

[54] SHAFT ANGLE TRANSDUCERS

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[51] Int. Cl. G08c 21/00

[58] Field of Search 340/177 R, 177 VZ, 177 VA, 340/177, 176; 73/188; 335/207; 307/317; 323/94, 96, 97

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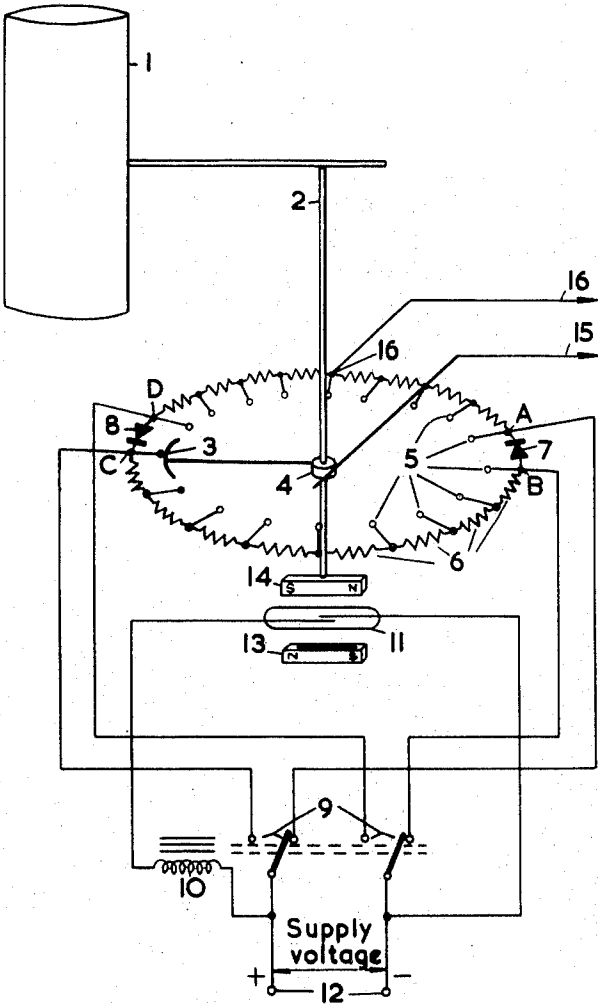
ABSTRACT

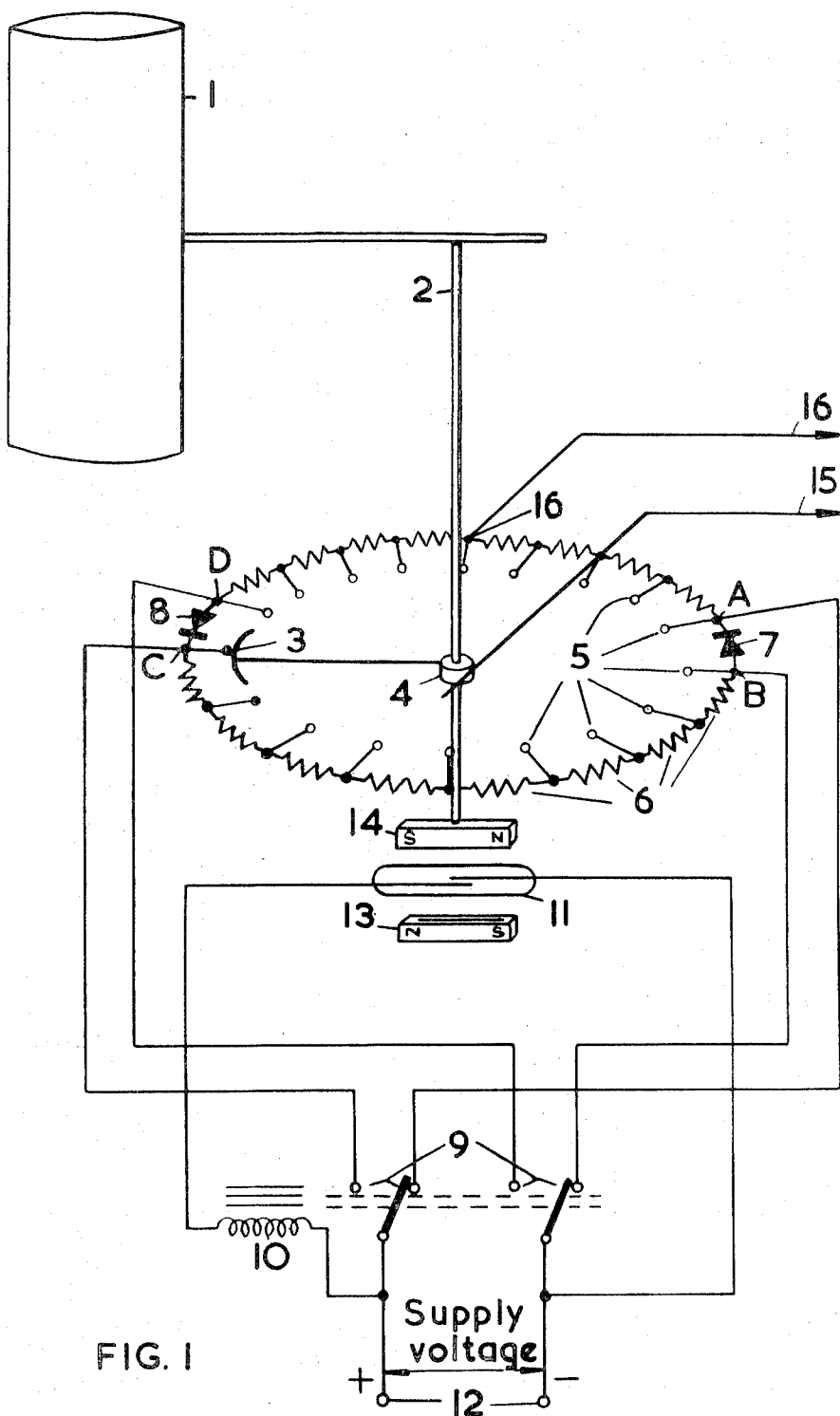
A continuously rotatable and reversible shaft angle transducer on a wind-vane shaft is a rotary potentiometer which in one form has a pair of spaced gaps respectively bridged by a pair of diodes passing current around in only one direction; D.C. supply is connected across one gap by bi-stable switching means which, when the potentiometer brush reaches that gap, transfer the supply connections to the other gap but which restore the first connection when the brush is at said other gap. The output, which is taken — from the brush by a lead and from a point between the gaps another by lead — to a voltmeter, varies over one or other of two ranges according to the position of the bi-stable switching means. The bi-stable switching means can comprise a combination of a relay with a biased reed switch triggered by a magnet on the shaft. Alternatively the bridging of the first gap by the brush triggers a pair of transistors to reverse the polarity of D.C. supply to the gaps, whereupon supply to the first gap is blocked by diodes but is admitted to the other gap by other diodes; the bridging of the second gap by the brush reverses this action.

In a modification the gaps are located adjacent one another and the D.C. supply is connected to the remote ends of the gaps through resistors; the output is taken from the potentiometer brush by leads, to which one or other pole of the D.C. supply is connected by the bi-stable biased reed switch triggered by a magnet on the shaft. Alternatively the reversal of supply connections to the common junction of the gaps is by bi-stable combination of a pair of transistors triggered by the bridging of one or the other said gaps.

The potentiometer comprises a continuous resistor engaged by a rotary brush, or resistor sections connected to studs engaged by a rotary brush, or resistor sections connected in circuit by magnetic reed switches or by light-sensitive switches.

