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G1N
G1U

(54) Portable magnetic field detector

(57) A portable magnetic field detector comprising a hall effect magnetic field sensor IC1 providing an output the polarity of which is dependent upon the direction of a magnetic field to which it is exposed. Circuitry detects when the sensor output exceeds a predetermined threshold, and the polarity of the sensor output when the threshold is exceeded. An indicator 1,2 provides a first output indication representative of an alternating magnetic field when the detected polarity alternates and a second output indication representative of a direct magnetic field when the detected polarity is stable.

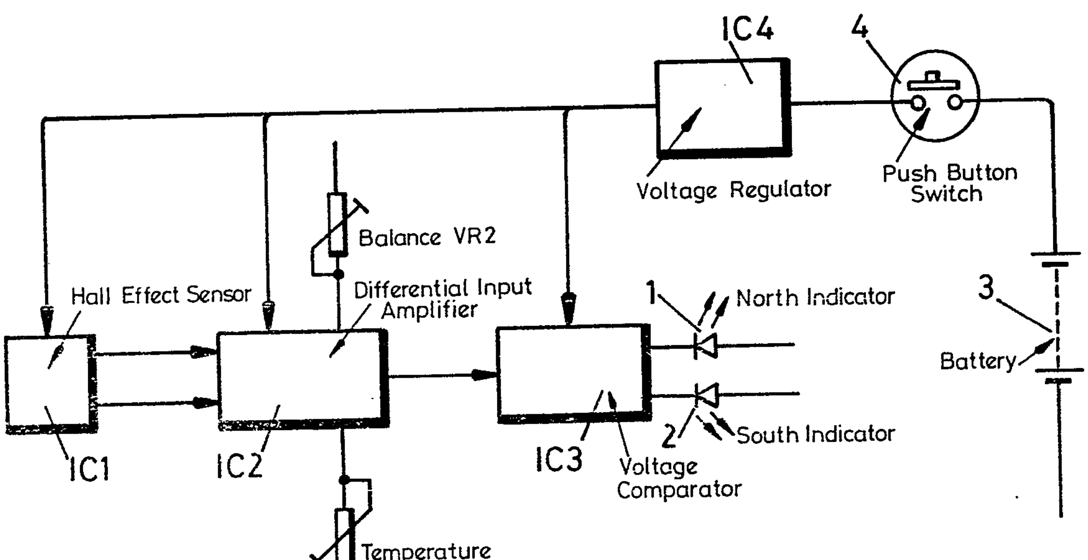

FIG.4

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The drawings originally filed were informal and the print here reproduced is taken from a later filed formal copy.

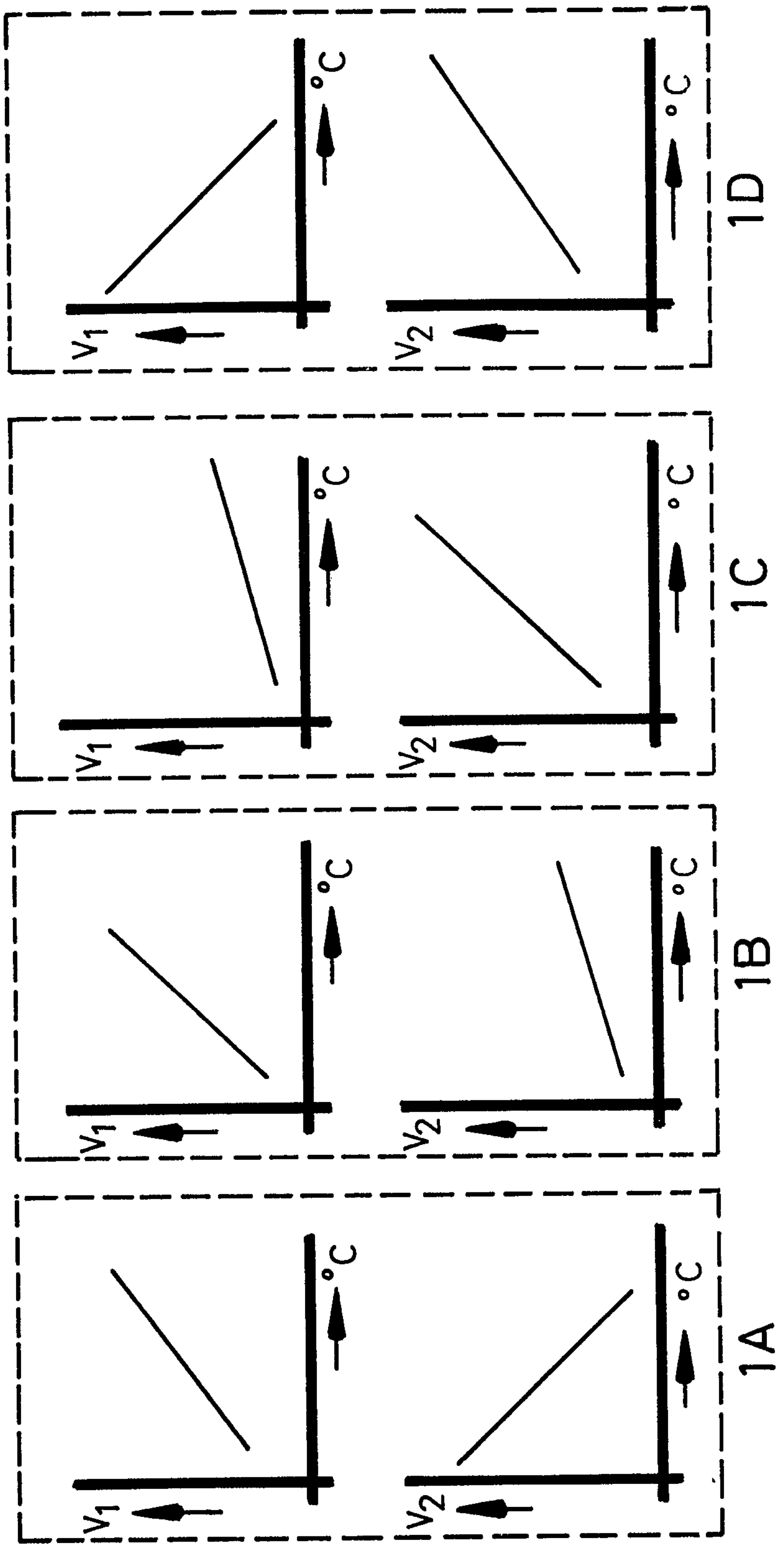

FIG. 1

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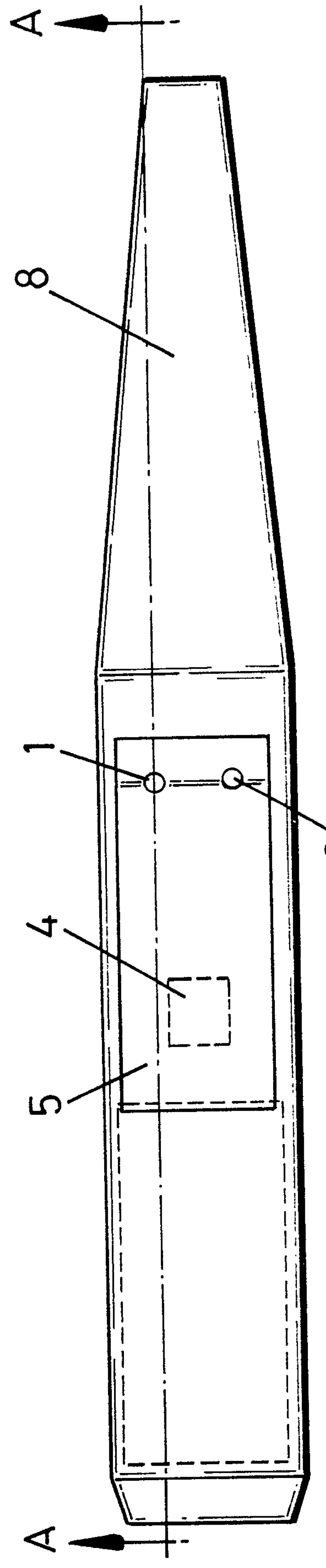

FIG. 2

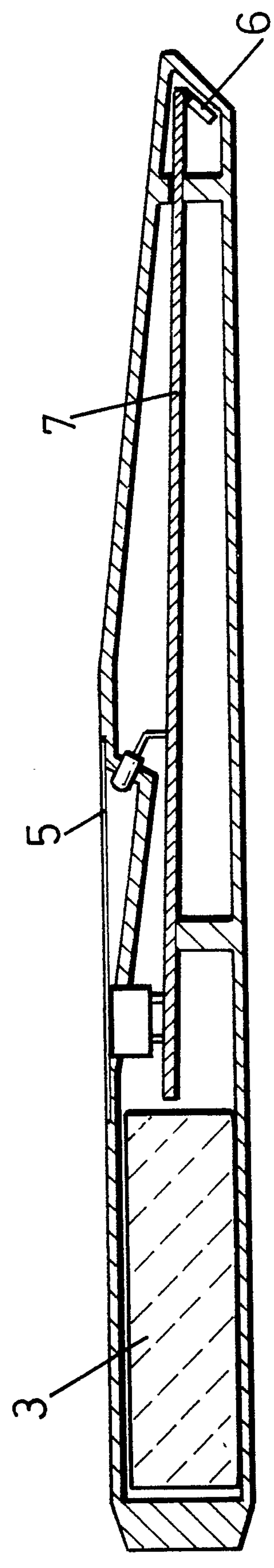

FIG. 3

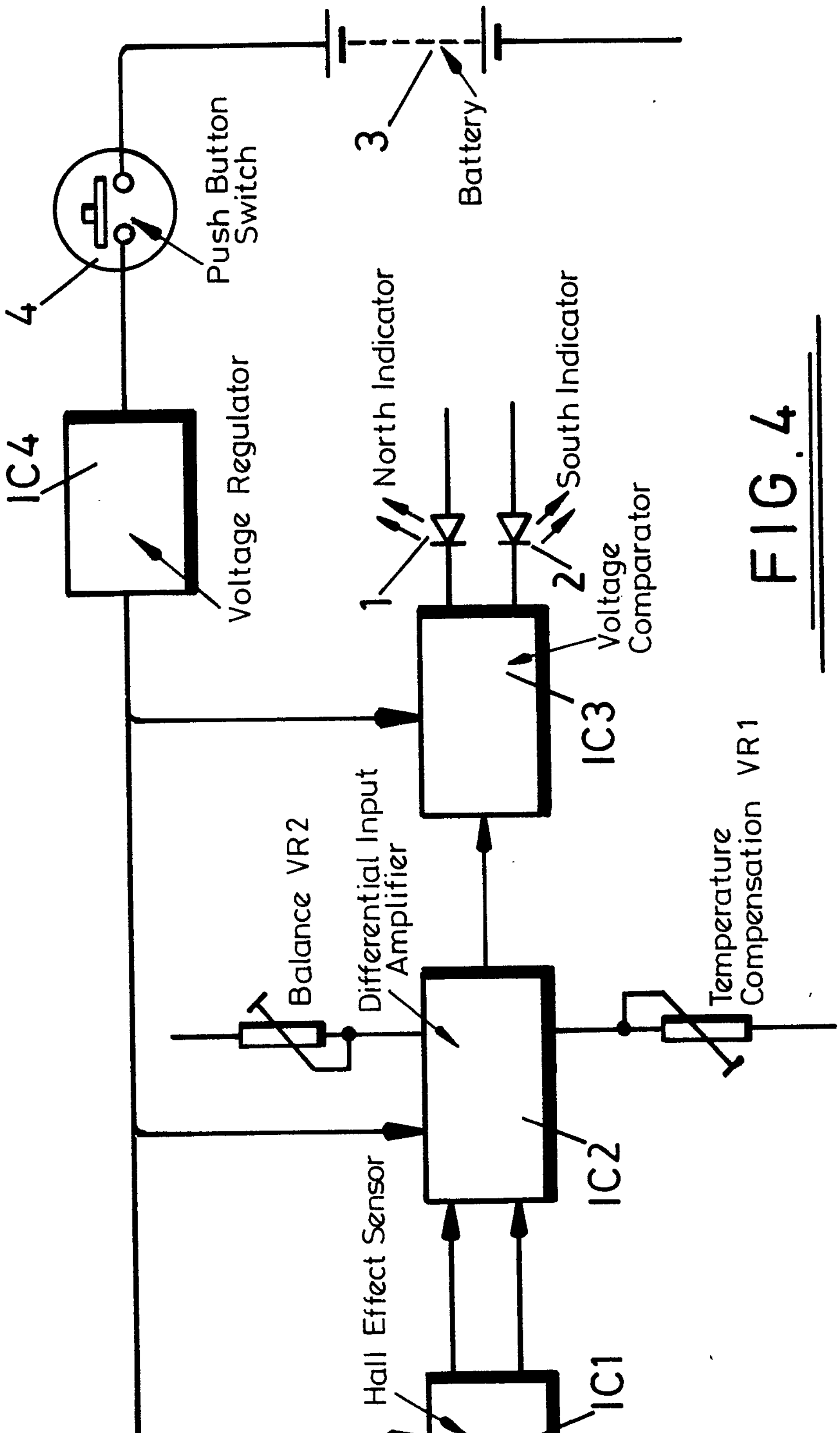
Push Button Switch
4
3
Battery
IC4
Voltage Regulator
North Indicator
South Indicator
1
2
Voltage Comparator
IC3
Balance VR2
Differential Input Amplifier
Temperature Compensation VR1
IC2
Hall Effect Sensor
IC1

