pipe so as to close the upward fluid flow path of the riser annulus. Fluid pressure in the riser annulus is then increased by pumping mud into the riser annulus either directly via a kill line or indirectly via the drill string and well bore. The diverter cannot be operated to contain fluid pressure in the riser annulus whilst the drill string is rotating, however.

Drilling methods, such as managed pressure drilling or mud cap drilling, which involve the pressurisation of fluid in the wellbore annulus are becoming increasingly important, and these require the ability to contain fluid pressure in the riser annulus during drilling. One system for providing pressurised riser assembly is disclosed in US 2008/0105434. In this system, a universal riser section (OURS) is placed in the riser below the slip joint. The OURS includes, amongst other things, at least one rotating control device (RCD), together with all the usual connections and attachments required to operate the RCD.

Herein disclosed is a first embodiment of~~According to a first aspect of the invention we provide~~ a drilling system including a drill string which extends from a floating drilling rig to a well bore, and a tubular riser which surrounds at least part of the portion of the drill string between the well bore and drilling rig, the riser having a telescopic joint between a first tubular portion and a second tubular portion, the first tubular portion extending down to a well head at the top of the well bore and the second tubular portion extending up towards the drilling rig, the telescopic joint comprising an inner tube part which is mounted within an outer tube part, the drilling system further including a riser closure device which is mounted in the second portion of the riser and which is operable to provide a substantially fluid tight seal between the riser and the drill string whilst permitting the drill string to rotate relative to the riser.

By virtue of locating the riser closure device above the telescopic joint, installation and maintenance of the well control system is considerably simplified.

The riser closure device may be a rotating control device.

According to a first aspect, there is provided a drilling system including a drill string which extends from a floating drilling rig to a well bore, and a tubular riser which surrounds at least part of the portion of the drill string between the well bore and drilling rig, the riser having a telescopic joint between a first tubular portion and a second tubular portion of the riser, the first tubular portion extending down to a well head at the top of the well bore and the second tubular portion extending up towards the drilling rig, the telescopic joint comprising an inner tube part which is mounted within an outer tube part, the drilling system further including a riser closure device which is mounted in the second tubular portion of the riser and which is operable to provide a substantially fluid tight seal between the riser and the drill string whilst permitting the drill string to rotate relative to the riser, wherein the riser has a main bore along which the drill extends, and a side bore which extends from the main bore of the second portion of the riser between the telescopic joint and the riser closure device to the exterior of the riser, wherein the side bore is connected to a fluid flow line which extends from the side bore to a fluid reservoir, the fluid flow line being part of a flow control system, wherein the drilling system also includes a damper system which comprises a vessel which is divided into first and second substantially fluid tight chambers by means of a movable divider, the first chamber being connected to the fluid flow line and the second chamber being connected to a pressurised fluid reservoir, wherein the damper system further includes a pressure regulator device which is operable to control the pressure of fluid in the second chamber.

As mentioned in the above first aspectAdvantageously, the riser has a main bore along which the drill string extends, and a side bore which extends from the main bore of the second portion of the riser between the telescopic joint and the riser closure device to the exterior of the riser. In this case, preferably the side bore is connected to a fluid flow line which extends from the side bore to a fluid reservoir, the fluid flow line being part of a flow control system.

The drilling system preferably further includes a flow control device, such as a valve or choke, which is provided in the fluid flow line and which is operable to restrict the flow of fluid along the fluid flow line to a variable degree. The flow control device is preferably controlled using an electronic control unit. The drilling system preferably further includes a pressure sensor which transmits an electrical signal indicative of the fluid pressure in the fluid flow line to the electronic control unit.

As mentioned in the above first aspect, the~~The~~ drilling system ~~may~~ also includes a damper system which comprises a cylinder which is divided into first and second substantially fluid tight chambers by means of a movable divider such as a diaphragm or piston, the first chamber being connected to the fluid flow line and the second chamber being connected to a pressurised gas reservoir. The damper system ~~preferably~~ further includes a pressure regulator device which is operable to control the pressure of fluid, such as gas, in the second chamber. Preferably the pressure regulator device is controlled using the electronic control unit.

Advantageously the drilling system includes a displacement meter which provides a displacement signal indicative of the displacement of the first portion of the riser relative to the second portion of the riser. The displacement meter may be in communication with the electronic control unit so that it can transmit the displacement signal to the electronic control unit.

