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An electronic weather vane for field science

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Abstract
This paper details the construction of a weather vane for the measurement of wind direction in field situations. The purpose of its construction was to analyse how wind direction affected the attractiveness of an insect pheromone in a dynamic outdoor environment, where wind could be a significant contributor to odour movement. The apparatus described provides a cheap and easy to construct alternative to commercial wind vanes, and was shown to provide accurate and continuous measurement of wind direction.

Introduction

Q.1 Physicists in educational institutions are often called upon to assist in other disciplines. One such example of a fruitful collaboration is described here. It involves a novel application of a simple potentiometer to solve a problem involving wind direction measurements and serves to illustrate to students how physics can be treated as an applied subject. At A-level, students often study biology and physics together, and this simple example of a circuit application demonstrates to the student more interested in biology how physics is of great value to them.

This study arose from research into the attraction of insect pheromones in an outdoor environment. The importance of wind direction in insect orientation to an odour is well established both in artificial wind tunnels (Cardé 1984) and in natural outdoor environments (Elkinton *et al*
Q.2 1984). In order to ascertain the effect of wind direction on the attractive range of an odour, it was necessary to continuously measure the direction in which the wind blew over a number of days, which required the development of specialized apparatus.

Commercial wind vanes used for detailed studies of this nature are often prohibitively expensive, ranging from £100 to £1000 at the time of this paper. Our laboratory does not have such a device and thus we devised a methodology for constructing a piece of apparatus quickly and cheaply. The device presented here is easy to make and requires very little by way of equipment. In addition, commercial wind vanes often require mains electricity, and cannot log data for long enough periods to support longer term field research. We therefore provide a cheap alternative, which is more flexible and suitable for a field scientist, whilst still providing the level of accuracy required for precise determination of wind direction.

Methodology

Our device is based on a simple volume control type potentiometer. As the spindle turns, the voltage on the middle terminal changes

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Table 1. Interpretation of direction readings from voltage.

Degrees of rotation	Compass reading	Voltage read	Direction interpretation
0	330	0	N
20	350	0	N
40	10	0	N
50	20	0	N
60	30	0.77	NE
80	50	0.77	NE
90	60	0.76	NE
100	70	0.74	E
120	90	0.68	E
140	110	0.62	E
160	130	0.56	SE
180	150	0.49	SE
200	170	0.44	S
220	190	0.39	S
240	210	0.33	S
260	230	0.26	SW
270	240	0.23	SW
280	250	0.19	W
300	270	0.11	W
320	290	0.05	W
340	310	0.01	NW
360	330	0	N

Q.3

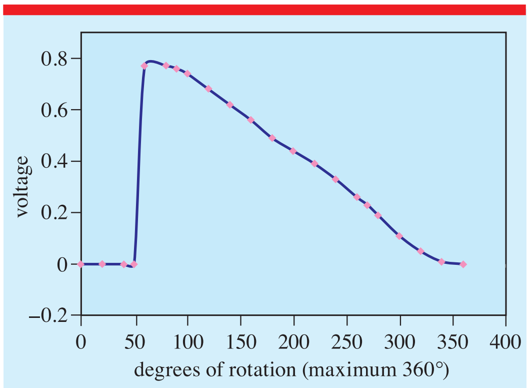

Figure 1. Voltage calibration curve as shown through 360° of rotation. A dead zone can be noted between 0° and 50°.

accordingly. In this way the position of the weather vane mounted on the spindle is converted to a voltage and can be measured linearly based on the degree of orientation. It must be noted that there is a dead section in the potentiometer resistance (figure 1), but this is always in the same position and therefore still provides positional information. Figure 1 shows how the output voltage changes with the rotational position of the vane.

Figure 2. The fully constructed wind measurement apparatus.

Use

Figure 2 shows the completed instrument. The output is by way of a jack socket which enables

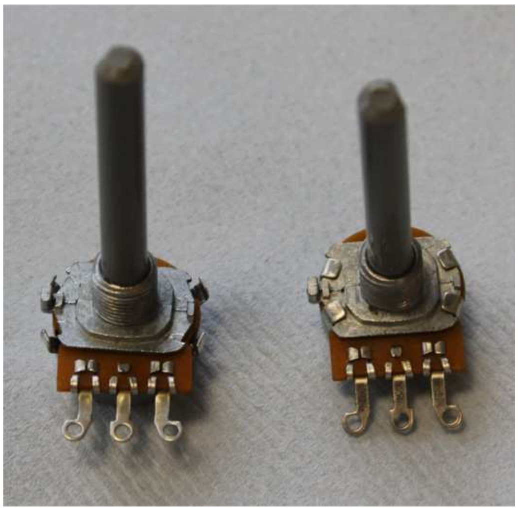

Figure 3. Potentiometer opened by bending back the metal strips holding the components in place. Right: unaltered potentiometer; left: opened potentiometer.

Figure 4. The base of the potentiometer. Notice the lug that prevents 360° rotation within this base.

connection to a data logger. The device is switched on using a single pole single throw switch and in the on state draws 8.2 μA. A light emitting diode (led) draws of the order of 350 mA and so a push button switch is connected in series so that the led is used to indicate the on/off nature of the device only when the button is pushed. A small plotting compass is attached to enable the device to be oriented correctly. The data collected on the logger can be converted to wind direction using the data in table 1.

