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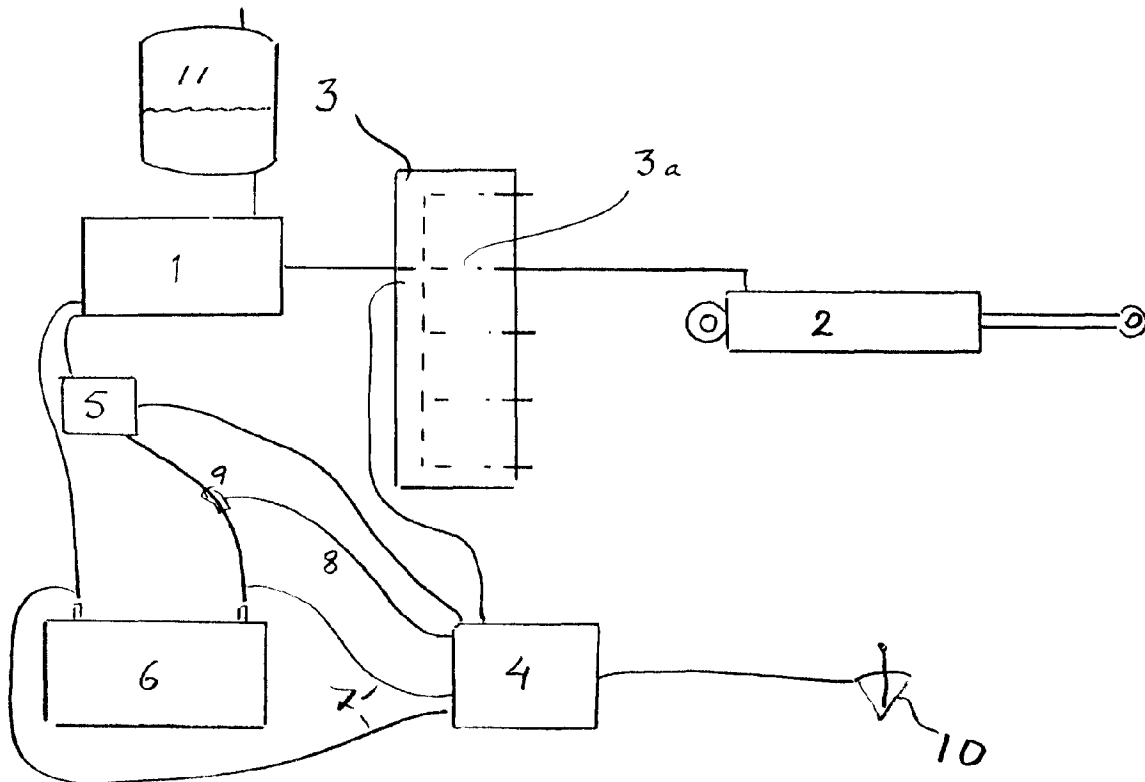
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(54) Arrangement at fork-lift trucks

(57) At motor driven trucks where the load forks may reach forwards in relation to the truck this is done by means of a hydraulic cylinder (2). The volume of hydraulic oil fed to this cylinder is measured (7) via the voltage of an electric motor driving the hydraulic pump (1), the motor may in particular be a DC motor. By then integrat-

ing the voltage over the time a measure is obtained corresponding to the oil volume delivered to or drawn from the cylinder and corresponds in turn to the piston position. The position measurement is then used for speed ramping at the end of stroke of the piston so that shock free movement stops can be obtained.



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## Description

At motor driven trucks of the kind where the forks or a lifting arm can be extended or reach out in relation to the truck this is today generally achieved by means of a hydraulic cylinder. In order to prevent the piston in this cylinder from hitting the end positions with full force and consequent shocks for the driver, the truck, and the load it is known to use special cylinders in which the flow is restricted when the piston comes close to its end positions, alternatively position sensors may initiate restriction of the hydraulic flow to the cylinder when the piston comes close to the intended end position, so called speed ramping.

These solutions are however comparatively expensive in particular in view of every type of truck requiring particular means and for each length of stroke the hydraulic cylinder or the position sensing must be arranged more or less individually. Since the forks work close to the ground and large forces are frequent there is a great risk that the sensor device is damaged, this in particular since the space for the position sensor, and possible protections for this, is very limited.

In view of the above problems the invention has as its object to provide a method and a device for the control of hydraulically propelled movements, in particular the extending forward of the forks at reach trucks enabling this movement to be slowed down close to the end positions of the movement in order to prevent shocks.

In accordance with the invention this object is solved by measuring or calculating the flow of hydraulic oil to the hydraulic means, for instance a piston, executing the movement and using the flow as a measure of the movement. Since the cross section of the hydraulic cylinder is constant the length of the stroke is proportional to the volume of hydraulic oil fed to the cylinder and a sufficiently exact indication of the position can be obtained in this simple manner. Even if a nonlinear transmission used, as for instance a pantograph mechanism, a distinct movement or stroke will be repeatable, each position corresponding to a precise volume of oil having been fed to the cylinder.

