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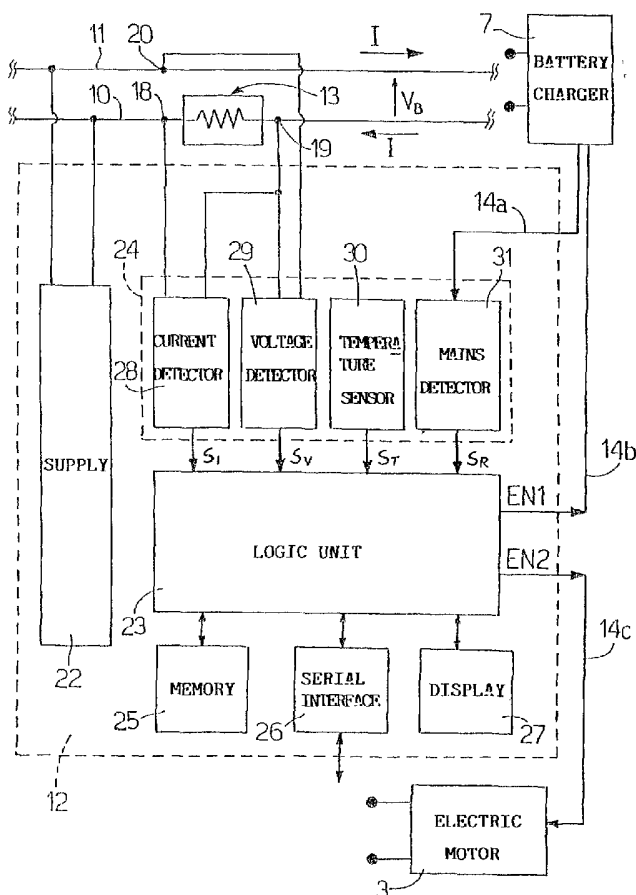
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[Continued on next page]

(54) Title: CONNECTING DEVICE FOR AN ELECTRIC WORK VEHICLE



(57) Abstract: A connecting device for an electric work vehicle, having a supporting body (8) made of insulating material and housing at least a first and a second supply cable (10, 11) connectable to a battery (5) and selectively connectable to a battery charger (7) and to at least one user device (3). The connecting device also has an electronic control circuit (12) connected to the first and second supply cable (10, 11); and a current transducer (13) for detecting a current flowing in the first and second supply cable (10, 11).



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CONNECTING DEVICE FOR AN ELECTRIC WORK VEHICLE

TECHNICAL FIELD

10 The present invention relates to a connecting device for an electric work vehicle.

BACKGROUND ART

As is known, numerous mechanical devices, such as fork-lift trucks or conveyors, are powered by electric
15 motors, which must supply high power levels, e.g. in the region of tens of kilowatts. Such devices must obviously be equipped with a battery (drive battery) connectable selectively to the electric motor and any other user devices during normal operation, and to a battery charger
20 for routine charging; which connection is made using special connectors capable of withstanding extremely high current (of over 300 A).

Operation and particularly charging of the battery are monitored by electronic control circuits, which are
25 normally included in the battery charger, and which, in particular, measure the battery voltage and various other operating parameters, such as temperature, and interrupt charging when the battery voltage reaches a predetermined

threshold.

Since the battery voltage, however, is also affected by external environmental factors and by ageing of the battery components, such a method fails to provide for
5 accurately controlling the actual charge of the battery, or for monitoring discharge of the battery during normal operation, i.e. when the battery is connected to the user devices as opposed to the charger.

In either case, the actual charge may be much lower
10 than estimated on the basis of the battery voltage.

This clearly constitutes a serious drawback, by the autonomy of a user device powered by an undercharged battery being less than predicted.

DISCLOSURE OF INVENTION

15 It is an object of the present invention to provide a connecting device and a method of controlling a supply system of an electric work vehicle, designed to eliminate the aforementioned drawbacks.

According to the present invention, there is
20 provided a connecting device comprising a supporting body housing at least a first and a second supply cable connectable to a battery; said first and second supply cable also being selectively connectable to a battery charger and to at least one user device; characterized by
25 comprising an electronic control circuit connected to said first and second supply cable; and current transducer means for detecting a current flowing in said first and second supply cable.

Said electronic control circuit is housed in a seat on said supporting body.

