JOURNAL OF HYDROLOGY (N.Z.) Vol. 9, No. 1, 1970

A HEATED ALPINE PRECIPITATION GAUGE

C. L. Batcheler*

ABSTRACT

A gauge for measuring total precipitation at an alpine station, where most winter precipitation is snow, is described. The heating system in the gauge employs an electro-mechanical device to control ignition and damping of a kerosene burner. Precipitation totalling 131 in., of which 37% was snow, was estimated for 1965 at an altitude of 4,700 ft. The recorded catch appears to be reasonably reliable.

INTRODUCTION

Studies of the mammals of Cupola Basin, 60 miles south-west of Nelson, were begun in 1960, and from April 1963 meteorological information was collected as part of the environmental data. A

FIG. 1 — View of the meteorological station at Cupola Basin. The thermometer screen and 5-inch manual rain gauge are on the left; the heated gauge is on the right. The eastern flank of Mt Cupola forms the background of the photograph.

---

* Forest and Range Experiment Station. N.Z. Forest Service, Rangiora.

standard Stevenson screen enclosing wet-bulb, dry-bulb, maximum and minimum thermometers, a 5-inch-orifice manual rain gauge, and an automatic temperature and rainfall recorder were installed on an undulating alpine bench site at 4,700 ft for this purpose by the N.Z. Meteorological Service in March 1963 (Fig. 1).

The problem of recording winter precipitation at the station was taken up as a hobby which, apart from the initial mechanical development, could be fitted in with the routine research on the animals. A gauge was required which could be read daily, yet have sufficient storage capacity and be sufficiently reliable to operate untended for up to three months in winter. It had to be able to operate in a snowpack of up to about 4 feet deep. The gauge described here proved suitable, and since similar specifications are becoming pertinent to many alpine precipitation gauging studies, the idea was thought to be worth recording.

THE GAUGE

The gauge is basically a storage gauge with a snow-melting mechanism housed in a ½-inch-thickness wooden cabinet measuring 14 in. wide × 16 in. long × 18 in. high. The receiving funnel is 8 inches in internal diameter and formed from 28-gauge galvanized iron. The orifice is 5 ft above ground level. The funnel protrudes 14 in. above the cabinet and supports an inverted frustrum held by wooden wedges (a modified Nipher shield), and a 4-inch-deep snow cross within the orifice (Fig. 2). This funnel discharges into a shallow conical pan mounted on a swinging arm and spring. Water collected in the pan drains through a screened aperture to a second funnel and drainpipe leading to a 4-gallon storage vessel.

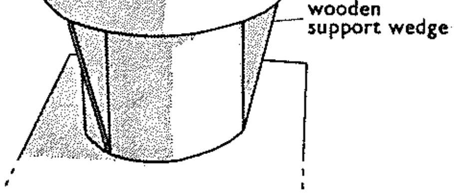

FIG. 2 — The snow cross and shield fitted to the heated gauge funnel.

Fig. 3 shows the electro-mechanical system which automatically ignites and snuffs the kerosene burner flame when snow or ice accumulates in the conical receiving pan (P).