FIG. 4

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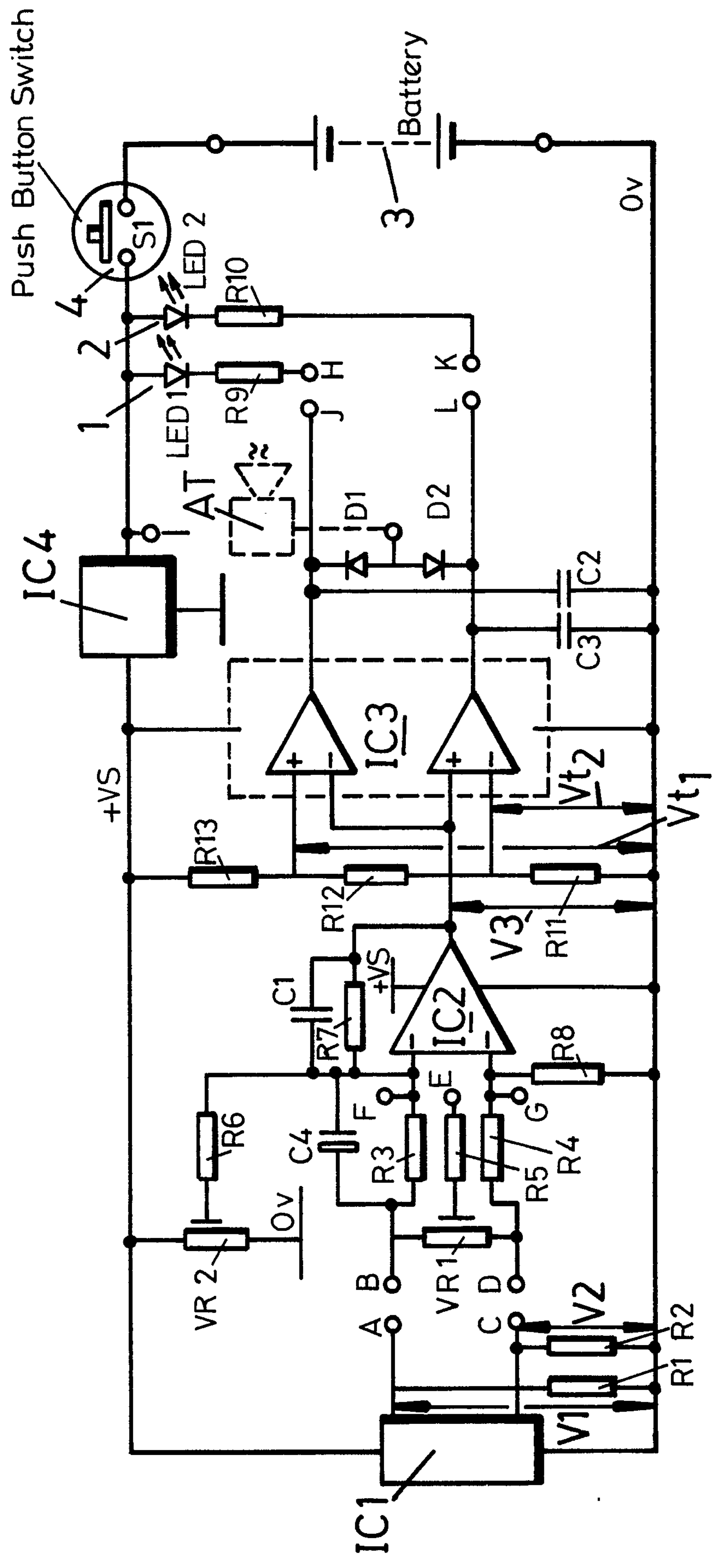

