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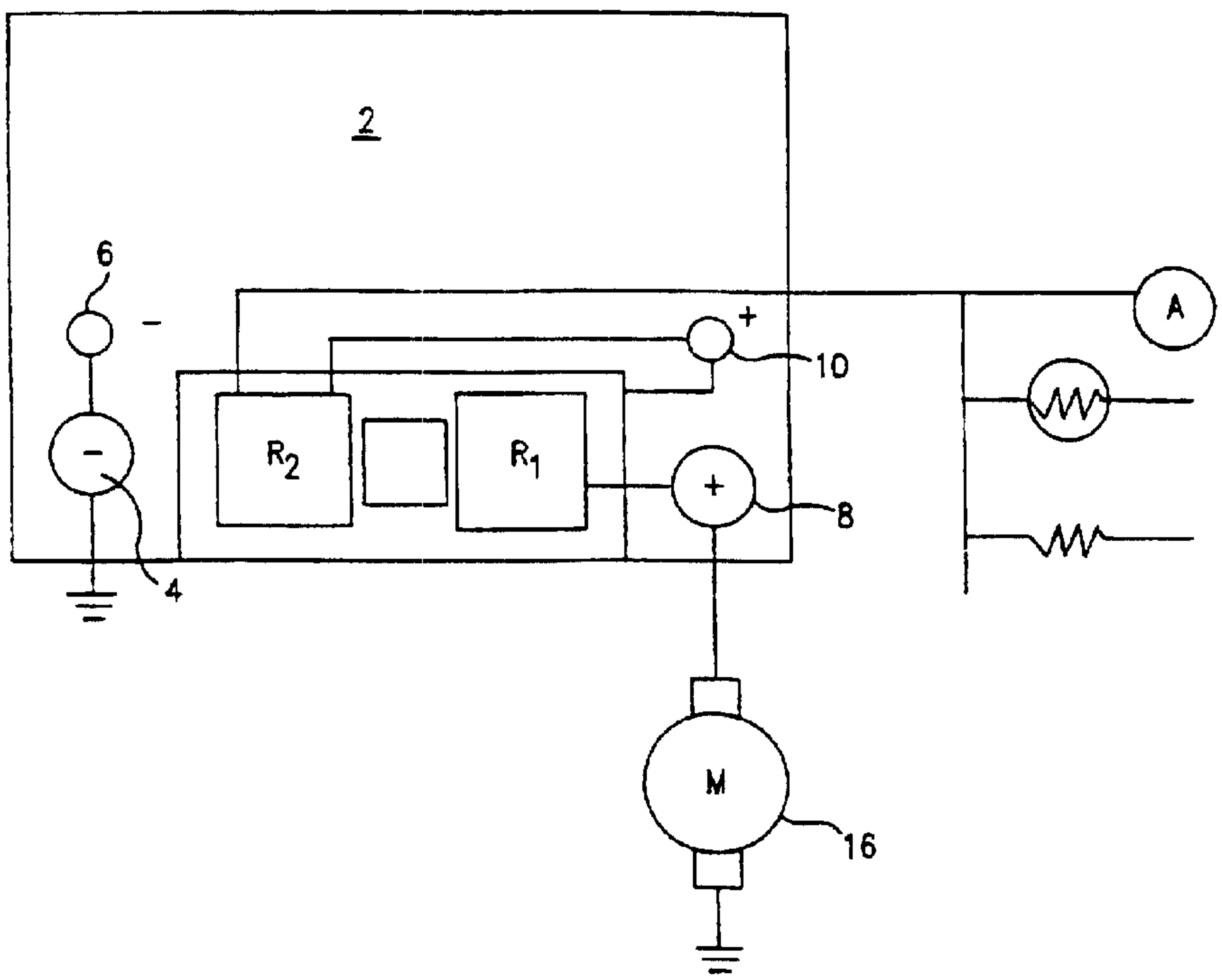
(54) **COMMANDE DE BATTERIES DOUBLES POUR VEHICULE, UTILISANT UN DETECTEUR DE MOUVEMENT**

(54) **VEHICLE DUAL BATTERY CONTROLLER UTILIZING MOTION SENSOR**




(57) A vehicle battery and controller combination is provided herein. This combination includes two batteries. Each battery has one positive terminal cell and an associated positive terminal conductor which is independent of any other terminal cell, and an associated terminal conductor. Each battery has one negative terminal cell and an associated terminal conductor which is independent of any other terminal cell. A sensor is provided for sensing current flow between the batteries. A controller is provided which includes a first switch for connecting and disconnecting at least one pair of like poles of the batteries. The controller opens the first switch to allow individual outputs from each battery, opens and closes the first switch to control the charging and discharging of at least one of the batteries and to preserve the state of charge of at least one battery, and closes the first switch to connect both batteries in parallel to receive charge from an alternator. The operation of the first switch is controlled in response to current flow between the batteries which is sensed by the sensor.

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## ABSTRACT

A vehicle battery and controller combination is provided herein. This combination includes two batteries. Each battery has one positive terminal cell and an associated positive terminal conductor which is independent of any other terminal cell, and an associated terminal conductor. Each battery has one negative terminal cell and an associated terminal conductor which is independent of any other terminal cell. A sensor is provided for sensing current flow between the batteries. A controller is provided which includes a first switch for connecting and disconnecting at least one pair of like poles of the batteries. The controller opens the first switch to allow individual outputs from each battery, opens and closes the first switch to control the charging and discharging of at least one of the batteries and to preserve the state of charge of at least one battery, and closes the first switch to connect both batteries in parallel to receive charge from an alternator. The operation of the first switch is controlled in response to current flow between the batteries which is sensed by the sensor.

(a) TITLE OF THE INVENTION

VEHICLE DUAL BATTERY CONTROLLER UTILIZING MOTION SENSOR

(b) TECHNICAL FIELD TO WHICH THE INVENTION RELATES

This invention relates to a vehicle battery and controller combination which is used in multiple battery installations in vehicles. The controller is intended for use in vehicles and equipment with gasoline or diesel motors, vessels, aircraft and other vehicles where battery failure could be undesirable or hazardous. This invention also relates to switches for assisting the operation of vehicle batteries of the type where provision is made for avoiding a low state of charge (SOC) to a level where the battery system cannot start the engine.

(c) BACKGROUND ART

Wiring looms in conventional vehicles and equipment are typically suited for a single conventional battery with two poles or terminals. The alternator charging current output is connected to the positive and negative poles as there is only one battery to charge.

When a three-pole battery was proposed for vehicle use, it became necessary for the controller to determine whether the alternator should charge the auxiliaries battery (AUX) or the cranking battery (CRA). Additionally, if the batteries were mutually connected to be charged, they had to be disconnected to preserve the all-important charge in the CRA battery on which the driver relied to start the vehicle.

In co-pending Canadian Patent Application Serial No. 2,115,405, a switch was described which was intended for connection between two positive poles of a three-pole battery. The controller connected the batteries in parallel to receive alternator output and disconnected them to maximize the individual outputs of the individual AUX and CRA batteries for the START. The controller prevented unsuitable discharge of the AUX battery by selective disconnection of the auxiliary loads, e.g., air conditioning, rear window heating and headlights, if these should be left on when the charging system was not operating.

The reliability of the controller depended partly upon, firstly, the use of microprocessor control, and secondly the selection of the values in the vehicle electrical system and in the battery itself for presentation to the microprocessor for evaluation of the state of charge.

In the above-identified Canadian Patent Application Serial No. 2,115,405, a controller was provided for vehicle batteries having a CRA battery and an AUX battery.

The provision of two batteries, whether they be in one envelope or be separate, confer advantages, but with them come problems concerning charging and discharging, battery life and ensuring that the battery system has sufficient charge to start the vehicle. These, in turn, depend upon assessing relationships between the batteries, e.g., voltage differences, or the assessment of the states of charge of the individual batteries or a combination of these or other measures.

WITEHIRA, in U.S. Patent No. 4,883,728, patented November 1989, inserted a thermal switch between the positive terminals of a three pole AUX/CRA battery. The switch was normally closed, but opened when excessive current heated a bimetallic strip. Different conditions and ambient temperatures led to unreliable results.

U.S. Patent No. 5,264,777, patented November 1993, by Smead, described an electrical network containing an alternator that charged a pair of two-pole batteries. A switch connected the batteries to the alternator and disconnected loads which one of the batteries serviced. The network was not suited to the changing loads of a vehicle or boat, and depended on the rate of discharge of the AUX battery for its operation.

U.S. Patent No. 5,154,985, patented October 1992, by Tanaka, described a pair of batteries, one being a smaller capacity reserve battery which was unused until the larger battery was discharged.

U.S. Patent No. 5,243, 270, described two 12V car batteries without any switching between them, nor any means to shed auxiliary loads when this became necessary.

U.S. Patent No. 5,336,932, described two batteries with a switch between them, but no provision was made to handle the discrepancy in charge when the batteries interconnected.

These references are exemplary only and more are known. Only published PCT/NZ93/00067 WAUGH, dealt with provision of a controller incorporating a microprocessor which assessed the state of charge and controlled charge and discharge such that the discrepancy in charge between the AUX and CRA did not become too large. This art entirely concerns controller and 3-pole battery combinations.

The controller was designed to avoid the situation where there was insufficient charge in the batteries for being able to start the vehicle, while maximizing the amount of energy which was available for using electrical accessories. The current outputs of the two batteries could be provided independently to the starter motor and to the other electrical systems in the vehicle. This had a number of benefits: firstly, the high starter motor current did not need to be switched between the two batteries; and secondly, the outputs of the two batteries could be provided separately, so while the vehicle was being started, the ignition could receive a stable voltage from one battery, while the starter motor was drawing current from the other battery, resulting in the voltage of the other battery falling and fluctuating heavily. One battery could be discharged by electrical auxiliaries while the other battery was kept in a fully-charged condition to start the vehicle.

The controller should be capable of operating two or more batteries that may not necessarily be of the same construction, but may be constructed differently. For example, one battery may be a starter battery (CRA), and may be of a construction optimised for providing high current as is required by a starter motor for cranking the engine during starting or by preheated catalytic converters. The other battery may be a deep cycle battery, optimised to withstand intermittent discharging (AUX). The capacities of the two batteries may be the same or they may differ as they are matched to the particular requirements of the vehicle and its intended usage.

## (d) DESCRIPTION OF THE INVENTION

By a first broad aspect of this invention, a vehicle battery and controller combination is provided comprising two batteries, each battery having one positive terminal cell and an associated positive terminal conductor independent of any other terminal cell, and an associated terminal conductor, and each battery having one negative terminal cell and an associated terminal conductor independent of any other terminal cell, a sensor for sensing current flow between the batteries, and a controller comprising a first switch for connecting and disconnecting at least one pair of like poles of the batteries, the controller opening the first switch to allow individual outputs from each battery, opening and closing the first switch to control the charging and discharging of at least one of the batteries and to preserve the state of charge of at least one battery, and closing the first switch to connect both batteries in parallel to receive charge from an alternator. The operation of the first switch is controlled in response to current flow between the batteries which is sensed by the sensor.

By one variant of this first broad aspect of this invention, one battery is a CRA battery which is connected to a starter motor of the engine of the vehicle.

By a second variant of this first broad aspect of this invention, and/or the above variant thereof, at least one of the batteries is an AUX battery which is connected to electrical auxiliaries of the vehicle, excluding a starter motor or the engine of the vehicle.

By a third variant of this first broad aspect of this invention, and/or the above variants thereof, the batteries are of different construction to each other. By a first variation thereof, at least two batteries are of different charge and discharge characteristics from each other.

By a fourth variant of this first broad aspect of this invention, and/or the above variants thereof, the operation of the first switch is determined by sensing current flow between the batteries and the voltages of the batteries.

By a fifth variant of this first broad aspect of this invention, and/or the above variants thereof, the sensor for sensing the current between the batteries results in a voltage drop between the batteries of less than 500 mV at a current of 50 amps when a first switch is closed.

By a sixth variant of this first broad aspect of this invention, and/or the above variants thereof, the sensor utilizes a Hall-effect current sensor which is located within an inductive ring.

By a seventh variant of this first broad aspect of this invention, and/or the above variants thereof, the sensor utilizes a current sensor, and the current sensor includes an operational amplifier for measuring the voltage drop across a resistor of low value.

By an eighth variant of this first broad aspect of this invention, and/or the above variants thereof, the controller includes a second switch which connects one of the batteries to auxiliary electrical loads, and the controller opens the second switch to preserve the state of charge of one of the batteries when it is discharged to a predetermined level of state of charge. By a first variation thereof, the second switch is an electromechanical device. By a second variation thereof, the second switch selectively-prioritizes disconnection of independent auxiliary loads according to predetermined threshold levels to preserve the state of charge of one of the batteries.

By a ninth variant of this first broad aspect of this invention, and/or the above variants thereof, an overcurrent protection means is provided to prevent excessive current from damaging the first switch. By a first variation thereof, the operational characteristics of the overcurrent protection means are unaffected by changes to the ambient temperature.

By a tenth variant of this first broad aspect of this invention, and/or the above variants thereof, an overcurrent protection means operates in combination with a latch delay means which holds the first switch open and extends overcurrent protection by preventing response to an activating signal for a predetermined period. By a first variation thereof, the second switch is a mechanical device. By a second variation thereof, the second switch is an electronic device.

By an eleventh variant of this first broad aspect of this invention, and/or the above variants thereof, the vehicle battery and controller further includes a filtering means which is connected in series with at least one of the batteries for filtering brief surges of current when electrical accessories are switched.

By a twelfth variant of this first broad aspect of this invention, and/or the above variants thereof, the vehicle battery and controller combination further includes an additional sensing means for determining when the first switch should be activated. By a first variation thereof, operation of the additional sensing means is cancelled when one battery exceeds a predetermined state of charge and is not being charged. By a second variation thereof, the sensing means is a movement sensor. By a third variation thereof, the sensing means is responsive to a signal which originated by the operator of the vehicle.

By a thirteenth variant of this first broad aspect of this invention, and/or the above variants thereof, the vehicle battery and controller combination includes a sensing means to determine the state of charge of at least one battery. By one variation thereof, in determining the state of charge, the sensing means utilizes any combination of at least two values selected from current, voltage, time and temperature in determining the state of charge. By a second variation thereof, the sensing means to determine state of charge utilizes a measurement of a characteristic of electrolyte of the batteries.

By a fourteenth variant of this first broad aspect of this invention, and/or the above variants thereof, operation of the controller is carried out by discrete circuits. By a first variation thereof, at least some of the discrete circuit is replaced with a microprocessor. By a second variation thereof, at least some of the discrete circuit is replaced by an application-specific integrated circuit device.

By a fifteenth variant of this first broad aspect of this invention, and/or the above variants thereof, the batteries include cell posts which are arranged to permit series connection of batteries of like function for the purpose of increasing voltage.

By a sixteenth variant of this first broad aspect of this invention, and/or the above variants thereof, the batteries are housed in a common envelope.

By a seventeenth variant of this first broad aspect of this invention, and/or the above variants thereof, the controller controls the current supply from a cranking battery to the starter motor of the vehicle and from the cranking battery to at least one other load which is smaller than that of the starter motor but which is larger than that of ordinary vehicle loads.

By an eighteenth variant of this first broad aspect of this invention, and/or the above variants thereof, one battery is connected in parallel with the other battery for starting until a predetermined condition is detected, whereupon the batteries are disconnected. By one variation thereof, the vehicle battery and controller combination includes a first switch which is capable of withstanding currents in excess of 100A.

By a second broad aspect of this invention, a vehicle battery and controller combination is provided comprising an auxiliary battery which is connected to electrical auxiliary loads in a vehicle, a cranking battery which is connected to a starter motor of an engine of a vehicle, and a controller comprising a first switch for connecting and disconnecting at least one pair of like poles of the cranking battery and the auxiliary battery, and including a sensing means which determines the current between the cranking battery and the auxiliary battery, the sensing means comprising a Hall-effect current sensor which is located within an inductive ring, where the sensing means results in a voltage drop between the batteries of less than 500mV at a current of 50amps when the first switch is in a closed position.

By one variant of this second broad aspect of this invention, the incorporation of the sensing means results in a voltage drop between the batteries of less than 200mV at a current of 50amps when the first switch is in a closed position.

By a second variant of this second broad aspect of this invention, and/or the above variant thereof, sensing means is a current sensor, and the sensor includes an operational amplifier which, in use, measures the voltage drop across a series resistor of low value. By a first variation thereof, the value of the series resistor is 0.1ohm to 0.005ohm.

By a third variant of this second broad aspect of this invention, and/or the above variants thereof, including an additional sensing means which also determines when the first switch should be activated. By a first variation thereof, the additional sensing means is inhibited from the first operating switch when the auxiliary battery exceeds a predetermined state of charge and is not being charged. By a second variation thereof, the additional sensing means is a movement sensor. By a third variation thereof, the movement sensor is a piezo sensor device. By a fourth variation thereof, the movement sensor is a inductive sensor device.

By a fourth variant of this second broad aspect of this invention, and/or the above variants thereof, the additional sensing means is responsive to a signal which is generated by the operator of the vehicle. By a first variation thereof, the operational characteristics of the overcurrent protection means are unaffected by changes to the ambient temperature.

By a fifth variant of this second broad aspect of this invention, and/or the above variants thereof, an overcurrent protection means which works in combination with a latch delay means which holds the first switch open, and extends overcurrent protection by preventing response by the first switch to an activating signal for a predetermined period.

By a sixth variant of this second broad aspect of this invention, and/or the above variants thereof, the vehicle battery and controller combination further includes a filtering means which is connected in series with at least one of the batteries for filtering brief surges of current when electrical accessories are switched on.

By a seventh variant of this second broad aspect of this invention, and/or the above variants thereof, the operation of the controller is carried out by discrete circuits. By a first variation thereof, some or all of the discrete circuit is replaced by a microprocessor. By a second variation thereof, some or all of the discrete circuit is replaced by an application-specific integrated circuit device.

By an eighth variant of this second broad aspect of this invention, and/or the above variants thereof, the first switch is a selected one of a mechanical, an electro-mechanical, or an electronic device.

By a ninth variant of this second broad aspect of this invention, and/or the above variants thereof, each battery has one positive terminal cell and an associated positive terminal cell conductor which is independent of any other terminal cell, and each battery has one negative terminal cell and an associated terminal cell conductor which is independent of any other terminal cell.

By a tenth variant of this second broad aspect of this invention, and/or the above variants thereof, the batteries are housed in a common envelope.

By an eleventh variant of this second broad aspect of this invention, and/or the above variants thereof, the batteries include cell posts which are arranged to permit series connection of batteries of like function for the purpose of increasing voltage.

By a twelfth variant of this second broad aspect of this invention, and/or the above variants thereof, the controller controls the current supply from the cranking battery to a starter motor of the vehicle and from the cranking battery to at least one other load which is smaller than that of the starter motor but which is larger than that of ordinary vehicle loads.

By a thirteenth variant of this second broad aspect of this invention, and/or the above variants thereof, the auxiliary battery is connected in parallel with the cranking battery for starting until a predetermined condition is detected, whereupon the batteries are disconnected.

By a fourteenth variant of this second broad aspect of this invention, and/or the above variants thereof, the disposition of posts of the batteries and the accommodation of the controller permit parallel connection of batteries of like function for the purpose of increasing capacity.

Thus, as described above, a first aspect of an embodiment of this invention provides a vehicle battery and controller combination having two batteries where each battery has one positive terminal cell and an associated positive terminal conductor which is independent of any other terminal cell, where each battery has one negative terminal cell and an associated terminal conductor which is independent of any other terminal cell, and a controller comprising a normally-open switch which is capable of connecting one or more pairs of like poles of the batteries, where that switch opens to allow individual outputs from each battery and to open and close to control the charging and discharging of at least one of the batteries and to preserve the state of charge of at least one battery.

That switch may have a normally-closed switch connecting the AUX battery to the electrical auxiliaries so as to charge both the CRA and AUX batteries and to meet fluctuating loads. The controller may include a microprocessor or ASIC. Alternatively, the controller may include circuits which monitor values which compose the state of charge.

A second aspect of an embodiment of this invention provides a vehicle battery and controller combination having an AUX battery which is connectable to the electrical auxiliary loads, a CRA battery which is connectable to the engine starter motor of the vehicle and a controller comprising a normally-open switch which is capable of connecting and disconnecting one or more pairs of like poles of the CRA and AUX batteries, where there is a sensing means to determine the current between the batteries, where the incorporation of these sensing means results in a voltage drop between the batteries of less than 500mV at a current of 50A when that switch is closed.

The operation of the controller opens that switch, in one aspect of this invention, to limit charging and to prevent overcharging of the CRA battery. In other aspects of this invention, that switch may be a mechanical device, e.g., a latching relay, a motorized switch, an electronic device or an equivalent. That switch may be a single device or that switch may be multiple devices, wherein one device controls the charge and discharge of the batteries and a second switching device is used with a higher current rating suitable for connecting the batteries in parallel during starting. Less power is required under non start-conditions to operate the lesser rated switch and less heat is generated.

In other aspects of this invention the means may be an operational amplifier which, in use, measures the voltage drop across a resistor of low value. The value of the resistor may be from 0.1 to 0.0001ohms, usefully 0.1 to 0.0001ohms. Preferably, the value would be lower than 0.018ohms. A low resistance is desirable as it reduces the voltage drop and power dissipation.

In other aspects of this invention, alternatively, the means may be a Hall-effect current sensor. The Hall-effect current sensor may lie within an inductive ring and produce an output voltage which is proportional to the current by relying on a small field. In another aspect, the means may be a current sensing relay, whereby the current passes through some turns of heavy wire which form the coil of the relay. Within the coil is a core which causes a pair of contacts to make or break when a pre-set current is exceeded. All of these embodiments supply signals to the controller which permit the controller to manage both the previously-referred-to switches.

The switch may be activated, according to another aspect of this invention, by a movement sensor for example, a piezo sensor device. An improved method of triggering the switch, according to another aspect of this invention is an arrangement where a magnet is mounted on a copper strip which is suspended over a bobbin would inductor. This device has numerous advantages over a piezo sensor device, as the first-mentioned device senses acceleration rather than vibration or noise. This device outputs a voltage pulse from the coil inductor in response to acceleration which is detected by circuitry in the controller and may be used to cause relay closure.

## (e) BRIEF DESCRIPTION OF THE DRAWINGS

In the accompanying drawings:

FIG. 1 is a diagram of a combined battery and switch, according to an aspect of an embodiment of this invention, where the switch has (R1) and (R2), and the connections to vehicle electrical components are shown;

FIG. 2 is a circuit diagram of a control circuit, according to an aspect of an embodiment of this invention, utilizing a Hall-effect current sensor;

FIG. 3 is a plan of the Hall-effect current sensor depicted in FIG. 2;

FIG. 4 is a section of the Hall-effect current sensor of FIG. 2;

FIG. 5 is a diagram of the Hall-effect current sensor, according to an aspect of an embodiment of this invention, in circuit and capable of supplying a voltage to a comparator as shown in FIG. 6;

FIG. 6 is a diagram of an alternative control circuit, according to an aspect of an embodiment of this invention, using a shunt and op-amps;

FIG. 7 is a diagram of an alternative version, according to an aspect of an embodiment of this invention, to FIG. 4, using a copper strip;

FIG. 8 is a perspective diagram of a battery plate array for a terminal cell showing the terminal conductor extending as a pole, according to an aspect of an embodiment of this invention; and

FIG. 9 is a diagram of a battery supply two large current consuming components, according to an aspect of an embodiment of this invention.

(f) AT LEAST ONE MODE FOR CARRYING OUT THE INVENTION

In one aspect of this invention, as depicted in FIG. 1, a vehicle battery 2 has a large negative terminal 4, a small negative terminal 6, a large positive terminal 8 and a small positive terminal 10. A moulded cavity in the case houses a box 12 containing a pcb and components for the control functions, and relays (R1) and (R2). Relay (R1) is connected between the large and small positive terminals 8, 10 of the AUX and CRA batteries. The negative terminals of the AUX and CRA batteries are joined and connected to an earth cable 14. The large positive terminal is connected to the starter motor 16.

Alternator 18 charges the AUX battery (terminal 10) first, and if relay (R1) is closed, also charges the CRA battery. Relay (R1) is normally-open, and relay (R2) is normally-closed, in order that the AUX battery can supply vehicle auxiliaries. Refinements of this aspect appear under the following headings.

OVERCURRENT PROTECTION (OCP) POWER SWITCH

According to one aspect of this invention, and referring to FIG. 2, the switch comprises relay (R3), relay (R4) and transistor (Q2). Its purpose is to provide power to the over current protection section of the switch when the relay is closed. When the switch is at rest and the relay is open, OCP is not required. Transistor (Q2) is normally held OFF by relay (R3) pulling the base to the supply rail. The base is pulled low via relay (R2) by the relay drive transistor (Q1) when relay drive transistor (Q1) is turned on due to transistor detection by the piezo sensor device. Power is then supplied to the current sensor and OCP sections.

CURRENT SENSOR

According to a second aspect of this invention as depicted in FIGS. 3 and 4, the Hall-effect current sensor is a metal ring (U3) which is used to concentrate the magnetic flux which is generated by the current flowing in the loops 22 of wire which encircle the mild steel metal ring.

The Hall-effect current sensor is only powered when the relay (R1) is closed, as its supply current is 10 mA. If given continuous power, the current consumption would prematurely discharge the CRA battery. Supply voltage is determined by the zener voltage rating.

With no current passing through the relay contacts, the device outputs 2.5V When 50A passes from AUX to CRA, the device outputs 1.3V, and when 50A passes in the opposite direction from CRA to AUX, the device outputs 3.8V. Thus, it follows that the voltage output versus current relationship is 26mV/A.

The metal ring (U3) has some retentivity in that it retains a small magnetic polarisation when the current flowing through the loops 22 is removed. This is not a problem as the currents are high, but the resulting hysteresis is low in proportion to the OCP trip points.

In this embodiment of an aspect of this invention, the loops 22 are formed by a combination of U-shaped wire links and printed circuit board traces 24. This obviates the need to wrap the wire around the metal ring and then to raise the assembly from the printed circuit board surface. It is important for the Hall-effect current sensor (UGN3503) to sit in the centre of the air gap and the ring. It does, however, mean that high current printed circuit board traces 24 can be used, e.g., additional solder placed on the traces to allow them to take continuous currrents of up to 50A. Peak currents due to inrush can be as high as 80A. The raised construction is probably more desirable if the winding of the wire around the ring, and maintaining the correct stand-off height is feasible in production quantities.

In FIG. 5, the Hall-effect current sensor (UGN3503) receives output from transistor (Q4) and provides output to comparators through terminal 26.

OCP WINDOW DETECTOR

According to a third aspect of this invention and referring now to FIG. 6, OCP window detector outputs a high voltage when the output of the current sensor exceeds predetermined levels. The sensor voltage is dependent on the current flowing in the relay contacts and loop.

The window detector comprises two op-amp stages (U2C) and (U2D) which are configured as comparators. Each op-amp compares the output of the current sensor with a level which is set by resistor divider network. As the output of the Hall-effect current sensor (UGN3503) is dependent on its supply voltage, and since the Hall-effect current sensor (UGN3503) is regulated only by a low cost zener diode, the positive rail of the divider networks must be derived from the same supply as the Hall-effect current sensor. This means that variations which occur due to the tolerance in the zener diode are also reflected in the divider network, negating errors due to the fluctuating zener-regulated voltage.

The set points for the comparator are set by relay (R5) and relay (R8) for current that flows in the CRA to AUX direction. Relay (R7) and relay (R9) give the trip point for the current flowing from AUX to CRA.

As with the current sensor, OCP inrush filter and OCP latch sections, the supply to op-amps which form the window detector is only enabled when the relay is closed.

OCP LATCH DELAY

According to a fourth aspect of this invention, the OCP latch delay section is, in op-amp stage (U2B), configured as a comparator. The negative input of this comparator is biased at 2.5V by relay (R12) and relay (R13). The output of the inrush filter is connected to the positive input of this op-amp. When the DC level from the input filter exceeds the level set by relay (R12) and relay (R13), the output of the op-amp rises. This is buffered by op-amp stage (U2A). The high level output from op-amp stage (U2A) turns on transistor (Q3) which immediately opens relay (R1) by pulling low the input to op-amp stage (U1D). A dwell period is introduced by (D7) and capacitor (C4), which in conjunction with op-amp stage (U1C) and transistor (Q4), prevent sensing of the piezo sensor device for a given dwell.

OCP INRUSH FILTER

According to a fifth aspect of this invention, the OCP inrush filter comprises two resistors, (R10) and (R11) and capacitor (C3) (see FIG. 7). These components provide a simple low pass filter which prevents the OCP circuit being triggered by large current rushes caused by incandescent lights, e.g., vehicle headlights. If the AUX battery has been discharged fully by leaving the headlights on for a long period of time, and the piezo sensor device connects relay (R1) in response to driver entry, a large current will flow from the CRA battery through the relay contacts and current detection LOOP. Incandescent lights may cause an inrush current 3 to 4 times the normal current which is required to operate the lights. The current surges for only 1 to 2.5 seconds. The low pass filter prevents the inrush current from tripping the OCP latch delay.

According to a sixth aspect of this invention as depicted in FIG. 6, the shunt resistor (R16) supplies a voltage to the op-amps which are arranged as comparators to monitor the same. Networks in this circuit generate small, highly-stable reference voltages.

COPPER STRIP VARIANT

According to a seventh aspect of this invention as depicted in FIG. 7, the copper strip 30 is in series with relay (R1). The circuit makes use of the voltage drop across this strip, the voltage drop being proportional to the amount of current flowing. The voltage drop is amplified and referenced to 2.5 Volt giving a bi-directional current measuring capability.

The small amount of voltage drop must be amplified to provide enough resolution for the (P) to discriminate between different levels of current. The referencing to 2.5V allows current to be measured in both directions.

Op-amp stage (U1B) divides by 2 and buffers the 5.00 Volt rail. This results in low impedance 2.50 Volt reference point at point D. The voltage at each end of the shunt is divided by 3.2 by relay (R1), and resistor (R10) and by relay (R4), and resistor (R11). This is done to avoid the possibility of the input voltage to op-amp stage (U1A) exceeding the supply voltage. Op-amp stage (U1C) and op-amp stage (U1D) buffer the divided voltages from each end of the shunt.

Referring now to FIG. 8, the bar 32 connects the plates 28 of the terminal cell to ascending conductor rod 34. This extends out of the case 36 as pole 38. This shows the type of battery with which the results, to be described hereinafter, have been obtained. In a vehicle, the starter motor is usually the largest current consumer and is supplied from the CRA battery. In FIG. 9 the CRA battery also supplies a catalytic converter 40 with 100A.

Having described embodiments of aspects of this invention, description of the functions of the components will now be given.

<u>Functions of Switch (R1)</u>

Switch (relay) (R1) is to connect to allow the CRA battery to be electrically in parallel with the AUX battery so the CRA battery may receive charge from the alternator. Switch (R1) is to disconnect in order mutually to isolate the CRA battery from the AUX battery to prevent undesirable discharging or over charging of the CRA battery by electrical loads that are connected to the AUX battery.

Switch (R1) may connect so that the CRA battery is electrically in parallel with the AUX battery so that the CRA battery may provide electrical energy to electrical accessories if the AUX battery is in a low state of charge and is not capable of providing sufficient voltage. Usually when switch (R1) is connected, the current that passes through switch (R1) is low. For example, during normal driving when the batteries are being charged by the alternator, the current across switch (R1) could be less than 10amps. In some circumstances, however, the two batteries may be at vastly different potential, and if switch (R1) was connected, then the current which would pass across switch (R1) would be very high. For example, if the vehicle was being started at low temperatures, if the SOC of the cranking battery was low and if the SOC of the AUX battery was high and if switch (R1) was connected, the current through switch (R1) may exceed 250amps. Large falls in voltage across switches are undesirable. They cause localized heating and deprive accessories of operating volts.

The limitations on the construction of the controller used in aspects of this invention are such that the switch (R1) may not be of sufficient current-carrying capability to withstand all the current that may pass through it in all conditions. Cost and physical constraints dictate the maximum current rating of switch (R1) that can be used, and as the controller may be built into the battery and have a life which is dictated by that of the battery, thus disposability dictates that cost is a significant factor.

For example, if switch (R1) was a relay, e.g., that known by the name Potter & Brumfield VF7-112D which has a 70amp rating, in some situations if the relay were connected, the current that would pass through the relay would far exceed 70amps and would damage the relay. Two types of damage to the relay occur: (1) damage to the contacts of the relay from arcing as the relay makes and breaks; and (2) thermal damage to the relay from large amounts of current passing through the relay over a period of time. Damage caused by arcing is avoided by preventing relay closure in anticipation of situations where arcing will occur, and thermal damage is prevented by opening the relay to prevent further current from flowing through the relay.

Connecting the relay (R1)requires 170mA of current, which, while the battery is being charged, is negligible. However, when the battery is not being charged, 170mA of discharge over a period of time can cause undesired reduction in SOC of the battery.

If the AUX battery and the CRA battery are both in a reasonably-charged condition, and if they are not being charged, then connecting switch (R1) serves no purpose. For example, the AUX battery is sufficiently able to supply a stable voltage to the auxiliaries and the CRA battery is sufficiently charged to supply large amounts of current to the starter motor.

The disadvantages of connecting under these circumstances if switch (R1) was a 70amp relay are:

(a) Switch closure will cause discharge of battery at a rate of 170mA, as opposed to the 2mA standby current if the relay was open. If batteries are shipped, charged, or stored in environments where they are prone to being triggered by an external stimulus, then they may suffer the increased risk of self-discharge, which is unnecessary and undesirable.

(b) If both batteries are in a good state of charge and charging is not present, then it would be desirable to inhibit the relay from connecting. Thus, if the vehicle was started, for example, a large automotive internal combustion engine could draw 800amps of current if started in cold weather, connecting switch (R1) would place both batteries in parallel. However, the current flow through switch (R1) could be as much as half of this current as the AUX battery would assist the CRA battery in providing current to the starter motor. Thus, 400amps could pass through switch (R1). This current may be in excess of normal operating current of switch (R1) and may cause damage. By keeping the AUX battery separated from the CRA battery during starting, the ignition system of the vehicle will receive a stable consistent voltage supply, while the voltage of the CRA battery fluctuates severely as the motor is cranked. Thus, starting may be improved as the ignition system receives a more stable voltage during startup. This arrangement in certain circumstances has been found dramatically to improve the starting performance of the vehicle.

(c) If the AUX battery is being discharged, its terminal voltage is still sufficiently high to power the ignition, and then there is no necessity to close the relay (R1). It is desirable to reserve the charge in the CRA battery so it may be kept in reserve to provide power to auxiliaries to start the vehicle when the AUX battery is unable to provide sufficient power. This is especially true if the AUX battery is of a deep cycle construction and the CRA battery is of a high current discharge construction, because if the two batteries were placed in parallel, the CRA battery would tend to provide more discharge current than the AUX battery during the initial stages of the discharge. Thus, by preventing connection of switch (R1) under certain conditions, undesirable discharging of the CRA battery can be avoided. Excessive current passage through switch (R1) should also be avoided.

The provision of switch (relay) (R2) prevents the AUX battery from being fully-discharged, and largely eliminates the need for switch (R1) to connect to assist the AUX battery during vehicle starting.

If switch (R1) was closed and if very high current passed through switch (R1), it would be desirable to open switch (R1) immediately, whereas if a lower but still excessive current was passed through switch (R1), the duration before opening could be greater. Thus, switch (R1) could be protected from excessive currents, while short term rush currents from devices, e.g., incandescent lights, could be ignored and would not cause switch (R1) to open.

The current detection circuit may open switch (R1), after detecting current flow from the AUX battery to the cranking battery and determining that, if switch (R1) were open, the ignition system would receive a higher and more stable voltage, this would be the case if switch (R1) was closed during vehicle starting and the AUX battery was in a reasonable state of charge.

Furthermore, it would be desirable that the method of detecting the current flow through switch (R1) not impose a significant series resistance, as this would require thermal dissipation and would also reduce the charging current to the CRA battery. For example, if the series resistance between the two terminals of the batteries were 10 milliohms, then a charging current of 20amps would result in a drop of 0.2 Volts, which would dramatically-increase the charging time of the starter battery and 4 watts of heat would need to be dissipated within the switch (R1).

Switch (R2) is optionally provided for disconnecting the AUX loads from the AUX battery to prevent complete discharge. The AUX battery is designed for deep cycling. Five main benefits result by incorporating switch (R2):

1) Electrolyte freezing is prevented.

2) Battery life is significantly extended.

3) The AUX battery is never discharged below 40% state of charge. Switch (R2) will not connect as the AUX battery will continue to provide constant voltage to the fuel injectors and microprocessors, even when the CRA battery voltage fluctuates.

4) The risk of stratification of the electrolyte of the AUX battery is reduced.

5) The AUX is prevented from being fully-discharged, and the need for switch (R1) to connect to assist the AUX battery in providing voltage to the ignition during starting is largely eliminated.

If a single load disconnection device is used, then load disconnection will only occur while the vehicle is stationary and the engine is not running. The art does not mention such problems nor mention making switch (R1) embodiments work reliably.

Transit Protection

The overcurrent protection (OCP as described hereinabove), which is active when switch (R1) is connected becomes the supplementary means, rather than the primary means, for protecting switch (R1) from excess current. These features can be embodied relatively simply by inhibiting connection of switch (R1) due to stimulus, for example, jarring during shipping, between specified voltages; for example, connection of switch (R1) could be inhibited when the AUX battery is between 10.8 Volts and 13.0 Volts. This could also be further enhanced according to aspects of this invention by the addition of filters and timers to take into account sudden changes in voltages and to take into account previous events in respect of new events.

For example, 10.9 Volts measured across the terminal of the AUX battery may indicate that it has been discharged at a low rate and is in a very low state of charge, or that it is being discharged at a medium current and is in a medium state of charge. If the battery voltage was in the region where external stimulus was ignored while stimulus occurred, and then its voltage was reduced to being below the inhibited region and within a fixed amount of time, it may be advantageous to connect the switch (R1). This algorithm is necessary if there is uncertainty of the state of charge of the AUX battery, and if the region in which connection of switch (R1) is inhibited is large.

Implementation of the controller using discrete components according to aspects of this invention, can be achieved resulting in a product which is cheap to manufacture and effective. As the operation of the controllers can be described linguistically using few linguistic variables, it would be simple to implement the operation of the controller using "fuzzy logic". Thus, implementing the controller using a microcontroller or an ASIC could result in significant improvements. Alternatively, if an ASIC or microcontroller were used, according to aspects of this invention, additional timers, filters or rules could be integrated into the device at low cost to improve the operation and reliability of the controller.

The switch (R1) is preferably protected against the passage of excessive current by opening and remaining open for a predetermined period, despite a signal from the movement detector to close. For example, if switch (R1) was a 70amp relay, current in excess of 70amps may signal the controller to open switch (R1) to prevent overheating it. Typically, the delay period is from 1 second to 60 seconds, preferably 6 seconds. A sub-circuit may filter brief surges of current which are experienced when accessories are switched on.

The controller is designed to operate on any multiple battery system. According to aspects of this invention, the batteries may be a pair of side-by-side, two-pole batteries; a three-pole battery with two positive poles; a pair of stacked two-pole batteries; an AUX battery and a CRA batter in one multi-cell case; a pair of high density batteries; or a pair of batteries where one is adapted to drive the electric starter motor and the other is adapted to run auxiliaries. According to aspects of this invention, the batteries may be located remotely from each other, with consideration for even weight distribution and efficient use of available space. Consideration needs to be given for keeping high current cabling lengths short, to keep weight and cost to a minimum.

Because aspects of this invention are designed for use in a vehicle without extensive modification, it is likely that the vehicle will only have a single alternator with a single current output. As two batteries are in the vehicle, the charging requirement of these batteries may differ. For example, the SOC of the CRA battery may be high and it may not require charging, while the SOC of the AUX battery may be low and it may require charging. Thus, it would be desirable to charge the AUX battery so it may become fully charged. However, further charging of the CRA battery would only result in gassing and overcharge damage, e.g., corrosion of the positive plates. Thus, in this situation, it would be desirable to open switch (R1) to prevent overcharging of the CRA battery resulting in energy savings, reducing battery water consumption and extending battery life.

Another aspect of the invention provides the combination of overcurrent protection with a latch delay device. The purpose of such aspect is to hold the relay open, thereby extending overcurrent protection by preventing response to a piezo sensor device or to an equivalent signal.

In use, the switch (R1) permits up to 70A to flow from the AUX to the CRA battery. This level of current can pass through the relay contacts without harming the relay. Larger currents are detected by the switch protection circuit and as soon as the threshold is exceeded, the contacts open while the starter is turning.

OVERCURRENT PROTECTION (OCP)

Battery current is supplied to a low resistance shunt (steel wire) with transistor detection of a voltage drop across the shunt. In practice, a voltage drop of 0.7V was required before the result could be used to interrupt the current. If the preferred current was 50amps, then 35 watts of heat would be produced at this current. This is not desirable, as the heat which is caused by this needs to be dissipated. Additionally, it reduces the electrical energy available, and will reduce charging currents across the switch.

If switch (R1) is of a suitably high current rating, then both batteries may be connected in parallel during starting to add to the cold-cranking-amps. Once the engine cranks rapidly enough, it is preferable to separate AUX and CRA. The AUX battery is free to supply improved voltage to the ignition, which assists starting. Engine cranking speed may be obtained by electronic coupling of the CRA battery voltage [or the current through switch (R1)], into a comparator. This gives a square wave input in the controller, so it can decide when cranking peaks. Instead, switch (R1) may open after a fixed period.

The following are typical examples of embodiments of this invention:

Example A

The vehicle is driven in heavy traffic conditions using all the accessories. The load exceeds the alternator output. The controller determines that the CRA battery is discharging and opens switch (R1), disconnecting the CRA battery from the AUX battery.

Example B

If the vehicle is being driven, and the charging system is providing less current than the electrical demand of the vehicle, then initially the CRA battery will separate from the AUX battery to prevent the discharge of the CRA battery. However, if this discharge is prolonged and the terminal voltage of the AUX battery falls below a level at which it cannot provide reliable power to the electrical systems in the vehicle, for example, 10.5 Volts, then the switch (R1) will connect. This means that the two batteries will be mutually-connected so that the vehicle will have additional energy available, and the effective useful reserve capacity available to the user when driving the vehicle is the sum of the two batteries. Thus, if the alternator failed when the vehicle is being driven, then the vehicle could still be driven for the maximum time period before both batteries expired. However, the effective reserve capacity available to the user if the vehicle is not being driven is limited to the reserve capacity of the AUX battery alone.

The controller has two switches, namely, a relay for mutually-connecting the two batteries in parallel [switch (R1)], and a switch for disconnecting the AUX loads from the AUX battery [switch (R2)], e.g., a latching relay.

Switch (R2) may not necessarily be a single device, e.g., a latching relay, but may comprise number of switches so that individual loads may disconnected in sequence. For example, high current loads may be disconnected while microprocessor memories may continue to be powered by the AUX battery. Alternatively, if the vehicle has a serial bus, it may be possible for the battery controller to instruct specific loads to switch off. By implementing switch (R2) using multiple disconnection devices, the utility of the system may be enhanced.

Example C

The vehicle is parked and the motor is stopped, but the accessories are still on. The microprocessor looks at the SOC of the AUX battery and when the SOC of the AUX battery falls to a predetermined threshold, e.g., 40% charged, the microprocessor instructs relay (R2) to disconnect the loads. Thus, the SOC of the CRA battery is 100% charged, and the SOC of the AUX battery is prevented from falling below 40% charged. Before disconnecting the loads, the controller ensures that the vehicle is not being driven and that the engine is not running. The controller may also warn the driver prior to the disconnection of the loads.

When the driver enters the vehicle, switch (relay) (R2) reconnects the auxiliaries to the AUX battery. Once the vehicle is restarted, then the alternator will charge both batteries.

The alternator output may be selected to prevent too high a charge, which might harm the battery. The charging current is kept constant until the batteries are almost entirely-charged. This may entail the charging voltage rising to 15.0V. Thereafter,the charging voltage decreases to 14.4V, and when fully-charged the voltage decreases to 13.8V.

Tests have shown that at 50amp of current flowing from AUX to CRA (or CRA to AUX), the voltage difference between points A and B is 40mV.

Op-amp stage (U1A) is configured as differential amplifier with a gain of 10. The equation describing output-to-input can be described as follows:

Point C (output = (Vb - Va) x 10) + 2.50, where Va is voltage at point A, and Vb is voltage at point B.

1. Example if current is flowing in CRA to AUX direction at 50amps.

Vb = 11.75 Volts

Va = 11.71 Volts

11.75 - 11.71 = 0.04

0.0.04 x 10 = 0.4

0.4 + 2.50 = 2.90 Volts

2. With current flowing in the opposite direction, i.e., AUX to CRA then,

Vb = 11.71 Volts

Va = 11.75 Volts

11.71 - 11.754 = 0.04

0.0.04 x 10 = 0.4

0.4 + 2.50 = 2.10 Volts

From the above, it can be seen that there is a relationship between output voltage and current, which can be further analyzed to give Volts per Amp (V/A). If, for example, there is 50amps of current, then the voltage drop measured at points A and B is 40mV, and then Volts per Amp before amplification becomes 0.008V/A or 8mV per Amp.

The final equation used is Current = 2.50 - Vc x 1

V/A

= 2.50 - Vc x 1

0.008 = 2.50 - Vc x 125

For 50 amps, using Example 2 above, results can be confirmed.

Example 2 gives Vc + 2.10 Volts @ 50 amps

2.50 - 2.10 + 0.4 0.4 x 125 = 50.

The accuracy of measurement at point C is dependent on the matching of resistors (R5),(R6),(R7) & (R8). Also, errors in the divide-by-2 stage will be amplified by the succeeding stage. To eliminate errors, as far as possible, there is a method (described below) which can be employed.

1) Auto zero

Because the calculation relies on the use of a constant of 2.50 Volts to realize the current, errors can arise if the divide-by-2 stage does not produce exactly 2.50 Volts at point D for a 5.00 Volt input. Errors at this point are due either to resistor mismatch in resistors (R2),(R3), or to the input voltage offset of the op-amp, or in the divider resistors.

Using better tolerance resistors or a higher specification op-amp is too expensive. Software can manage this by attempting to measure the current with the relay open. With the relay open, obviously no current can be flowing in the copper strip. An auto zero scheme can be employed which simply takes sample measurements and uses the measurement with the open relay as the constant in the current equation.

Example D

When the relay is open, i.e., no current flowing, if errors in the divide-by-2 stage produces 2.47 Volts at point C instead of the 2.50V as expected, then by using 2.47 in the current equation instead of 2.50, this error can be largely eliminated.

The equation would now be Current = (2.47 - Vc) x 125.

The advantages the Hall-effect curent sensor embodiment of an aspect of this invention are:

1. Hall-effect current sensors are inexpensive to provide; they reduce the need for precision components; they lower the overall parts count; and they provide an electrically-isolated method of sensing the current which enhances the reliability.

2. The output of the Hall-effect current sensor may be fed into an a/d converter as a current input, which may in turn be used to help in the determination in combination with other SOC data.

## CLAIMS

1. A vehicle battery and controller combination comprising:

(a) two batteries, wherein each battery has one positive terminal cell and an associated positive terminal conductor independent of any other terminal cell, and an associated terminal conductor, and wherein each battery has one negative terminal cell and an associated terminal conductor independent of any other terminal cell;

(b) a sensor for sensing current flow between said batteries; and

(c) a controller comprising a first switch for connecting and disconnecting at least one pair of like poles of said batteries, where said controller:

(i) opens said first switch to allow individual outputs from each battery;

(ii) opens and closes said first switch to control the charging and discharging of at least one of said batteries and to preserve the state of charge of at least one battery; and

(iii) closes said first switch to connect both batteries in parallel to receive charge from an alternator;

wherein the operation of said first switch is controlled in response to current flow between said batteries which is sensed by said sensor.

2. The vehicle battery and controller combination as claimed in claim 1, wherein one battery is a CRA battery which is connected to a starter motor of the engine of said vehicle.

3. The vehicle battery and controller combination as claimed in claim 1, wherein one of said batteries is an AUX battery which is connected to electrical auxiliaries of the vehicle excluding a starter motor or the engine of said vehicle.

4. The vehicle battery and controller combination as claimed in claims 1 to 3, wherein said batteries are of different construction to each other.

5. The vehicle battery and controller combination as claimed in claim 4, wherein at least two batteries are of different charge and discharge characteristics from each other.

6. The vehicle battery and controller combination as claimed in claims 1 to 5, wherein the operation of said first switch is determined by sensing current flow between said batteries and the voltages of said batteries.

7. The vehicle battery and controller combination as claimed in claims 1 to 6, wherein said sensor for sensing the current between said batteries results in a voltage drop between said batteries of less than 500mV at a current of 50amps when a first switch is closed.

8. The vehicle battery and controller combination as claimed in claims 1 to 7, wherein said sensor utilizes a Hall-effect current sensor which is located within an inductive ring.

9. The vehicle battery and controller combination as claimed in claims 1 to 7, wherein said sensor utilizes a current sensor, and wherein said current sensor includes an operational amplifier for measuring the voltage drop across a resistor of low value.

10. The vehicle battery and controller combination as claimed in claims 1 to 9, wherein said controller includes a second switch which connects one of said batteries to auxiliary electrical loads, and wherein said controller opens said second switch to preserve the state of charge of said one of said batteries when it is discharged to a predetermined level of state of charge.

11. The vehicle battery and controller combination as claimed in claim 10, wherein said second switch is an electromechanical device.

12. The vehicle battery and controller combination as claimed in claim 10 or claim 11, wherein said second switch selectively-prioritizes disconnection of independent auxiliary loads according to predetermined threshold levels to preserve the state of charge of said one of said batteries.

13. The vehicle battery and controller combination as claimed in claims 1 to 12, including an overcurrent protection means to prevent excessive current from damaging said first switch.

14. The vehicle battery and controller combination as claimed in claim 13, wherein the operational characteristics of said overcurrent protection means are unaffected by changes to the ambient temperature.

15. The vehicle battery and controller combination as claimed in claims 1 to 12, including an overcurrent protection means which operates in combination with a latch delay means which holds said first switch open and extends overcurrent protection by preventing response to an activating signal for a predetermined period.

16. The vehicle battery and controller combination as claimed in claim 10, wherein said second switch is a mechanical device.

17. The vehicle battery and controller combination as claimed in claim 10, wherein said second switch is an electronic device.

18. The vehicle battery and controller combination as claimed in claims 1 to 17, further comprising a filtering means which is connected in series with at least one of said batteries for filtering brief surges of current when electrical accessories are switched.

19. The vehicle battery and controller combination as claimed in claims 1 to 18, further comprising an additional sensing means for determining when said first switch should be activated.

20. The vehicle battery and controller combination as claimed in claim 19, wherein operation of said additional sensing means is cancelled when one battery exceeds a predetermined state of charge and is not being charged.

21. The vehicle battery and controller combination as claimed in claim 19, or claim 20, wherein said sensing means is a movement sensor.

22. The vehicle battery and controller combination as claimed in claim 19, or claim 20, wherein said sensing means is responsive to a signal which was originated by an operator of said vehicle.

23. The vehicle battery and controller combination as claimed in claims 1 to 22, including a sensing means to determine the state of charge of at least one battery.

24. The vehicle battery and controller combination as claimed in claim 23, wherein, in determining the state of charge, said sensing means utilizes any combination of at least two values selected from current, voltage, time and temperature.

25. The vehicle battery and controller combination as claimed in claim 23, wherein said sensing means to determine state of charge utilizes a measurement of a characteristic of electrolyte of said batteries.

26. The vehicle battery and controller combination as claimed in claims 1 to 25, wherein operation of said controller is carried out by discrete circuits.

27. The vehicle battery and controller combination as claimed in claim 26, wherein at least some of said discrete circuits are replaced with a microprocessor.

28. The vehicle battery and controller combination as claimed in claim 26, wherein at least some of said discrete circuits are replaced by an application-specific integrated circuit device.

29. The vehicle battery and controller combination as claimed in claims 1 to 28, wherein said batteries include cell posts which are arranged to permit series connection of batteries of like function for the purpose of increasing voltage.

30. The vehicle battery and controller combination as claimed in claims 1 to 29, wherein said batteries are housed in a common envelope.

31. The vehicle battery and controller combination as claimed in claims 1 to 30, wherein said controller controls the current supply from a cranking battery to the starter motor of said vehicle, and from said cranking battery to at least one other load which is smaller than said starter motor but which is larger than ordinary vehicle loads.

32. The vehicle battery and controller combination as claimed in claims 1 to 31, wherein one battery is connected in parallel with said other battery for starting until a predetermined condition is detected, whereupon said batteries are disconnected.

33. The vehicle battery and controller as claimed in claim 32, wherein said first switch is capable of withstanding currents in excess of 100A.

34. A vehicle battery and controller combination comprising: an auxiliary battery which is connected to electrical auxiliary loads in a vehicle, a cranking battery which is connected to a starter motor of an engine of a vehicle, and a controller comprising a first switch for connecting and disconnecting at least one pair of like poles of said cranking

battery and said auxiliary battery, where a sensing means determines the current between said cranking battery and said auxiliary battery, said sensing means comprising: a Hall-effect current sensor which is located within an inductive ring, wherein said sensing means results in a voltage drop between the batteries of less than 500mV at a current of 50amps when said first switch is in a closed position.

35. The vehicle battery and controller combination as claimed in claim 34, wherein the incorporation of said sensing means results in a voltage drop between said batteries of less than 200mV at a current of 50amps when said first switch is in a closed position.

36. The vehicle battery and controller combination as claimed in claim 34 or claim 35, wherein said sensing means is a current sensor; and wherein said sensor includes an operational amplifier which, in use, measures the voltage drop across a series resistor of low value.

37. The vehicle battery and controller combination as claimed in claim 36, wherein the value of said series resistor is from 0.1ohm to 0.005ohm.

38. The vehicle battery and controller combination as claimed in claims 34 to 37, including an additional sensing means which also determines when said first switch should be activated.

39. The vehicle battery and controller combination as claimed in claim 38, wherein said additional sensing means is inhibited from said first operating switch when said auxiliary battery exceeds a predetermined state of charge and is not being charged.

40. The vehicle battery and controller combination as claimed in claim 38, wherein said additional sensing means is a movement sensor.

41. The vehicle battery and controller combination as claimed in claim 40, wherein said movement sensor is a piezo sensor device.

42. The vehicle battery and controller combination as claimed in claim 40, wherein said movement sensor is a inductive sensor device.

43. The vehicle battery and controller combination as claimed in claims 38 to 42, wherein said additional sensing means is responsive to a signal which is generated by an operator of said vehicle.

44. The vehicle battery and controller combination as claimed in claim 44, wherein operational characteristics of said overcurrent protection means are unaffected by changes to the ambient temperature.

45. The vehicle battery and controller combination as claimed in claims 34 to 43, including an overcurrent protection means which works in combination with a latch delay means which holds said first switch open, and which extends overcurrent protection by preventing response by said first switch to an activating signal for a predetermined period.

46. The vehicle battery and controller combination as claimed in claims 34 to 45, further comprising a filtering means which is connected in series with at least one of said batteries for filtering brief surges of current when electrical accessories are switched on.

47. The vehicle battery and controller combination as claimed in claims 34 to 46, wherein the operation of said controller is carried out by discrete circuits.

48. The vehicle battery and controller combination as claimed in claim 47, wherein some or all of said discrete circuits are replaced by a microprocessor.

49. The vehicle battery and controller combination as claimed in claim 48, wherein some or all of said discrete circuits are replaced by an application-specific integrated circuit device.

50. The vehicle battery and controller combination as claimed in claims 34 to 49, wherein said first switch is a selected one of a mechanical, an electromechanical, or an electronic device.

51. The vehicle battery and controller combination as claimed in claims 34 to 50, wherein each battery has one positive terminal cell and an associated positive terminal cell conductor which is independent of any other terminal cell, and wherein each battery has one negative terminal cell and an associated terminal cell conductor which is independent of any other terminal cell.

52. The vehicle battery and controller combination as claimed in claims 34 to 51, wherein said batteries are housed in a common envelope.

53. The vehicle battery and controller combination as claimed in claims 34 to 52, wherein said batteries include cell posts which are arranged to permit series connection of batteries of like function for the purpose of increasing voltage.

54. The vehicle battery and controller combination as claimed in claims 34 to 53, wherein said controller controls the current supply from said cranking battery to a starter motor of said vehicle and from said cranking battery to at least one other load which is smaller than the load of said starter motor but which is larger than ordinary vehicle loads.