The connecting device so formed advantageously provides for measuring current flow in the supply cables both when charging and during normal operation (discharging) of the battery, so that the overall charge of the battery can be determined accurately instant by instant. For which purpose, in particular, the electronic control circuit is used.

Moreover, the connecting device is cheap and easy to produce, is compact, and can be installed extremely easily.

According to the present invention, there is also provided a method of controlling a system for supplying an electric work vehicle, and comprising an electric motor, a battery, a battery charger, and electromechanical operating members;

the method comprising the steps of charging said battery and discharging said battery;

and the method being characterized in that said steps of charging and discharging comprise:

- connecting said battery to said battery charger and, respectively, to said electric motor by means of a first and a second supply cable;

- measuring a current flowing in said first and second supply cable; and

- determining an available charge of said battery on the basis of said current.

BRIEF DESCRIPTION OF THE DRAWINGS

A non-limiting embodiment of the invention will be described by way of example with reference to the accompanying drawings, in which:

5 Figure 1 shows a simplified view in perspective of a fork-lift truck powered by an electric motor;

Figure 2 shows a simplified block diagram of a system for supplying and recharging the Figure 1 fork-lift truck;

10 Figure 3 shows a cross section of a connecting device in accordance with the present invention;

Figure 4 shows a top plan view, with parts removed for clarity, of the Figure 3 connecting device;

Figure 5 shows a block diagram of part of the Figure
15 3 connecting device;

Figures 6 and 7 show flow charts of procedures implemented by the Figure 3 connecting device.

BEST MODE FOR CARRYING OUT THE INVENTION

The present invention may be applied to advantage,
20 for example, to a fork-lift truck powered by an electric motor, to which reference is made in the following description purely by way of example.

Figure 1 shows a fork-lift truck 1 with movable arms (forks) 2 for lifting and transporting loads, and powered
25 by an electric motor 3 supplied by a battery 5.

As shown schematically in Figure 2, battery 5 is connectable selectively, by means of a connecting device 6, to electric motor 3 and to a battery charger 7. More

specifically (Figures 3 and 4), connecting device 6 comprises a supporting body 8 made of insulating material and housing a first and a second supply cable 10, 11 connected to battery 5; an electronic control circuit 12 housed at least partly in a seat 15 on supporting body 8; and a current transducer 13 for detecting a current I flowing in supply cables 10, 11. Connecting device 6 also comprises a first, a second, and a third control cable 14a, 14b, 14c, also housed in supporting body 8 and connected to the electronic control circuit. More specifically, the first and second control cable 14a, 14b are connectable to battery charger 7, and the third control cable 14c is connectable to electric motor 3. Figures 3 and 4 also show, by dash lines, a first and a second connecting element 17a, 17b forming part of a known connector (not shown in detail) connectable to connecting device 6 (and of which connecting cables 50, 51 are provided for connecting electric motor 3 and battery charger 7 to battery 5 - Figure 2).

Current transducer 13 comprises a resistive element ("shunt") 16 preferably made of manganin and located in series with first or second supply cable 10, 11, e.g. first supply cable 10. At opposite ends, resistive element 16 has a first and a second detecting contact 18, 19 connected to electronic control circuit 12 as explained in detail later on; a third detecting contact 20, also connected to electronic control circuit 12, is provided on second supply cable 11; and current

transducer 13 and detecting contacts 18-20 are all housed in seat 15.

As shown in Figure 5, electronic control circuit 12 comprises a supply circuit 22; a logic processing unit 23; a sensor assembly 24; a memory 25; a serial interface 26; and a display device 27. More specifically, sensor assembly 24 comprises:

a current detecting circuit 28 having two inputs connected respectively to first and second detecting contact 18, 19; and an output connected to logic processing unit 23 and supplying a first control signal S_I indicating the current I flowing in supply cables 10, 11;

a voltage detecting circuit 29 having two inputs connected respectively to first and third detecting contact 18, 20; and an output connected to logic processing unit 23 and supplying a second control signal S_V indicating the voltage V_b between supply cables 10, 11;

a temperature sensor 30 having an output connected to logic processing unit 23 and supplying a third control signal S_T ; and

a mains detector 31 having an input connectable to battery charger 7 over first control cable 14a; and an output connected to logic processing unit 23 and supplying a fourth control signal S_R having a first value when battery 5 is connected to battery charger 7, and a second value when it is not.

