

- 18 -

Claims

1. An apparatus for operating a work tool of a machine, the apparatus comprising:

5 a cylinder comprising a cylinder wall extending between first and second cylinder ends;

a piston comprising a piston rod attached to a piston head, the piston head being mounted in the cylinder such that the piston is moveable relative to the cylinder; and

10 a gas spring arrangement for biasing the piston head away from the first cylinder end, the gas spring arrangement comprising:

a first gas chamber extending between the first cylinder end and piston head and a second gas chamber extending between piston head and second cylinder end, the first and second gas chambers having a variable volume based upon the position of the piston head in the cylinder; and

15 a gas connection arrangement fluidly connecting the first gas chamber to the second gas chamber and configured to enable gas to flow between the first and second gas chambers if the piston moves relative to the cylinder.

2. An apparatus as claimed in claim 1 wherein the piston head
20 comprises first and second head surfaces, wherein the first head surface has a greater surface area than the second head surface such that a pressurised gas in the gas spring arrangement biases the piston head away from the first cylinder end.

25 3. An apparatus as claimed in claim 1 further comprising a secondary head mounted inside the piston rod to form a first piston chamber between the secondary head and piston head and a second piston chamber between the secondary head and an outer piston end of the piston rod.

30 4. An apparatus as claimed in claim 1 further comprising an actuator fluid system for moving the piston relative to the cylinder, the actuator

- 19 -

fluid system comprising at least one fluid chamber inside the piston and at least one fluid pump for selectively supplying fluid via at least one actuator conduit to the at least one fluid chamber to move the piston relative to the cylinder.

- 5 5. An apparatus as claimed in claim 4, further comprising a secondary head mounted inside the piston rod to form a first piston chamber between the secondary head and piston head and a second piston chamber between the secondary head and an outer piston end of the piston rod, wherein the at least one fluid chamber comprises the first and second piston chamber,
10 further wherein the at least one actuator conduit comprises a first actuator conduit extending from the first piston chamber and a second actuator conduit extending from the second piston chamber.

6. An apparatus as claimed in claim 5 further comprising a fluid
15 lock arrangement comprising a check valve located in the first actuator conduit and a check valve pilot conduit extending from the second actuator conduit to the check valve for opening the check valve if the pressure in the first actuator conduit reaches a preset lock pressure value.

- 20 7. An apparatus as claimed in claim 1 wherein the second gas chamber is outside of the piston and extends from the piston head towards the second cylinder end between the piston rod and cylinder wall.

8. An apparatus as claimed in claim 3 wherein the second gas
25 chamber is inside the piston and comprises the first piston chamber.

9. An apparatus as claimed in claim 1 wherein the gas connection arrangement comprises at least one gas passageway extending through the piston head.

- 20 -

10. An apparatus as claimed in claim 1 wherein the gas connection arrangement comprises at least one gas conduit extending between the first and second gas chambers and around the piston head.

5 11. An apparatus as claimed in claim 1 further comprising a gas storage apparatus comprising at least one gas storage tank having a fixed volume and fluidly connected to at least one gas chamber, wherein the gas spring arrangement is configured to enable open fluid communication between the at least one gas storage tank and at least one gas chamber if the piston moves
10 relative to the cylinder.

 12. An apparatus as claimed in claim 1 further comprising a gas port apparatus fluidly connected to the at least one gas chamber, the gas port apparatus comprising a gas port valve for selectively controlling the flow of gas
15 into the at least one gas chamber and at least one adapter for mounting at least one gas supply tank.

 13. A method of operating a machine comprising a work tool and an apparatus mounted to the work tool, the apparatus comprising:
20 a cylinder comprising a cylinder wall extending between first and second cylinder ends;
 piston comprising a piston rod attached to a piston head, the piston head being mounted in the cylinder; and
 a gas spring arrangement comprising:
25 a first gas chamber extending between the first cylinder end and piston head and a second gas chamber extending between piston head and second cylinder end; and
 a gas connection arrangement fluidly connecting the first gas chamber to the second gas chamber,
30 wherein the method comprises:

- 21 -

biasing the piston head away from the first cylinder end by a gas in the gas spring arrangement;

moving the piston head such that first and second gas chambers vary in volume and gas is transmitted from the first gas chamber to the second
5 gas chamber via the gas connection arrangement.

14. A method as claimed in claim 13 comprising moving the piston head towards the first cylinder end by applying a force to the piston and/or cylinder, the force comprising a gravitational down force of the work tool and/or
10 a force applied by an actuator, such that the pressure of the gas increases.

15. A method as claimed in claim 13 further comprising moving the piston head towards the second cylinder end by applying a force to the piston, the force being at least partially applied to the piston head by gas in the first gas
15 chamber.