The volume of the hydraulic oil that has been fed to the cylinder can for instance be measured with a sensor that registers the number of revolutions that the driving pump execute. This solution also requires the use of a sensor, but this can be placed in shielded places with a reduced risk for damages and drive disturbances.

In preferable further developments of the invention also the arranging of a specific sensor can be avoided.

Since in most cases trucks of this kind includes a hydraulic pump driven by an electric motor, the pump being common to all actuation devices using hydraulic oil as a drive medium, the voltage of the electric motor driving the hydraulic pump can be used as a parameter for the calculation, this in particular for DC-motors. At a DC-motor the voltage (at the poles of the engine) essentially corresponds to the RPM of the motor. By inte-

grating the voltage over the time a measure is obtained corresponding to the oil volume delivered to/or removed from the cylinder, which in turn corresponds to the position of the piston. Oil temperature and the size of the load may influence the measured results, but by using the amperometric value of the current to the motor as additional measuring or control parameter the precision can be improved further when establishing (calculating) the position of the hydraulic piston. The position measuring can then be used for instance for speed reduction (ramping) at the ends of the working stroke of the piston in its respective directions.

At the use of principally synchronously working AC-motors instead the number of revolution (or parts thereof) of the motor can be obtained directly from the electronic circuit controlling the magnetic field of the motor.

The invention does not only provide the possibility of slowing down and stopping a piston at suitable end positions with a constant speed between these, but it is also possible with a more or less harmonic movement with a fast intermediate movement zone and a successively reduced speed towards the end positions. In this way no shocks are obtained in the end positions and furthermore the fork movement can be executed faster and with a reduced risk of tilting or instability.

In a further development of the invention the control device of the movement may also include a selflearning function. This may for instance be done in such a way that when the truck is started the piston movement is executed a first time with a very early cautious ramping stored in a memory. The control device then registers the mechanically fixed end positions for instance by monitoring the current to the hydraulic pump motor. As the piston reaches its respective end positions the amperometric value of the current will rise immediately and much. Also this indication can be obtained without special and cost demanding parts. In the control device, that may for instance include a small computer this notes in a suitable memory the oil volumes corresponding to the end positions of the movement back and forth. At repeated use the movement speed is reduced shortly before the reaching of these mechanical end positions. Alternatively a harmonic movement speed profile is adapted to the intended end positions that are located slightly within the mechanical end positions. Preferably an accumulated memory is arranged for the movements, that is the number of engine revolutions or the integral of the voltage so that the position will always be registered even if the movements are interrupted and resumed many times or even executed in alternating directions without reaching the ultimate end positions.

Preferably the control device is configured for continuous monitoring so that if, for instance due to changing drive conditions (for instance between hot or cold hydraulic oil) the pistons strikes an end position with too high speed the computer enters a corresponding correction of the control parameter for the next movement. This strike or contact will however normally take place

with a reduced speed since the movement in the proximity of the end positions is slowing down and the pre-programmed ramp distance is large.

Since the number of occasions with hard strikes of different parts against each other is reduced the used components will have a reduced wear with a correspondingly prolonged time of life. The driver will have a more shock-free, more silent and thus improved environment that makes him or her less tired than otherwise.

Since the end stop contact shocks further corresponds to a power loss the invention also improves the possible time of use between recharging.

The invention is in particular intended for the horizontal fork extending movement of a reach truck, but within the inventive thought even other pistons or even hydraulic motors may be controlled in this way to execute or simplify the execution of a particular movement in one or the other direction before a retarding or stopping is initiated by a control device and one can also consider monitoring the positions of several hydraulic means in the same machine and the controlling of their movements in this way and with common electronic devices based on a common oil pump that is driven by an electric motor.

Within the inventive thought presumably also stepped or divided hydraulic cylinders may be controlled, by monitoring the current and the voltage values of the motor that drives the hydraulic devices so that the computer via the amperometric value of the current can keep track of the actual piston area that at each specific movement takes part in the movement.

The electronic control of the piston movement may either take place by influencing the driving of the electric motor and/or by controlling electrically controlled valves. By the use of the electrical valves it is possible to register where to the oil is delivered without additional sensors, and a computer can keep track of the piston position for one or several hydraulic cylinders even if the piston movements only are partial.

Within the inventive thought not only the fork extension or reach may be supervised and controlled but also lifting, side-shift, mast tilting and even the driving of the truck may be controlled. The obtained position information may then not only be used for speed ramping for different movements but also for position control, and a reduction of permitted driving speed when the forks are high up and the truck therefore is less stable.

By the possibility to measure and control the position as well as executed hydraulic forces as a function of a movement position it will even be possible to increase the actual speed with which the work can be carried out.

Further advantages and characteristics of the invention are apparent from the following description of a preferred embodiment shown in the enclosed drawing.

The principal configuration of a piston control shown in the drawing includes a hydraulic pump 1 connected to a hydraulic cylinder 2 via a valve 3a in an elec-

tric valve unit 3 which is controlled by a computer 4 and a reservoir 11. The hydraulic pump 1 is driven by an integrated electrical DC-motor that in turn via electronically controlled speed regulation 5 is connected to a battery 6 and the computer 4. At the connections of the engine the drive voltage is monitored via a connection 7 and via a connection 8 also an amperometric drive current sensor 9 is connected to the computer.

When the hydraulic cylinder 2 is to be activated the driver at the truck indicates this by means of an actuator 10, the computer registers this, starts the motor and opens the valve 3a. The motor is preferably started successively and increasingly independently of how the driver has influenced the actuator 10, alternatively one can consider that the deflection of the actuator 10 controls how fast the total movement is to be executed and thereby in the initial part of the movement how steep the end position ramp should be.

Simultaneously with the starting of the movement, the computer starts integrating the engine voltage over the time in order to monitor the position of the piston in accordance with the preceding description of the invention.

As the piston is coming close to its end position the computer controls the motor during a speed reduction ramping so that it runs slower and slower to the stop of the piston and a closing of the valve 3a. This end position does not have to be the mechanical end position of the piston as such. The computer may also note possible obstructions by the corresponding increase of the current for instance if the load when placed on a shelf is hindered by another load and the computer may be programmed to interrupt the movement in such a case. The computer may even by monitoring the amperometric value of the current register if the fork is unloaded and thus can be moved faster.

When using a synchronously or non-synchronously working AC-motors the control may be executed in analogy with the above example, but with the difference that the controlling electronics for the motor delivers the information regarding the rotation of the motor directly since the information for the rotation of the field in the motor is directly accessible in the control electronic of the motor.

The invention can also be used for the fork lifting, this in particular when using AC-motors or a separate tachometer or angle sensor for the oil pump. By the use of electronic valves it is possible to register the amount of oil that flows back from a hydraulic piston by letting this flow pass through the oil pump. The oil pump with its motor may at such a return flow be driven as a motor in order to increase the speed in the movement or as a generator driven by the oil flow from the lifting cylinders in order to deliver a charging current to the batteries of the truck. This return oil may simultaneously be delivered to some other user, making it possible simultaneously to keep track of two movements, for instance a lowering of the forks and the retraction of the forks. The

driving speed may be restricted until the forks and the load have been lowered to a lower level with an increased total stability.

It may at a first glance be considered as a restriction that most two movements can be monitored simultaneously. In reality however several simultaneous movements are not necessary and since for economic reasons available power is restricted no time is actually gained in trying to execute several movements simultaneously, in particular since it is more tiring for the driver to keep track of several things at the same time it will probably take more time if one tries to execute several movements at one time. If however special needs should exist for this, one can consider to arrange particular volume feed sensors in the connections to cylinders and hydraulic motors.

Since the invention works just as well at hydraulic motors as at cylinders it may be used with the same good results at different types of trucks were turning, reach movements and possibly even lifting movements are transferred by means of motors, pinions, racks, wires, chains or screws in combination.

Essentially the invention gives a simple and practical way to monitor and control all the movements of the truck including steering movements so that a smooth, harmonic, fast and easily controlled manner of working with increased security can be obtained.

If the movement is controlled to stop before reaching the ultimate mechanical end stop of the movement, for instance when a pistons comes in contact with the cylinder end wall, the computer may at intervals run a reset program, with extended travel until contact is registered, to secure that movement does not stop too far away from the end position. Alternatively the driver may have the possibility to overrule or initiate a resetting of the monitoring and control system.

The method in accordance with the invention is initially intended for the reach movement which is repeated essentially in its entire length most of the time, however the obtained data may also, for instance for the lift movement be used to control the reaching of intermediate positions as for instance different storage levels.

## Claims

1. Method for position monitoring and control of hydraulic means, particularly the hydraulic cylinder for a reach movement of the forks of a truck, **characterized in** that the position or stroke of a movement is calculated by measuring the amount the hydraulic oil fed to or tapped from the hydraulic means in question, the position measuring being used for the reduction of the speed of the movement, speed ramping, in the vicinity of the end positions of the movement.

2. Method according to claim 1, **characterized in** that

the speed of the pump is calculated as a function of the feed voltage to an electric series motor driving the hydraulic pump.

3. Method according to claim 1, **characterized in** that the feed of the pump is calculated from the rotational angle of the field of a synchronous motor.

4. Method according to any of the previous claims, **characterized in** that the mechanical stop or end positions of the hydraulic means are registered and stored by monitoring the amperometric value of the current to an electric motor driving the hydraulic pump, which current will rise abruptly when this end position is achieved, the amperometrically registered end stops of the movement are then used at subsequent movements to initiate appropriate ramping to avoid abrupt shocks on contact in the end positions.

5. Method according to claim 4, **characterized in** the use of an initially set ramping sequence securing that the movement the first time it is carried out is slow well before the reaching of the end stops so that shocks are avoided also this first time.

6. Method according to any of the preceding claims, **characterized in** the movement normally being stopped before reaching the mechanically defined end stops.

7. Device for the execution of the method according to claim 1, **characterized in** that it includes a control device in the form of a computer and a measuring device in form of voltage sensor that registers the motor voltage of the motor propelling the movement.

8. Device according to claim 6, **characterized in** that it includes an amperometric current sensor for the current to the motor for the detection of mechanical end positions or mechanical stops or obstructions for the movement.