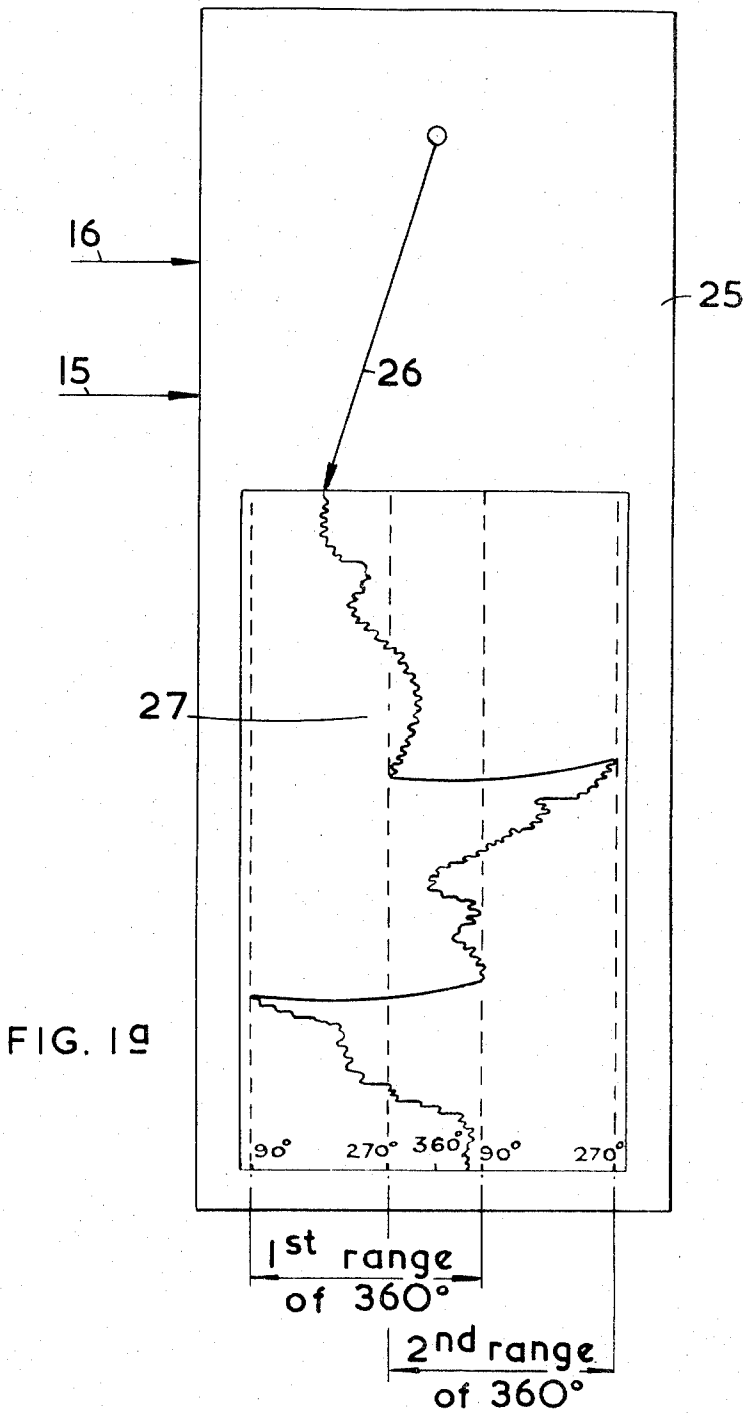
15 Claims, 12 Drawing Figures





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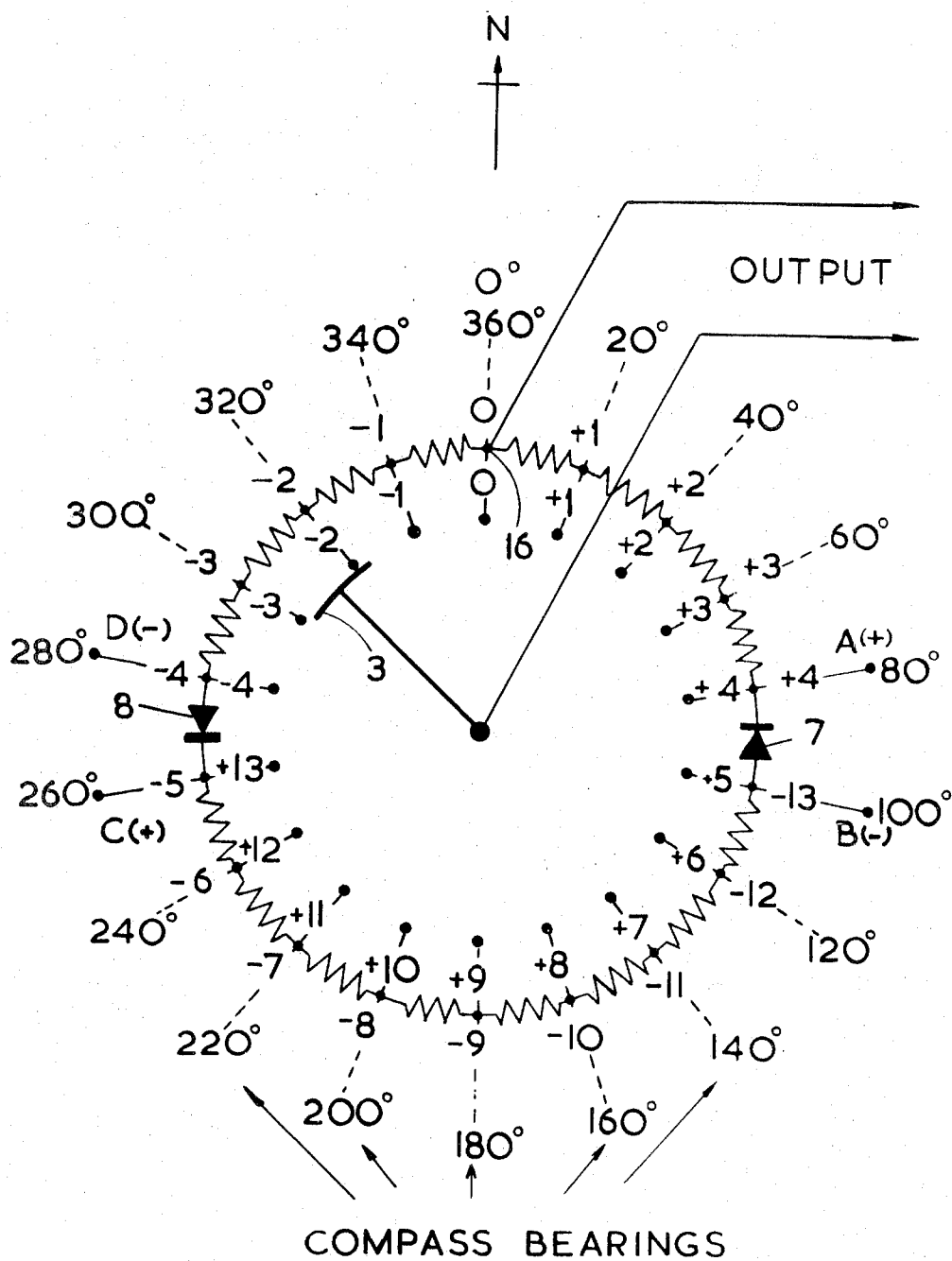


FIG.2

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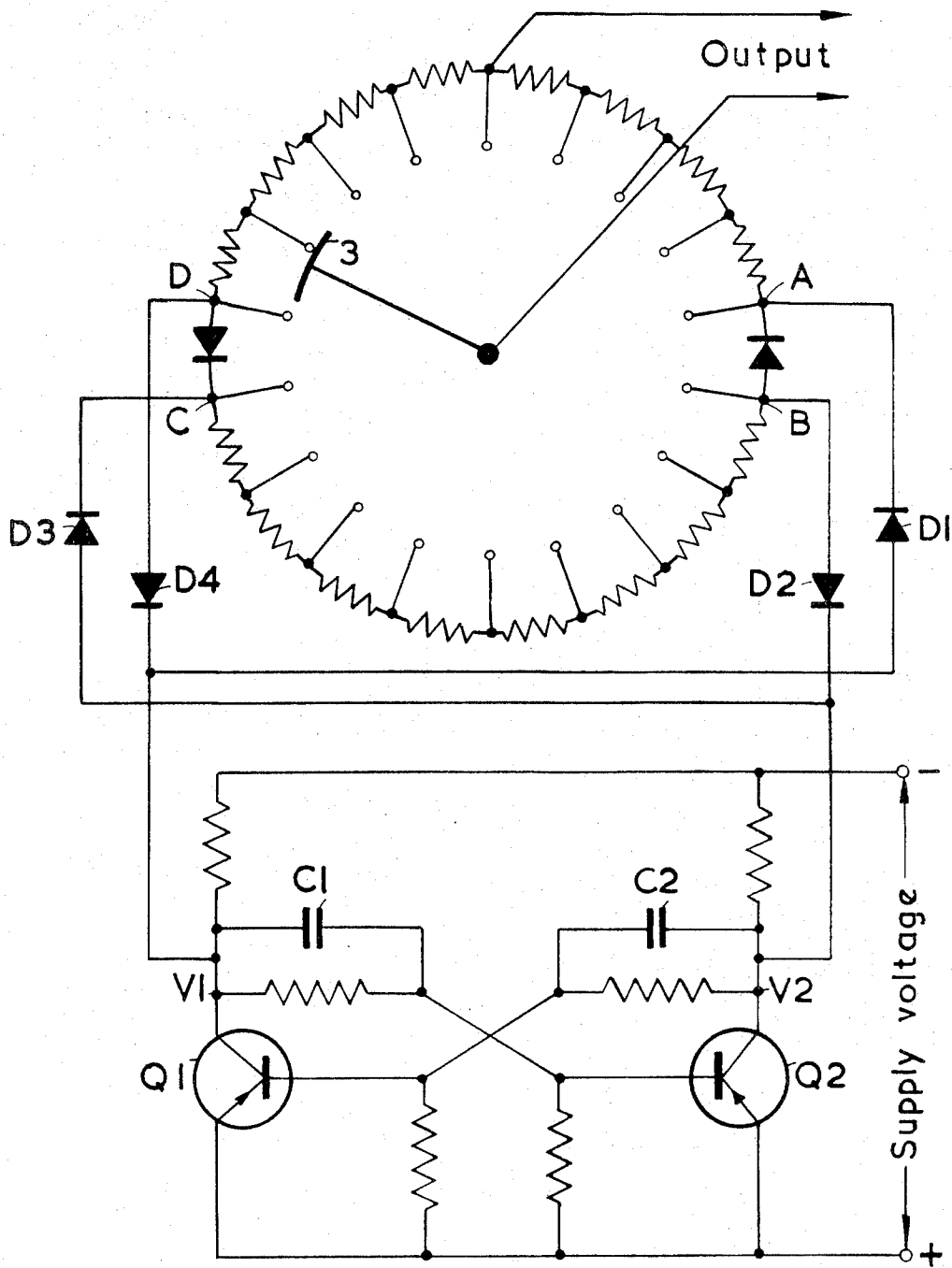
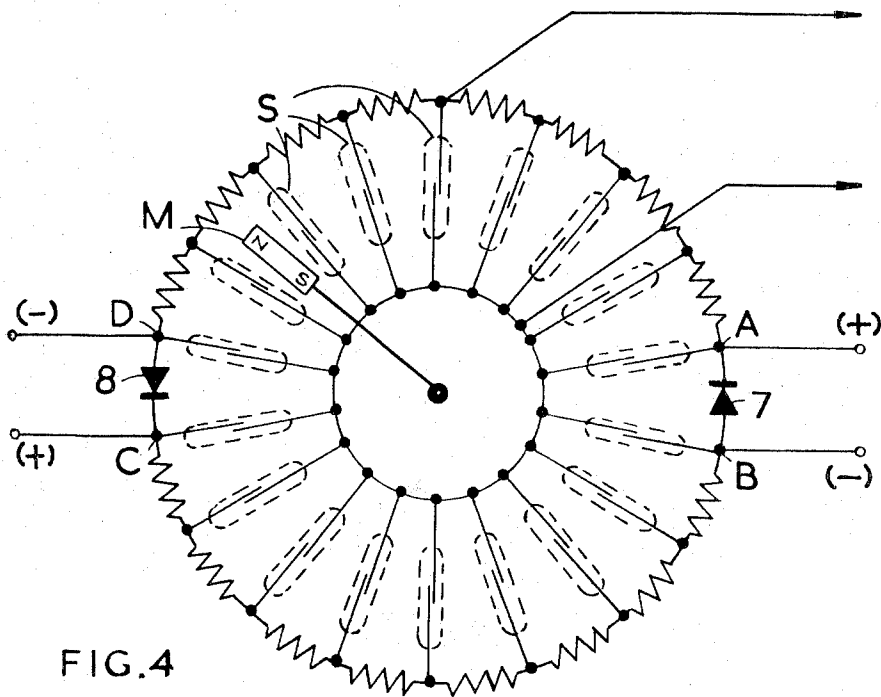
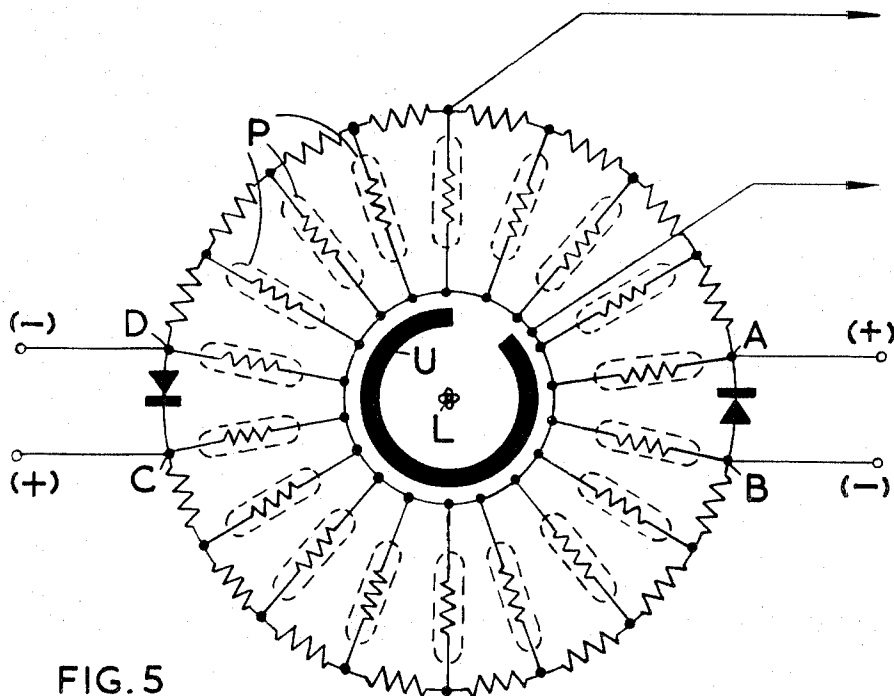


FIG. 3

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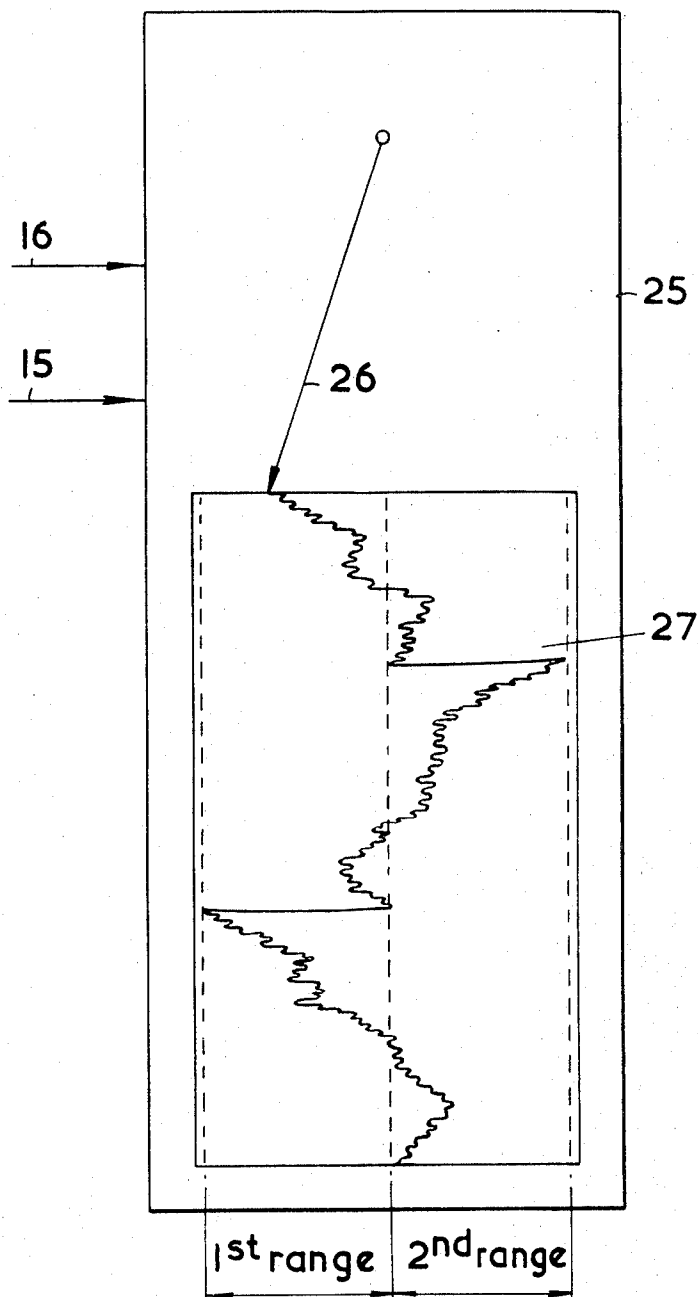