FIG. 5

SPECIFICATION

A portable magnetic field detector

The present invention relates to a portable magnetic field detector.

Weak electric fields are generated in the vicinity of a variety of equipment, for example electrical, electronic, electro-pneumatic and electro-mechanical equipment. It would be useful to be able to detect such fields with a hand held instrument so as to for example diagnose faults in the equipment and in addition it would be useful to have a hand held instrument which could determine the polarity of magnetic fields resulting from electro-magnetic effects or the presence of permanent magnets.

It is known to use hall effect devices to detect the presence of magnetic fields but it is well known that with such devices the characteristics of individual sensors all produced with nominally the same characteristics can in fact vary significantly from one sensor to another. For this reason it is standard practice when packaging hall effect devices to provide associated bias circuits which effectively render the sensors insensitive to very weak fields. Furthermore it is well known that the output characteristics of the known hall effect sensors vary significantly with temperature to a degree sufficient to effectively swamp the response of the sensor to small changes in magnetic fields.

A hall effect sensor could be used with a direct current blocking capacitor which would be effective to separate the effects of an alternating magnetic field from the effects of temperature changes so that at least in the case of alternating magnetic fields the problems of the variations of output with temperature can be overcome. However if one is concerned solely with the detection of small alternating magnetic fields it would be possible to use an inductive magnetic field sensing method rather than a relatively complex hall effect device.

For the reasons set out above it has not been thought possible to produce a portable magnetic field sensor based on hall effect technology and the only practical way of detecting direct (that is to say non-alternating) weak magnetic fields has been the use of a conventional compass. Such a device cannot be used in a wide range of positions however.

It is an object of the present invention to provide an improved portable magnetic field detector incorporating a hall effect sensor.

According to the present invention, there is provided a portable magnetic field detector comprising a hall effect magnetic field sensor providing an output the polarity of which is dependent upon the direction of a magnetic field to which it is exposed, means for detecting when the sensor output exceeds a predetermined threshold, means for detecting the polarity of the sensor output when the threshold is exceeded, and an indicator responsive to the polarity detecting means to provide a first output indication representative of an alternating magnetic field when the detected polarity alternates and a second output indication representative of a direct magnetic field when the detected polarity is stable.

Preferably, the indicator comprises two indicator devices one of which is activated when one polarity is detected and the other of which is activated when the other polarity is detected, whereby an alternating field is indicated by activation of both the indicator devices.

Preferably, a temperature compensating network is incorporated in the device for adapting the temperature related characteristics of the hall effect device to the detecting means. The temperature compensating network can comprise a series of resistors connected between the hall effect device and a differential amplifier. The output of the differential amplifier is applied to a voltage comparator which compares the amplifier output with the output of a high stability voltage regulator to determine the polarity of the amplifier output.

Embodiments of the present invention will now be described, by way of example, with reference to the accompanying drawings, in which:

Figure 1 is a schematic representation of the different outputs which can be expected from nominally identical hall effect devices;

Figure 2 is a view from above of the casing of an embodiment of the present invention;

Figure 3 is a section on the line A-A of Figure 2;

Figure 4 is a schematic block diagram of the circuitry incorporated in the embodiment of Figures 2 and 3; and

Figure 5 is a more detailed schematic illustration of the circuit illustrated in block form in Figure 4.

