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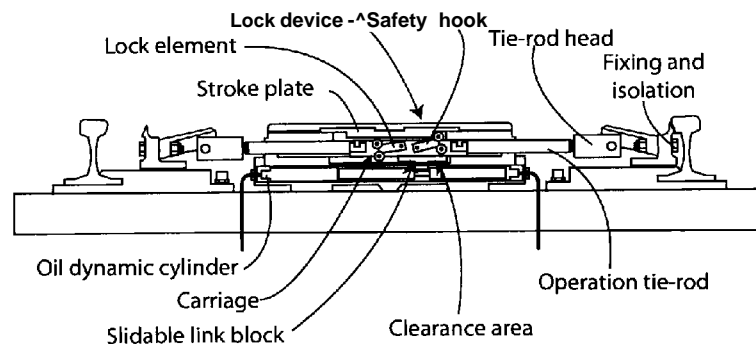
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(54) Title: METHOD FOR OPERATING RAILROAD SWITCHES, AND OIL HYDRAULIC CIRCUIT FOR REALISING THE METHOD



**Fig.4**

(57) Abstract: The present invention concerns a hydraulic circuit comprising a plurality of branches individually operated by a respective servo-valve, which allow the independent operation of as many rail actuators, the service pump being an only one for all the branches. The hydraulic circuit can be used according to the method of the invention to control any hydraulic actuator, and in particular conveniently in the railroad switches by varying pressure along time to avoid bending due to the interference of foreign body with the switch rails.



METHOD FOR OPERATING RAILROAD SWITCHES, AND OIL  
HYDRAULIC CIRCUIT FOR REALISING THE METHOD

5 The present invention concerns a method for operating railroad switches, and relevant hydraulic circuit for realizing the method.

10 More in detail, the present invention concerns a hydraulic circuit comprising a plurality of branches individually operated by a respective servo-valve, which allow the independent operation of as many rail actuators, the service pump being an only one for all the branches. The hydraulic circuit can be used according to the method of the invention to control any hydraulic actuator, and in particular conveniently in the railroad switches by varying pressure along time to avoid bending due to the interference of foreign body with the switch rails.

15 The present invention includes by reference the integral text of the Italian patent application N. RM2012A000002 filed on January 3, 2012.

20 A railroad switch is currently constituted as shown in figures 3 and 4. The switch rails of a switch (that together with the V of a crossing constitutes the railroad switch) is structured between two stock rails and is constituted by two switch rails operated by moving means installed between the two switch rails. The two switch rails are each termed alternately "close-by" and "far removed" rail if it is close to or fare removed from the relevant stock rail.

The moving means comprise:

- 25
- A carriage;
  - A slidable link block;
  - Two lock elements of the moving means or safety hooks;
  - Two simple-effect cylinders faced to each other.

Moreover the two switch rails are connected by connection tie-rods so as to increase the inertial momentum.

30 Making reference to figure 5, the operation of the switch rails is made in three steps (with "step 0" one indicates the inertial situation, with the right switch rail that is close-by and locked, before the moving to change the role of the switch rails):

- The first step comprises the internal displacement of the link block till the freeing of the lock element of the closed-by switch rail and the engaging of the far-removed switch rail;
- The second step comprises the continuation of the displacement of the slidable link block to the end of effecting the displacement of the switch rails; indeed, the second lock element is hinged on the carriage which, in turn, is integral to the tie-rods connected to the two switch rails;
- The third step comprises the push of the second lock element with the filling of the clearance of the second lock element (on the left) in such a way that this be blocked within its seat.

The current hydraulic control of the rail actuators has a problem when foreign bodies fall between switch and stock rails, in particular between the movement points of the moving means. Indeed, the switch rail in this case bends and, even though it succeeds to break up the foreign body, it does not pulverize it and therefore the switch rail cannot come correctly into contact with the stock rail. This creates a reduction of gauge (distance between the two points of rolling of the train wheels flanges) which, if it is smaller than 1426 mm, the train wheel raises and endangers the train itself.

Nowadays hydraulic circuits are used for the moving of the railroad switches, provided with a central unit represented by a diagram of the type of that of Fig. 1.

System 100 is constituted essentially by an engine 111 driving a pump 110 that provides the flow rate and the pressure needed to operate the switch by supplying some pistons 115 as in Fig. 2.

There are also a manual pump 107, a non-return valve 105, a pressure relief valve 106, a filter 112, a tank 113 and a level switch 114, the non-return valves 105,108,109, as well as the electro-valve 104 and the rapid connections 101.

The turning off of the engine is caused by the manostat 102 or 103 detecting the maximum pressure on the supplied branch. More in detail, the pump 110 begins to provide a pressure that is sufficient to operate the

two switch rails of the railroad switch. The switch rails are hence displaced and one of the two ones reaches the travel end on the relevant stock rail. At this point, the pressure raises necessarily owing to the impossibility of a further moving of the switch rail, and the transducer (manostat) 102 or 103  
5 detects a pressure beyond a maximum level (40 bar). As a consequence, the supply to the engine is cut off because the switch has been effected.

This system has the advantage of being simple but has limitations such as the impossibility to vary the flow rate on the single actuator (pistons 115), the maximum pressure during the operation travel and to  
10 have different pressure in the single actuators with progressing travel.

These limitations generate some problems: the constant flow rate impede the synchronous movement of the switch rails (mobile part of the railroad switch) and even the simultaneous unlocking of the lock elements relevant to the closed-by switch rail that is usually blocked by an extra-  
15 stroke of the piston, stroke that is not always equal in all the maneuver points. Moreover on switches with very flexible switch rails and with sliding difficulties for ice or misalignment of the sliding bearings, a pressure can be needed that is sufficiently large for the moving but is also enough low in the final part of the operation of the switch rail not to have deformations in  
20 case of stones that interposes between switch rail and stock rail, as above illustrated.

It is object of the present invention a method for controlling a railroad switch that solves the problems and overcomes the drawbacks of the prior art.

25 It is further specific subject-matter of the present invention a hydraulic and electro-dynamic circuit configured to realize the method subject-matter of the invention.

It is subject-matter of the present invention a method for controlling a railroad switch, the railroad switch comprising at least a switch rail, at  
30 least a relevant stock rail, a number  $N \geq 1$  of rail actuators, a central unit comprising a central oil pump (201), a pressure regulation circuit providing a flow rate of oil under pressure to  $N$  servo-valves respectively associated to said rail actuators, each rail actuator further comprising:

- a piston associated to said respective servo-valve;
- at least an operation tie-rod for the operation of said at least a switch rail in such a way that said at least a switch rail will position itself as close-by switch or far-removed switch from the respective at least a stock rail,
- a slidable link block driven by said piston,
- two lock elements each associated to one of the close-by or far removed positions of said at least a switch rail and hinged on an carriage integral to said at least a tie-rod, with two relevant seats wherein the two lock elements engage,

the method comprising the execution of the following sub-sequent steps for each rail actuator:

- A. displacing the slidable link block till the first encountered lock element, relevant to the switch rail that is currently close-by, and engaging in the relevant seat the second encountered lock element, relevant to the switch rail that is currently far-removed;
- B. continuing the displacement of slidable link block to realize the displacement of the at least a switch rail;
- C. continuing the displacement of slidable link block to lock the second lock element in an engaged position in said relevant seat;

the method being characterized in that the piston stroke of each rail actuator is constantly detected by means of a respective volume counter, and in that for each rail actuator:

- in step A and in a first portion of step B corresponding to first  $d \geq 0$  mm of travel of said at least a switch rail, providing to the piston, by the respective servo-valve, a pressure with a first value  $P^1$ ;
- in a second portion of step B, providing to the piston, by the respective servo-valve, a pressure with a second value  $P^2$ ;
- in a final portion of step B corresponding to the last  $d' > 0$  mm of travel of said at least a switch rail, and in step C, providing to the piston, by the respective servo-valve, a pressure with a third value  $P^3$ ;

wherein  $P^1 > P^2 \geq P^3$ , and  $P^1$ ,  $P^2$ ,  $P^3$  are values pre-determined for each rail

actuator in such a way to move said at least a switch rail along its length in a synchronous way.

Preferably according to the invention, when a rail actuator stops because of an obstacle without finishing the travel of the second portion of step B, said at least a switch rail is moved back reproducing steps B and C to displace the switch rail in the opposite direction, by the following steps:

- storing the stroke run by the piston till the stop of said rail actuator;
- providing to all the other rail actuators a flow rate  $Q$  that is specific to each rail actuator till a time instant when all the rail actuators reach the position of said a stopped rail actuator, and at this time instant:
- providing to all the rail actuators including said a stopped actuator a flow rate corresponding to the portion of step B or C wherein they find themselves and continue according to the subsequent portions of steps B and C complying with the relevant pressure requirements.

Flow-rates  $Q$  are for example determined by following diagrams indicating the flow rates for each step.

Preferably according to the invention,  $P^2 = P^3$  and  $d = 0$  i.e. said first portion of step B is a null portion, and wherein:

- said a railroad switch comprises two switch rails and two relevant stock rails;
- the lock elements are safety hooks.

Preferably according to the invention,  $d'$  and/or  $d$  are comprised between 5 and 10 mm, in particular around 5 mm.

Preferably according to the invention, in each step A, B, C said servo-valve provides respective flow-rate values  $Q_A$ ,  $Q_B$ ,  $Q_C$ , pre-determined for each rail actuator and such that  $Q_B \neq Q_A$  and  $Q_B \neq Q_C$ , in such a way that all the actuators realize each of steps A, B, C in a synchronous way.