FIG. 6a

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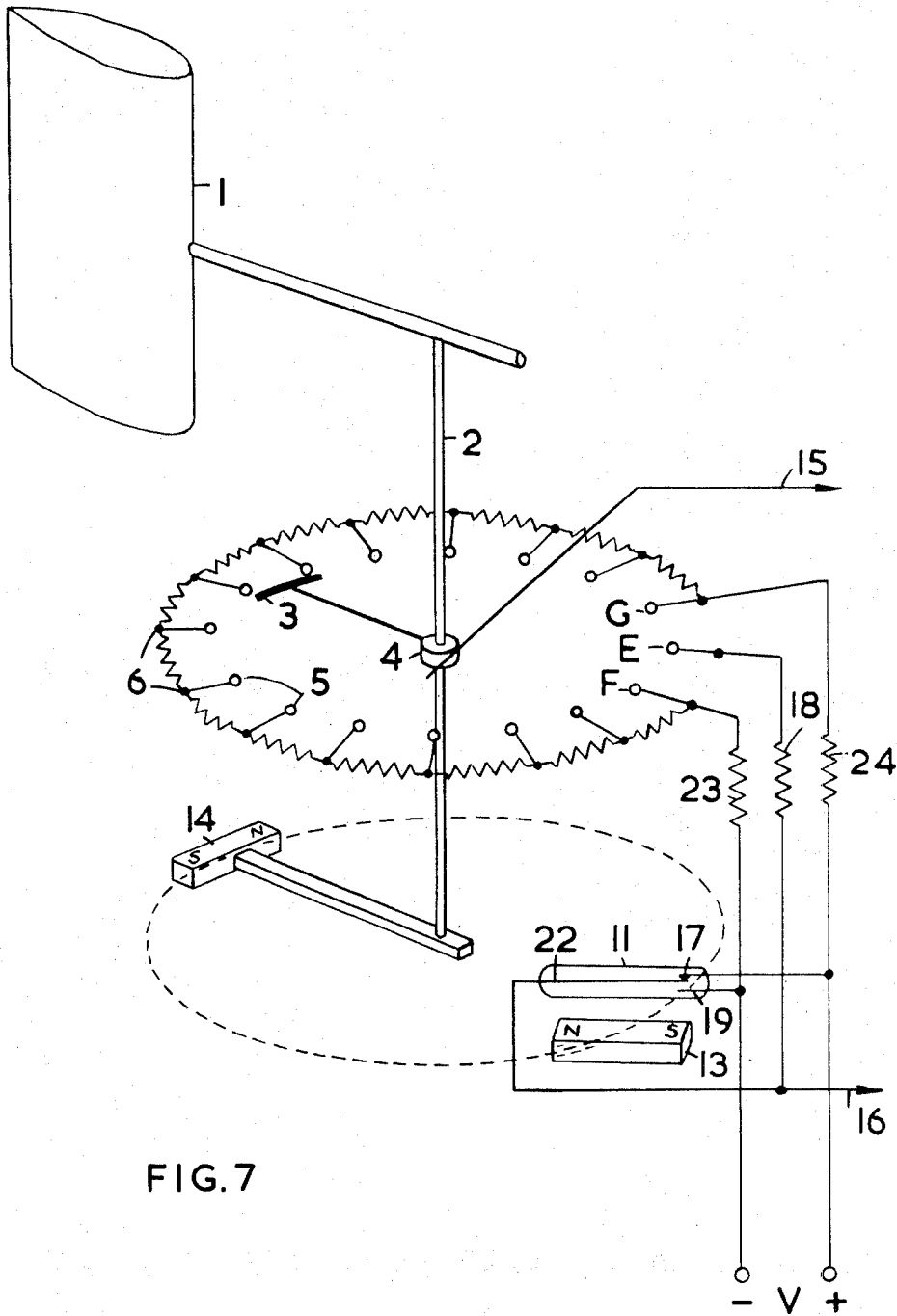


FIG. 7

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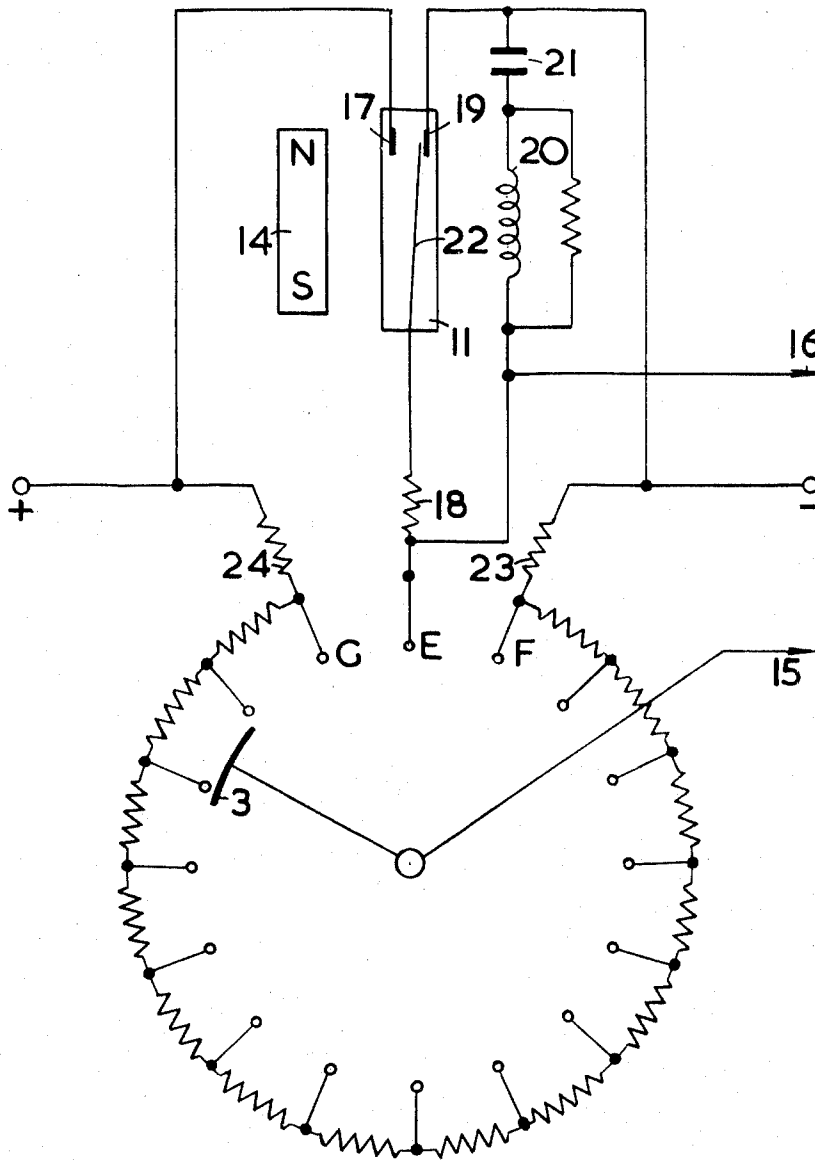
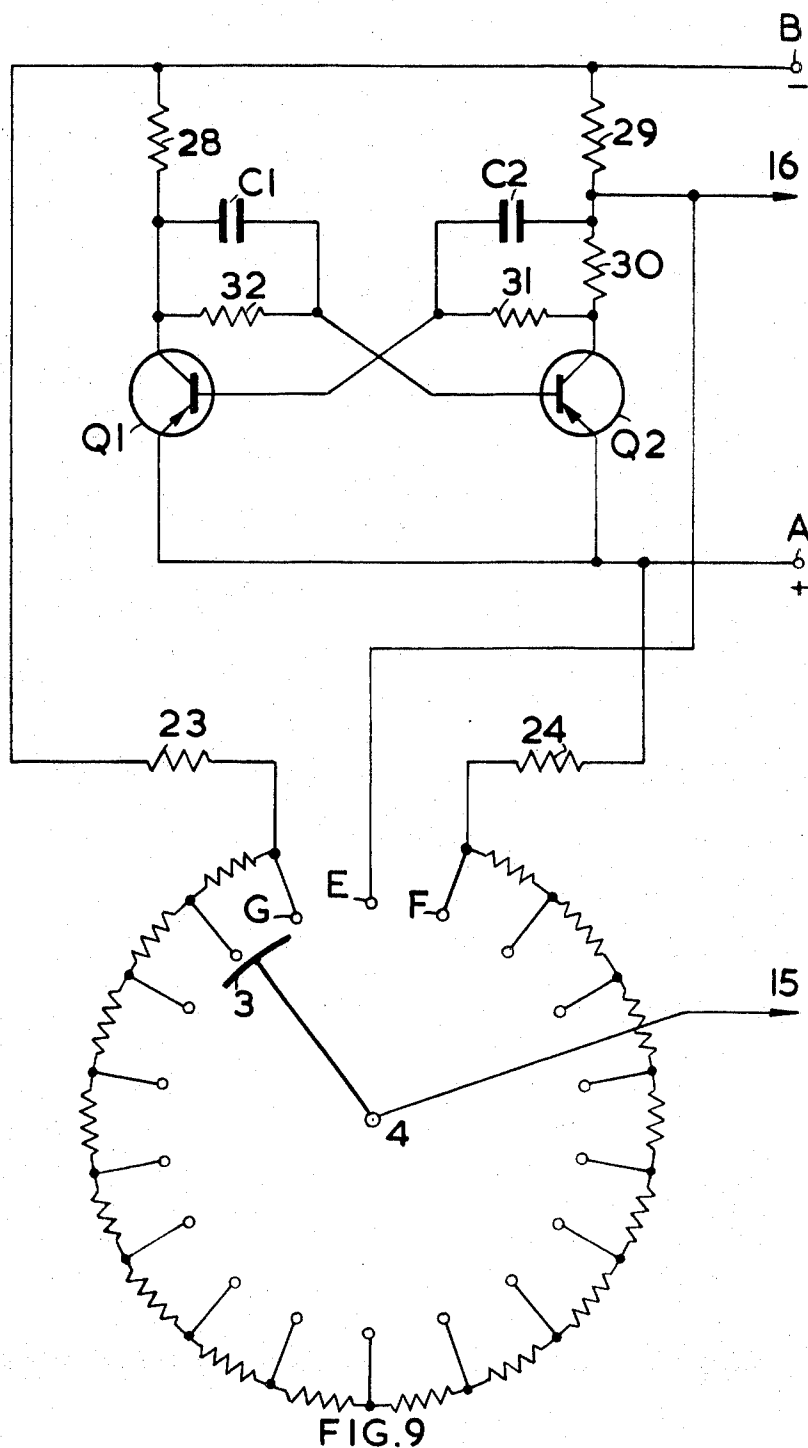