The embodiment of the invention described hereinafter uses a hall effect device providing two voltage outputs one of which increases with an increase in magnetic flux whilst the other decreases with an increase in flux. Typically the gradient of the two output voltages is one volt per thousand gauss. The output voltage is however variable with temperature and Figures 1A to 1D illustrate the way in which the two output voltages V1 and V2 of four nominally identical hall effect devices vary with temperature. It is necessary to take account of these variations in output voltage with temperature when one is concerned with measuring weak magnetic fields as the change in voltage with temperature is of the same order of magnitude as the change in voltage with weak fields of for example ten gauss.

Referring now to Figures 2 and 3, the physical construction of an embodiment of the invention is illustrated.

The instrument has two solid state indicator lamps 1 and 2 designated north and south. In the presence of an alternating electro-magnetic field such as that which may be produced by a transformer or other inductive alternating current carrying component, both lamps are illuminated with equal intensity. In the presence of a steady unchanging field such as that which may be produced by a direct current solenoid, only one lamp will be illuminated, the magnetic polarity indicated being dependent on the direction of current flow through the solenoid.

Standard manufacture electronic components and integrated circtuis are assembled onto a printed circuit board 7 and the whole encased by a "styled" enclosure 8.

The enclosure is profiled to converge to a wedge shaped point at which a hall effect sensor 6 is internally situated and positioned to provide an ergonomic design which maximises viewing capability of 1 and 2 and magnetic field performance of the sensor 6 in normal envisaged use.

Power to the circuit is derived from a user accessible battery 3 fitted within the case and is applied momentarily for a desired duration using a push button switch 4. The switch is actuated by applying thumb pressure onto the surface of a thin plastic-type membrane 5 which covers both the switch 4 and the indicator lamps 1 and 2. The printed membrane 5 serves as a splashproof panel and is designed, using techniques known to those in the art, to be part opaque and part translucent.

Referring now to Figure 4, the circuitry of the device comprises four integrated circuits of standard manufacture:

ICI (type 634552 from Honeywell): a linear differential output hall effect position sensor;

IC2 (type CA 3140 from RCA): an operational voltage amplifier, configured as a differential input amplifier;

IC3 (type LM 393 from National Semiconductor): a dual voltage comparator, configured to detect and display upper and lower input voltage transitions about a known centre value; and

IC4 (type 78 LO5 from National Semiconductor): a precise voltage regulator.

I would be possible to further integrate the functions of IC2, IC3 and IC4 into one custom made integrated circuit.

Referring now to Figure 5, the circuit of Figure 4 is illustrated in more detail. When the device is first manufactured, it is necessary to tailor the circuitry to the particular characteristics of the sensor ICI. If VI is greater than V2, terminals A and D are connected and terminals C and B are connected. If V1 is less than V2, terminals A and B are connected and terminals C and D are connected. This matches the outputs V1 and V2 to the inputs of IC2. Thereafter, terminals E and F are connected and resistors VR1 and VR2 are adjusted to give a zero output at a first set temperature, e.g. 0°C. The temperature is then increased to a second set level, e.g. 50°C and the resistors VR1 and VR2 are re-adjusted, the process being repeated until one setting of the resistors is effective at both temperatures. If this cannot be done, terminals E and G are connected rather than terminals E and F and the process is repeated until a satisfactory setting of the resistors is achieved.

Appropriate connections to terminals A, B, C, D enable different hall effect sensors to set up correct input voltage conditions for IC2 to act as a biasedoutput single-ended differential input linear voltage amplifier with variable input bias control effected by VR2. The range of bias adjustment is set by R6 and allows for the worst case difference between V_1 and V_2.

The connections made to terminals E, F, G, coupled with VR1 and R5 allows IC2 to analogically adjust, within the scope of normal operational amplifier theory employing negative feedback, for the four relative conditions of the hall effect sensor likely to be encountered within the specification of the manufacturer as illustrated in Figure 1.

The "setting-up" procedure described above achieves means stability for voltage V_3 (Figure 5) over the desired temperature range in conditions of zero gauss.

To further eliminate anomalous "north" or "south" weak magnetic field readings caused by small variations in the characteristics of the circuitry (which small variations are brought about by hall effect tracking non-linearities) the resultant voltage V_3 is applied to the input of IC3. IC3 is a circuit which detects positive or negative voltage excursions of V_3 above or below present thresholds V_{t1} and V_{t2}. The threshold limits are set by R_{11}, R_{12} and R_{13}. Within a few millivolts of V_t, the comparator switches its appropriate current sinking output "on" and allows current to flow through the output indicating device 1, 2.

IC4 is employed to provide a stable reference voltage supply for use within the circuit which would otherwise suffer from the unbalancing effects of a changing battery supply voltage, a condition which raises during normal use. In additon the parameters of IC4 are such that when the battery voltage drops below an inherent threshold level, its output reference voltage falls sharply to approximately that of the exhausted battery. An unbalanced condition is then created within the circuit which manifests itself as a visual indication on one output indicator lamp.

Terminals H, J, K, L are connection nodes within the circuit to provide for wire links between HJ and KL or between HL nd KJ. The choice is dependent on the manner in which ICI was initially connected. This facility serves to reference a magnetic pole indicator to either the left or right hand side of the instrument case so that regardless of the output characteristic of the hall effect sensor fitted, the user would at all times be presented with consistent outputs.

The optimum sensitivity to magnetic fields is normally internally fixed and chosen by careful judgement as being a compromise between the function that it was intended to fulfil with consideration of field proximity and distance effects, and its required operating temperature range.

Static field sensitivity is determined by the ratio of resistors R_3 and R_7 or by the adjustment of the upper and lower detection threshold limits which are set by R_{11}, R_{12} and R_{13}.

Dynamic field sensitivity may be separately determined by the reactance of capacitor C_4 which serves to increase the voltage gain of the differential input amplifier with frequency (by reducing its input impedance) in accordance with normal operational amplifier theory employing negative feedback.

By virtue of the charge storage effect, capacitor C_4 also serves to provide the instrument with a 'health status' indicator check pulse at switch on. Such a feature instills confidence in the user, verifies that the instrument has been properly activated by a healthy battery, and quickly checks that the hall effect sensor has powered-up and that the following stages are functioning in response to that immediate condition.

Capacitor C_1 "rolls off" the dynamic gain of the differential input amplifier at high frequencies and by doing so prevents erroneous responses due to electrical noise.

Capacitors C_2 and C_3 assist to minimise locally generated electrical noise which may be produced by rapid current switching at the voltage comparator outputs.

Diodes D1 and D2 perform the boolean "wired-or" function and provide a common curent sinking output whch may be used to give an audible alarm in the presence of a magnetic field of either polarity. An audible transducer AT may be fitted inside the instrument or plugged in externally.

Resistors R_9 and R_{10} limit the current flowing through the light emitting diodes to a permitted value within the range of the device which gives useful light output intensity for maximum battery life.

LED1 and LED2 are intensity matched visible light emitting diodes used to provide the indication of magnetic polarity e.g. north or south.

CLAIMS

1. A portable magnetic field detector comprising a hall effect magnetic field sensor providing an output the polarity of which is dependent upon the direction of a magnetic field to which it is exposed, means for detecting when the sensor output exceeds a predetermined threshold, means for detecting the polarity of the sensor output when the threshold is exceeded, and an indicator responsive to the polarity detecting means to provide a first output indication representative of an alternating magnetic field when the detected polarity alternates and a second output indication representative of a direct magnetic field when the detected polarity is stable.

2. A portable magnetic field detector according to claim 1, wherein the indicator comprises two indicator devices one of which is activated when one polarity is detected and the other of which is activated when the other polarity is detected, whereby an alternating field is indicated by activation of both the indicator devices.

3. A portable magnetic field detector according to claims 1 or 2 comprising a temperature compensating network for adapting the temperature related characteristics of the hall effect device to the detecting means.

4. A portable magnetic field detector substantially as hereinbefore described with reference to the accompanying drawings.

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