It is possible to read the flow rates and decide whether they are correct or not and to regulate them accordingly. Therefore the values are pre-determined but they can also be verified.

It is further specific subject-matter of the present invention an oil hydraulic circuit for the control and monitoring of a number  $N \geq 1$  of rail actuators, within a railroad switch, each actuator comprising a piston, the oil hydraulic circuit comprising a central unit including :

- 5           - a pump connected to  $N$  respective servo-valves electrically connected to
- an electronic control unit;
- $N$  volumetric counters associated respectively to said  $N$  servo-valves, for the measurement of the volume and therefore the piston
- 10           stroke;

each servo-valve being associated to said piston within the respective rail actuator in such a way to be able to control it independently, the oil hydraulic circuit being characterized in that the electronic control unit is provided with means configured to realize the method according to

15           the invention.

              Preferably according to the invention, each servo-valve is hydraulically connected to a transducer for the detection of the hydraulic pressure on the piston within each rail actuator, said transducer being electrically connected to said electronic control unit, so as to control along

20           time the servo-valve as a function of the measurement of hydraulic pressure on the piston and the displacement of the same.

              Preferably according to the invention, the circuit further comprises an only transducer for the detection of the maximum hydraulic pressure, hydraulically connected to said  $N$  servo-valves and electrically connected

25           to said electronic control unit.

              Preferably according to the invention, the data detected by said  $N$  volume counters and said transducers for the detection of the hydraulic pressure are sent to a remote center to diagnosis ends.

              Preferably according to the invention, the data are further sent

30           which have been detected by said an only transducer for the detection of the maximum hydraulic pressure.

              The invention will be now described by way of illustration but not by way of limitation with particular reference to the figures of the annexed

drawings, wherein:

- Fig. 1 shows an electro-dynamic circuit according to the prior art;
- Fig. 2 shows pistons connected in series and supplied by the circuit of Fig. 1;
- 5 - Fig. 3 shows a railroad switch according to the known art;
- Fig. 4 shows the cross-section in detail of one of the railroad switch point of Fig. 3;
- Fig. 5 shows the steps of moving of the point lock system (operation box of a railroad actuator) of the railroad switch of Fig. 4 according to the known art;
- 10 - Fig. 6 shows the diagram of a preferred embodiment of the oil dynamic circuit according to the present invention;
- Fig. 7 shows the diagram of the progression of the maximum pressure, the current pressure and the flow rate (as a function of the piston stroke moving the carriage) in one of the railroad
- 15 actuators, according to the present invention.

Although the following description of the preferred embodiment refers to the railroad field, the circuit according to the invention can be used to control any hydraulic actuator with feedback, providing to the same a pressure variable with varying time.

Making reference to Fig. 6, the oil dynamic circuit 200 according to the invention is constituted by a common part and a plurality of branches at whose ends as many actuators (pistons) 211 are connected.

A pump motor 201 is present, which is operated by a PLC and sends oil to a plurality (in general an integer number  $N \geq 1$ ) of servo-valves 206 depending on the number of cylinders to be operated. These servo-valves, together with other components, constitute hydraulic-electronic equipments allowing to vary both the pressure and the flow rate by means of a software in the PLC managing the electronic card of the same servo-valve 206.

There are also the following components for each branch:

- A pressure filter 202,
- A maximum pressure valve 203,

- A manometer 204,
- A maximum pressure transducer 205,
- A volume counter 207,
- A sequence valve 208,
- 5 - A further pressure transducer 209,
- A check valve 210,
- A bypass 212,
- A manual diverter 213,
- A manual pump 214.

10 In other words, one can assign to each servo-valve 206 an initial pressure and flow rate value and effect the moving. One knows the stroke made by the pistons by reading the displacement volume (one can also make the movement more precise by comparison between pre-set flow rate and real flow rate and correct via software) and associate to particular

15 values of the stroke variations of flow rate and/or pressure. In such a way, one can unlock on each branch the lock elements at the same time by assigning different flow rates depending on the different strokes to be effected on the actuators, the vary again the speed to have a synchronous movement and still again vary the speed to have a simultaneous end

20 stroke.

In particular, to solve the problem of foreign bodies between switch and stroke rail, thanks to the circuit according to the invention, it is possible to provide a minimum pressure in the last link block push step (filling of clearance step), i.e. just sufficient to close by the switch rail and

25 displace the link block itself and not so high any longer to bend the switch rails (the circuit provides a pressure with a first value  $P_i$  in the first step whilst in a final portion of the second step and in the third step, corresponding to the last 5÷10 mm of travel of switch rails, the servo-valve sends to the slidable link block a pressure  $P_j$ ). In such a way, one does not

30 consent to the switch rail to bend because the applied force is minimal, and hence, in presence of an obstacle, the failed end-travel does not allow to the system to provide the electric position control and the train cannot run across the railroad switch.