The drilling system may include a flow meter which is located in the fluid flow line, preferably between the side bore and the flow control device, the flow meter providing a flow signal indicative of the rate of fluid flow along the fluid flow line. The flow meter may be in communication with the electronic control unit so that it can transmit the flow signal to the electronic control unit.

Preferably the telescopic joint includes one or more seals which extend between the inner tube part and the outer tube part of the telescopic joint so as to provide a substantially fluid tight seal between the inner tube part and the outer tube part whilst permitting the inner tube part and outer tube part to slide relative to one another. The outer tube portion of the telescopic joint may be provided on the first portion of the riser, and the inner tube portion of the telescopic joint provided on the second portion of the riser.

The riser preferably further includes an angular displacement joint which is located in the second portion of the riser between the riser closure device and the drilling rig and which allows angular movement of the riser relative to the drilling rig.

According to a second aspect, there is provided a method of operating a drilling system according to the first aspect, the drilling system including a flow control device which is provided in the fluid flow line and which is operable to restrict the flow of fluid along the fluid flow line to a variable degree, and a pressure regulator device which is operable to control the pressure of fluid in the second chamber, the method including the steps of controlling operation of both the flow control device and the pressure regulator to maintain a substantially constant fluid pressure in the fluid flow line.

According to a third aspect, there is provided a method of operating a drilling system according to the first aspect, the flow control system including a flow meter which is located in the fluid flow line, the flow meter providing a flow signal indicative of the rate of fluid flow along the fluid flow line, the flow control system further including a displacement meter which provides a displacement signal indicative of the displacement of the first portion of the riser relative to the second portion of the riser, wherein the method includes the steps of using the displacement signal to calculate a change in volume of fluid in the riser over a particular period of time (δV), and using the flow signal and the calculated change in volume of fluid in the riser to produce an adjusted out flow rate, comparing the adjusted flow rate with the rate of flow of drilling fluid into the drill string (the in flow rate), and if the adjusted out flow rate differs from the in flow rate by more than a first predetermined amount raise an alarm signal to alert an operator of this, if the adjusted out flow rate exceeds the in flow rate by more than a second predetermined amount, operating the flow control system to carry out a kick control procedure, and, if the adjusted out flow rate is less than the in flow rate by more than a third predetermined amount, operating the flow control system to carry out an in flow control procedure.

According to a fourth aspect, there is provided a method of operating a drilling system according to the first aspect, the drilling system including a flow control device which is provided in the fluid flow line and which is operable to restrict the flow of fluid along the fluid flow line to a variable degree, the flow control system further including a displacement meter which provides a displacement signal indicative of the displacement of the first portion of the riser relative to the second portion of the riser, wherein the method includes the steps of using the displacement signal to calculate a change in volume of fluid in the riser over a particular period of time (δV), and operating the flow control device to decrease the fluid pressure in the fluid flow line if there is an decrease in the riser volume or to increase the fluid pressure in the fluid flow line if there is an increase in the riser volume.

There is disclosed~~According to a second aspect of the invention we provide~~ a method of operating a drilling system according to the first embodiment~~claim 1~~ wherein the riser has a main bore along which the drill string extends, and a side bore which extends from the main bore of the second portion of the riser between the telescopic joint and the riser closure device to the exterior of the riser, the side bore being connected to a fluid flow line which extends from the side bore to a fluid reservoir, the fluid flow line being part of a flow control system which includes a flow control device, such as a valve or choke, which is provided in the fluid flow line and which is operable to restrict the flow of fluid along the fluid flow line to a variable degree, the flow control system further including a damper system which comprises a vessel (or chamber) which is divided into first and second substantially fluid tight chambers by means of a movable divider such as a diaphragm or piston, the first chamber being connected to the fluid flow

line and the second chamber being connected to a pressurised gas reservoir, and a pressure regulator device which is electrically operable to control the pressure of gas in the second chamber, the method including the steps of controlling operation of both the flow control device and the pressure regulator to maintain a substantially constant fluid pressure in the fluid flow line.

