claim, the method further comprising measuring the pressure of fluid at the bottom of the bore hole, and altering the rotational speed of the drill string or the rate of pumping of drilling fluid into the drill string to bring the measured pressure to a desired level.

7. The method according to any preceding claim comprising automatically changing the rate of pumping of the drilling fluid into the drill string in response to a change in the speed of rotation of the drill string, or automatically changing the speed of rotation of the drill string in response to a change in the rate of pumping of the drilling fluid into the drill string.

8. An apparatus for drilling a bore hole comprising a drill string, a driver operable to cause rotation of the drill string along its longitudinal axis, a pump operable to pump drilling fluid into the drill string, a driver controller which is

operable to control the driver to vary the speed of rotation of the drill string, and a pump controller which is operable to control the pump to vary the rate of pumping of drilling fluid into the drill string, characterised in that the driver controller and pump controller are in communication so that the pump controller automatically changes the rate of pumping of the drilling fluid into the drill string in response to a change in the speed of rotation of the drill string, and / or the driver controller automatically changes the speed of rotation of the drill string in response to a change in the rate of pumping of the drilling fluid into the drill string.

9. An apparatus according to claim 8 wherein the driver controller is an electronic driver controller, and the pump controller is an electronic pump controller, there being an electrical connection between the driver controller and the pump controller, to provide for the transmission of a control signal between the top drive controller and the pump controller.

10. An apparatus according to claim 9 wherein the driver controller is programmed to transmit to the pump controller a control signal instructing the pump controller to either increase or decrease the speed of operation of the pump depending on whether the rotational speed of the drill pipe is decreasing or increasing.

11. An apparatus according to claim 10 wherein the pump controller is programmed to monitor this signal, and automatically to alter the speed of operation of the pump in accordance with the instruction given in the control signal.

12. An apparatus according to claim 11 wherein the driver controller is programmed to send a control signal to the pump controller instructing the pump controller to reduce the speed of operation of the pump as the speed of rotation of the drill pipe increases, and to increase the speed of operation of the pump as the speed of rotation of the drill pipe decreases.

13. An apparatus according to claim 9 wherein the pump controller is provided with an input for receipt of a signal indicative of the speed of rotation of the drill pipe.

14. An apparatus according to claim 13 wherein the pump controller is programmed to respond to a signal indicating that the drill pipe speed is decreasing by increasing the speed of operation of the pump, or where more than one pump is provided, one or more of the pumps, and vice versa.

15. An apparatus according to any one of claims 9 to 14 wherein the driver controller and pump controller are integrated to comprise a single electronic controller which is operable to control the speed of operation of the pump and the speed of rotation of the drill string.

16. An apparatus according to any of claims 9 to 15 wherein the controller or one or both of the controllers has a pressure input for receipt of a signal from a pressure sensor located on the drill string which transmits a signal indicative of the fluid pressure in the bore hole to the or each controller to which it is connected.

17. An apparatus according to claim 16 wherein the or each controller having said pressure input is programmed to use this pressure signal to determine if the fluid pressure is at a desired level, and, if not, make further adjustments to the pump speed and/or speed of rotation of the drill string to bring the fluid pressure to the desired level or to within an acceptable range.

18. An apparatus according to any of claims 9 to 17 wherein the controller or one or both of the controllers has a flow input for receipt of a signal from a flow meter which transmits a signal representative of the rate of flow of drilling fluid down the drill string to the or each controller to which it is connected.

19. An apparatus according to any one of claims 9 to 18 further including an annulus return line which connects the annular space in the bore hole around

the drill string with a reservoir for pressurised fluid, an adjustable choke in the annular return line, and an electronic choke controller which controls operation of the adjustable choke to vary the restriction of flow of fluid along the annulus return line.

CLAIMS

1. A method of drilling a subterranean bore hole comprising:

a) pumping a drilling fluid down a drill string, the drill string having a drill bit at an end thereof,

b) rotating the drill string about its longitudinal axis to that the bit forms bore hole in the ground,

the method further comprising the steps of:

c) changing the rate of pumping of the drilling fluid into the drill string in response to a change in the speed of rotation of the drill string, and / or changing the speed of rotation of the drill string in response to a change in the rate of pumping of the drilling fluid into the drill string, characterised in that the rate of pumping of the drilling fluid is increased as the speed of rotation of the drill string is decreased, and the rate of pumping of the drilling fluid is decreased as the speed of rotation of the drill string is increased, and / or the speed of rotation of the drill string is increased as the rate of pumping of the drilling fluid is decreased and the speed of rotation of the drill string is decreased as the rate of pumping of the drilling fluid is increased.

2. The method of claim 1 further including the steps of:

d) stopping the rotation of the drill string,

e) pumping drilling fluid into a side port adjacent the uppermost end of the drill string,

f) ceasing pumping of drilling fluid into the uppermost end of the drill string,

g) connecting a new section of drill pipe to the uppermost end of the drill string,

h) commencing pumping of drilling fluid into the uppermost end of the new section of drill pipe,

i) ceasing pumping of drilling fluid into the side port, and

j) recommencing rotation of the drill string.

3. The method of claim 2 wherein the rate of pumping of fluid into the drill string is increased as the speed of rotation of the drill string is decreased in step d, and the rate of pumping of fluid into the drill string is decreased as the speed of rotation of the drill string is increased in step j.

4. The method of any preceding claim further comprising directing drilling fluid leaving the bore hole along an annulus return line, and varying the fluid pressure in the well bore by varying the degree of restriction of fluid flow along the annulus return line.

5. The method according to any preceding claim, the method further comprising measuring the pressure of fluid at the bottom of the bore hole, and altering the rotational speed of the drill string or the rate of pumping of drilling fluid into the drill string to bring the measured pressure to a desired level.

6. The method according to any preceding claim comprising automatically changing the rate of pumping of the drilling fluid into the drill string in response to a change in the speed of rotation of the drill string, or automatically changing the speed of rotation of the drill string in response to a change in the rate of pumping of the drilling fluid into the drill string.

7. An apparatus for drilling a bore hole comprising a drill string, a driver operable to cause rotation of the drill string along its longitudinal axis, a pump operable to pump drilling fluid into the drill string, a driver controller which is operable to control the driver to vary the speed of rotation of the drill string, and a pump controller which is operable to control the pump to vary the rate of pumping of drilling fluid into the drill string, characterised in that the driver controller and pump controller are in communication so that the pump controller automatically increases the rate of pumping of the drilling fluid into the drill string in response to a decrease in the speed of rotation of the drill string, and automatically decrease the rate of pumping of the drilling fluid into the drill string in response to an increase in the speed of rotation of the drill

string and / or the driver controller automatically increases the speed of rotation of the drill string in response to a decrease in the rate of pumping of the drilling fluid into the drill string, and automatically decreases the speed of rotation of the drill string in response to an increase in the rate of pumping of the drilling fluid into the drill string.

8. An apparatus according to claim 7 wherein the driver controller is an electronic driver controller, and the pump controller is an electronic pump controller, there being an electrical connection between the driver controller and the pump controller, to provide for the transmission of a control signal between the top drive controller and the pump controller.

9. An apparatus according to claim 8 wherein the driver controller is programmed to transmit to the pump controller a control signal instructing the pump controller to either increase or decrease the speed of operation of the pump depending on whether the rotational speed of the drill pipe is decreasing or increasing.

10. An apparatus according to claim 9 wherein the pump controller is programmed to monitor this signal, and automatically to alter the speed of operation of the pump in accordance with the instruction given in the control signal.

11. An apparatus according to claim 10 wherein the driver controller is programmed to send a control signal to the pump controller instructing the pump controller to reduce the speed of operation of the pump as the speed of rotation of the drill pipe increases, and to increase the speed of operation of the pump as the speed of rotation of the drill pipe decreases.

12. An apparatus according to claim 8 wherein the pump controller is provided with an input for receipt of a signal indicative of the speed of rotation of the drill pipe.

13. An apparatus according to claim 12 wherein the pump controller is programmed to respond to a signal indicating that the drill pipe speed is

decreasing by increasing the speed of operation of the pump, or where more than one pump is provided, one or more of the pumps, and vice versa.

14. An apparatus according to any one of claims 8 to 14 wherein the driver controller and pump controller are integrated to comprise a single electronic controller which is operable to control the speed of operation of the pump and the speed of rotation of the drill string.

15. An apparatus according to any of claims 8 to 14 wherein the controller or one or both of the controllers has a pressure input for receipt of a signal from a pressure sensor located on the drill string which transmits a signal indicative of the fluid pressure in the bore hole to the or each controller to which it is connected.

16. An apparatus according to claim 15 wherein the or each controller having said pressure input is programmed to use this pressure signal to determine if the fluid pressure is at a desired level, and, if not, make further adjustments to the pump speed and/or speed of rotation of the drill string to bring the fluid pressure to the desired level or to within an acceptable range.

17. An apparatus according to any of claims 8 to 16 wherein the controller or one or both of the controllers has a flow input for receipt of a signal from a flow meter which transmits a signal representative of the rate of flow of drilling fluid down the drill string to the or each controller to which it is connected.

18. An apparatus according to any one of claims 8 to 17 further including an annulus return line which connects the annular space in the bore hole around the drill string with a reservoir for pressurised fluid, an adjustable choke in the annular return line, and an electronic choke controller which controls operation of the adjustable choke to vary the restriction of flow of fluid along the annulus return line.