To all this one can associate variations of maximum available pressure depending on the positions of the switch rail; for example high pressure at the time of the first detachment and lower pressure at the end of the maneuver to hinder the bending of the switch rail.

5           The foregoing is possible for each single servo-valve 206 independently from the other ones according to what is provided by the software. The PLC moreover controls the maximum available pressure, the strokes and the pressures (therefore the forces) during the moving on all the maneuver points and makes the data available for the transmission  
10 to a remote station for the diagnosis of the whole maneuver oil dynamic system (central unit plus rail actuators) and for example one can know if and which piston did not perform the desired stroke and whether a maneuver point undergone loads that are larger than usually. An analysis of the curves along time - force-stroke can be useful to monitor the  
15 functioning of a railroad switch, verify if there is a decay of some parameters and intervene before a failure appears.

The proposed system overcomes all the limits above-mentioned in the description of the prior art system. It is moreover possible to make the system SIL4 (safety integrity level 4) fulfill CENELEC regulation that is not  
20 yet at disposal in the current oil dynamic systems.

#### Description of the functioning

By making the pump 201 rotate by means of the relevant electric engine, one sends a oil flow towards the N servo-valves. On the outlet  
25 pipe a high-pressure filter 202 for the filtering of oil is mounted. The group has a maximum pressure valve 203 that will determine the maximum possible pressure in the plant, a pressure gauge 204 and a maximum pressure transducer 205 for the sending of data to the PLC. The central unit will have also all the alarm means for temperature and oil level in the  
30 tank that are not indicated in the diagram of Fig. 6.

The pumped oil reaches the servo-valve 206 which, in condition of rest, has the uses outletting with pipes maintained full of oil by means of the check valve 210. The PLC controls, beyond the engine, also the

position (left or right branch), pressure and flow rate of the servo-valve 206 as provided by the software. The volume counter 207 measures the volume (and therefore the displacement) of the piston and gives the feedback to the PLC that verifies if and when the flow rate or pressure, which is monitored by the transducer 209, is to be varied.

The PLC turns off the engine and carries back the servo-valves in the rest position when the assigned strokes are attained or, in case of maneuver not completed because of an obstacle, after a time pre-set by a timer that is not quoted by annex A.

The pistons 211 have a bypass system 212 for the washing, elimination of the air bubbles and the substitution of the oil. The system is completed by a emergency manual maneuver system that does not have all the above-described functional characteristics of the plant but allows the movement of the system. It is constituted by a manual pump 214, which, by means of a manual diverter 213 sends oil to the left or right branch of the piston. The sequence valves 208, when they detect the pressure generated by the manual maneuver, open the conduit and make the oil flow in the piston. For the time being, on this branch of the plant, a maximum pressure valve is not provided for (thug it is possible to provide it) because the force applicable by hand does not generate dangerous pressures and because of the impossibility of moving the lever of the pump gives the indication that the maneuver is completed as well.

In the foregoing, preferred embodiments have been illustrated but it is intended that those skilled in the art will make variation and changes without so departing from the scope of protection of the invention, as defined in the enclosed claims.

## RIVENDICAZIONI

1) Method for controlling a railroad switch, the railroad switch comprising at least a switch rail, at least a relevant stock rail, a number  $N \geq 1$  of rail actuators, a central unit comprising a central oil pump (201), a pressure regulation circuit providing a flow rate of oil under pressure to  $N$  servo-valves respectively associated to said rail actuators, each rail actuator further comprising:

- a piston associated to said respective servo-valve;
- at least an operation tie-rod for the operation of said at least a switch rail in such a way that said at least a switch rail will position itself as switch close-by or far-removed from the respective at least a stock rail,
- a slidable link block driven by said piston,
- two lock elements each associated to one of the close-by or far removed positions of said at least a switch rail and hinged on an carriage integral to said at least a tie-rod, with two relevant seats wherein the two lock elements engage,

the method comprising the execution of the following sub-subsequent steps for each rail actuator:

- A. displacing the slidable link block till the first encountered lock element, relevant to the switch rail that is currently close-by, and engaging in the relevant seat the second encountered lock element, relevant to the switch rail that is currently far-removed;
- B. continuing the displacement of slidable link block to realize the displacement of the at least a switch rail;
- C. continuing the displacement of slidable link block to lock the second lock element in an engaged position in said relevant seat;

the method being characterized in that the piston stroke of each rail actuator is constantly detected by means of a respective volume counter, and in that, for each rail actuator:

- in step A and in a first portion of step B corresponding to first  $d \geq 0$  mm of travel of said at least a switch rail, providing to the piston, by the respective servo-valve, a pressure with a first value  $P^1$ ;

- in a second portion of step B, providing to the piston, by the respective servo-valve, a pressure with a second value  $P^2$ ;
- in a final portion of step B corresponding to the last  $d' > 0$  mm of travel of said at least a switch rail, and in step C, providing to the piston, by the respective servo-valve, a pressure with a third value  $P^3$ ;

wherein  $P^1 > P^2 \geq P^3$ , and  $P^1$ ,  $P^2$ ,  $P^3$  are values pre-determined for each rail actuator in such a way to move said at least a switch rail along its length in a synchronous way.