There is also disclosed~~According to a third aspect of the invention we provide~~ a method of operating a drilling system according to the first embodiment~~claim 1~~ wherein the riser has a main bore along which the drill string extends, and a side bore which extends from the main bore of the second portion of the riser between the telescopic joint and the riser closure device to the exterior of the riser, the side bore being connected to a fluid flow line which extends from the side bore to a fluid reservoir, the fluid flow line being part of a flow control system, the flow control system including a flow meter which is located in the fluid flow line, preferably between the side bore and the flow control device, the flow meter providing a flow signal indicative of the rate of fluid flow along the fluid flow line (Q_{out}), the well control system further including a displacement meter which provides a displacement signal indicative of the displacement of the first portion of the riser relative to the second portion of the riser, wherein the method includes the steps of using the displacement signal to calculate a change in volume (δV) of fluid in the riser over a particular period of time (δT), and using the flow signal and the calculated change in volume of fluid in the riser to produce an adjusted out flow rate, comparing the adjusted flow rate with the rate of flow of drilling fluid into the drill string (the in flow rate), and if the adjusted out flow rate differs from the in flow rate by more than a first predetermined amount raise an alarm signal to alert an operator of this, if the adjusted out flow rate exceeds the in flow rate by more than a second pre-determined amount, operating the well control system to carry out a kick control procedure, and if the adjusted out flow rate is less than the in flow rate by more than a third pre-determined amount, operating the well control system to carry out an in flow control procedure.

Preferably δV is calculated using the formula

$\delta V = \delta D.(A_{SJ}-A_{DS})$,

where δD is the change in displacement of the first portion of the riser relative to the second over the period of time,

A_{SJ} is the internal cross-sectional area of the inner tube section of the telescopic joint, and

A_{DS} is the external cross-sectional area of the drill string.

Preferably the adjusted out flow rate ($Q_{out.adj}$) is calculated using the formula volumetric:

$Q_{out.adj} = Q_{out} + \delta V/\delta T$

where Q_{out} is the measured volumetric out flow rate.

There is further disclosed~~According to a fourth aspect of the invention we provide~~ a method of operating a drilling system according to the first embodiment~~claim 1~~, wherein the riser has a main bore along which the drill string extends, and a side bore which extends from the main bore of the second portion of the riser between the telescopic joint and the riser closure device to the exterior of the riser, the side bore being connected to a fluid flow line which extends from the side bore to a fluid reservoir, the fluid flow line being part of a flow control system which includes a flow control device, such as a valve or choke, which is provided in the fluid flow line and which is operable to restrict the flow of fluid along the fluid flow line to a variable degree, the well control system further including a displacement meter which provides a displacement signal indicative of the displacement of the first portion of the riser relative to the second portion of the riser, wherein the method includes the steps of using the displacement signal to calculate a change in volume of fluid in the riser over a particular period of time (δV), and operating the flow control device to decrease the fluid pressure in the fluid flow

tight seal between the inner tube part and the outer tube part whilst permitting the inner tube part and outer tube part to slide relative to one another.

12. A method of operating a drilling system according to claim 1, the drilling system including a flow control device which is provided in the fluid flow line and which is operable to restrict the flow of fluid along the fluid flow line to a variable degree, and a pressure regulator device which is operable to control the pressure of fluid in the second chamber, the method including the steps of controlling operation of both the flow control device and the pressure regulator to maintain a substantially constant fluid pressure in the fluid flow line.

13. A method of operating a drilling system according to claim 1, the flow control system including a flow meter which is located in the fluid flow line, the flow meter providing a flow signal indicative of the rate of fluid flow along the fluid flow line, the flow control system further including a displacement meter which provides a displacement signal indicative of the displacement of the first portion of the riser relative to the second portion of the riser, wherein the method includes the steps of using the displacement signal to calculate a change in volume of fluid in the riser over a particular period of time (δV), and using the flow signal and the calculated change in volume of fluid in the riser to produce an adjusted out flow rate, comparing the adjusted flow rate with the rate of flow of drilling fluid into the drill string (the in flow rate), and if the adjusted out flow rate differs from the in flow rate by more than a first predetermined amount raise an alarm signal to alert an operator of this, if the adjusted out flow rate exceeds the in flow rate by more than a second predetermined amount, operating the flow control system to carry out a kick control procedure, and, if the adjusted out flow rate is less than the in flow rate by more than a third predetermined amount, operating the flow control system to carry out an in flow control procedure.

14. A method according to claim 13~~14~~ wherein δV is calculated using the formula: