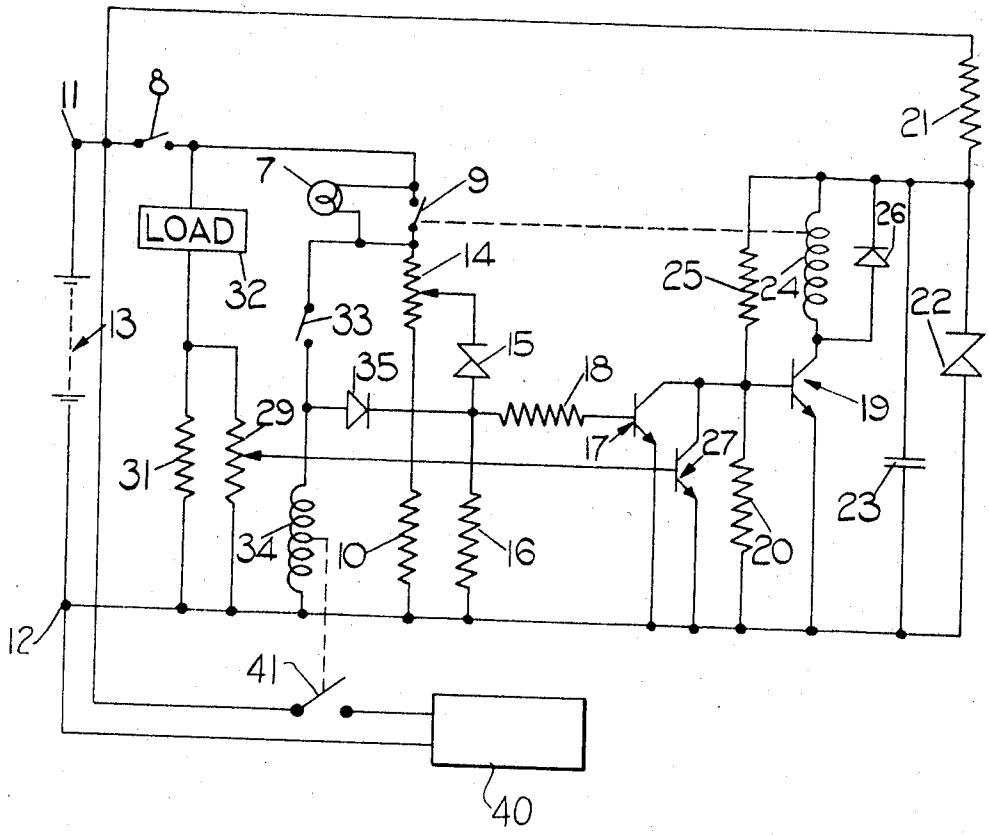
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CIRCUIT FOR INDICATING WHEN A BATTERY IS DISCHARGED

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CIRCUIT FOR INDICATING WHEN A BATTERY IS DISCHARGED

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ABSTRACT OF THE DISCLOSURE

An industrial truck control circuit for indicating low battery charge occuring during operation thereof, comprising a transistorized voltage-sensitive circuit that is conductive at reduced battery terminal voltage only at a prescribed current level determined by a current-sensitive circuit which counteracts circuit voltage variations due to load. When low charge occurs, the voltage-sensitive circuit effects disconnecting power to truck non-drive operating components, such as a lift mechanism, thereby indicating low battery condition in addition to energizing a warning light if desired.

This invention relates to a circuit which, when connected to a battery, will give an indication when the battery is discharged.

A circuit according to the invention comprises in combination voltage-sensitive means operable when the voltage of the battery falls below a predetermined value for giving said indication, and current-sensitive means which inhibits the action of the voltage-sensitive means if the current drawn from the battery by a specified load or loads is above a value at which the voltage of the battery could fall below said predetermined value without the battery being discharged.

The accompanying drawing is a circuit diagram illustrating one example of the invention as applied to an industrial lift truck.

Referring to the drawing, there are provided a pair of terminals **11**, **12** which in use are connected to the positive and negative terminals respectively of the battery **13**. The terminals **11**, **12** are bridged by a series circuit including a switch **8** which must be operated by the driver before the truck can be moved, a normally closed relay contact **9** and resistors **14**, **10**. A variable point on the resistor **14** is connected to the cathode of a Zener diode **15** having its anode connected to the terminal **12** through a resistor **16**, and to the base of a transistor **17** through a resistor **18**. The emitter of the transistor **17** is connected to the terminal **12**, whilst its collector is connected to the base of a transistor **19**, the emitter of which is connected to the terminal **12**, and the base of which is connected to the terminal **12** through a resistor **20**.

The terminals **11**, **12** are further interconnected through a resistor **21** and a Zener diode **22** in series, the Zener diode **22** being bridged by a capacitor **23**. A point intermediate the resistor **21** and Zener diode **22** is connected to the collector and base of the transistor **19** through the relay coil **24** and a resistor **25** respectively, the relay coil **24** being bridged by a diode **26** for conducting back E.M.F., and serving when energised to open the contact **9**. The base of the transistor **19** is further connected to the collector of a transistor **27**, the emitter of which is connected to the terminal **12** and the base of which is connected to a variable point on a resistor **29**. The resistor **29** bridges a resistor **31** connected at one end to the terminal **12** and at its other end to the terminal **11** through

a load **32** in series with the switch **8**, the load **32** being powered by the battery **13**.

The junction of the contact **9** and resistor **14** is connected to the terminal **12** through a microswitch **33** and a contactor coil **34** in series, the junction of the microswitch **33** and coil **34** being connected through a diode **35** to the junction of the Zener diode **15** and resistor **16**. The microswitch **33** can be operated by the driver to energise the coil **34**, which in turn operates contact **41** for operating the lift mechanism **40** of the truck.

In operation, when the battery is in charged condition the voltage across the Zener diode **15** is sufficient to cause it to conduct, and so current flows through the resistor **18** and the base and emitter of the transistor **17** to switch the transistor **17** on. Current flow through the resistor **25** is now diverted through the collector and emitter of the transistor **17**, and so no base current flows in the transistor **19**, which remains off.

When the battery discharges, its voltage falls, and when its voltage falls below a value predetermined by the position of the slider on the resistor **14**, the Zener diode **15** ceases to conduct. The transistor **17** is now switched off, and current flow through the resistor **25** switches the transistor **19** on to energise the relay **24**, which opens the contact **19** so that the warning lamp **7** is illuminated. Opening of the contact **9** also breaks the circuit to the Zener diode **15**, which therefore cannot conduct again until the supply is removed. The resistor **21**, Zener diode **22** and capacitor **23** stabilise the supply to the transistors, and prevent damage by transients.

The circuit thus far described is sensitive solely to battery voltage. For a given discharge rate, a battery may have a voltage per cell of 2.0 when the battery is charged, and 1.7 per cell when the battery is discharged, and so the slider movable over the resistor **14** can be set to operate so that the indication is given when the voltage per cell falls to 1.7. The indication will of course only be precisely accurate at the chosen discharge rate, because the battery voltage varies with the current drawn from it. However, for low values of current (for example below 200 amps), the battery voltage is substantially independent of current, and so the indication will be substantially accurate. The difficulty arises where higher currents are drawn from the battery, for example when the truck is accelerated from rest. In this case, the battery voltage may well fall below 1.7 per cell, even though the battery is not discharged, but nevertheless the circuit so far described would give an indication that the battery is discharged. In order to overcome this problem, the transistor **27** and its associated components are included. The load **32** is constituted by the traction motor of the truck, and when the current through the motor is above a level predetermined by the position of the slider on the resistor **29**, the transistor **27** can conduct, and acts in the same way as the transistor **17** to maintain the transistor **19** off. Thus, for a high current flow through the motor, the transistor **17** may be switched off, but the transistor **27** will be switched on so the relay **24** is still not energised and the indication is not given. However, if the transistor **17** is switched off at any time when the current flowing through the motor, is below the predetermined value, the transistor **27** will also be off, and so the relay **24** will be energized to give the indication. It will be apparent that the predetermined current chosen above which the indication will not be given must be a current above which the voltage of the battery starts to fall significantly.

The resistor **31** carries the full motor current, and obviously its resistance must be as low as possible. In the preferred example, the resistor **31** consists of a length of power cable, and the transistor **27** is chosen to operate at a very low voltage so that the power losses are kept to a minimum.

The arrangement disclosed prevents an indication from being given if the motor current is high, but in some trucks there may be other loads such as lift mechanism **40** which will take a current sufficiently high to result in a false indication being given. In this case, further current sensing may be required, or alternatively the total battery current could be sensed instead of the current through a specified load. In most trucks, the traction motor is the only load which can result in any serious incorrect indication, although the current taken by the lifting mechanism **40** of the truck can also depress the battery voltage, but to a lesser extent than the traction motor. Separate sensing of the lifting mechanism **40** current may or may not be required, depending on the truck, but as will be explained the particular circuit shown caters for this problem in a different way.

The indication given by the lamp **7** is only incidental to the main indication in the preferred example, which is that the lifting mechanism **40** is put out of action. Thus, as soon as the coil **24** is energised, the contact **9** opens to break the circuit through the microswitch **33** to the contactor coil **34**, so preventing the driver from using the lifting mechanism **40**, whilst permitting him to drive the truck to a battery charging area. Current flowing through the lamp **7** is insufficient to energise the coil **34**. The diode **35** performs three functions. Firstly, it maintains the transistor **17** conductive independently of the Zener diode **15** while the lifting mechanism **40** is being used, so that when the battery is discharged, the indication will only be given when the lifting mechanism **40** is in its lowered position. Secondly, it ensures that no false indication will be given as a result of the current drawn by the lifting mechanism **40**. Thirdly, it ensures that the contact **9** only opens when the circuit through the coil **34** is dead, so that the contact **9** only has to break the small current flowing through the resistors **14, 10**.

The invention is primarily designed for use in industrial trucks, but can be used in any application where a straightforward measurement of battery voltage would be unsatisfactory because the voltage is from time to time affected by high currents drawn from the battery.

It will be appreciated that to de-energise the coil **24**, one of the battery terminals must be disconnected. The coil **24** will also of course be de-energised when the truck is accelerated, but it will become energized again before the truck stops.

Having thus described my invention what I claim as new and desire to secure by Letters Patent is:

1. A circuit which, when connected to a battery, will give an indication when the battery is discharged, comprising in combination voltage-sensitive means in said circuit operable when the voltage of the battery falls below a predetermined value for giving said indication, and current-sensitive means in said circuit which inhibits the action of the voltage-sensitive means if the current drawn from the battery by a load is above a value at which the voltage of the battery could fall below said predetermined value without the battery being discharged and said current responsive means being operable continuously as long as such load current is being drawn from the battery.

2. A circuit as defined in claim **1**, wherein the load includes an industrial truck traction motor.

3. A circuit as defined in claim **2**, wherein said circuit includes a warning lamp indicator which is illuminated when said voltage sensitive means operates for indicating the battery is discharged.

4. A circuit as defined in claim **1**, wherein said circuit includes means for preventing operation of the load upon operation of said voltage-sensitive means, thereby giving an indication when the battery is discharged.

5. A circuit as defined in claim **4**, including means for preventing the indication from being given while the load is in operation.

6. A circuit as defined in claim **5**, wherein the load includes an industrial truck traction motor and a lift mechanism, said circuit includes means for preventing operation of raising of the lift mechanism upon operation of said voltage-sensitive means, thereby giving an indication when the battery is discharged, said circuit includes means for preventing the indication from being given while the lifting mechanism is in operation and said circuit including a warning lamp indicator which is illuminated when said voltage means operates for indicating the battery is discharged.

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