Logic processing unit 23 is also connected to memory 25, to serial interface 26, and to display device 27, and has a first output 25a connectable over second control cable 14b to an enabling input of battery charger 7 and supplying a first enabling signal EN1, and a second output 25b connectable over third control cable 14c to a user enabling input of truck 1 and supplying a second enabling signal EN2.

Serial interface 26, in itself known, permits connection to an external electronic computer (e.g. a palmtop computer) to access memory 25, both to read its content (utilization history and charge operations) and to program a number of operating parameters (threshold values, maximum charge times) explained in detail later on.

Display device 27, also of known type, provides for displaying information relative to the status of battery 5, e.g. charge level or any alarms.

In actual use, logic processing unit 23 receives control signals S_I , S_V , S_T , S_R , samples them in known manner, and uses them to perform one of the control procedures described in detail later on. On the basis of the value of first control signal S_I , showing instant by instant the current I flowing in supply cables 10, 11, the logic processing unit determines the available charge Q_B value of battery 5, and records it in memory 25 (normally in ampere-hours, Ah).

The following is a description, with reference to

Figure 6, of a discharge control procedure performed by logic processing unit 23 when battery 5 is connected to electric motor 3 (in the example shown, when the fork-lift truck is operating). In this case, the second output 5 25b of the logic processing unit is connected to the enabling input of electric motor 3 over third control cable 14c.

To begin with (block 100), the available charge Q_b value of battery 5 is made equal to an initial charge Q_i value recorded in memory 25, and which is the charge value determined and memorized after the last time battery 5 is charged or used. The value of current I (block 110) is then measured by means of current detecting circuit 28, and the available charge Q_b value 15 is decreased and recorded in memory 25 (block 120). More specifically, the available charge Q_b value is calculated by time integration of current I.

The available charge Q_b value is then compared with a threshold charge Q_{MIN} value (block 130). If the 20 available charge Q_b is higher than the threshold charge (YES output of block 130), the second control signal EN2 is set to a first, e.g. high, logic value to enable normal operation of fork-lift truck 1 (block 140); conversely (NO output of block 130), the second control 25 signal EN2 is set to a second (low) logic value (block 150) to disable operation of forks 2 of truck 1 (e.g. to disable the solenoid valves controlling the hydraulic circuit (not shown) powering forks 2).

In other words, to prevent battery 5 from discharging completely before it can be charged, at least some of the user devices of truck 1 are disabled, and the threshold charge Q_{MIN} is used as a reserve to get truck 1 to battery charger 7.

The cycle of measuring current I (block 110), estimating the available charge Q_B (block 120), and monitoring the remaining charge (block 130), is performed continually until battery 5 is disconnected from electric motor 3, or until threshold charge Q_{MIN} is reached.

The following is a description, with reference to Figure 7, of a charge control procedure performed by logic processing unit 23 when battery 5 is connected to battery charger 7. In this case, the input of mains detector 31 and the first output 25a of the logic processing unit are connected to battery charger 7 over first and second control cable 14a, 14b respectively. More specifically, at this step, mains detector 31 is activated and sets the fourth control signal S_R to the first value, so that logic processing unit 23 is controlled to perform the charge control procedure.

To begin with, the available charge Q_B value is made equal to the initial charge Q_I value recorded in memory 25 (block 200); the values of current I and battery voltage V_B are then measured by means of current detecting circuit 28 and voltage detecting circuit 29 respectively (block 210); and the available charge Q_B value is then increased and recorded in memory 25 (block

220). In this case too, the available charge Q_B is estimated by time integration of current I .

A first test is then performed (block 230), in which the battery voltage V_B is compared with a nominal voltage (V_{MAX}) value of, say, $2.4 \cdot N$ V, where N is the number of component elements of battery 5. If the battery voltage V_B is less than the nominal voltage V_{MAX} (NO output of block 230), a second test is performed (block 240) to determine whether the charge time T_c , since the start of the charge operation, is greater than a limit time T_{LIM} . If it is (YES output of block 240), an alarm is generated and displayed by display device 27 (block 250), the charge procedure is terminated (block 260), the first enabling signal is set to a predetermined (e.g. low) logic value, and battery charger 7 is disabled. Conversely, charging continues, and current I and battery voltage V_B are again measured (block 210).

If, on the other hand, battery voltage V_B is greater than nominal voltage V_{MAX} (YES output of block 230), a third test is performed to determine whether the available charge Q_B has reached a maximum value Q_{MAX} corresponding to the capacity of battery 5 (block 270). If it has (YES output of block 270), the charge procedure is terminated (block 260); if it has not (NO output of block 270), the charge procedure continues. In other words, a double check is made of battery voltage V_B and available charge Q_B , and the charge procedure is not terminated until battery 5 has been charged sufficiently

to restore the maximum charge value Q_{MAX} .

Further advantages of the present invention will be clear from the foregoing description.

In particular, monitoring the current and
5 calculating the remaining charge of the battery provide
for optimizing the battery charge procedure by injecting
exactly the amount of current required to replace the
amount discharged during operation of the battery, thus
reducing the time and energy required to charge the
10 battery, and preventing premature ageing of the battery.

Moreover, by providing the connecting device with a
control circuit comprising a logic processing unit and a
memory, the available charge can be determined and
recorded over time, thus not only giving a reliable
15 indication of the battery charge level, but also
measuring energy consumption within a given time
interval. This is particularly useful in that work
vehicles, such as fork-lift trucks, are frequently hired,
and electric energy consumption is a reliable parameter
20 by which to determine cost.

Clearly, changes may be made to the connecting
device as described herein without, however, departing
from the scope of the present invention.

CLAIMS

1) A connecting device for an electric work vehicle, comprising a supporting body (8) made of insulating material and housing at least a first and a second supply cable (10, 11) connectable to a battery (5); said first and second supply cable (10, 11) also being selectively connectable to a battery charger (7) and to at least one user device (3); characterized by comprising an electronic control circuit (12) connected to said first and second supply cable (10, 11); and current transducer means (13) for detecting a current flowing in said first and second supply cable (10, 11).

2) A device as claimed in Claim 1, characterized in that said electronic control circuit (12) and said current transducer means (13) are housed in a seat (15) on said supporting body (8).

3) A device as claimed in Claim 1 or 2, characterized in that said current transducer means (3) comprise a resistive element (16) located in series with said first or said second supply cable (10, 11); said resistive element (16) having, at opposite ends, a first and a second detecting contact (18, 19) connected to said electronic control circuit (12).

4) A device as claimed in any one of the foregoing Claims, characterized in that said electronic control circuit (12) also comprises a current detecting circuit (28) connected to said first and second detecting contact

(18, 19) of said current transducer means (13) and supplying a first control signal (S_I); a voltage detecting circuit (29) supplying a second control signal (S_V) related to a voltage (V_B) between said first and
5 second supply cable (10, 11); and temperature sensing means (30).

5) A device as claimed in Claim 4, characterized in that said electronic control circuit (12) comprises numeric processing means (23) connected to said current
10 detecting circuit (28) and to said voltage detecting circuit to receive said first and second control signal (S_I , S_V), and to supply a number of enabling signals (EN1, EN2); memory means (25) connected to said numeric processing means (23); and serial communication means
15 (26).

6) A system for supplying an electric work vehicle, and comprising an electric motor, a battery (5), a battery charger (7), and a connecting device (6) for connecting said battery (5) alternatively to said user
20 device (3) and to said battery charger (7); characterized in that said connecting device (6) is as claimed in any one of Claims 1 to 5.

7) A method of controlling a system for supplying an electric work vehicle, and comprising an electric motor,
25 a battery (5), a battery charger (7), and electromechanical operating members;

the method comprising the steps of charging said battery (5) and discharging said battery (5);

and the method being characterized in that said steps of charging and discharging comprise:

- connecting said battery (5) to said battery charger (7) and, respectively, to said user device (3) by means of a first and a second supply cable (10, 11);
- measuring a current flowing in said first and second supply cable (10, 11); and
- determining an available charge (Q_B) of said battery (5) on the basis of said current (I).

8) A method as claimed in Claim 7, characterized by comprising the step of memorizing said available charge (Q_B).

9) A method as claimed in Claim 7 or 8, characterized in that said step of charging also comprises:

- comparing said available charge (Q_B) with a first reference value (Q_{MAX});
- enabling said battery charger (7) when said available charge (Q_B) is less than said first reference value; and
- disabling said battery charger (7) when said available charge (Q_B) is greater than said first reference value (Q_{MAX}).

10) A method as claimed in Claim 7 or 9, characterized in that said step of discharging also comprises:

- comparing said available charge (Q_B) with a second reference value (Q_{MIN});

- enabling said electromechanical operating members when said available charge (Q_B) is greater than said second reference value (Q_{MIN}); and
 - disabling said electromechanical operating members
- 5 when said available charge (Q_B) is less than said second reference value (Q_{MIN}).

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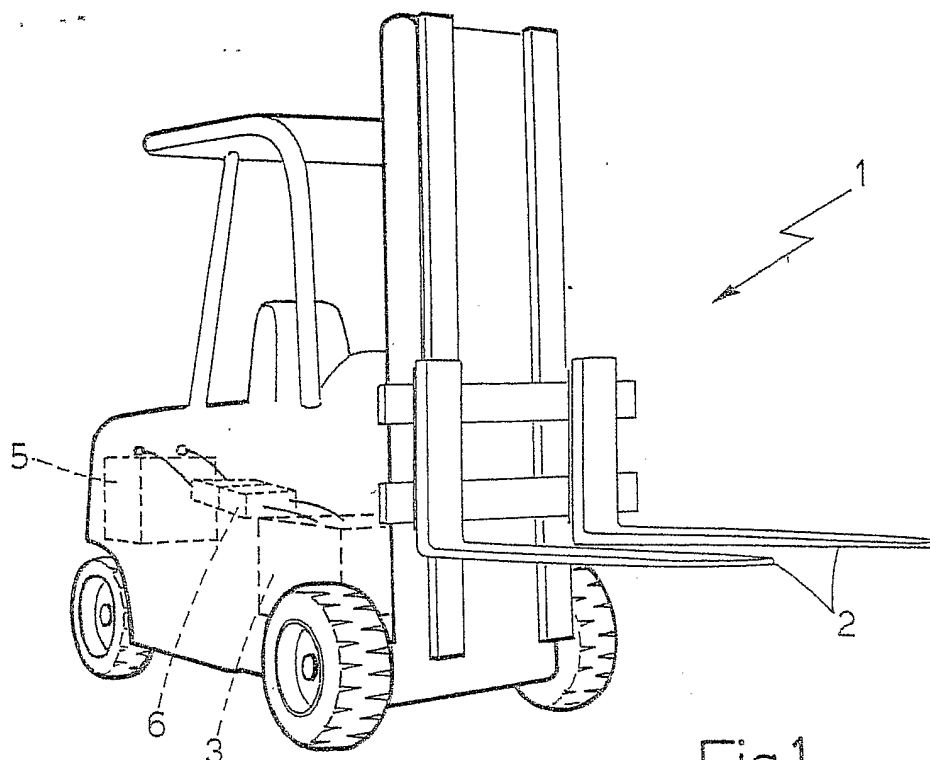


