

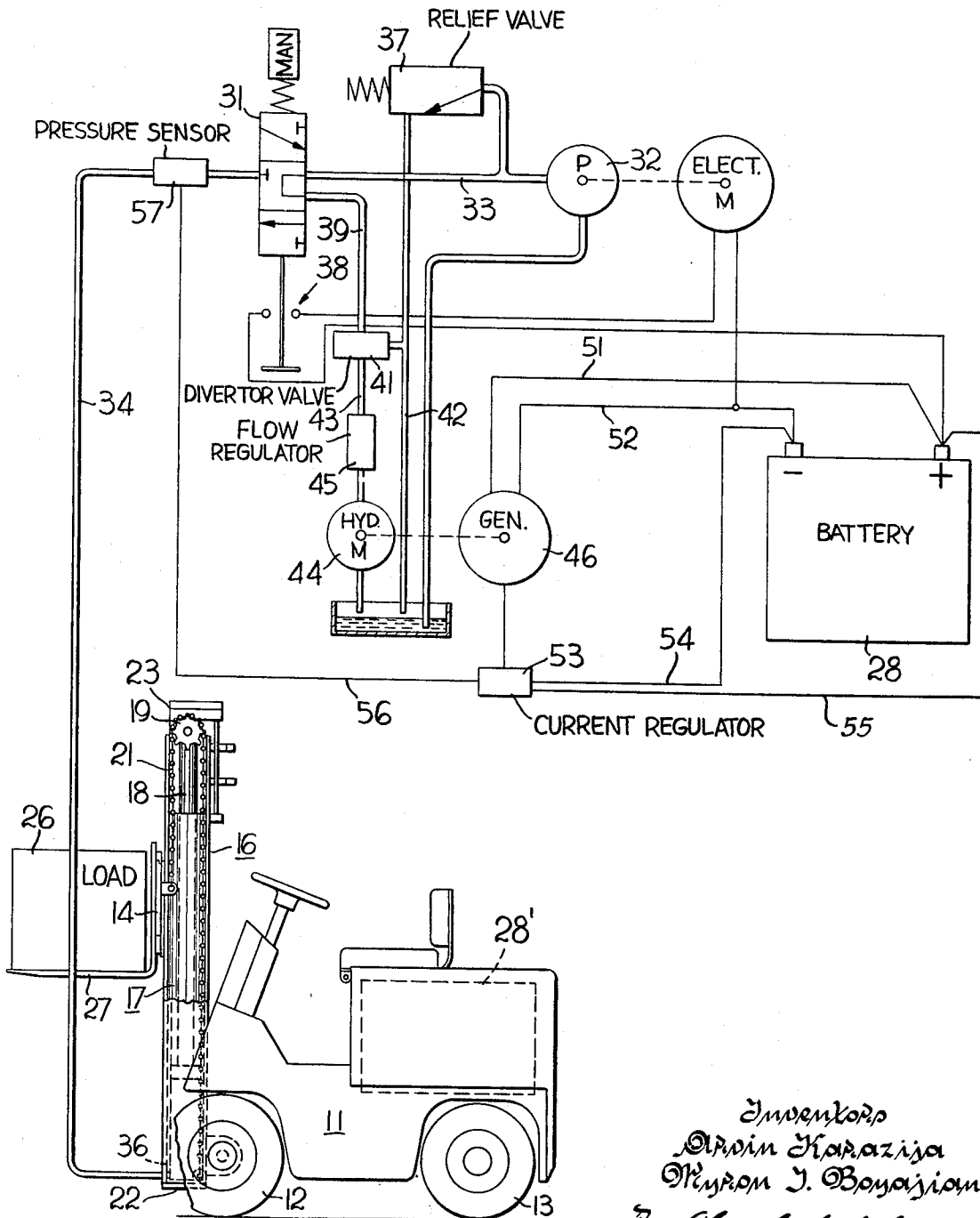
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A. KARAZIJA ET AL

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ELEVATED LOAD POTENTIAL ENERGY RECOVERY IN AN ELECTRIC TRUCK

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Inventors  
Ardin Karazija  
Myron J. Boyajian  
By Charles L. Schuch  
Attorney

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**ELEVATED LOAD POTENTIAL ENERGY RECOVERY IN AN ELECTRIC TRUCK**

Arvin Karazija, Oak Forest, and Myron J. Boyajian, Chicago, Ill., assignors to Allis-Chalmers Manufacturing Company, Milwaukee, Wis.

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4 Claims

**ABSTRACT OF THE DISCLOSURE**

The potential energy of an elevated load in an electric lift truck is converted into battery charging current during lowering of the load. When the pressure in the return to reservoir circuit of the hydraulic lift cylinder control is sufficiently great, the fluid is diverted to a hydraulic motor, via a flow regulator, which drives a generator to produce a battery charging current. The current output of the generator is regulated in accordance with the battery potential and the hydraulic pressure of the lift cylinder.

This invention relates to means for converting the potential energy of an elevated load into useful energy and relates more particularly to converting the potential energy of an elevated load of an electric lift truck into battery charging current.

In electric lift truck design and operation, it is essential to conserve power to achieve economic lift truck use. By this invention the useful work time of a battery is extended by converting the energy of loads stored at elevated heights into battery charging current.

It is an object of this invention to provide energy recovery means to extend the work hours per battery charge of an electric lift truck.

It is a further object of this invention to convert the potential energy of elevated loads to battery charging current during load lowering operations.

It is a further object of this invention to provide means for carrying out the foregoing objectives wherein automatic controls are provided to regulate generator output in accordance with the fluid pressure in the lift cylinder and the battery potential.

It is a further object of this invention to provide the heretofore outlined potential energy conversion system wherein exhaust flow from the lift cylinder is diverted to a pump for driving an electric generator only when the pressure of the exhaust fluid exceeds a predetermined value.

These and other objects and advantages of this invention will be apparent to those familiar with the art upon reading the following description in conjunction with the drawing which shows the invention incorporated in an electric lift truck, with some parts shown schematically.

Referring to the drawing, the present invention is shown incorporated in an electric lift truck 11 having a pair of drive wheels 12 and a pair of steerable wheels 13, only one of each of which is shown. A load carriage 14 is raised and lowered on the mast 16 by a lift ram 17. The rod component 18 of ram 17 carries a suitable sprocket 19 at its upper end over which a lift chain 21 is trained. One end of the lift chain 21 is connected to the carriage 14 and its other end is connected to the stationary section 22 of the mast 16. The carriage is reciprocally mounted on the inner section 23 of the mast, the latter being picked up by the rod component 18 of the lift ram upon its movement upwardly a predetermined distance. The load 26 carried by the forks 27 on carriage 14 represents potential energy which may be converted into electric current to charge battery 28 as hereinafter

described. The installed position of the electric battery 28 is shown by broken lines 28'.

When it is desired to raise the carriage 14, the manual control valve 31 is shifted upwardly to its "raise" position in which the output of the hydraulic pump 32 is delivered to the lift ram 16 via a pump output conduit 33 interconnecting the pump 32 and valve 31 and via a ram supply conduit 34 interconnecting valve 31 and the bottom end of the cylinder component 36 of ram 17. A conventional relief valve 37 is provided to protect the hydraulic components against excessive pressure during lift operations, as for instance when the piston 18 reaches the end of its stroke during expansion of the lift ram.

Preferably, the electric motor driving pump 32 is energized only when the valve 31 is moved to its raise position. This is achieved by providing a valve operated switch 38 which is closed upon the valve being moved to its raise position.

A warehouse full of stacked goods represented considerable potential energy due to its elevated position. Such potential energy is converted into electric current to charge the battery 28 in the following manner. After engaging a load and moving away from the stack the operator will move the control valve 31 downwardly from its illustrated "neutral" position to its "lower" position in which the ram supply conduit 34 is connected to exhaust conduit 39. Thus the weight of the load 26 will force fluid to flow from the ram 17 to flow diverter valve 41. When the pressure fluid in conduit 39 is below a predetermined pressure the diverter valve 41 connects exhaust conduit 39 to a return to reservoir conduit 42 and when the pressure is above such predetermined pressure the diverter valve 41 will automatically connect conduit 39 to a hydraulic motor supply conduit 43. This insures that sufficient power is available to properly operate the hydraulic motor 44 and electric generator 46 connected therewith. The diverter valve 41 thus operates as a generator control means placing the generator 46 in operation only when the exhaust fluid pressure is above a predetermined value.

In order to insure proper speed of operation of hydraulic motor 44 and generator 46, a flow regulator 45 is inserted in hose 43 between diverter valve 41 and the motor 44. The flow regulator 45 not only insures a relatively uniform speed of operation of hydraulic motor 44 and generator 46, but also effects a desirable, uniform load lowering speed.

The generator 46 is connected in charging relation to the battery 28 by leads 51, 52 and its current output is regulated by generator regulating means in the form of a current regulator 53 which regulates generator output in proportion to battery potential and lift ram pressure. Battery potential is sensed by regulator 53 through leads 54, 55 and fluid pressure in ram 17 is sensed through lead 56 connected to a pressure sensor 57 which acts as a transducer to convert fluid pressure into a proportional electric signal. The current regulator 53 is operative to cause the generator to charge the battery 28 at a rate proportional to the magnitude of the raised load and the battery charge condition, that is, its electric potential.

Although only one embodiment of this invention is illustrated and described other embodiments and variations within the scope of the claims will be apparent to those familiar with the art.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. In an electric lift truck having an electric battery supplying power to a first electric motor driving a first hydraulic motor supplying pressure fluid to a lift ram, a control valve controlling the flow of fluid to the lift ram from said first motor and the exhaust of fluid from the

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lift ram to a reservoir by way of a fluid exhaust conduit, an energy recovery system comprising:

means for converting the energy of fluid exhausted from said ram, when said load elevating means is lowering a load, into battery charging current including

a second hydraulic motor connected to said exhaust conduit,

an electric generator connected in driven relation to said second motor and in electric charging relation to said battery and hydraulic pressure responsive generator control means for effecting operation of said generator only when the exhaust fluid pressure is above a predetermined minimum.

2. The invention of claim 1 wherein said generator control means includes a diverter valve connected to said exhaust conduit and operative during load lowering operations to direct exhaust fluid from said ram to said reservoir when the pressure of said exhaust fluid is below a predetermined value and operative to connect said exhaust conduit to said hydraulic motor when the pressure of said exhaust fluid is above said predetermined pressure.

3. In an electric lift truck having an electric battery and hydraulically powered load elevating means including a lift ram, a control valve controlling the flow of fluid to the lift ram from a source of pressure fluid and the exhaust of fluid from the lift ram to a reservoir by way of a fluid exhaust conduit, an energy recovery system comprising:

means for converting the energy of fluid exhausted

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from said ram, when said load elevating means is lowering a load, into battery charging current including

a hydraulic motor connected to said exhaust conduit, an electric generator connected in driven relation to said motor and in electric charging relation to said battery and

generator regulating means including a current regulator connected to said generator and operative to regulate generator output in response to the electric potential of said battery and the pressure of fluid in said lift ram.

4. The invention of claim 3 further comprising a diverter valve connected to said exhaust conduit and operative during exhaust of fluid from said lift ram to connect said exhaust conduit to said reservoir when the fluid pressure therein is below a predetermined value and operative to connect said exhaust conduit to said hydraulic motor when the fluid pressure in said exhaust conduit is above said predetermined value.

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J. D. MILLER, Primary Examiner

JOHN M. GUNTHER, Assistant Examiner

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