A SIMPLE RECORDING WIND GAUGE

I. MECHANISM AND METHOD OF RECORDING

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INTRODUCTION. Ecological studies on the movement patterns of mosquito populations require accurate knowledge of the prevailing wind and its variations in direction and force during the period of observation.

Existing meteorological instruments for measuring air movement are of two types: indicating and recording. The former require frequent or continuous observation; while the latter, such as the pressure tube anemograph with direction finder, are expensive pieces of equipment often requiring permanent installation and suitable only for airports and meteorological stations.

The instrument described here gives an accurate, continuous record of wind direction and estimated wind force and can be constructed from materials costing less than 30 U. S. dollars.

PRINCIPLE. Wind direction and speed are constantly fluctuating entities; caused by a continuous succession of gusts and lulls varying around a mean direction (Pick, 1938; Met. Office, 1958). In a sensitive wind vane this continuous variation of force and direction produces an oscillatory movement as long as the air movement is greater than Force I on the Beaufort scale; furthermore, the stronger the wind, the greater the frequency of oscillation and the more variable its direction, the greater the width of the oscillation.

The instrument described is based on the ability of a well balanced sensitive wind vane to produce a proportional response to these oscillations, which can then be recorded graphically in proper chronological sequence on a clock driven surface.

MECHANISM. Since the instrument was developed and built under field conditions in Africa, where some components are hard to obtain, its design was adjusted to the only suitable clock which was available, namely, a clock drum from a "Casella" thermohydrograph. This is not the best motor for, although the clock is designed to make one complete revolution each day, its gearing allows sufficient space or time for the clip-bar that normally holds the thermo-hydrograph chart; thus the drum takes 26 hours to complete one revolution. These two extra hours have to be allowed for in interpreting the recorded wind trace.

The whole instrument (except the head) is housed in a Perspex box with a door to allow the turn-table to be changed and the top is arbitrarily marked with the cardinal points of the compass.

1. *The Head and Wind Vane* (Figs. 1A, 2 and 3). A very sensitive vane is obtained by using an open cone surmounted by a large vertical fin as figured. The cone is held coaxially, on the lever arm or boom (a) of the gauge by four radially disposed struts (sr.).

The lever arm is formed by a 24 in. long piece of ¼ in. iron rod and joins the vane to a brass counterpoise (ctp.) after passing through the head of the gauge's spindle (s.). All attachments with the boom, i.e. the tail, spindle and counterpoise, are made through tightly fitting holes supplied with lock screws (a.).

The brass spindle (s) connecting the head to the recording apparatus is supported in the top of the rainproof Perspex case (pb.) by two coaxial bearings. The spindle is fitted with a circular rain baffle

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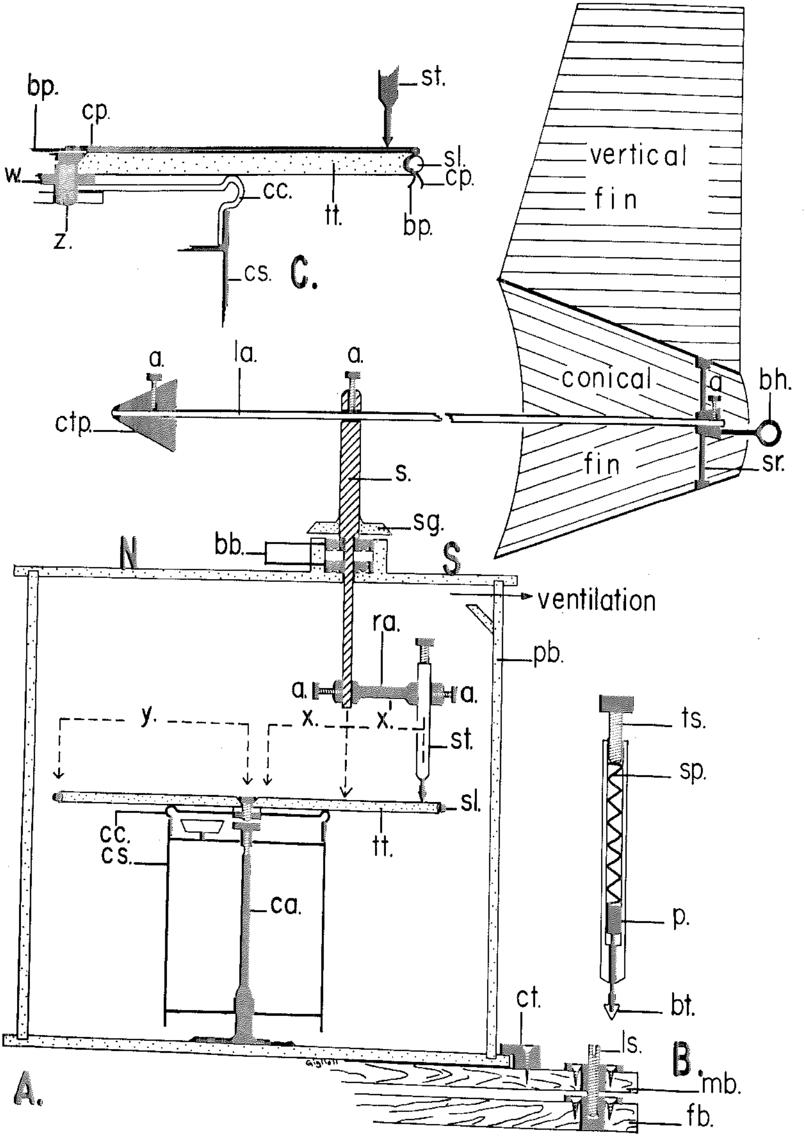

