

APPARATUS AND METHOD FOR RAISING AND LOWERING A PISTON IN A PISTON-CYLINDER ARRANGEMENT IN A DERRICK

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The present invention relates to an apparatus for a derrick, comprising two or more hydraulic piston/cylinder arrangements for raising and lowering a yoke which travels on guide rails in the derrick itself, where two or more wire lines are strung over sheaves rotatably attached to the yoke, said wire lines being at one end attached to the top drive and at the other end to an attachment point adjacent to a drill floor, said two or more wire lines being run in two sets of lines, the attachment points of which are spaced apart.

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A derrick structure, developed by the present inventor in 1987, that has shown great promise is the RamRigTM concept. Two or more hydraulic piston/cylinder arrangements are used in the derrick for raising and lowering the drill string. The cylinders operate between the drill floor and a yoke which travels on guide rails in the derrick itself. The advantages of this concept are numerous, some of the most important being that it is possible to place the drill floor at a higher level than the platform floor, that a derrick having significantly lower air resistance can be constructed, and that the most expensive components of the derrick attain higher safety and a longer lifetime.

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Since it is possible to position the drill floor higher than the platform floor, pipe handling is significantly simplified. There is no longer any need to arrange the pipe handling equipment at a high level in the derrick. All pipe handling equipment can be placed on the platform floor and the drill floor.

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The object of the present invention is to solve important, practical problems in the realization of the RamRigTM

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concept. This object is achieved by means of the features apparent from the characterizing clause of the subsequently disclosed claim 1.

5 The invention will now be explained in greater detail with reference to the enclosed drawings, where

Figure 1 shows a RamRigTM derrick in every essential detail;

10 Figure 2 shows the derrick schematically, viewed from the side;

Figure 3 shows the derrick schematically, viewed from the front, with the top drive in its lowest position;

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Figure 4 shows the derrick schematically, viewed from the front, with the top drive in its highest position;

20 Figures 5 - 13 show the drive means of the piston/cylinder arrangements in various modes of operation.

Figure 1 shows a derrick 1 positioned on a drill floor 2. The drill floor is positioned at a higher level than the platform floor 3, so that the pipe handling equipment 4 can be placed, in the main, between the platform floor 3 and the drill floor 2. The derrick 1 is substantially gantry-shaped, with gantry legs 5, 6. Guide rails 7 for a yoke 8 and a top-drive 9 run along each gantry leg 5, 6. Hydraulic piston/cylinder arrangements 10, 11 are positioned so that they extend along each gantry leg 5, 6 and operate between the drill floor 2 and the yoke 8, for moving the yoke 8 vertically along the guide rails 7.

35 The yoke 8 is provided with a plurality of sheaves 12, preferably four, for running wire lines 13. The wire lines 13 run from the drill floor 2 along each gantry leg 5, 6, over the sheaves 12 and down to the top drive 9. By retracting and

extending the piston/cylinder arrangement 10, 11, it is thus possible to raise and lower the top drive 9.

5 In Figures 2, 3 and 4, the function of the lift system is seen most clearly. In Figures 2 and 3, the piston/cylinder arrangement 10, 11 is shown in a completely retracted condition. The top drive 9 is then in its lowest position, quite close to the drill floor. The yoke 8 is at the upper end of the piston/cylinder arrangement.

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When the pistons in the piston/cylinder arrangement are extended, the yoke 8 is lifted along the guide rails 7 up to the top of the derrick 1. The top drive is then lifted, as a result of the exchange created by the wire lines 13 being run
15 over the sheaves 12, from its position adjacent to the drill floor 2 to a position directly below the yoke 8. The height to which the top drive 9 is lifted is thus the double of that to which the yoke 8 is lifted.

20 There may, for example, be as much as eight wire lines 13 arranged in the lift means described above, where two and two are strung in their own separate tracks over the same sheave 12. Four sheaves are arranged in pairs at each end of the yoke 8. The wire lines 13 are thus arranged in two sets 13a
25 and 13b, extending from attachment points 14a and 14b at the drill floor 2, over the sheaves 12 and down to the top drive 9. The attachment points 14a and 14b are horizontally spaced apart by a distance approximately like the length of the yoke 8.

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In Figure 5 the piston/cylinder arrangements 10, 11 are schematically illustrated. Here the yoke 8 is also shown, together with the sheaves 12 and the top drive 9. The drill floor 2 is also indicated. From the drill floor 2 each of the
35 wire lines 13 runs over its own sheave 12 and down to the top drive 9.