FIG. 8

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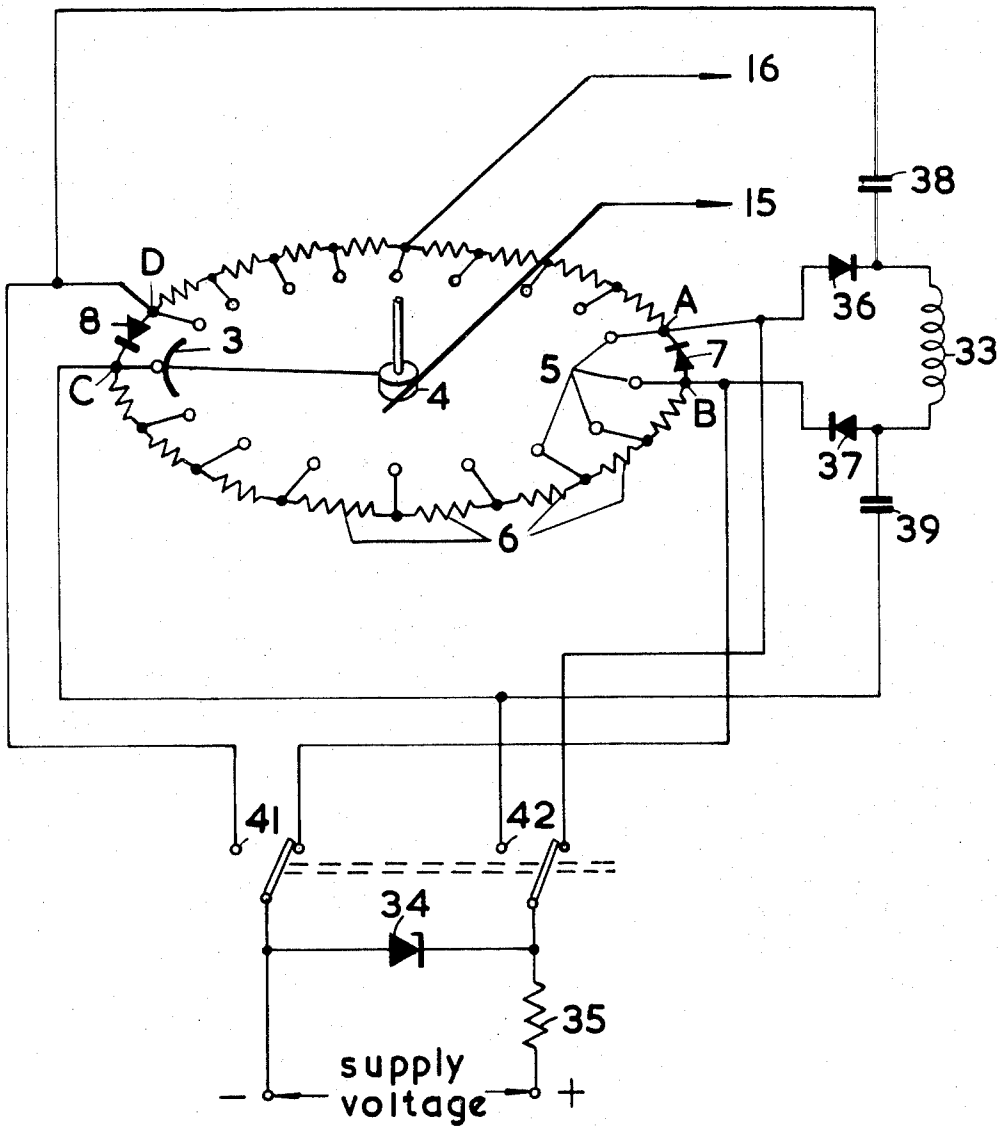


FIG. 10

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SHAFT ANGLE TRANSDUCERS

SUMMARY OF THE INVENTION

The invention relates to shaft angle transducers.

One aim of the invention is to provide a transducer that can be made to have an electrical voltage output representing the angular position of a rotating shaft in a form suitable for indicating or recording on a conventional voltmeter or chart recorder of the galvanometer type and such that the indication or record is clear and unambiguous and permits the magnitude of any angle and the time-average magnitude of large angular fluctuations to be clearly shown or registered.

Another aim is to provide a shaft angle transducer which may be constructed to be of light weight, small size, and low mechanical inertia, such a transducer being suitable for incorporation in a sensitive wind direction sensor.

According to the invention a rotary potentiometer type transducer is combined with bi-stable switching means responsive to shaft angular position to change over a supply connection to the potentiometer when the shaft is in one position and to restore the original connection when the shaft is at another position.

A rotary potentiometer is a rotary voltage-divider enabling the voltage applied to an output circuit to be varied progressively with the angular position of a rotor. It comprises essentially a fixed resistor, with supply connections thereto, a rotor and means operated by the rotor to make a tapping connection sequentially to successive points on the resistor, the output voltage being derived between the tapping connection and a second output connection on the resistor. Such a device will be referred to as a rotary potentiometer as herein defined.

According to a feature of the invention the potentiometer has two gaps therein, between which the second output connection is located, and means by which the action of the bi-stable switching means firstly cause connection of a supply across one or other of said gaps — according to the stable state of said switching means — and secondly bridge the gap. In one form of the invention the gaps are spaced apart and bridging is effected by diodes connected across the gap. In another form the gaps are adjacent; the second output connection is at their junction, the supply is connected across the remote ends of the gaps and bi-stable switching means connect one pole or the other of the supply to the second output terminal.

According to another feature of the invention the bi-stable switching means consists of or comprises a magnetically biased reed switch triggered by a magnet rotating with the potentiometer. According to an alternative feature the bi-stable switching means comprise an electronic circuit — with static switches — triggered by response to the bridging of each gap by the movement of the potentiometer itself.

Other features of the invention will appear from the following description.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention is illustrated by the accompanying drawings wherein:

FIG. 1 is a diagrammatic perspective view and circuit of a wind direction sensor in which the shaft angle transducer employs a step potentiometer and a bi-stable circuit in the form of a magnetically biased reed switch and relay.

FIG. 1A is a continuation of FIG. 1 showing the voltmeter.

FIG. 2 is the circuit diagram of a rotary switch potentiometer as in FIG. 1 having 18 contacts, showing the distribution of voltage potentials around the potentiometer circuit, relative to the fixed output connection, when the supply voltage is applied to one input or the other.