FIG. 1.—A. The recording wind gauge showing its construction and the exact spatial relationship between the head and stylus and the clock driven recording surface. B. The stylus showing the mechanism used to obtain an adjustable spring loaded ball point. C. The turn-table with its marginal groove and ring of curtain spring showing how the layers of bond and carbon paper are flattened and held under the stylus.

(sg.) to protect the bearings and prevent rain leakage on to the recording apparatus. The lower end of the spindle, in the Perspex case, supports a short adjustable rod, the rotating recording arm (ra.) situated at right angles to its axis and in vertical alignment with the lever arm of the vane. The other end of the recording arm is also perforated and fitted with a lock screw to hold the stylus (st.).

Any movement by the vane produces proportional rotation of the recording arm, causing the stylus to inscribe an arc on the clock driven recording surface below it.

2. *The Stylus* (Fig. 1B). A 2 in. long and ¼ in. wide turned copper cylindrical casing is constructed as figured. A small free moving piston with shank (p.) is machined to fit inside the casing so that the piston's shank projects through the hole at the lower end of the casing. The piston is held at this end of the stylus by a light helical spring (sp.) whose tension can be adjusted by the setting screw (ts.) at the top of the casing. The "nib" of an ordinary ball point pen (bt.) is fitted on to the end of the shank.

The assembled instrument provides a spring loaded scriber which will gently and freely ride over uneven surfaces, rarely tearing the graph but always remaining in light and intimate contact with it.

3. *Recording Apparatus* (Figs. 1, 2, 3 and 5). This consists of a clock supporting a turn-table.

The removable Casella drum clock revolves around its fixed spindle (ca.) which is bolted in a set position (see later) to the floor of the Perspex case (Fig. 2). The top of this type of clock is a tightly fitting cylindrical lid (cc.) which presses down into the clock drum (cs.) to form a weather-proof lid over the winding key and spindle lock nut.

An 11 in. diameter turn-table of ¼ in. Perspex sheet is attached to the clock lid (cc.) by a countersunk central screw and nut (z). The outer edge of the turn-table is cut to form a wide (¼ in.) and deep (¼ in.) groove (Fig. 1, A and C.) which loosely accommodates a ring made from a length of curtain spring (Fig. 1, 2 and 5, sl.).

To record the trace of the stylus a sheet of lead carbon paper (cp.) is placed over a sheet of good quality bond on the turn-table. They are anchored by placing the spring wire ring over them and forcing it down over the papers, into the marginal groove (Fig. 1C). The excess carbon and paper are trimmed off (Fig. 5) before the table is replaced on the clock drum and the stylus lowered against the carbon paper.

4. *Alignment of the Head and Turn-Table* (Fig. 1A). When the vane is rotated the stylus inscribes a circle whose radius, X, corresponds to the length of the recording arm (ra). The diameter of this circle, $(X+X^1)$ must be smaller than the radius of the turn-table so that the stylus can record complete circles radially around the turn-table as time passes. To ensure this the spindle (s) of the wind vane must be aligned vertically to the mid point of the radius of the turn-table; this is a critical relationship and must be made with great care and accuracy.

PREPARING THE GAUGE FOR OPERATION. The gauge rests on two baseboards held on a metal stand (Fig. 4). The lower baseboard (fb.) is fixed to the stand and attached to the upper baseboard by three levelling screws (ls.) disposed in a triangle (Fig. 1 and 3). The gauge casing is held firmly to the upper baseboard by four brass toggle clamps (ct.).

Once the cardinal points (Fig. 3, cn.) marked on the top of the gauge are aligned to true North with a prismatic compass, the wind gauge is levelled by adjusting the levelling screws against a spirit level.

The stylus is then lowered on to the turn-table so that its ball point touches the carbon paper and retracts slightly into its casing which is then locked in this position. A light but continuous

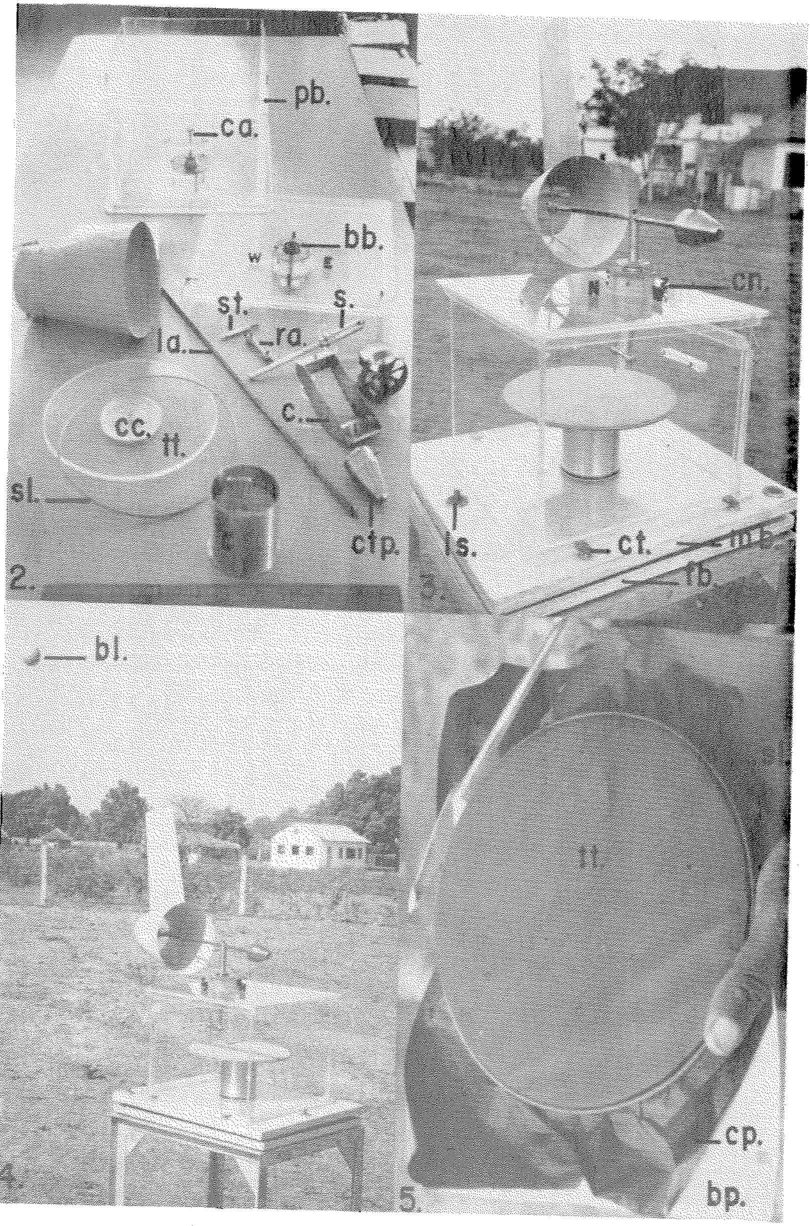

FIG. 2.—The components of the wind gauge, the cradle and air flow meter used instead of the counterpoise when accurate recordings of wind speed are required. FIG. 3.—The wind gauge *in situ* showing the position of the stylus on the turn-table when the wind vane points west. FIG. 4.—The wind gauge with drogue hydrogen balloon for measuring air movement below Beaufort Force I. FIG. 5.—Trimming the excess bond and carbon paper from the turn-table of a smaller gauge. Note retaining marginal spring wire ring.