Fig. 1

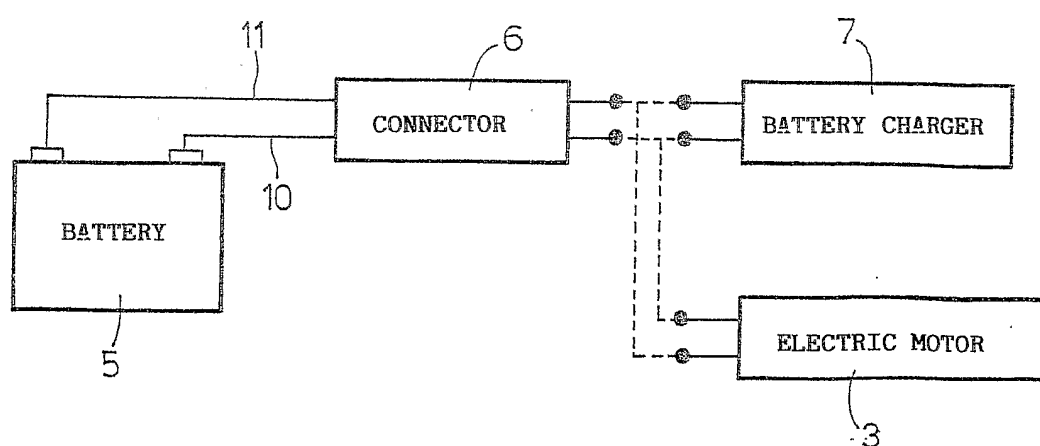
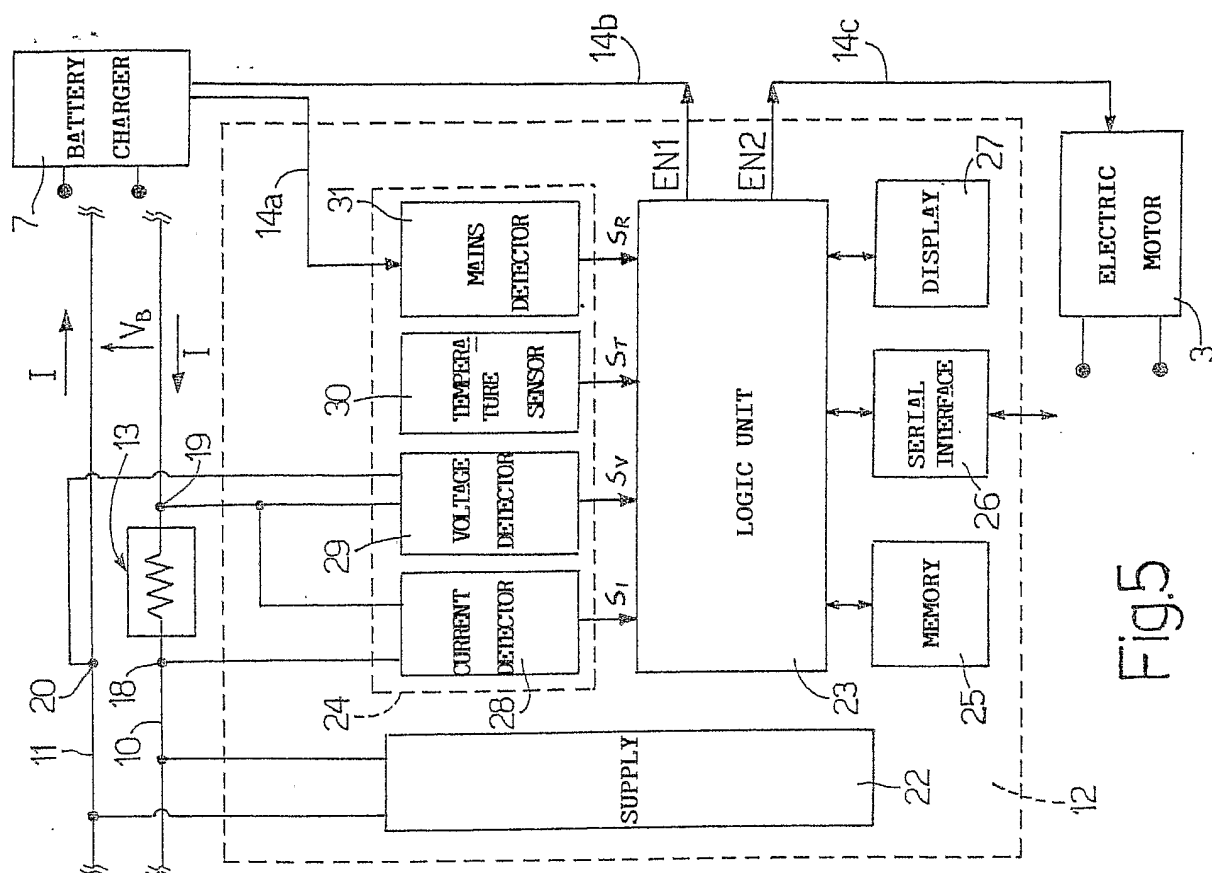


Fig. 2



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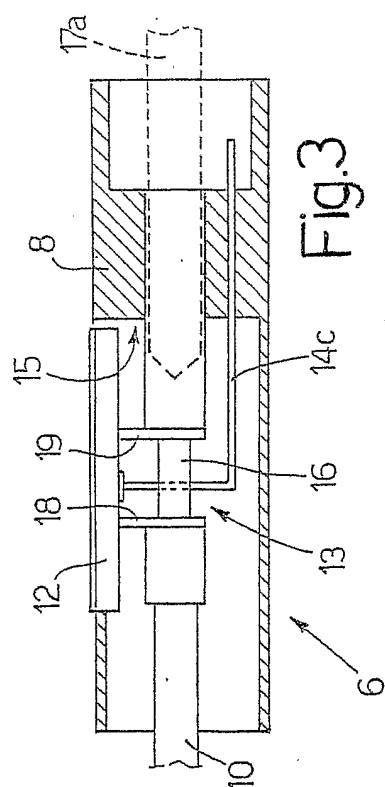


Fig. 3.