Each piston/cylinder arrangement 10, 11 consists of a cylinder and a piston 21 having a piston rod 22. The cylinder 20 is at one end attached to the drill floor 2, whereas the piston rod 22 is attached to the yoke 8. The piston 21 divides the cylinder into two chambers, a lower chamber 23 and an upper chamber 24. The lower chamber 23 is circular/cylindrical and only delimited by the walls of the cylinder 20 and the lower end surface 25 of the piston 21. The upper chamber 24 is also delimited by the walls of the cylinder 20, but is in addition delimited by the piston rod 22 and the upper annular surface 26 of the piston 21. It will thus be seen that hydraulic fluid in the lower chamber 23 has a larger operating surface with respect to the piston 21 than hydraulic fluid in the upper chamber 24, since the lower end surface 25 of the piston is larger than its upper annular surface 26.

The drive system which is here generally designated by reference numeral 30, consists of a reservoir 31, a feed pump 32 driven by a motor 33, one or more main pumps 34 driven by one or more motors 35, a control valve 36, an accumulator/-valve plate 37, a cylinder valve 38 for each cylinder 20, one or more accumulators 39 and one or more pressure tanks 40.

From each side of the main pumps 34 lines 41, respectively 42, lead to a separate port a, b for each, in the control valve 36. A line 43 leads from the reservoir 31, via the feed pump 38 to a third port c in the control valve 36. From a fourth port d in the control valve 36 a line 44 leads to the accumulator/valve plate 37. From a fifth port e in the control valve 36 a line 45 leads via a ramification 46, where the line 45 branches so as to create one line for each cylinder 20 leading into a port f in each cylinder valve 38. The line 44 which leads into a port g in the accumulator/valve plate 37, splits here into branches which lead from a number of ports h to the control valve 38 of each cylinder

20 into a port i for each control valve 36. The accumulators 39 are connected to the accumulator valve plate 37 via ports j. It must be understood that both ports h and ports j respectively may represent a plurality of ports or optionally one port branching outside the accumulator/valve plate 37. The accumulators 39 are connected to the pressure tanks 40 via a line 47.

A line 48, connected with the upper chamber 24 of the cylinder 20, extends from a port k in each cylinder valve 38. From a port l in each cylinder valve a line 49 leads to the chamber 23 of the cylinder 20. A line 50 connects ports m in each cylinder valve 38.

Now, since the construction of the drive means 30 of the piston/cylinder arrangements 10, 11 has been explained, the mode of operation of this drive means 30 shall be explained by means of Figures 5 - 13, as follows.

In Figure 5, the piston/cylinder arrangements 10, 11 are in a locked position. The main pump 34 is set for zero displacement volume, and the connection between the ports k and the ports f and i is closed. Thus, there is no flow of hydraulic fluid in the system.

In figure 6 the piston/cylinder arrangements are extended for maximum thrust power, but at low velocity. Now the displacement volume of the main pump 34 is adjusted so that hydraulic fluid flows from the reservoir 31, via the feed pump 32 and the line 43, in through the port c in the control valve 36, out through the port b, through the line 42 via the main pump 34 and the line 41 to port a of the control valve 36, out through the port e, via the line 44 to port g of the accumulator valve plate and from this via the ports h to the ports i in the cylinder valves 38 and further out through the ports l and the lines 49 to the chamber 23 of the cylinder 20. Hydraulic fluid, displaced from the chamber

24 of the cylinder 20, flows via the lines 48, via the cylinder valves 38 and the line 45 back to the control valve 36 and main pump 34. The ports j in the accumulator valve plate 37 are closed. The connection 50 between the ports m of the cylinder valves 38 is open, however, in order to ensure that there is equal pressure on the underside 25 of the pistons 21. In this mode the piston/cylinder arrangements 10, 11 would be extended at a comparatively low velocity, but with a relatively high thrust power.

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In Figure 7 another mode is shown which, with respect to hydraulic fluid circulation, is quite in accordance with the mode shown in figure 6. However, here the ports j in the accumulator valve plate 37 have been opened up so that the accumulators 39, which are influenced by pressure from pressure tanks 4 via the line 47, increase the pressure in the hydraulic fluid which flows through the line 44 to the lower chamber 23 of the cylinders 20. The velocity of the pistons 21 is then somewhat increased at the same time as the thrust power is maintained at a high level.

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In Figure 8 a mode is shown where the travelling speed of the pistons 21 has been further increased. At the same time the thrust force is reduced. This mode is thus well suited for raising the unloaded top drive 9. In this mode the connection is opened between the ports i, k, l and m in the control valves 38, so that the lower chamber 23 and the upper chamber 24 of the cylinders 20 are short circuited. Hence, the hydraulic pressure acts on a differential area which is equal to the difference between the area of the underside 25 of the piston 21 and the top side 26 of the piston 21, i.e., the cross-sectional area of the piston rod 22. Thus the piston 21 obtains a greater travelling speed at the same hydraulic pressure. In this mode the ports j in the accumulator valve plate 37 are closed so that the accumulators 39 do not function.