55. The vehicle battery and controller combination as claimed in claims 34 to 54, wherein said auxiliary battery is connected in parallel with said cranking battery for starting until a predetermined condition is detected, whereupon said batteries are disconnected.

56. The vehicle battery and controller combination as claimed in claims 34 to 55, wherein the disposition of posts of said batteries and the accommodation of said controller permit parallel connection of batteries of like function for the purpose of increasing capacity.

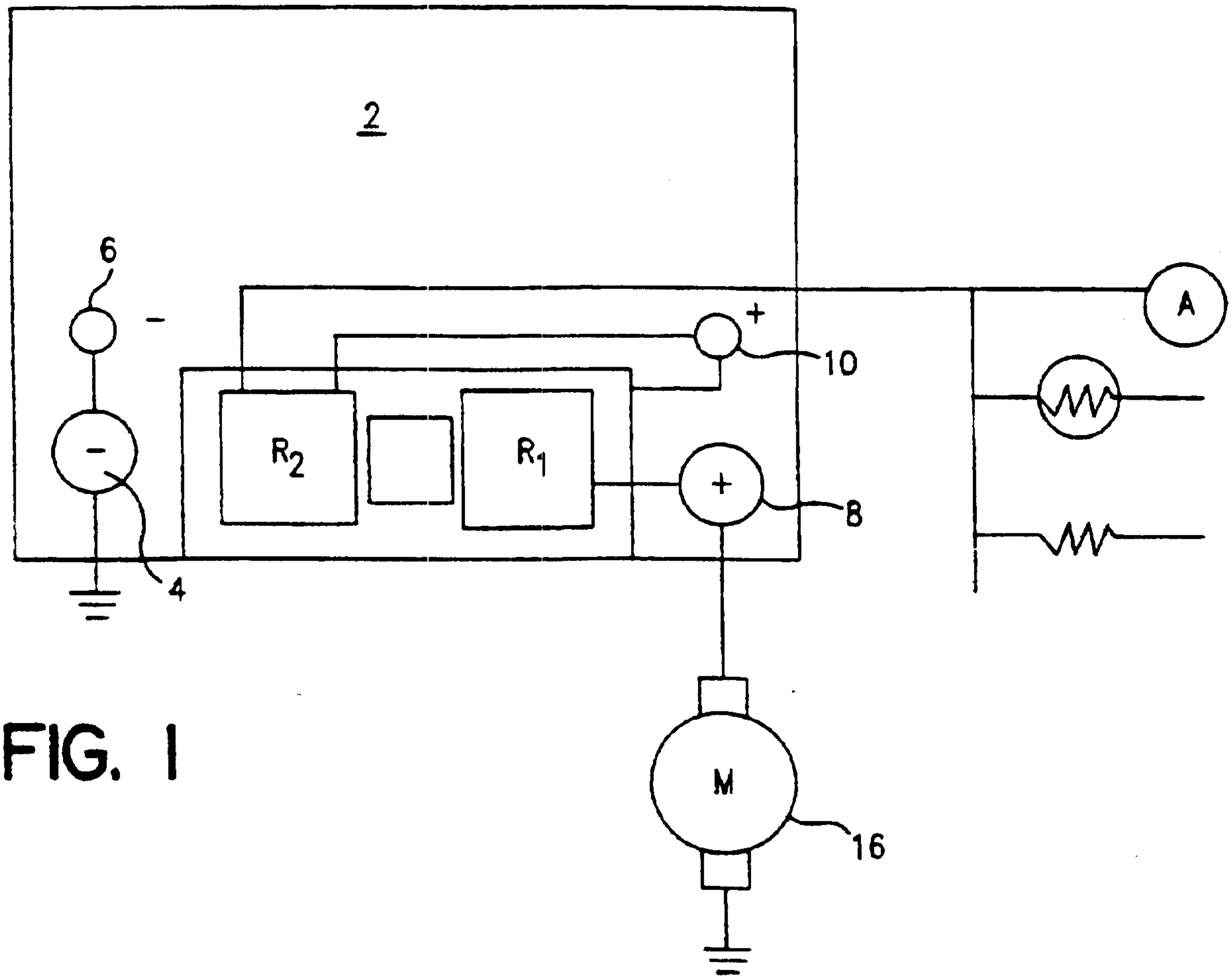


FIG. 1

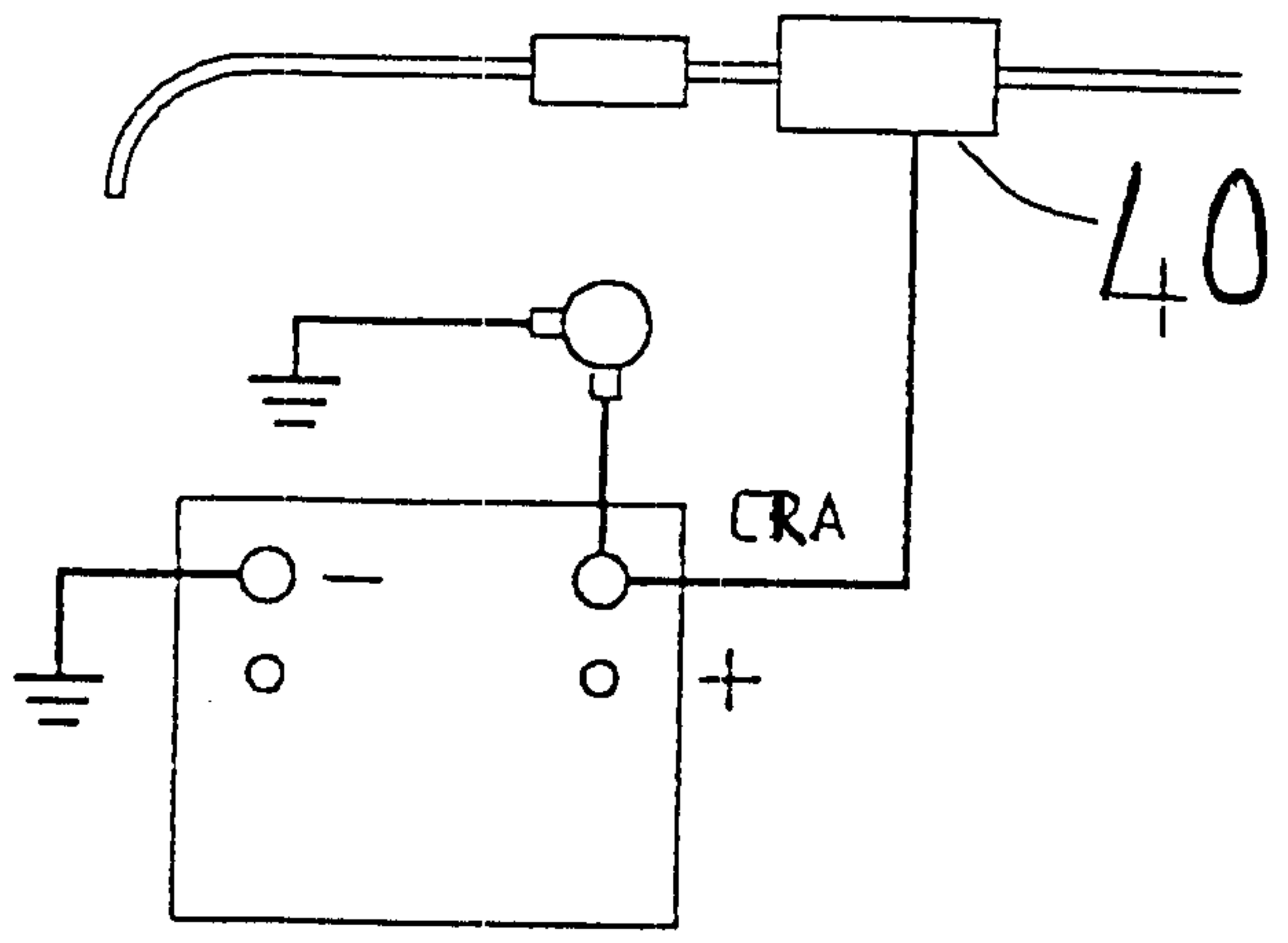


Fig 9

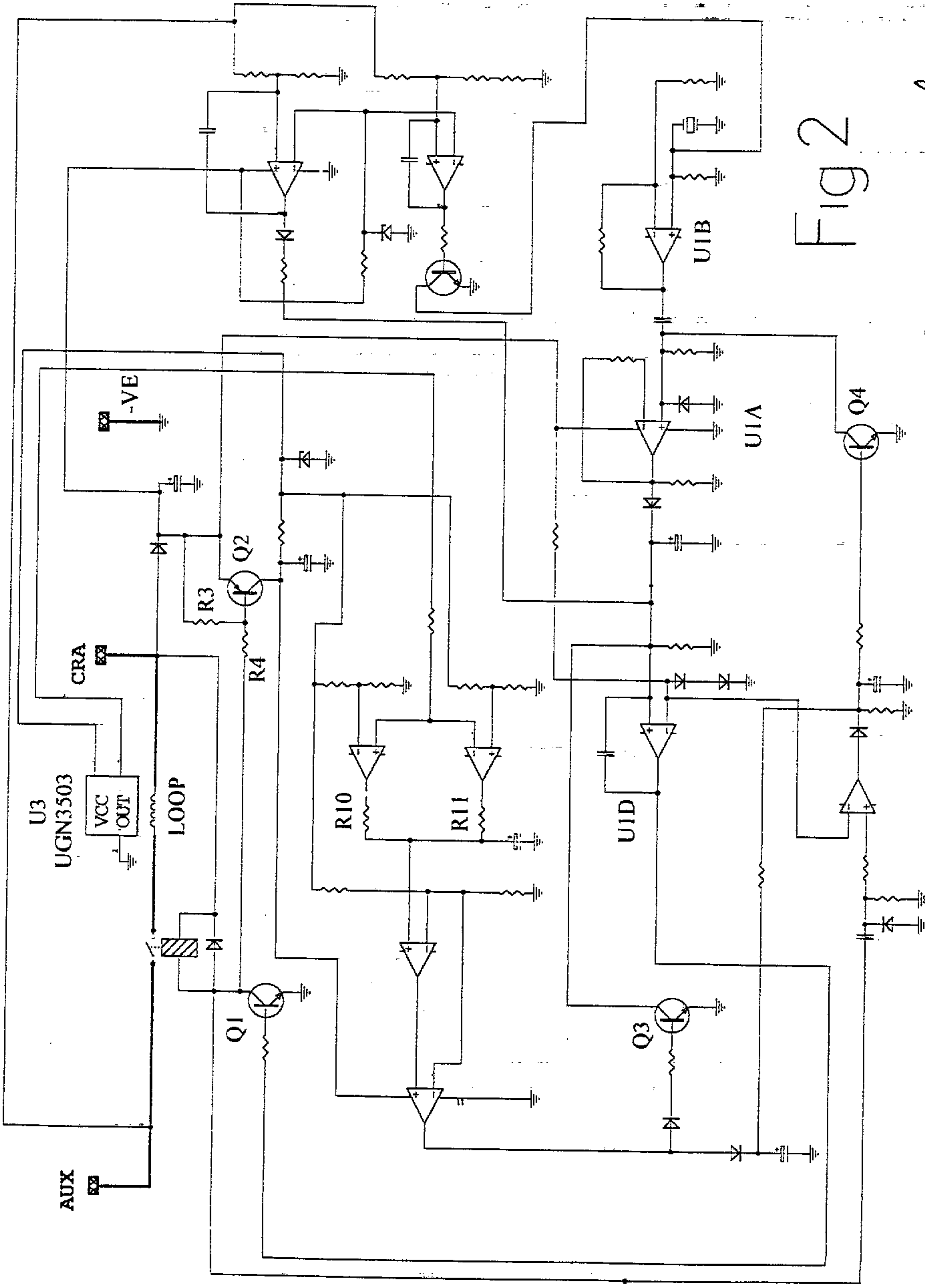


Fig 2

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Fig 3

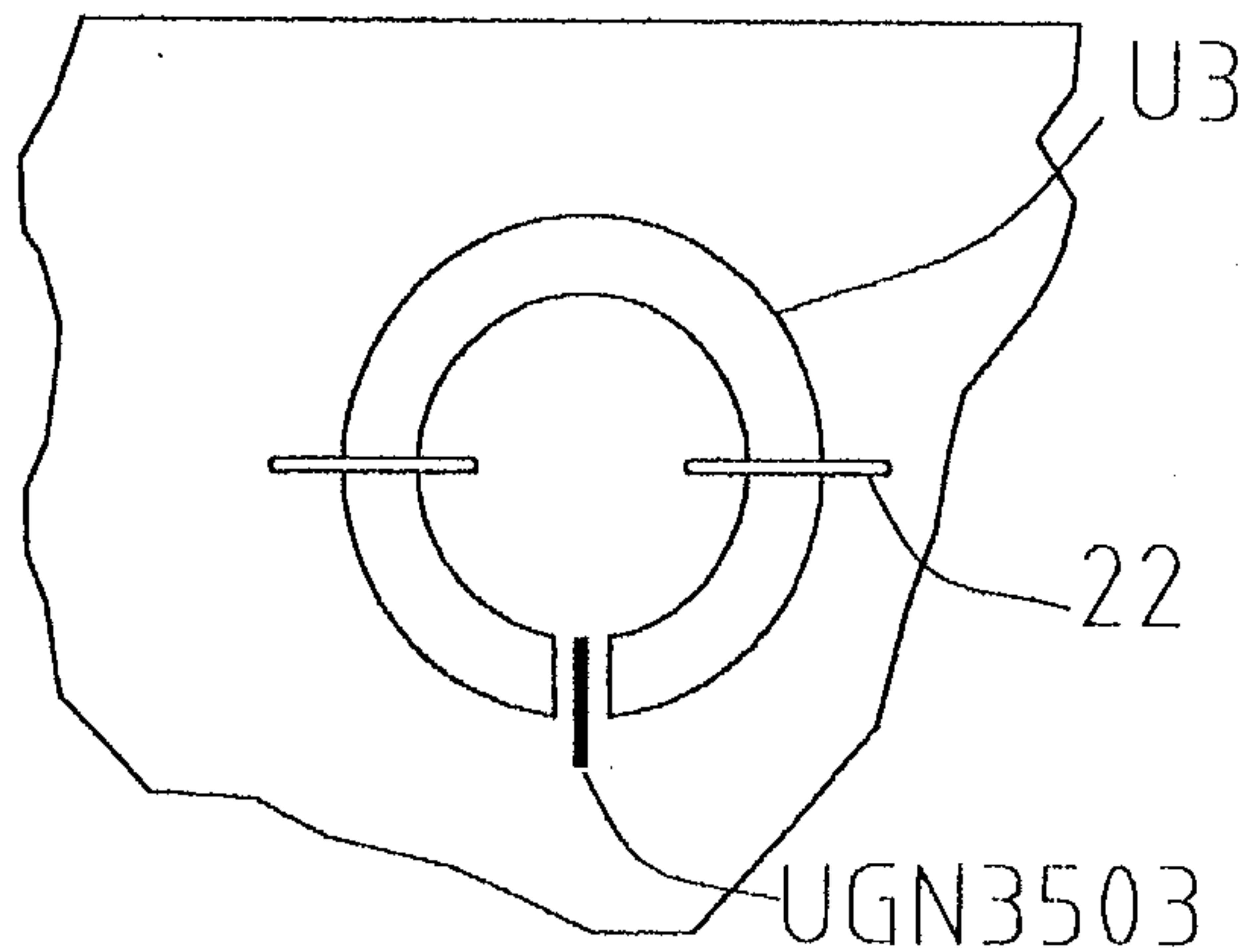
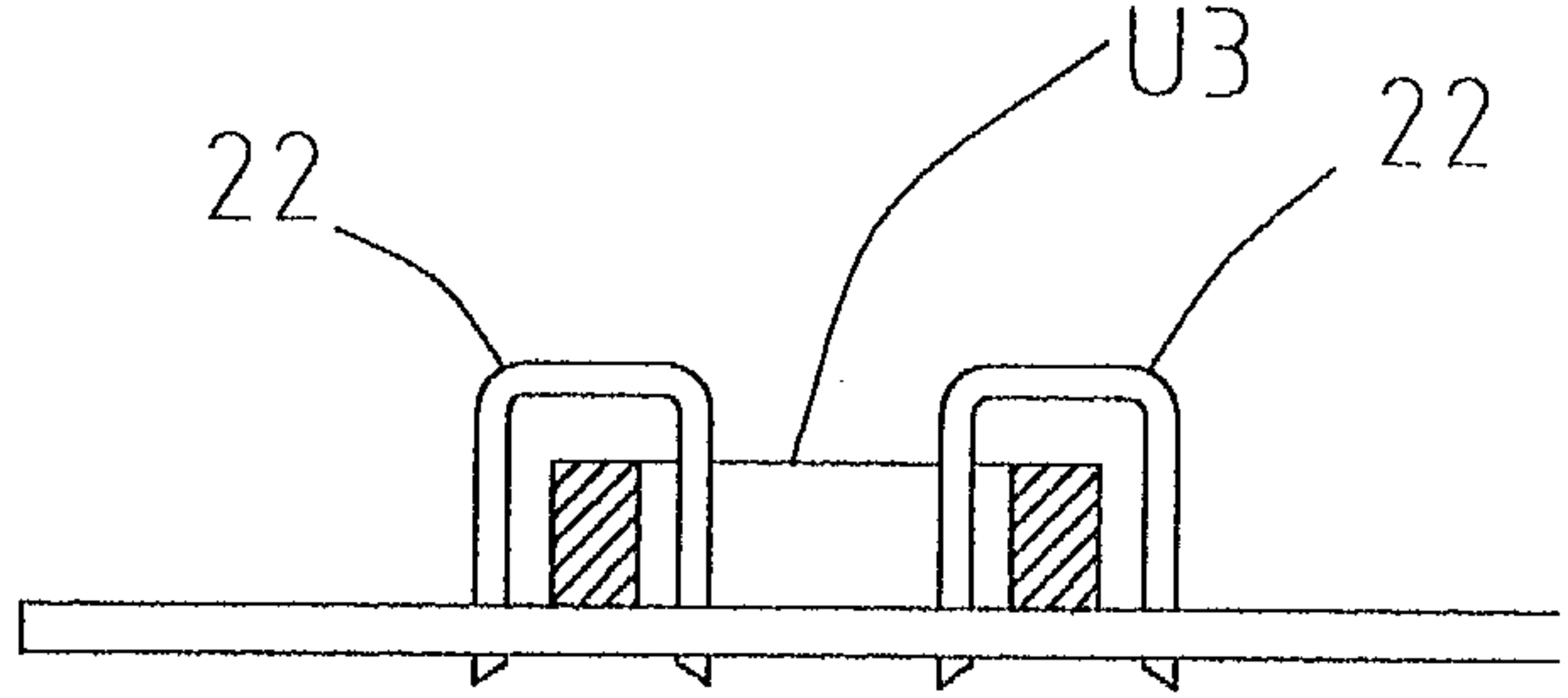



Fig 4

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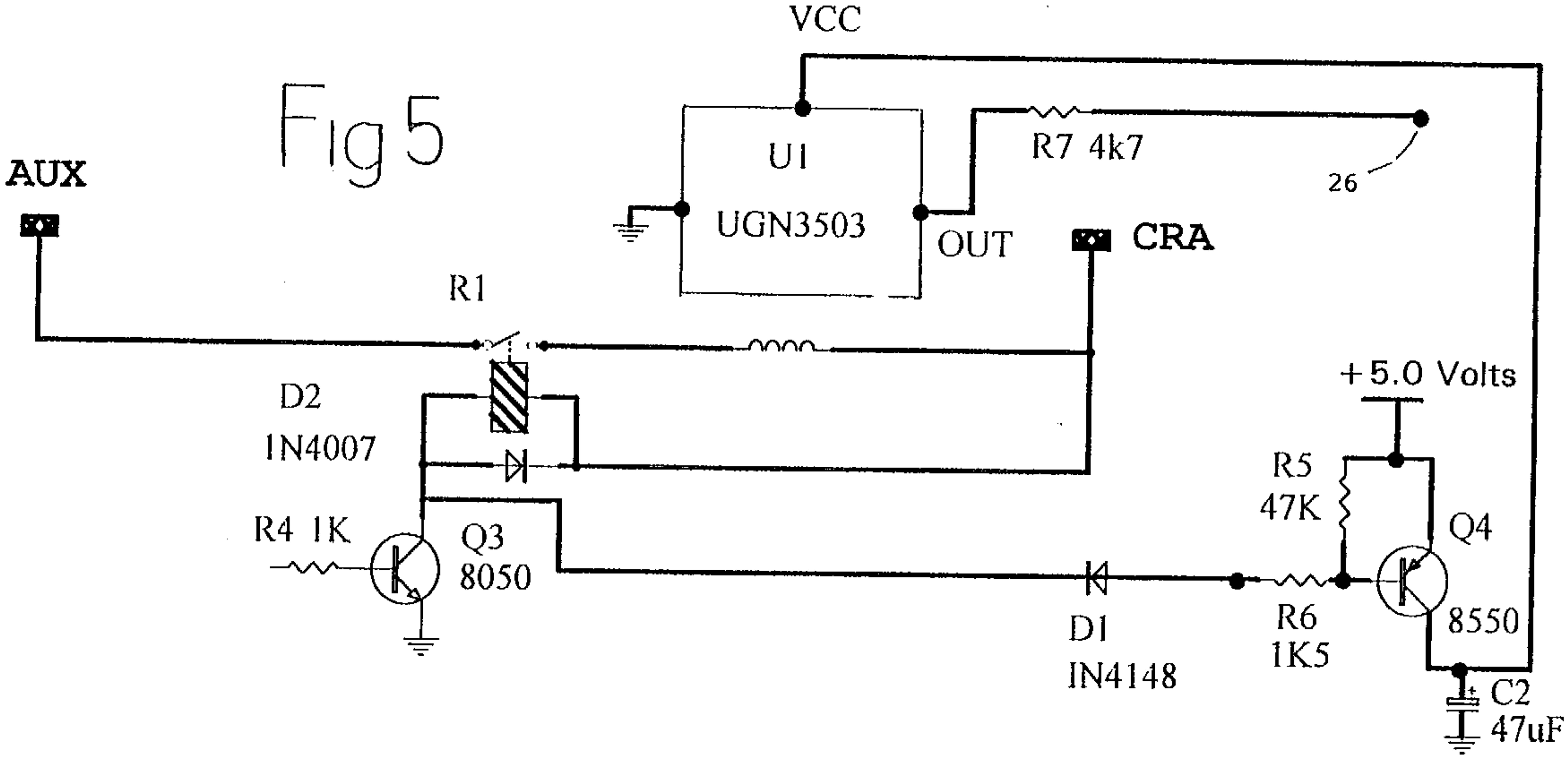


