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(54) **Potentiometer.**

(57) A potentiometer comprises a resistive first track (1) with first and second terminals (2, 3) to which a voltage is applied. A conductive wiper (5) traverses the first track and is connected to a third terminal (7) to provide an analogue output signal dependent on the position of the wiper. A conductive second track (8) has discrete insulating regions (9) along its length and is provided with a fourth terminal (10). The wiper (5) also traverses this second track (8). It is arranged that sharply defined transitions in electrical output (logic transitions) occur at the fourth terminal (10) as the wiper (5) traverses boundaries between the insulating regions (9) and the second track (8). The analogue output from the third terminal (7) at positions of the wiper (5) where the output transitions at the fourth terminal (10) occur, provide calibration points to permit accurate relating of the wiper position to the output from the third terminal (7) at any location between the calibration points. Particularly applicable to position sensing, e.g. in engine management systems.

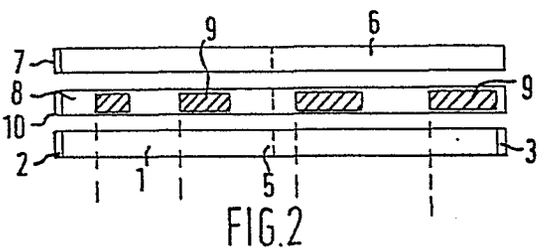

FIG.2

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POTENTIOMETER

This invention relates to potentiometers of linear and rotary type, in which an electrically conductive wiper is arranged to traverse an electrically resistive track, a voltage being applied to terminals at opposite ends of the track. An analogue output voltage is obtained from a terminal associated with the wiper, the magnitude of this voltage being a function of the position of the wiper along the track.

It is often necessary to employ potentiometers of this type in applications where the wiper output voltage is used to derive the position of the wiper or, more specifically, the position of an external device connected to the wiper. A particular application is in the automotive field where there is an increasing requirement to monitor accurately the angular position of a throttle or butterfly in the induction manifold of an engine as part of a microprocessor controlled engine management

system. It is known to use for this purpose a rotary potentiometer in which a shaft rotating with the throttle or butterfly is connected to the rotatable wiper carrier of the potentiometer. The resistive track of a potentiometer is designed to provide a particular law which defines the relationship between the output voltage from the wiper and the extent of linear or angular displacement of the wiper from one end of the track. It is well known to provide electrically resistive tracks in the form of films deposited onto suitable electrically insulating substrates. Such tracks may, for example, comprise electrically conductive polymer materials deposited by screen printing methods. The law accuracy of such tracks depends upon a number of variables related to their deposition.

In practice, if a track is deposited aimed at providing a particular law, errors in the deposition process leading, for example, to non-uniformities in the track will result in reduction in the law accuracy. This means that if the voltage output at the wiper is being used to provide an indication of the position of the wiper, or of some mechanical component or device connected thereto, and theory predicts that a particular voltage will relate to a particular position of the wiper, in practice the wiper may not be exactly at the predicted position when that particular output voltage is recorded. Such errors in determining the wiper position are undesirable. Furthermore, it may happen that after the potentiometer has been in service for some time, wear which occurs in the track as a result of the action of the wiper can also lead to further errors of this nature.

It is an object of the present invention to provide an economical means to minimise or overcome the aforementioned disadvantages.

The present invention provides a potentiometer comprising an electrically resistive first track provided with first and second electrically conductive terminals at

opposite ends thereof adapted to have a voltage applied thereto; a wiper of electrically conductive material arranged to traverse said first track; a third electrically conductive terminal connected to said wiper and adapted to provide an analogue output signal of magnitude dependent upon the position of said wiper on said first track; said potentiometr being characterised in that an electrically conductive second track is provided having a plurality of discrete electrically insulating regions in predetermined spaced relationship along the length thereof so that boundaries between the insulating regions and the second track define predetermined known positions therealong, a fourth electrically conductive terminal being provided at an end of said second track; said wiper or a further wiper in ganged relationship therewith, being arranged to traverse said second track; the arrangement being such that upon movement of said wiper or wipers, sharply defined transitions in electrical output occur at said fourth terminal as the wiper or further wiper traverses the boundaries between said insulating regions and said second track. The analogue output signals from said third terminal at positions of said wiper or wipers where said transitions in output occur at said fourth terminal suitably provide calibration points to enable the output signal from the third terminal to be accurately related to the position of the wiper or wipers at any location between said calibration points.

The said insulating regions may comprise areas in which conductive material is absent or may comprise insulating material deposited on said second track. The said first and second tracks are suitably each provided in the form of films deposited onto an electrically insulating substrate. Suitably said films comprise conductive polymer materials and may be deposited by screen printing techniques.

The electrical output from the fourth terminal is effectively in the form of logic transition signals. The

logic and analogue components of the potentiometer suitably complement each other. The analogue component may provide information as to which particular insulating region is involved in the signalling of a logic output. The logic component may provide calibration positions or in a rotatory potentiometer angles and so enables the angle relating to the electrical output from the potentiometer to be known with a greater degree of precision than could be deduced from the output of an uncorrected potentiometer used on its own. The potentiometer may provide a linear or non-linear law and benefit in either case from the addition of the logic, ie second, track. The logic component of the potentiometer is, in effect, an incremental encoder, designed to have a resolution that is greater than the worst case of law linearity tolerance of the associated analogue potentiometer component. This arrangement endows an incremental- encoder with absolute encoder characteristics during the logic transitions. The resulting system provides calibration angles for the incremental encoder.

It is also within the scope of the invention for the second track to be arranged for switching on or off (i.e. controlling) external equipment according to the position of the wiper or ganged wipers and the fourth terminal being appropriately connected to the equipment for this purpose.

A plurality of the said second tracks, each with its own said fourth terminal may be provided if desired. An example of such an arrangement could be a combined potentiometer and plural-bit encoder, e.g. a Gray encoder, the number of second tracks and arrangement of insulating and conducting regions thereon being selected according to the number of bits and the bit sequence required.

The invention is described by way of example with reference to the accompanying drawing in which:

Figure 1 is a circuit diagram representation of a

potentiometer according to the invention;

Figure 2 is a representation of essential components of an embodiment of potentiometer according to the invention;

Figure 3 is a graph illustrating the analogue output signal as a function of wiper position for the potentiometer of Figure 2.

Figure 4 illustrates the sharply defined transitions in electrical output as a function of wiper position provided in the potentiometer of the invention and used for calibration purposes.

A potentiometer, which may be of rotary or linear form comprises an electrically resistive first track 1 (e.g. of screen printed electrically conductive polymer material) provided with first and second electrically conductive terminals 2 and 3 at opposite ends thereof adapted to have a voltage applied thereto from a source 4 (Figure 1). A resilient wiper 5 of electrically conductive material is arranged to traverse the first track 1 and pick-up conductor 6 (e.g. a slip ring in the case of a rotary potentiometer) which is connected to a third terminal 7. An analogue output signal is obtained at terminal 7 of magnitude dependent upon the position of the wiper 5 on the track 1.

An electrically conductive second track 8 (.e.g. of screen printed electrically conductive polymer material) is provided adjacent the first track 1 and provided with a plurality of discrete electrically insulating regions 9 in predetermined spaced relationship along the length thereof, a fourth electrically conductive terminal 10 being provided at an end of this second track. The wiper 5 is arranged to traverse this second track 8 also. The insulating regions 9 may either comprise areas in which conductive material is absent, or may be formed by depositing (e.g. by screen printing) a suitable electrically insulating material on top of the conductive track 8. A high value pull-up resistor 11, e.g. having a

resistance value of about one hundred times that of the resistive first track 1, is connected between the terminal 10 and the voltage source 4.

Upon linearly or angularly displacing the wiper 5 along the tracks 1 and 8 (as indicated by symbol θ in Figures 3 and 4) according to whether the potentiometer is of linear or rotary type, sharply defined logic transitions in electrical output are seen at the fourth terminal 10 as the wiper traverses the boundaries between the insulating regions 9 and the second track 8. This is illustrated in Figure 4. The positions of the insulating regions and hence the transitions in electrical output at the fourth terminal 10 are related to known predetermined positions of the wiper 5. At the positions of the wiper 5 where the transitions in output occur at the fourth terminal 10 the analogue (i.e. voltage) output signals from the third terminal 7 provide calibration points (e.g. points A and B in Figure 3) to enable the output signal from the third terminal 7 to be accurately related by interpolation techniques to the position of the wiper 5 at any location (e.g. θ_1) between the calibration points.

By way of comparison with the prior art, if reference is made to Figure 3, a rotary potentiometer may have an actual output characteristic as indicated by the curved line although the expected characteristic would be the dotted ideal straight line. When the output voltage is V_1 with the prior art potentiometer it would be expected that the wiper would be at a position θ_2. However using the arrangement of the present invention and identifying the calibration points A and B, the correct angular position θ_1, of the wiper is deduced by interpolation.

Instead of using a single wiper 5 traversing tracks 1 and 8, a pair of separate ganged wipers could be used, a second pick-up conductor or slip ring similar to that denoted by reference numeral 6 being provided.

It is important to note that the equipment connected

at the fourth terminal 10 to sense the electrical output should be of high electrical impedance to minimise electric current drain at that terminal.

The potentiometer of the present invention is especially suitable for use in applications, such as engine management systems, involving microprocessor control.

In microprocessor applications it would be possible to store the angle and potentiometer output data of the logic transition points. The microprocessor will process this information and predict the voltage output for angular positions between the calibration points, thereby reducing the angular error tolerance of the measurement system.

A potentiometer according to the invention used with a measurement system with calculating ability would enable potentiometer tracks with large linearity errors, caused by track wear in prolonged service, to be linearised by interpolation techniques using the angular calibration signals.

CLAIMS:

1. A potentiometer comprising an electrically resistive first track (1) provided with first and second electrically conductive terminals (2, 3) at opposite ends thereof adapted to have a voltage applied thereto; a wiper (5) of electrically conductive material arranged to traverse said first track (1); a third electrically conductive terminal (7) connected to said wiper (5) and adapted to provide an analogue output signal of magnitude dependent upon the position of said wiper (5) on said first track (1); said potentiometer being characterised in that an electrically conductive second track (8) is provided having a plurality of discrete electrically insulating regions (9) in predetermined spaced relationship along the length thereof so that boundaries between the insulating regions (9) and the second track (8) define predetermined known positions therealong, a fourth electrically conductive terminal (10) being provided at an end of said second track (8); said wiper (5) or a further wiper in ganged relationship therewith being arranged to traverse said second track (8); the arrangement being such that upon movement of said wiper (5) or wipers, sharply defined transitions in electrical output occur at said fourth terminal (10) as the wiper (5) or further wiper traverses the boundaries between said insulating regions (9) and said second track (8).

2. A potentiometer according to Claim 1, in which the analogue output signals from said third terminal (7) at positions of said wiper (5) or wipers where said transitions in output occur at said fourth terminal (10) provide calibration points to enable the output signal from the third terminal (7) to be related accurately to the position of the wiper (5) or wipers at any location between said calibration points.

3. A potentiometer according to Claim 1 or 2, in which the said insulating regions (9) comprise areas in which conductive material is absent.

4. A potentiometer according to Claim 1 or 2, in which the said insulating regions (9) comprise insulating material deposited on said second track.

5. A potentiometer according to any preceding claim, in which the said first and second tracks (1, 8) are each provided in the form of films deposited onto an electrically insulating substrate.

6. A potentiometer according to Claim 5 in which said films comprise conductive polymer materials.

7. A potentiometer according to Claim 6 in which said films are deposited by screen printing.

8. A potentiometer according to any preceding Claim in which the electrical output from the fourth terminal is effectively in the form of logic transition signals.

9. A potentiometer according to any preceding claim, in which said second track is arranged for controlling external equipment according to the position of the wiper or ganged wipers, said fourth terminal being connected to said equipment.

10. A potentiometer according to any preceding claim in which a plurality of said second tracks is provided, each said second track having a said fourth terminal provided at an end thereof.