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In Figure 9 a further mode is shown, where the ports j of the accumulator valve plate 37 are opened so that the accumulators 39 supply an additional pressure into the line 44. As in Figure 8, the connection between ports i, k and l in the cylinder valves 38 is open. The ports m may also be open in this mode, although this is not shown here. In this mode, the travelling speed of the piston 21 will be further increased because of the increased pressure in the line 44. The thrust force will still be comparatively low, however.

In Figure 10 there is shown a lowering mode at maximum load and controlled speed. The main pump 34 is now readjusted so that the hydraulic fluid flows into the pump through the line 41 and out of the pump through the line 42. In this case the connection between the ports k of the lines 48 in the cylinder valves 38 and the port f of the line 45 in the cylinder valves 38 is open so that the hydraulic fluid flows into the upper chamber 24 of the cylinder. At the same time the connection between the port l and the port i in the cylinder valves 38 is open so that the hydraulic fluid in chamber 23 of the cylinder 20 flows out in the line 44. A part of the hydraulic fluid will flow back to the reservoir 31 for the very reason that the chamber 24 of the cylinder 20 has a smaller cross sectional area than the chamber 23.

In Figure 11 a lowering mode is shown where the lowering is carried out at up to maximum load and up to maximum velocity. Here the ports f, i, k and l in the cylinder valves 38 are connected with each other. Thus hydraulic fluid can freely flow out of the chamber 23 of the cylinder 20. Some of this fluid will flow back to the cylinder and into the chamber 24, whereas the remainder will flow through the lines 44 and 45 and further, to the reservoir 31. The lowering speed can be controlled to a certain degree by means of the main pump 34, but because of the fact that the connection between the cylinder valves 38 and the reservoir 31 via the line 45 is completely open, it will be expedient to control the lowering

speed by means of a throttling 51, which, as shown here, may lie in the connection between the port l and the ports f, i and k in the cylinder valves 38. This mode will be well suited for carrying out hard thrusts with the drill string, if the need should arise.

Figure 12 shows a mode of operation where constant load is maintained during the movement of the piston/cylinder arrangements 10, 11. This mode is used, for example, for the drilling itself. In this mode the fluid flow goes back and forth in the system, and the displacement volume of the main pump 34 is adjusted in both directions in accordance with signals given from a load distributor (not shown). The connection between the ports f and k in the cylinder valve 38 is open, as is the connection between the ports i and l. The hydraulic fluid thus flows between the main pump 34 and the cylinder valve 38 via the line 44 and the line 45, respectively. The directions of the flow of fluid in these two lines will at all times be opposite to each other. A certain exchange of hydraulic fluid with the reservoir 31 will also occur, since the cross-sectional areas of the lower chamber 23 of the cylinder 20 and of the upper chamber 24 are different.

Figure 13 shows a similar mode of operation, where the purpose is to maintain a constant load while the pistons 21 are moved. In this mode, however, a greater velocity is achieved with respect to the travel of the piston. The port f in the valve 38 is now closed, so that there no longer will be any fluid flow in the line 45. The ports i, k and l in the cylinder valve 38 are connected with each other, however. Thus, in the same manner as in the mode according to Figure 9, the area of piston 21 activity will be the differential area between the area of the lower surface 25 of the piston and the area of the upper annular surface 26 of the piston. This corresponds to the cross-sectional area of the piston

rod 22. A faster move of the piston 21 will then be obtained even if the pressure in the system is unchanged.

Even though the use of the accumulators 39 to provide
5 increased pressure in the system has been shown in only a few
of the modes shown in Figures 5-9, it must nevertheless be
understood that the accumulators may be used in any one of
the modes shown, for increasing the pressure in the system
and thus increase either the velocity of the piston movement,
10 the force by which the piston 21 is moved or both. In the
lowering of the pistons 21, it will be expedient to open the
ports j in the accumulator valve plate 37 in order to
transfer some of the pressure created hereby into the
accumulators 39, which thereby charge the pressure tanks 40
15 via the line 47. Hence, it will be ensured that there is
extra power available from the accumulators 39 when this is
needed. Even in the modes for constant loads it may be
expedient to use the accumulators 39.