Fig 5

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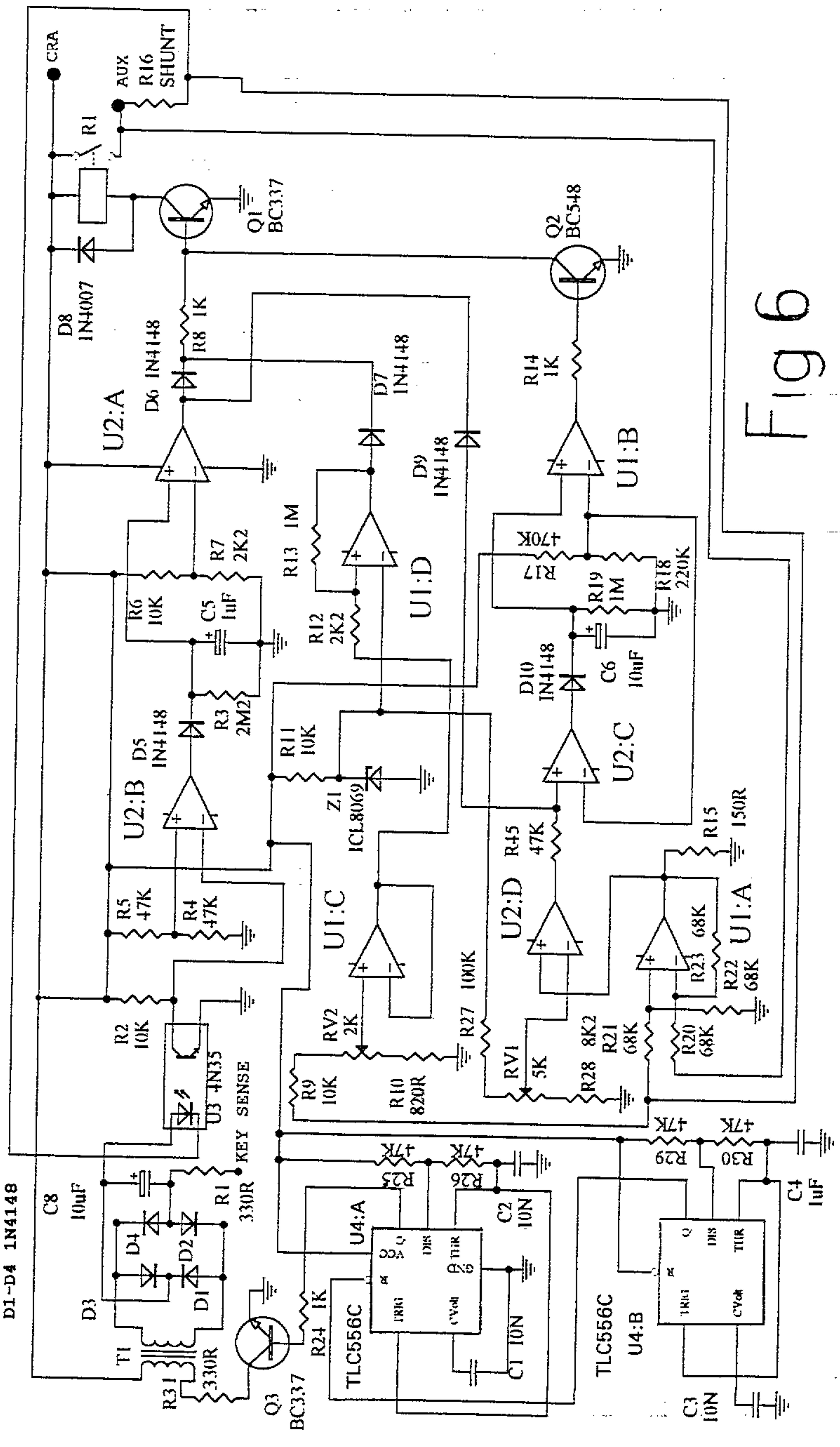


Fig 6

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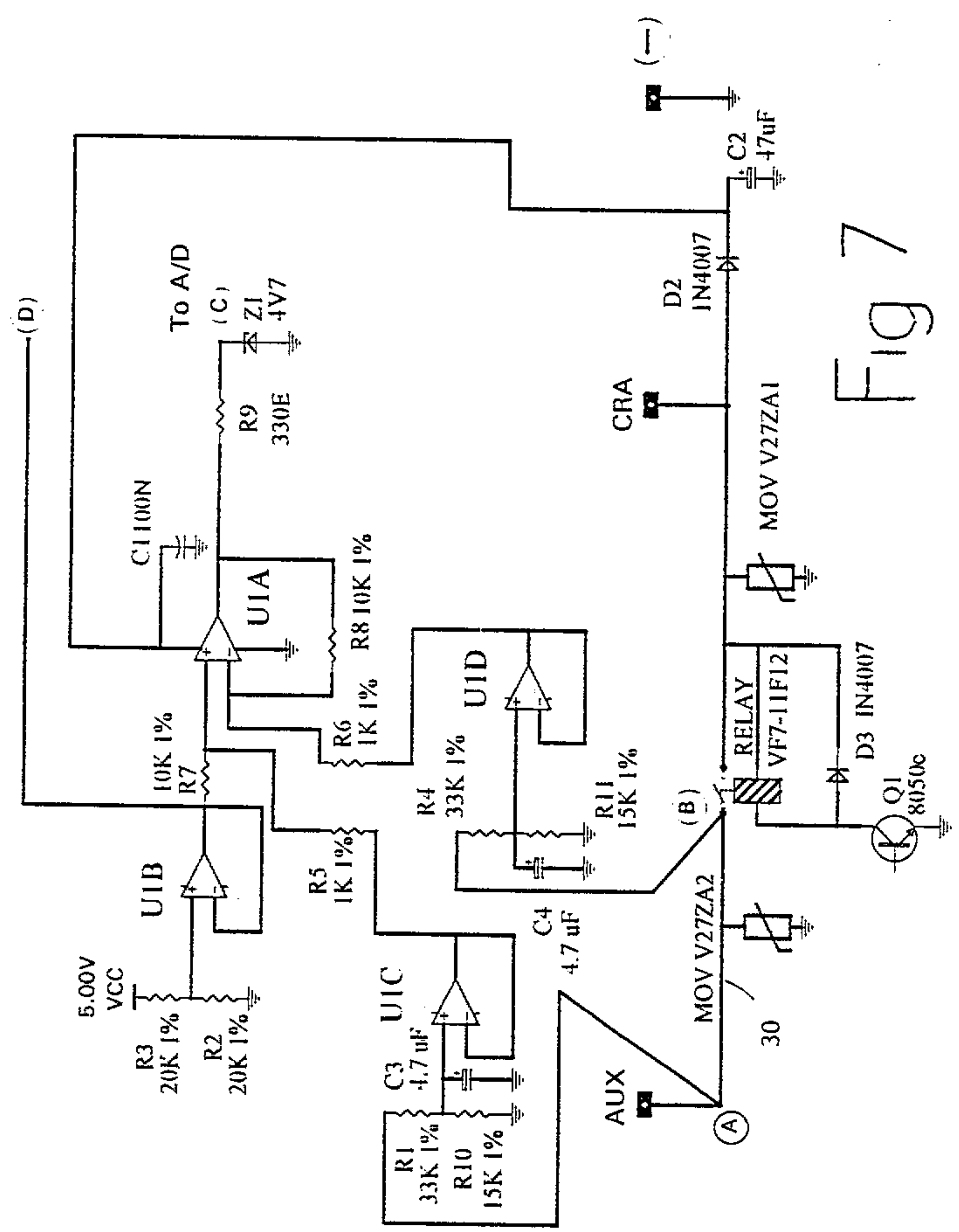


Fig 7

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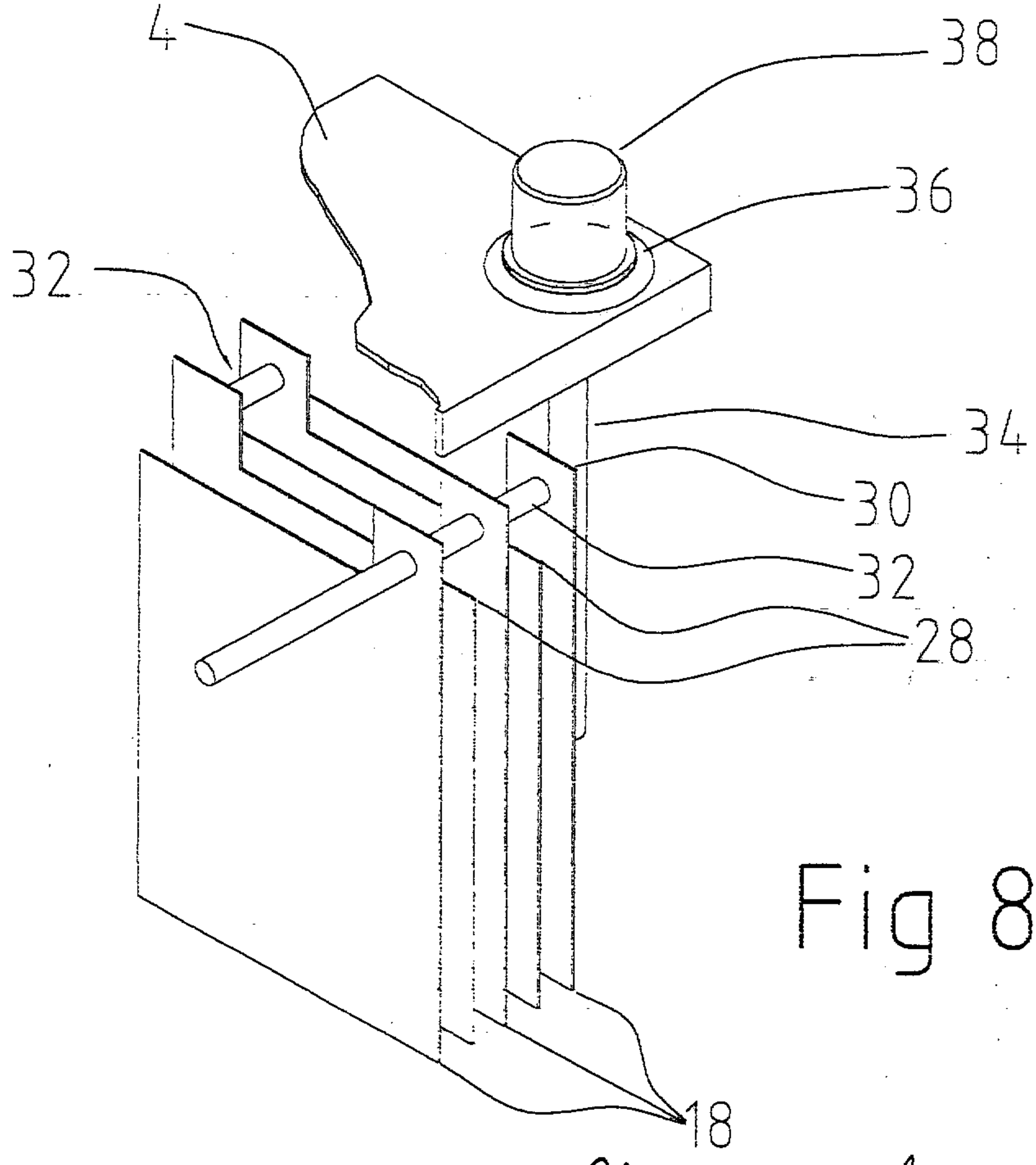


Fig 8

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