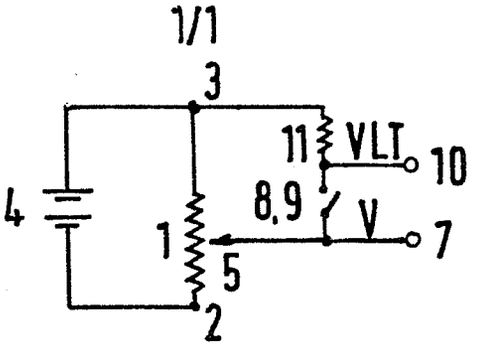

FIG.1

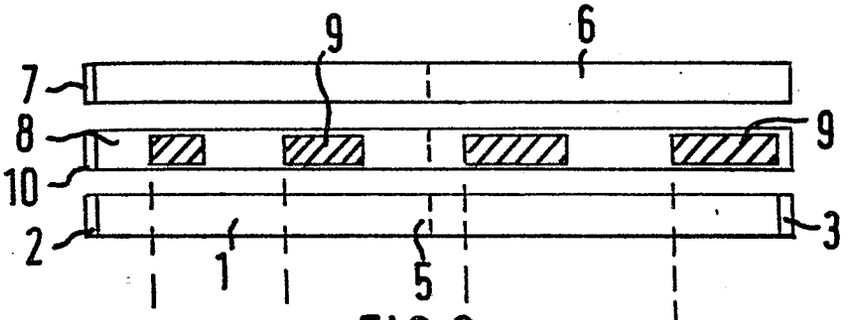

FIG.2

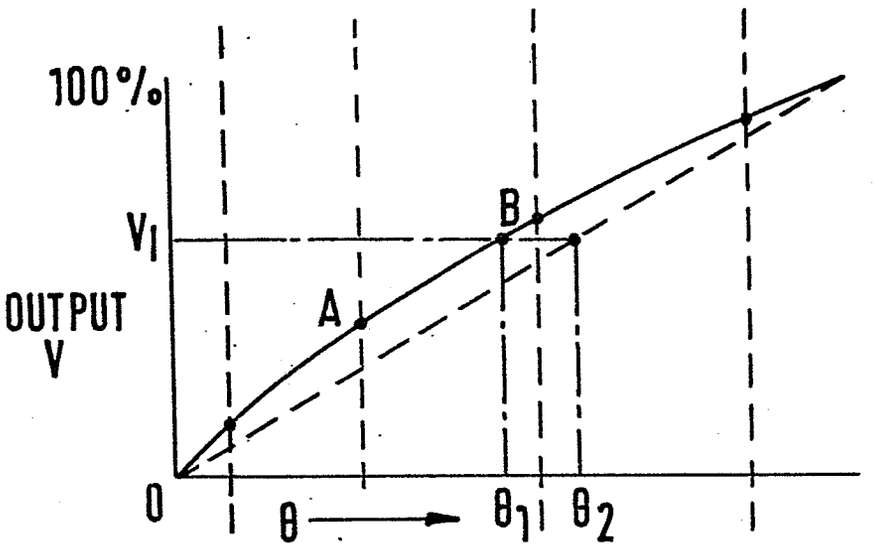

FIG.3

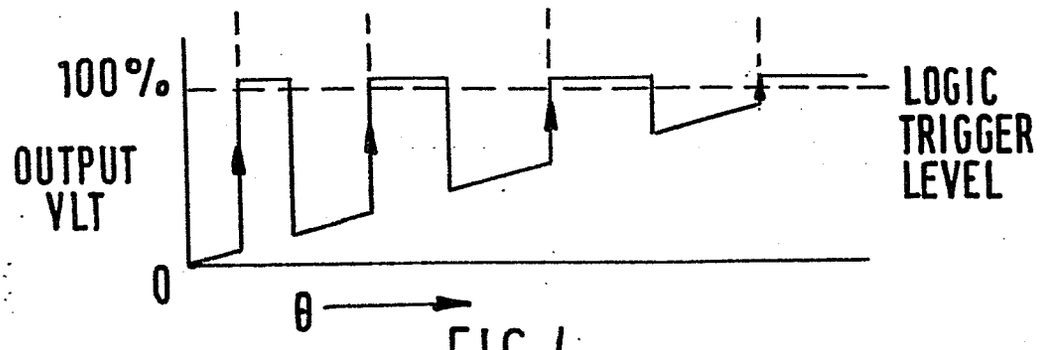

FIG.4

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EUROPEAN SEARCH REPORT

0118247
Application number

EP 84 30 1032

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl. ³)
A	US-A-3 679 848 (P.F. GERWITZ) * Claim 1; column 2, lines 57-70; figure 6 *	1,3,10	H 01 C 10/50 // F 02 D 35/00
A	FR-A-2 051 375 (MATSUSHITA ELECTRIC INDUSTRIAL CO.) * Claims 1,3; page 5, line 35 - page 6, line 4; figures 7,8 *	1,3,10	
A	DE-A-2 265 331 (ROBERT BOSCH GmbH) * Claim 1; page 8, second paragraph *	1,5,6, 7,9	

TECHNICAL FIELDS SEARCHED (Int. Cl. ³)

H 01 C
G 01 D

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	28-05-1984	DECANNIERE L.J.

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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