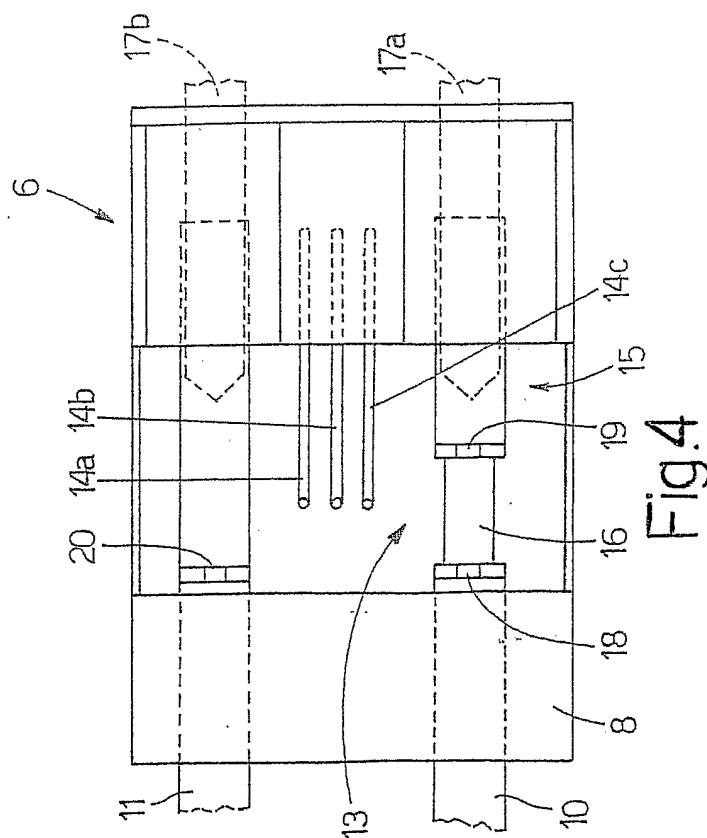


Fig. 4

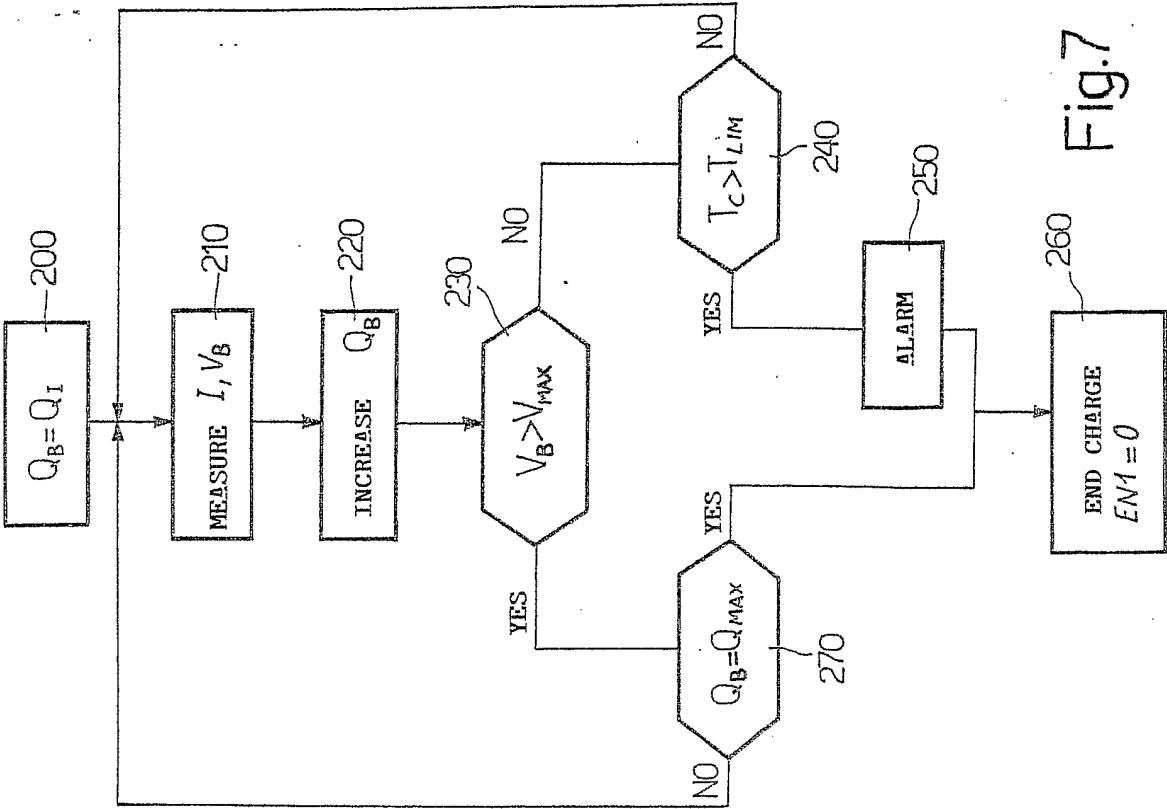


Fig. 6

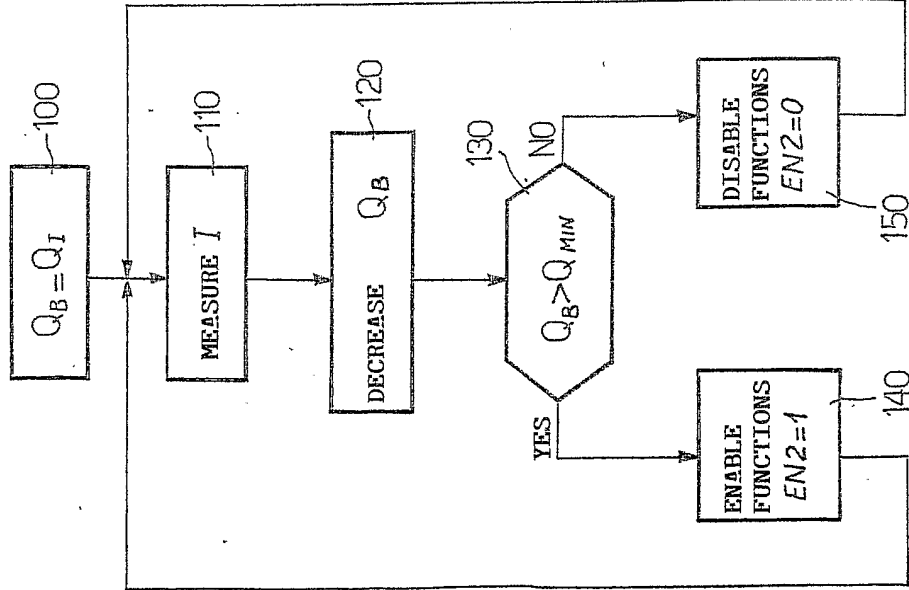


Fig. 7

INTERNATIONAL SEARCH REPORT

International Application No

PCT/IT 02/00197

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 B60L11/18

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 B60L

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 practical, search terms used)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	GB 2 121 971 A (LUCAS IND PLC) 4 January 1984 (1984-01-04) abstract ----	1-8,10
X	US 6 057 688 A (SAKAJO YUICHI ET AL) 2 May 2000 (2000-05-02) abstract column 1, line 13 - line 25 column 11, line 53 -column 12, line 35 figures 1,4 ----	1-3,6-9
X	US 5 534 759 A (EVANS LE ANDRA E ET AL) 9 July 1996 (1996-07-09) abstract column 5, line 35 - line 39 -----	1,2,5,7, 9

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

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INTERNATIONAL SEARCH REPORT

Information on patent family members

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Patent document cited in search report		Publication date	Patent family member(s)	Publication date
GB 2121971	A	04-01-1984	DE 3321045 A1	15-12-1983
			FR 2528582 A1	16-12-1983
			JP 59005975 A	12-01-1984
			US 4558281 A	10-12-1985
US 6057688	A	02-05-2000	JP 10246760 A	14-09-1998
US 5534759	A	09-07-1996	NONE	