2) Method according to claim 1, wherein, when one rail actuator stops because of an obstacle without finishing the travel of the second portion of step B, said at least a switch rail is moved back reproducing steps B and C to displace the switch rail in the opposite direction, by the following steps:

- storing the stroke run by the piston till the stop of said rail actuator;
- providing to all the other rail actuators a flow rate  $Q$  that is specific to each rail actuator till a time instant when all the rail actuators reach the position of said one stopped rail actuator, and at this time instant:
- providing to all the rail actuators including said a stopped actuator a flow rate corresponding to the portion of step B or C wherein they find themselves and continue according to the subsequent portions of steps B and C complying with the relevant pressure requirements.

3) Method according to claim 1 or 2, wherein  $P^2 = P^3$  and  $d = 0$  i.e. said first portion of step B is a null portion, and wherein:

- said a railroad switch comprises two switch rails and two relevant stock rails;
- the lock elements are safety hooks.

4) Method according to any claim 1 to 3, characterized in that  $d'$  and/or  $d$  are comprised between 5 and 10 mm, in particular around 5 mm.

5) Method according to any claim 1 to 4, characterized in that in

each step A, B, C said servo-valve provides respective flow-rate values  $Q_A$ ,  $Q_B$ ,  $Q_C$ , pre-determined for each rail actuator and such that  $Q_B \neq Q_A$  and  $Q_B \neq Q_C$ , in such a way that all the actuators realize each of steps A, B, C in a synchronous way.

5           6) Oil hydraulic circuit (200) for the control and monitoring of a number  $N \geq 1$  of rail actuators, within a railroad switch, each actuator comprising a piston (21 1), the oil hydraulic circuit comprising a central unit including :

- 10           - a pump (201) connected to  $N$  respective servo-valves (206) electrically connected to
- an electronic control unit;
- $N$  volumetric counters (207) associated respectively to said  $N$  servo-valves, for the measurement of the volume and therefore the piston stroke;

15           each servo-valve being associated to said piston (21 1) within the respective rail actuator in such a way to be able to control it independently, the oil hydraulic circuit being characterized in that the electronic control unit is provided with means configured to realize the method according to any claim 1 to 5.

20           7) Oil hydraulic circuit according to claim 6, characterized in that each servo-valve (206) is hydraulically connected to a transducer (209) for the detection of the hydraulic pressure on the piston within each rail actuator, said transducer being electrically connected to said electronic control unit, so as to control along time the servo-valve (206) as a function  
25           of the measurement of hydraulic pressure on the piston and the displacement of the same.

            8) Oil hydraulic circuit according to claim 6 to 7, characterized in that it further comprises an only transducer (205) for the detection of the maximum hydraulic pressure, hydraulically connected to said  $N$  servo-valves (206) and electrically connected to said electronic control unit.  
30

            9) Oil hydraulic circuit according to any claim 6 to 8, characterized in that the data detected by said  $N$  volume counters (207) and said transducers (209) for the detection of the hydraulic pressure are sent to a

remote center to diagnosis ends.

10) Oil hydraulic circuit according to claim 9, characterized in that the data are further sent which have been detected by said an only transducer (205) for the detection of the maximum hydraulic pressure.