ABBREVIATIONS IN FIGURES.

a.	locking screws.	mb.	moving base-board.
bb.	bearings.	p.	piston and shank.
bh.	balloon hook.	pb.	"Perspex" box.
bl.	balloon.	ra.	recording arm.
bp.	bond paper.	s.	spindle of vane.
bt.	ball point head.	sg.	rain baffle.
c.	cradle for anemometer.	sl.	retaining spring loop.
ca.	spindle of clock.	sp.	spring.
cc.	clock cover.	sr.	tail struts.
cn.	cardinal points.	st.	stylus.
cp.	carbon paper.	ts.	tension adjustment.
cs.	case of clock.	tt.	turn-table.
ct.	clamping toggle.	w.	washer.
ctp.	counterpoise weight.	X, X^1.	length of recording arm.
fb.	fixed base-board.	y.	radius of turn-table.
la.	lever arm.	z.	centre screw.
ls.	levelling screw.		

pressure of the ball point on the carbon is obtained by adjusting the tension screw at the top of the stylus.

With the tail vane and lever arm aligned N. to S. so that the counterpoise (ctp.) points North (Fig. 1), the time and position of the stylus are noted by a small pencilled arrow with the time written on the margin of the turn-table; this is sufficient to show the beginning of the record and *must* be done before the vane is released.

THE RECORDED TRACE. Any arc produced by the circular movement of the stylus is related to a position of the vane on the compass once the wind gauge is oriented. Thus, when the vane points northwards, the stylus traces an arc parallel and near the perimeter of the turn-table (Figs. 1A and 4). Vice versa, a south wind is recorded as a trace near the centre of the turn-table. East and west (Fig. 3) winds move the pen to opposite and intermediate locations between the centre and periphery of the turn-table. These positions are on the tangent of the circle whose radius equals half that of the turn-table.

With the exception of periods of very variable winds ("boxing the compass") which may produce circular tracings due to complete revolutions by the wind vane, other winds, strong or light, produce proportional oscillation of the pen to give arc-like tracings along some segment of its circle of rotation, depending on the direction of the wind. Since the clock-driven turn-table is moving at the same time as the stylus oscillates, the arc-like tracings fuse to produce a continuous anti-clockwise pattern of varying width and radial disposition as the day progresses and as long as wind strength remains greater than Beaufort I.

When air movement falls below Force I, oscillations cease and the trace becomes a single line. If, however, an accurate measurement of this is required a 2 ft. diameter meteorological balloon filled with hydrogen (Fig. 4) can be attached by 150 ft. of light line and a swivel to the loop (bh.) provided at the end of the lever arm. The ballon acts as a sensitive drogue drifting behind the gauge where it oscillates with the slightest air movement, which is then recorded by proportional displacement of the stylus.

Wind speed can be estimated with experience by observing the frequency and width of the oscillations in the trace or by calibration with another anemometer. The counterpoise (ctp.) on the lever arm can be replaced by a cradle (Fig. 2, C.) which supports a portable vane-driven air flow meter.

Wind direction is read off the graph with the use of overlays, which are described in the second part of this paper.

TECHNICAL NOTES. A ventilation baffle should be left under the upper surface of the case to stop condensation, which, under tropical conditions, softens the graph and carbon paper and may cause them to tear under the stylus.

The turn-table used in this model has a 5½ in. radius and the circle inscribed by the stylus is 4¼ in. in diameter. These dimensions were limited by the strength of the clockwork and the availability of large sheets of paper and carbon. However, it should be noted that the larger one makes the circle inscribed by the stylus and, thus, the turn-table, the more accurate and easy it is to interpret the recorded trace.

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A SIMPLE RECORDING WIND GAUGE

II. INTERPRETING THE RECORDED WIND TRACE

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INTRODUCTION. The principle and mechanism of this apparatus have been described in the preceding paper, Part I. (Giglioli, 1964). However, since the record obtained consists of a circular graph (Fig. 5) with no scale and only a marginal note indicating the time and place the record began, it is necessary to have an overlay to interpret the results and their chronology during the 24 hours of the record.

THE RECORDED TRACE. 1. *Removal from the Gauge* (Fig. 1). After lifting the stylus the turn-table is removed from the gauge and the retaining spring loop holding the paper record and carbon overlay slipped off. Both papers are taken off the turn-table (tt.) and the carbon paper (cp.) peeled off the underlying record (r.). Four representative examples of these records are shown in Figure 5 where a circular trace of radially disposed fused arcs can be seen, often separated by sectors connected by only a single trace. The latter are produced when the wind falls below Beaufort Force 1.

2. *The Trace* (Fig. 5A). In interpreting the circular record two factors, time and wind direction, must be read, and wind speed estimated.

(a) The time factor (Fig. 5A and C). Since the gauge's turn-table makes one revolution every 26 hours its circumference must be divided into 26 equal parts, i.e. chronological calibration. The two hours in excess of a day's duration in the Casella thermo-hydrograph clock are marked in Figure 5A by the "overlap" sector. The gauge was normally changed between 0900–1000 every day, thus, the

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