FIG. 3 is a circuit diagram of a modified shaft angle transducer in which a step-potentiometer and an electronic bi-stable switch are employed.

FIG. 4 is a circuit diagram of a modified step-potentiometer constructed of reed switches and operated by a permanent magnet attached to the shaft of the transducer.

FIG. 5 is a circuit diagram of a modification comprising light-sensitive switches operated by a light source co-acting with an apertured cylinder attached to the shaft of the transducer.

FIG. 6 is a diagram illustrating the principle of a modified form of rotary potentiometer transducer.

FIG. 6A is a continuation of FIG. 6 showing the voltmeter.

FIG. 7 is a diagrammatic perspective view and circuit of a wind direction sensor in which a shaft angle transducer according to FIG. 6 employs a bi-stable switch in the form of a biased reed switch and in which the trigger device is a permanent magnet attached to the shaft of the transducer.

FIG. 8 is a circuit diagram of the shaft angle transducer of FIGS. 6 and 7 in which the bi-stable change-over switch is a biased reed switch and the triggering device is an electromagnet.

FIG. 9 is the circuit diagram of a shaft angle transducer according to FIGS. 6 and 7 in which the bi-stable change-over switch is a transistor bi-stable circuit.

FIG. 10 shows a transducer with a bi-stable relay.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIG. 1 shows, in diagrammatic form, a wind direction sensor having a wind vane 1 mechanically connected to, and rotatable with, a shaft 2. The shaft 2 carries a contact brush 3, and slipping 4 of a multi-position make-before-break rotary switch, the fixed contact studs 5 of which are interconnected by resistor sections 6. Two diodes 7 and 8 are connected at A and B and at C and D across gaps in the place of two of the sections 6 on opposite sides of the potentiometer, such as to form a continuous circuit to direct current round a potentiometer circuit. The ohmic value of the resistor sections 6 and the characteristics of the diodes 7 and 8 are chosen such that the forward voltage across each diode is equal to the voltage across each section. For operation from a 12 volt supply, suitable diodes would be A.E.I. germanium gold bonded type CG85-H with 14 10 ohm resistors or 20 ohm resistors if the supply voltage is reduced to 7½ volts. Matching may be achieved, if desired, by the use of additional resistors, not shown in the figure, in series with the diodes. The output contacts 9 of a two-pole two-way relay switch are connected to diodes 7 and 8 in the potentiometer circuit and the operating coil 10 of the relay is connected in series with a reed switch 11 and the supply voltage applied to the input terminals 12 of the transducer. The reed switch 11 is biased by a magnet 13 which has insufficient strength to cause the contacts to close but sufficient strength to hold the contacts together once closed. The reed switch 11 and its bias magnet 13 are mounted such as to come under the influence of the magnetic field of an operating magnet 14 mechanically connected to, and rotatable with, shaft 2.

FIG. 1A shows the leads 15 and 16 connected to supply a voltmeter 25 having a pointer 26 making a record, as shown on a chart 27.

The manner of operation of the wind direction sensor illustrated in FIG. 1 is as follows:

A voltage is applied to positions A and B on the potentiometer, via the contacts 9 of the relay, the voltage being positive at A, the cathode of diode 7 and negative at B, the anode of diode 7. Little current then flows through diode 7 but the circuit is complete round the chain of resistors 6, via diode 8, and the voltage change is uniform round the potentiometer circuit. Wind incident on vane 1 aligns it with the direction of the wind, causing shaft 2 to rotate carrying with it the attached contact 3. Contact 3 transfers the voltage of the connecting fixed contact, via slipping 4, to an output connection 15. The second output connection is taken from a fixed position 16 on the potentiometer circuit, between and preferably midway between, the cathode of diode 7 and anode of diode 8. The biased reed switch 11 is aligned parallel with a chord passing through the input connections on each side of the potentiometer and the operating magnet 14 is aligned with the radius passing through the moving contact 3.

As vane 1 responds to the changing direction of the wind, contact 3 will operate through a range equal to the full supply voltage for a change in wind direction of $337\frac{1}{2}^\circ$. The voltage range relative to the fixed output connection 16 would be from $+1/5$ to $-4/5$ of the supply voltage. As contact 3 nears the ends of this range at positions A or B on the potentiometer, operating magnet 14 approaches alignment with the bias magnet 13, thus reinforcing the magnetic field, and reed switch 11 closes, causing the relay operating coil 10 to energize. Contacts 9 then change over, transferring the supply voltage to C and D. Positive is applied to C and negative to D, the cathode and anode respectively of diode 8, so that little current now flows through diode 8 but the circuit is again complete through the potentiometer though this time through diode 7. The reed switch is held in the closed position by the bias magnet 13 and remains so until the vane, together with contact 3 and operating magnet 14 turn a further half revolution approximately, in one direction or the other, when the supply voltage will be re-connected to positions A and B on the potentiometer. While the voltage is applied to C and D, the output voltage range becomes $-1/5$ to $+4/5$ of the full supply voltage. By reference to FIG. 2, the complete output range of a wind direction sensor and its relationship to the orientation of the vane is now considered.

FIG. 2 is a circuit diagram of an 18 position rotary switch connected as a continuous circular potentiometer by means of sixteen resistors of equal ohmic value and two diodes 7 and 8. In the present example the diodes are connected in diametrically opposite sides of the circuit, but this is not a necessary feature of the invention. The diodes may be positioned closer to connection 16 in the circuit if a greater overlap in the range of the transducer is required but they should preferably still be symmetrically placed in relation to the fixed output connection 16 in order to utilize fully the symmetrical scale of a center-zero indicator or recorder.

For the purpose of the present explanation let the supply voltage be applied first to A and B, positive to A and negative to B, and let this voltage be seventeen volts so that the potential between each fixed contact of the rotary switch, except between A and B, is 1 volt. Let the moving contact 3 be aligned with the wind vane and let the orientation of the circuit be such that the indicated angular positions of the fixed contacts represent directions relative to North. The output voltage of the transducer for a given wind direction is shown by the numbers written against the contacts on the outside of the circuit and, relative to contact 16 (which represents North), ranges from $+4$ volts at A to -13 volts at B. When the supply voltage is applied to C and D, the voltages on the contacts of the rotary switch, relative to contact 16 are indicated against the contacts on the inside of the circuit and range, in one volt steps, from $+13$ volts at C to -4 volts at D.

Consider now the case where the input voltage is initially applied to A and B and the moving contact 3 is at the 100° position. The output voltage will be -13 volts, and increase in steps of 1 volt per 20° as the contact moves clockwise round the circuit. This increase will continue through -9 volts at 180° , -5 volts at 260° and zero at 360° to $+4$ volts at 80° . Further clockwise rotation of the moving contact causes the change-over switch to operate and the input voltage is switched to C and D instead of A and B. The output voltage, however, remains unchanged at $+4$ volts for 80° and continues to increase in 1 volt steps, through 180° for a second time, when the output is now $+9$ volts, to $+13$ volts at 260° . At this angle, further clockwise rotation of the moving contact causes the change-over switch to transfer the input voltage back to A and B, and the output voltage changes suddenly back onto its original range, giving -5 volts for 260° , -4 volts for 280° and so on through 360° to $+4$ volts at 80° .

A similar range is obtained for anticlockwise rotation, starting at 260° where the output is $+13$ volts (input applied to C and D), and decreasing in steps of 1 volt per 20° through South, to $+5$ volts at 100° and on through North to -4 volts at 280° .

Thus, by the use of the recording voltmeter shown in FIG. 1A having a center zero movement and a full scale corresponding to ± 13 volts, connected to the output of the transducer, wind direction over a continuous range of $\pm 260^\circ$ i.e., 520° , may be recorded. When the scale extremities are reached, on the positive or negative sides, the record is discontinued and restarts on the opposite side of the scale following a displacement of 360° . The overlap of the two ranges by 160° on either side of the scale prevents a confused recording, as would be made when the moving contact of a conventional potentiometer fluctuates across the supply points. A typical record produced on a chart is as shown on the figure wherein the trace across the chart on change from one range to the other is clearly seen.

The overlap of 160° quoted above refers to the particular potentiometer circuit chosen and the position of the two diodes in the circuit. The same reasoning may, however, be used for potentiometers of higher resolution, i.e., potentiometers with a larger number of contacts and resistors, or a continuous wire-wound or infinite resolution potentiometer. Overlap may then be increased to approximately 180° when the diodes are connected on diametrically opposite sides of the circuit, or to larger angles if the diodes are moved nearer to the reference contact 16. In the latter case, the reed switch 11 and operating magnet 14, shown in FIG. 1 are mounted eccentrically with respect to the axis of rotation of the shaft 2.