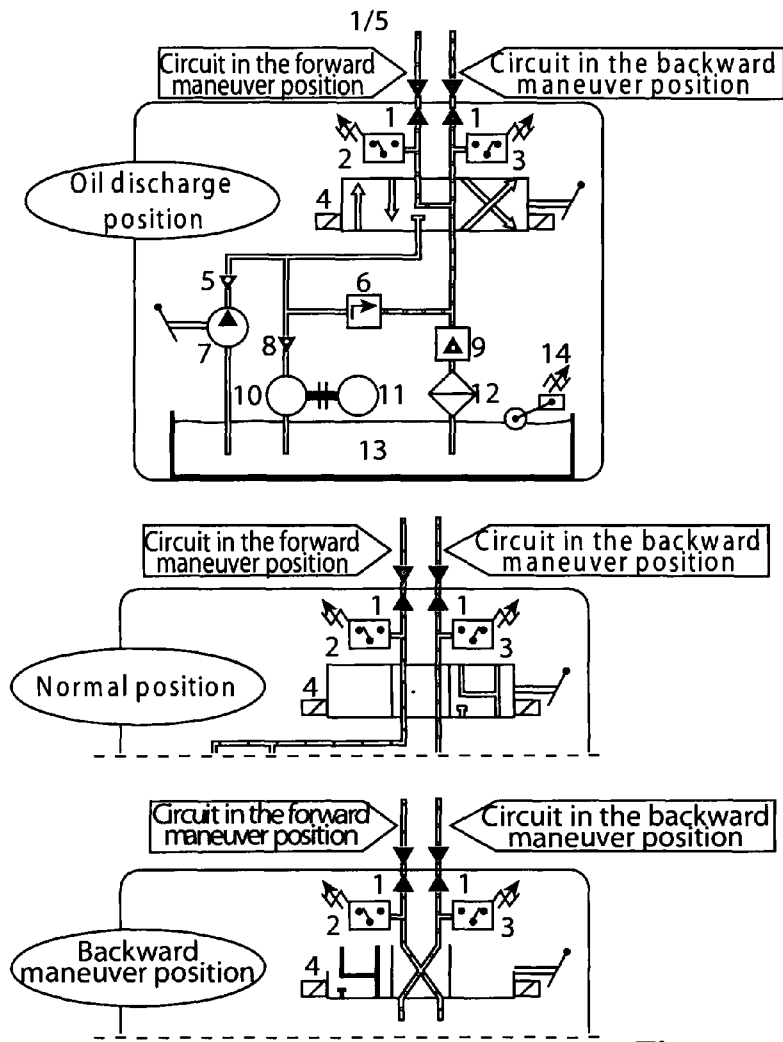


Fig. 1

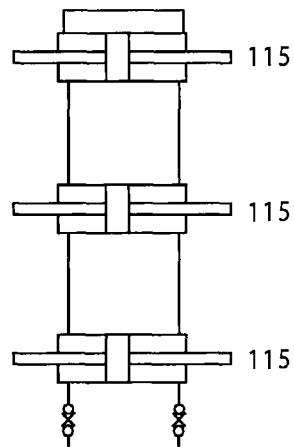


Fig. 2

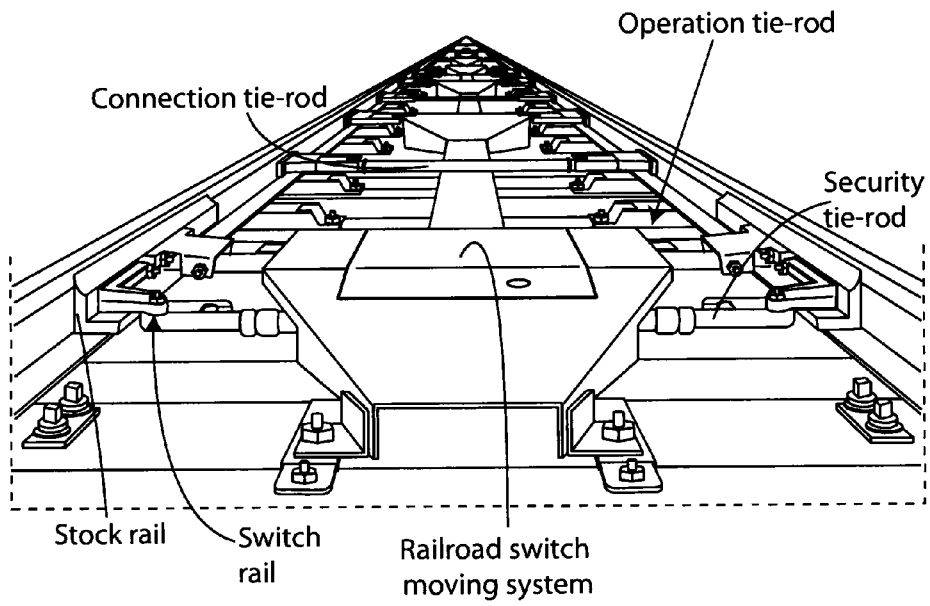


Fig. 3

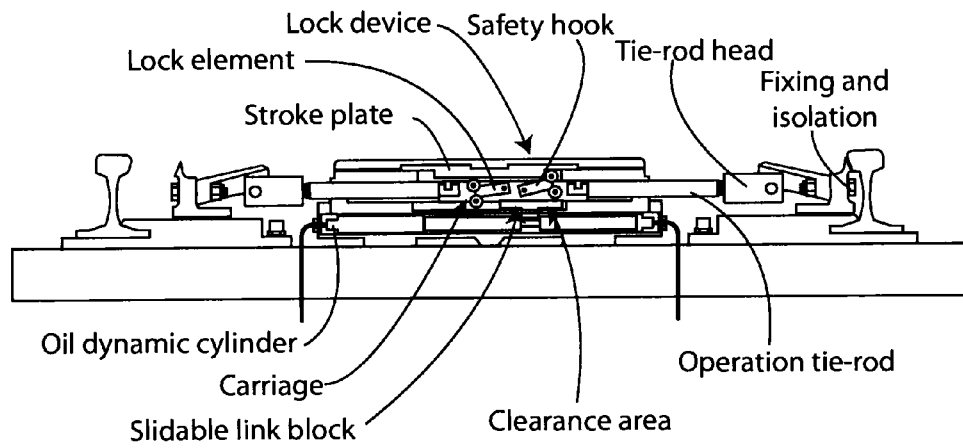


Fig. 4

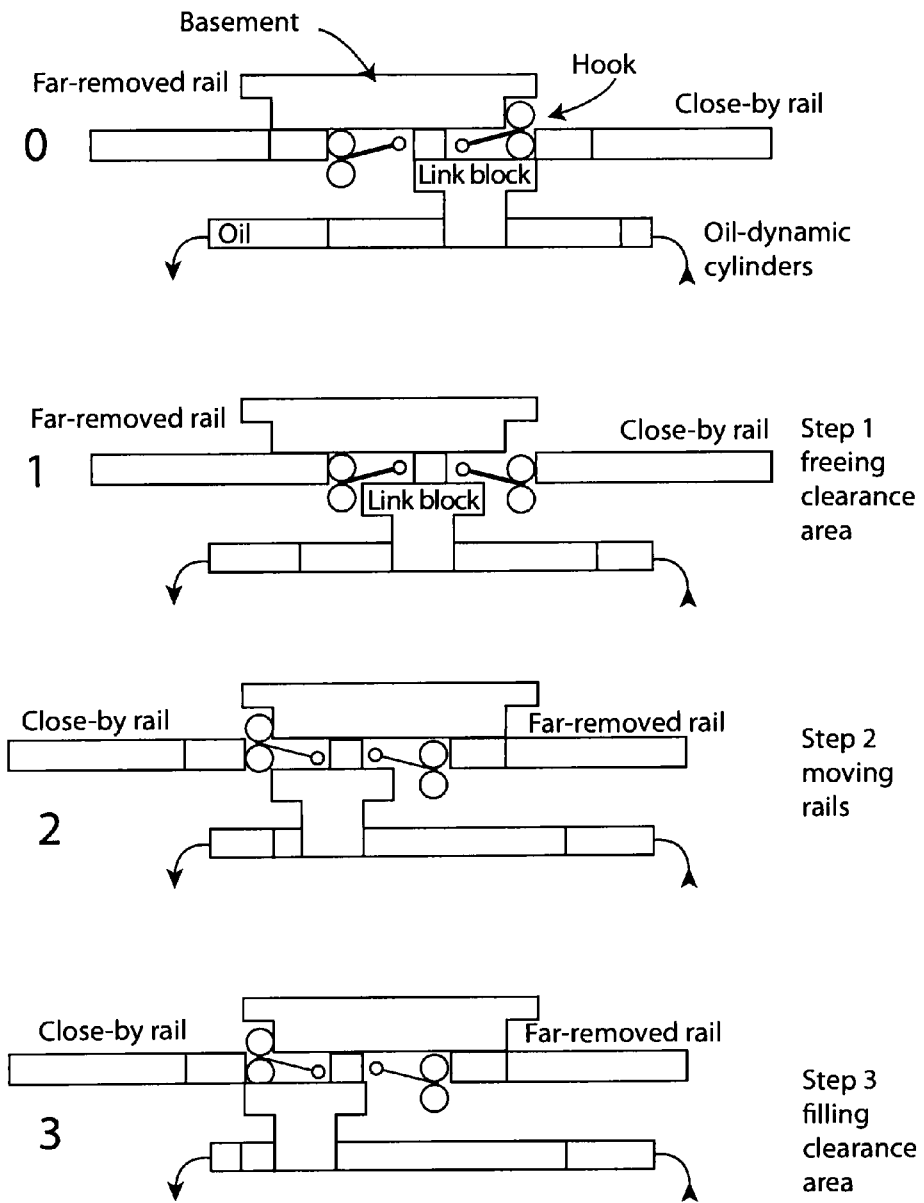


Fig. 5



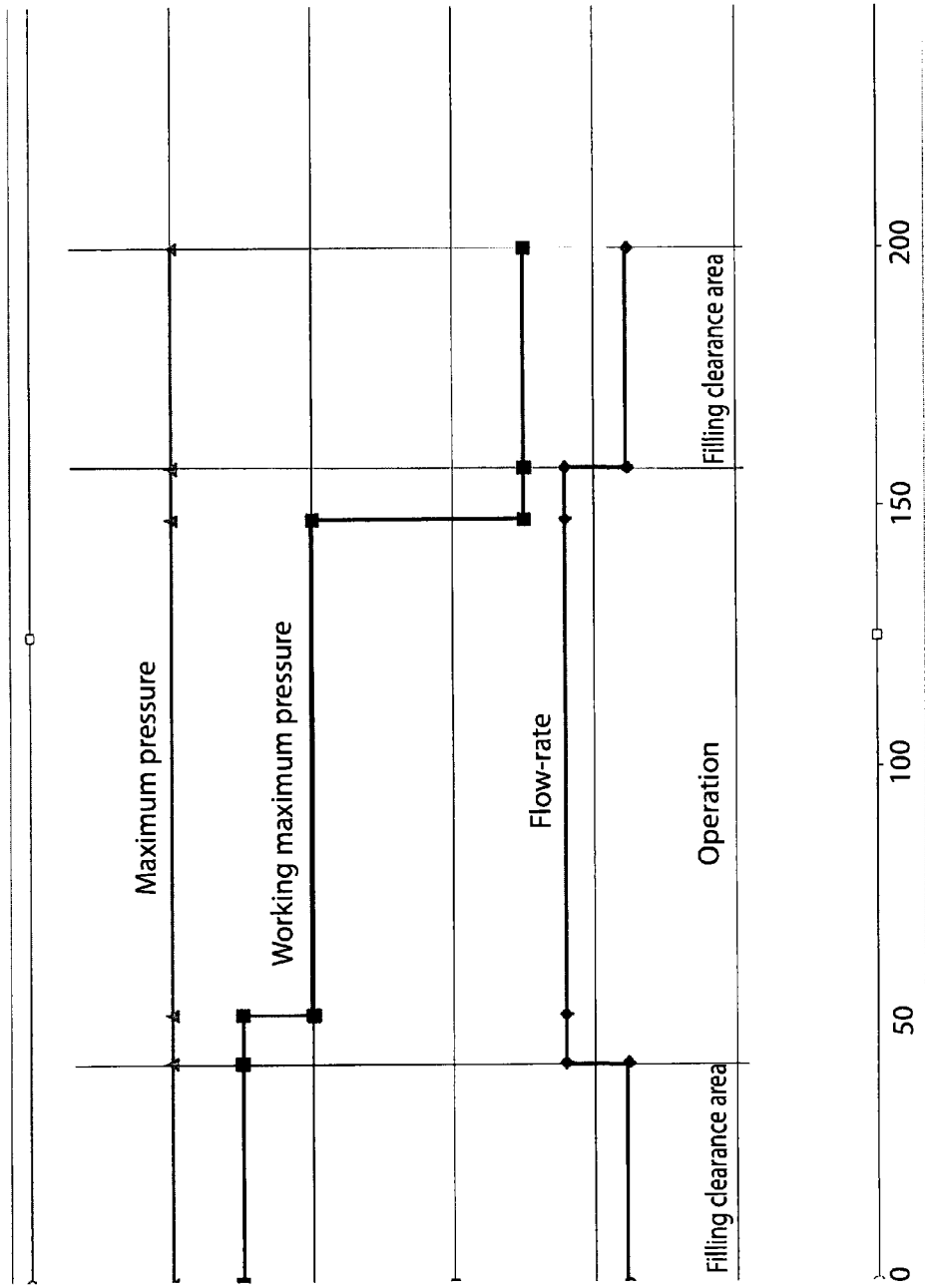


Fig. 7

# INTERNATIONAL SEARCH REPORT

International application No  
PCT/IT2013/00Q001

<b>A. CLASSIFICATION OF SUBJECT MATTER</b> INV. B61L5/04 ADD.		
According to International Patent Classification (IPC) or to both national classification and IPC		
<b>B. FIELDS SEARCHED</b>		
Minimum documentation searched (classification system followed by classification symbols) B61L		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched		
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) EPO-Internal		
<b>C. DOCUMENTS CONSIDERED TO BE RELEVANT</b>		
<b>Category*</b>	<b>Citation of document, with indication, where appropriate, of the relevant passages</b>	<b>Relevant to claim No.</b>
Y	wo 2011/127875 A2 (DT VYHYBKARNA A STROJLRNA A S [CZ] ; NAVRATIL DUSAN [CZ] ; PUDA BOHUSLAV) 20 October 2011 (2011-10-20)	1,3,6
A	page 4, last paragraph - page 6, last paragraph figures 1,3	2,4,5 , 7-10
Y	----- EP 2 192 020 AI (ALSTOM TRANSPORT SA [FR] ) 2 June 2010 (2010-06-02) paragraph [0051] - paragraph [0056] ; figure 2 -----	1,3,6
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# INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/IT2013/00Q001

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