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Patent Claims

1.
An apparatus for a derrick, comprising two or more hydraulic
5 piston/cylinder arrangements (10, 11) for raising and
lowering a yoke (8) which travels on guide rails (7) in the
derrick itself, a hydraulic system (30) for operation of the
piston/cylinder arrangements (10, 11), where the hydraulic
10 system comprises at least one main pump (34), having inlet
and outlet ports for supplying hydraulic fluid pressure to
the piston/cylinder arrangements (10, 11), cylinders (20),
valves (36, 37, 38) for control of hydraulic pressure to a
lower cylinder chamber (23) and an upper cylinder chamber
15 (24), respectively, located in the cylinder (20), said
chambers (23, 24) being separated by a piston (21) which, via
a piston rod (22), is connected to the yoke (8), the surface
of the piston (21) facing the chamber (23) being different
from the surface of the piston (21) facing the chamber (24),
c h a r a c t e r i z e d i n that at least one of the
20 valves is a cylinder control valve (38) which is adapted to
open and close the connection between ports (f, i, k, l) in
the valve (38) so as, in various modes of operation,
establish connection between
- 25 (1) the chamber (23, 24) of the cylinder (20) and the
outlet, respectively the inlet, port of the main pump (34)
for normal raising and lowering of the yoke (8),
- (2) the chambers (23, 24) of the cylinder (20), between
30 said chambers and the inlet port in the main pump (34),
and, optionally, directly between said chambers and a
reservoir (31), for rapid lowering of the yoke (8), or
- (3) the chambers (23, 24) of the cylinder (20), and
35 between said chambers and the outlet port of the main pump
for rapid raising of the yoke (8).



2.

An apparatus according to claim 1,
c h a r a c t e r i z e d i n that the hydraulic system
(30) comprises one or more accumulators (39), which are
5 adapted for connection with the line (44) for hydraulic fluid
leading to the lower chamber (23), during the raising of the
piston (21), in order to provide extra pressure to the
chamber (23), so that the piston (21) moves faster.

10 3.

An apparatus according to claim 2,
c h a r a c t e r i z e d i n that the accumulators (39)
are adapted for connection with the line (44) during the
lowering of the piston (21), so that hydraulic pressure
15 generated in the lower chamber will charge the accumulators
(39).

4.

An apparatus according to claims 1, 2 or 3.

20 c h a r a c t e r i z e d i n that the cylinder control
valve (38) comprises a first port (f) for coupling to a line
(45) for transport of hydraulic fluid to and from one side of
the main pump (34), a second port (i) for coupling to a line
(44) for transport of hydraulic fluid to and from the other
25 side of the main pump (34), a third port (k) for coupling to
a line (48) for transport of hydraulic fluid to and from the
upper chamber (24) and a fourth port (l) for coupling to a
line (49) for transport of hydraulic fluid to and from the
lower chamber (23); that during normal raising and lowering
30 of the piston (21) the first port (f) is connected with the
third port (k) and the second port (i) is connected with the
fourth port (l); and that during rapid raising or lowering,
the third port (k) and the fourth port (l), and the first
port (f) and/or the second port (i) are connected with each
35 other.



5.

An apparatus according to claim 4,
c h a r a c t e r i z e d i n that the cylinder control
valve (38) also comprises a fifth port (m) which is adapted
5 to be connected with a corresponding port (m) in another or
in a plurality of other cylinder control valve(s) (38) via a
line (50) and further is unrestricted in connection with the
fourth port (l) so as to provide the possibility of equali-
zing the pressure differences between the lower chambers (23)
10 of the various cylinders (20).

6.

An apparatus according to claims 5 or 6,
c h a r a c t e r i z e d i n that the connection between
15 the line (49), extending from the lower chamber (23) and the
line (44), leading to the other side of the main pump (34)
comprises a throttle (51).

7.

20 A method for raising and lowering a piston (21) in two or
more piston-cylinder arrangements (10, 11) for the purpose of
raising and lowering a yoke (8) which travels on guide rails
(7) in a derrick,
c h a r a c t e r i z e d i n that for normal raising or
25 lowering of the piston (21), the lower cylinder chamber (23)
of the piston/cylinder arrangements (10, 11) is connected
with a first side of a main pump (34), whereas the upper
cylinder chamber (24) of the of the piston/cylinder arrange-
ments (10, 11) is connected with the other side of the pump;
30 that for rapid raising of the piston (21) the lower chamber
and the upper chamber (23, 24) are connected with each other
and with the outlet side of the main pump (34); and that for
rapid lowering of the piston (21) the lower chamber and the
upper chamber (23, 24) are connected with each other and with
35 the inlet side of the main pump (34) and/or directly with a
reservoir (31).



8.

A method according to claim 7,

c h a r a c t e r i z e d i n that one or more accumulators
(39) are placed in connection with the lower chamber (23) for
supply of extra pressure during the raising of the piston
(21), and that the accumulators (39) stay connected with the
lower chamber (23) during the lowering of the piston (21) for
charging the accumulators.

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