Points A and B across which the supply is connected, and similarly the points C and D, could each be wider apart and span for example a quadrant; the diodes can then be omitted and the gaps eliminated by making the potentiometer continuous but more energy would be dissipated by current then flowing ineffectively in the resistance bridging the gap than in the effective part of the potentiometer in parallel therewith.

In order that the method of changing over the supply voltage from one side of the potentiometer to the other by use of the electronic bi-stable switch may be more fully understood, a description is now given with the aid of FIG. 3.

An electronic bi-stable circuit including two transistors Q1 and Q2 has the collectors of its transistors connected via diodes D1, D2, D3 and D4 to the inputs A, B, C and D as shown in FIG. 3. The anode of D1 and cathode of D4 are connected to Q1 and the cathode of D2 and anode of D3 are connected to Q2 while D1 cathode is connected to A, D2 anode to B, D3 cathode to C and D4 anode to D. When Q1 conducts and Q2 is not conducting and the voltages V1 and V2 at the collectors of Q1 and Q2 are positive and negative respectively, the bi-stable circuit output voltage is conducted via diodes D1 and D2 to the potentiometer inputs A and B, positive to A and negative to B, and when the circuit changes state and V1 becomes negative and V2 positive, the output voltage is conducted via diodes D3 and D4 to inputs C and D, positive to C and negative to D. The bi-stable circuit is caused to change state automatically when the moving contact 3 short-circuits the input voltage. When A and B are short-circuited while the input voltage is applied thereto, the collectors of transistors Q1 and Q2 are also short-circuited via diodes D1 and D2 causing the negative voltage on Q2 to rise. This rise is transferred, via capacitor C2, to the base of transistor Q1 causing a reduction in its current and collector voltage V1. The decreasing collector voltage is transferred to the base of transistor Q2, via capacitor C1, causing Q2 to start conducting and its collector voltage to rise further. The cycle continues until Q1 is cut off and Q2 fully conducts. V1 is then negative and V2 positive and the potential difference is then applied, via diodes D3 and D4, to the inputs C and D of the potentiometer. When C and D are short-circuited by the moving contact the same process is repeated, but in reverse, and the input voltage is automatically transferred back to A and B.

As an alternative to a potentiometer constructed from a multi-contact rotary switch as illustrated in FIGS. 1, 2, and 3, a potentiometer constructed from reed switches may be employed in the shaft angle transducer. The circuit of such a potentiometer is shown in FIG. 4 where reed switches S, regu-

larly spaced in a circular array, either in one plane or round the sides of a cylinder, are operated by a magnet attached to the shaft of the transducer. The magnet field width is such that the reed switch closed for the time being under the influence of the field, is not released until an adjacent reed switch is also closed.

As a second alternative to the rotary contact switch, a potentiometer constructed from a number of light-sensitive switches may be employed. Such an arrangement is illustrated in FIG. 5 where the light-sensitive devices P are illuminated from a centrally placed light source L through a slot in a drum U attached to, and rotatable with, the shaft of the transducer. The width of the slot is sufficient to expose two light-sensitive switches simultaneously though insufficient to expose three switches.

As a third alternative to the rotary contact switch, a continuous circular potentiometer of high resolution may be employed, the input voltage being applied across an arc of the potentiometer circuit on one side or the other, as the change-over switch operates. A diode may be inserted into a small discontinuity in each arc and the width of the arc reduced to a minimum consistent with insulation requirements. FIG. 6 shows the circuit diagram of a sixteen-way rotary switch having the make-before-break contact brush 3, connected by means of fourteen equal resistor sections 6 as a linear step potentiometer. There are two immediately consecutive gaps E-F and E-G. Two resistors 23 and 24 equal in resistance to individual resistors 6 connect the input points F and G of the potentiometer to a supply voltage V. A single pole change-over switch has its moving contact 22 connected to the contact of the potentiometer, situated at the junction point E of the gaps between contacts to which the input voltage is supplied. The two fixed contacts 17 and 19 of the change-over switch are connected to the supply voltage V. The output voltage is measured between the moving contact brush 3 of the potentiometer and the moving contact 22 of the change-over switch. The change-over switch is caused to operate when the moving contact brush 3 approaches and passes the fixed contact point G of the potentiometer the sense of switch being as follows. For both directions of rotation, as brush 3 approaches or passes point G, contact 22 of the change-over switch switches over to contact 19 before, or as soon as, fixed contacts at E and F are interconnected by moving brush 3, and contact 22 changes over to contact 17 before, or as soon as, contacts at E and G are interconnected by the moving brush 3. Consider now the voltages on the contacts of the rotary potentiometer relative to point E thereon, and hence the output voltage, when contact 22 of the change-over switch makes contact first with contact 19 and then with contact 17. For the purpose of this explanation let the supply be sixteen volts, positive on the left in the diagram and negative on the right, so that the potential difference across each resistor is 1 volt. When contacts 22 and 19 are interconnected, point E will be at the negative potential of the supply and the voltage around the potentiometer will increase in steps of 1 volt in a clockwise direction starting from +1 volt at F to +15 volts at G. When contacts 22 and 17 are interconnected, point E will be at the positive supply potential and the voltage around the potentiometer will decrease in an anti-clockwise direction in one volt steps from -1 volt at G to -15 volts at contact F. Two ranges are thus provided, zero to +15 volts, corresponding to a clockwise rotation of $337\frac{1}{2}^\circ$ of arc from point E, and zero to -15 volts corresponding to the same angle from point E but in an anticlockwise direction. Change-over from one range to the other takes place automatically when brush 3 passes point E and is described in detail below. Thus, an extreme output voltage (+ or -15 volts) always returns to zero when a further increase in angle occurs and an oscillation of the shaft, and hence brush 3, about the zero position (say the contact oscillates between positions F and G on the potentiometer) causes the output to fluctuate only from +1 volt through zero to -1 volt and not from one extreme to the other, as would be the case if two ranges were not provided.

FIG. 6A shows the leads 15, 16 connected to the voltmeter.

FIG. 7 shows, in diagrammatic form, a wind direction sensor having a wind vane 1 mechanically connected to, and rotatable with, a shaft 2. The shaft 2 again carries the brush 3 and slipping 4 of the multi-position rotary switch connected as a potentiometer, as in FIG. 1. The potentiometer is supplied from a voltage source V via resistors 23 and 24 and the voltage distribution will be as described for FIG. 6. In FIG. 7 the change-over bi-stable switch consists of a single pole change-over reed switch 11 biased by magnet 13 which has insufficient strength to operate the reed switch but sufficient strength to hold on the reed switch once it has operated. The reed switch is caused to operate, thereby changing over its output contact 22 from the positive side of the supply to the negative side, or vice versa, by means of the operating magnet 14 attached to, and rotatable with, the shaft 2. The manner in which the change-over action is caused to take place is as follows. Consider shaft 2 and with its brush 3 and magnet 14 turning in an anti-clockwise direction. As the south pole S of magnet 14 approaches reed switch 11 the field of bias magnet 13 is reinforced so that reed switch 11 operates and by its moving contact 22 connects output lead 16 — and point E on the potentiometer via resistor 18 — to the negative side of the supply voltage V. Resistor 18 is employed in the circuit to limit current through reed switch 11 should points E and F (or E and G) be temporarily interconnected by brush 3 before the reed switch changes over to the required position. If contact 22 changes over when brush 3 is in contact with the stud at F only, the output voltage measured between the output leads 15 and 16, will change from -15 volts to +1 volt, or to zero if brush 3 bridges the gap between points E and F. As the operating magnet 14 passes over reed switch 11 (and brush 3 passes point E) the field of bias magnet 13 becomes opposed by the north pole (N) of the operating magnet and reed switch 11 changes back to its original position. Output lead 16 is then again connected to the positive supply and the output voltage, now measured between positive and point G, becomes -1 volt. Reed switch 11 then remains in this position for further anti-clockwise rotation of the shaft until the moving brush 3 again approaches point F. For clockwise rotation the reverse action takes place at the reed switch, output lead 16 being connected to positive when brush 3 approaches point G and to negative when brush 3 passes point F. It should be noted that if output lead 16 is already connected to the required polarity as magnet 14 approaches reed switch 11 (and brush 3 approaches contact E) no switching action takes place at the reed switch until the center of magnet 14 passes over the reed switch.