Construction

A standard potentiometer has resistance to twist and usually has a stop position at one angle so that it cannot move round and round continuously. These two properties need to be negated. Figure 3 shows how to open the potentiometer by bending back the retaining strips. The can at the base is first removed. Inspection of this can, figure 4, shows a lug that prevents more than 360° rotation. This can be hammered back into position, as shown in figure 5. Next, the whole assembly is disassembled, figure 6. Figure 7 shows a region of the spindle thickly coated in a high viscosity lubricant. This lubricant should be wiped off and the section of the spindle should be sanded down to reduce its diameter, as shown in figure 8. The now free running potentiometer is reassembled.

Figure 5. The base of the potentiometer with the lug hammered out to allow 360° rotation.

The components are mounted to a box as shown in figure 2 and connected according to

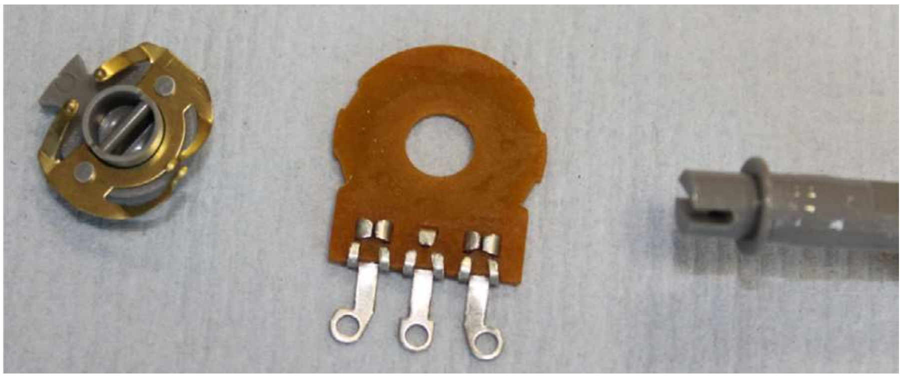

Figure 6. The potentiometer components disassembled.

Table 2. List of components for construction of the wind measurement apparatus (prices as of 26/07/2013).

Component	Supplier	Order code	Unit price
Grey box, 85 mm (l) × 56 mm (w) × 39 mm (h)	Farnell	1171593	£8.67
Potentiometer, LIN 100K, 20%, 400 mW	Farnell	350102	£1.25
Socket, 2.5 mm jack, three pole	Farnell	1267372	£0.79
Data logger, 0 to 30 V, 32 000	Farnell	8522901	£45.18
Switch, SPDT, 2.0 A, 250 V	Farnell	9473378	£1.24
9 V battery	Staples	WW-409055	£3.80
Battery strap, 9 V, wire lead	Farnell	4530044	£0.39
Durable A4 spine bars, 6 mm, black, 10 pack	Staples	WW-366566	£3.60
LED, 5 mm, red, 2.3 mcd, 626 nm	Farnell	1003232	£0.11
Correx plastic board, 3 mm, 840 mm × 594 mm sheet	www.kcswebshop.co.uk/	10600912	£24.66
Switch, SPNO, 0.5 A, 50 V DC, THT, 10 pack	Farnell	599270	£3.68
One sided standard stripboard, SRBP, 160 mm × 100 mm	R S Components	206-5841	£3.02
Resistor, carbon film, 1 K, 0.25 W, 5%	Farnell	9339051	£0.02
Resistor, thick film, 0.25 W, 1 MΩ, 5%	Farnell	1292550	£0.09
Copper tubing, microbore	Plumbworld	—	—
Extra flexible single wire, red	Philip Harris	B8F83121	£7.14
Mounting clip, ring, 5 mm, LED	Farnell	8576378	£0.28

Q.4

Figure 7. Lubricated spindle of the potentiometer to allow smooth and even rotation.

the circuit diagram in figure 9. The materials and costings for all components are also shown in table 2.

A piece of copper tubing with internal diameter matching the spindle of the potentiometer is cut to a suitable length and the tube is fitted onto the spindle by tapping with a hammer. The protruding section is flattened in a vice. A piece of Correx® plastic is cut to shape and the straight edges are reinforced with an A4 spine bar and secured to the flattened section of the copper tubing using a hot weld glue gun.

Figure 8. The potentiometer spindle should be sanded down to an appropriate diameter to allow smooth 360° rotation.

Conclusion

Field trials showed that the device provides the necessary information and the data fit well with the expected behaviour of the insects in the trial.

In addition, this device could be used for numerous other applications in both teaching and research, particularly for institutions with limited resources or restricted access to suppliers.

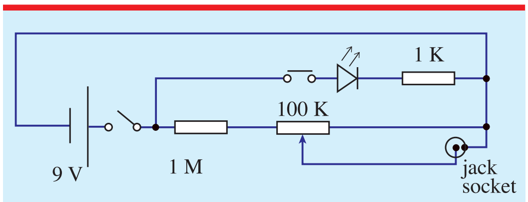

Figure 9. Circuit diagram of the wind measurement apparatus.

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