It will be seen as shown in FIG. 6A that the two voltmeter ranges now meet without overlap.

FIG. 8 shows the circuit diagram of a shaft angle transducer in which the change-over bi-stable switch is a biased reed switch, but in which the triggering mechanism is a fixed position electro-magnet. In this circuit, as moving brush 3 bridges and short circuits gap E-G the electro-magnet 20 is energized temporarily by current passed therethrough from the positive pole of the supply via resistor 24 to the negative pole of the supply via capacitor 21, the polarity of the field being such as to cause reed switch 11 biased by magnet 14, to change over so that contact 22 is connected to the positive pole of the supply via contact 17. Output lead 16 and point E are then connected to positive via resistor 18. When moving brush 3 bridges and short-circuits gap E-F, electro-magnet 20 is energized in the reverse direction, causing biased reed switch 11 to change over and connect point E and output lead 16 to negative.

FIG. 9 shows the circuit of a shaft angle transducer in which an eighteen way rotary switch is used as a potentiometer and in which the change-over switch is a transistor bi-stable circuit such as already described with reference to FIG. 3. The supply voltage is applied directly to the bi-stable circuit but via resistors 23 and 24 to the potentiometer circuit and the output voltage of the transducer is measured between lead 15 from brush 3 and 4 of the potentiometer and lead 16 from a junction of two resistors 29 and 30 connected in series to form the

collector load of transistor Q2. Lead 16 is also connected to the contact at point E on the potentiometer. The change-over action of the circuit is as follows. When brush 3 bridges and short-circuits gap E-G, the negative supply voltage is applied to the junction of resistors 29 and 30 and applied via capacitor C2 to the base of transistor Q1. This trigger action causes transistor Q1 to conduct and transistor Q2 to become cut off so that said junction and lead 16 now become negative. When brush 3 bridges and short-circuits gap E-F a positive voltage is applied to said junction and lead 16, and, via capacitor C2, to transistor Q1, causing the bi-stable circuit to change state and lead 16 to become positive. Resistors 23, 24, 28, 29, 30, 31 and 32 are chosen such that when lead 16 is negative, the voltage across gap E-G is the same as that between all other adjacent contacts of the potentiometer (except across gap E-F) and when lead 16 is positive the voltage across gap E-F is equal to that same voltage (but not now the voltage across gap E-G). Suitable values are given below, and though these may be varied over a wide range, depending on the output resistance required of the transducer, the ratios of the resistors should not be altered substantially. Resistors 29, 30 and 31 in FIG. 9 may be 450 ohms, 50 ohms and 4,000 ohms respectively, making the output voltage level at lead 16 one-tenth of the full supply voltage above the negative, or below the positive, potential of that supply. With this particular voltage level at output terminal 16, resistors 23 and 24 should each be equal to $R + nR/8$, where R is the resistance of individual resistor sections in the step potentiometer and n is the total number of steps in the potentiometer. Thus, if $n = 18$ and $R = 10$ ohms, resistors 23 and 24 are each equal to $32\frac{1}{2}$ ohms, or to 30 ohms if $n = 16$.

In the modification shown in FIG. 10 the elements 3 to 8 are as described with reference to FIG. 1. The bi-stable switching means comprise a relay having change-over contacts 41 and 42 and an operating coil 33. A zener diode 34 is connected across the switch to stabilize the voltage; a resistance 35 in series with the supply limits the current when either gap is bridged by the rotary brush 3. Diodes 36 and 37 allow current to pass through the coil 33 from the supply when the latter is connected across the gap A-B but isolate the coil 33 from the rest of the circuit when, in operation as will be described, the capacitors 38 and 39 supply the coil with a re-setting pulse. In operation, the relay 33-41-42 is held in the position shown by current supplied from the mains through diodes 36 and 37 until, when the gap A-B is bridged by brush 3, the coil 33 is thus short-circuited, whereupon the relay contacts disconnect the supply from across the gap A-B and connect the supply across gap C-D. This action disconnects the supply from the coil 33 and the relay accordingly remains for a time in its new stable position. If subsequently the brush 3 short-circuits the gap C-D the coil 33 will then receive a pulse from discharge of the capacitors 38-39 which will reverse the relay to the former position in which it will then maintain itself by supplying the coil 33 across the supply applied to gap A-B.

What I claim is:

1. An angular position transducer of the rotary potentiometer type comprising a potentiometer resistor, a rotor for making a tapping connection to said resistor, a first output connection making said tapping connection to said resistor in accordance with the position of said rotor, said resistor having two gaps therein, a fixed tapping point between said gaps, a second output connection connected to said fixed tapping point, positive and negative power supply connections, bistable switching means operable in one of its two states to connect said power supply connections across one of the two gaps in said resistor and simultaneously to make an electrically conducting connection across the other of said gaps, and operable in the other of its two states to connect said power supply connections across said other of the two gaps in said resistor and simultaneously to make an electrically conducting connection across said one of the two gaps, and means responsive to the angular position of said rotor for switching said switching means to one of its states when said rotor is in a first predeter-

mined angular position with respect to said gaps and for switching said switching means to the other of its states when said rotor is in a second predetermined angular position with respect to said gaps.

2. An angular position transducer according to claim 1 in which said two gaps are directly adjacent one another, said fixed tapping point being an isolated tapping point located immediately between said two gaps, the positive and negative power supply connections being connected respectively to the ends of said resistor next to said gaps.

3. An angular position transducer according to claim 2 wherein the switching means is operated by movement of said rotor such that when said rotor moves across said gap from the positive end of said resistor to said isolated tapping point said switching means connects said positive supply connection to said isolated tapping point, and when said rotor moves across said gap from the negative end of said resistor to said isolated tapping point said switching means connects said negative supply connection to said isolated tapping point.

4. An angular-position transducer according to claim 2 wherein said bi-stable switching means comprises an electronic bi-stable device triggered to one state when said rotor bridges one of said gaps and said isolated tapping point, and triggered to its opposite state when said rotor bridges the other of said gaps and said isolated tapping point.

5. The angular position transducer of claim 1 including a voltmeter connected to said first and second output connections.

6. An angular position transducer according to claim 1 comprising a plurality of magnetic reed switches connected on one side thereof to successive points on said resistor and connected on the other side thereof to said first output connection, said rotor including a magnet for operating said switches arranged so that as the rotor rotates each switch is closed in sequence by proximity of said magnet thereto thereby to connect said first output connection sequentially to successive points on said resistor.

7. An angular position transducer according to claim 1 wherein said last-named means comprises a magnetically biased reed switch co-acting with a magnet carried by said rotor.

8. An angular position transducer according to claim 1 comprising a light source, a plurality of photoelectric devices connected on one side thereof to successive points on said resistor and connected on the other side thereof to said first output connection, said rotor including a slotted drum co-acting with said light source whereby, when said rotor rotates, light is directed onto said photo-electric devices successively to operate said photo-electric devices thereby to connect said first output connection sequentially to successive points on said resistor.

9. An angular position transducer according to claim 1 including a pair of unidirectional conducting devices connected across said pair of gaps respectively and arranged in said potentiometer resistor so that current can flow in only one direction through said resistor, said bi-stable switching means being operable in response to movement of said rotor past either gap in said potentiometer resistor to disconnect the power supply connections across the unidirectional conducting device associated with that gap and to connect the power supply connections across the other of said devices.

10. The angular position transducer of claim 9 including a voltmeter connected to said first and second output connections.

11. An angular position transducer according to claim 9 in which said unidirectional conducting devices are solid-state devices.

12. An angular position transducer according to claim 9 comprising a plurality of magnetic reed switches connected on one side thereof to successive points on said resistor and connected on the other side thereof to said first output connection, said rotor including a magnet for operating said reed switches, arranged so that, as the rotor rotates, each reed

switch is closed in sequence by proximity of said magnet thereto thereby to connect said first output connection sequentially to successive points on said resistor.

13. An angular position transducer according to claim 9 wherein said bi-stable switching means comprises a magnetically biased reed switch co-acting with a magnet carried by said rotor.

14. An angular position transducer according to claim 9 comprising a light source, a plurality of photo-electric devices connected on one side thereof to successive points on said resistor and connected on the other side thereof to said first out-

put connection, said rotor including a slotted drum co-acting with said light source whereby, when said rotor rotates, light is directed onto said photo-electric devices successively to operate said photo-electric devices so that said first output connection is connected sequentially to successive points on said resistor.

15. A transducer according to claim 9 wherein said bi-stable switching means comprises an electronic bi-stable device triggered from one to the other of its states when said rotor bridges one or the other of said pair of gaps respectively.

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