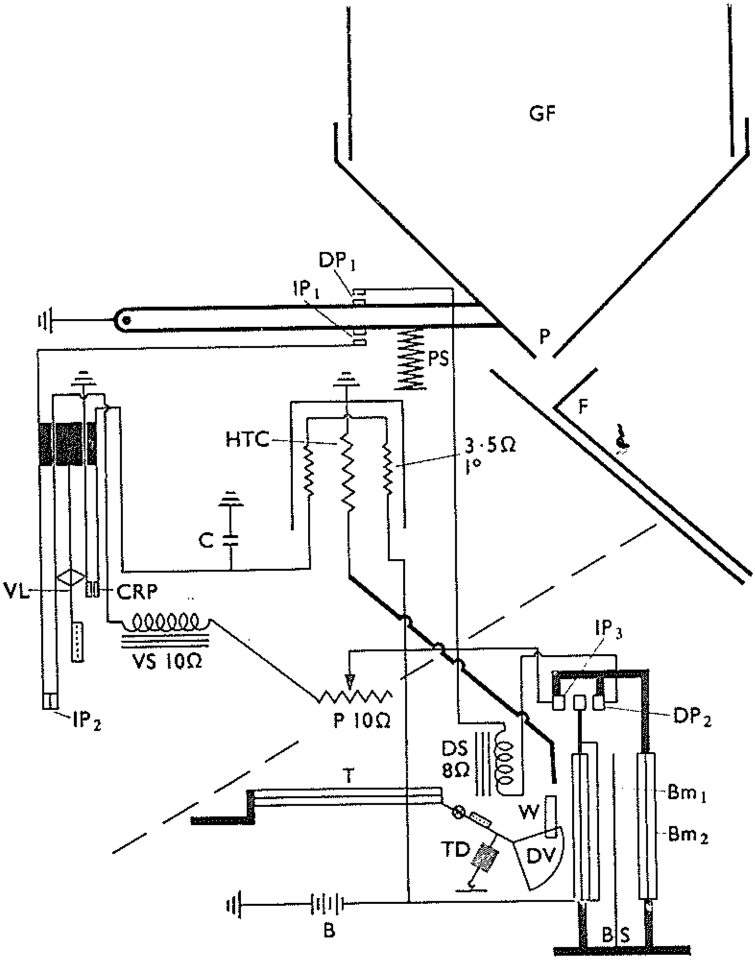

FIG. 3 — The electro-mechanical system of the heated gauge. The mechanism below the broken diagonal line is drawn in horizontal plan; that above the line, including the receiving pan, is drawn in vertical section. Abbreviations from top to bottom: GF. 8-inch gauge funnel; P, receiving pan; DP_1, damper circuit point No. 1; IP_1 ignition control circuit point No. 1; PS, receiving pan spring; F, funnel and discharge pipe to storage tank; HTC, 6-volt high-tension coil; C, capacitor; VL, vibrator lever; CRP, coil relay point; VS, vibrator solenoid; P 10Ω, wire-wound potentiometer; IP_2 and IP_3, ignition control circuit points; DP_2, damper circuit control point; D, damper solenoid; T, cabinet thermostat bimetal strip; W, wick; TD, thermostat and damper pivot arm; DV, damper vane; Bm_1 and Bm_2, bimetal circuit control strips; BS, heat baffle strip; B, 6-volt dry-cell battery.

Ignition

The ignition consists of three circuits: (1) a 6-volt relay and control circuit; (2) a high-tension coil primary circuit; (3) a coil secondary (high-tension) circuit. The negative battery lead is connected to a double-faced electrical point mounted on one of two bimetal strips, Bm$_1$. This strip is set to bend away from the flame as the temperature rises. An opposing point, IP$_3$, is connected through a 10-ohm potentiometer and 10-ohm vibrator solenoid coil to two spring-mounted make-and-break contacts, IP$_2$, and a lead from these completes the ignition relay circuit through contacts IP$_1$ mounted on the receiving pan support arm. The contacts IP$_3$ are set to remain closed when there is no local heat from the wick area, and the make-and-break contacts are held closed by pressure of the vibrator lever, VL. With this arrangement, the only break in the ignition control and relay circuit in dry weather is at IP$_1$.

The vibrator is energized when snow weighs down the receiving pan and closes the points IP$_1$. This generates an intermittent high-tension spark across a 3/16–$\frac{1}{4}$-in. gap on to the metal surround of the wick. The kerosene usually ignites within about a second.

Within 5 to 10 seconds of ignition, heat from the flame distorts the bimetal strip Bm$_1$ sufficiently to break the ignition relay circuit. The double-faced point continues moving with distortion of the bimetal mounting until the terminal closes with the opposing damper control point, DP$_2$, and this position is retained while the flame continues to burn.

Flame Control

A bimetal strip (T) is fitted inside the cabinet with its free end resting against the heel of the pivoted damper vane arm (DV). It is arranged to govern movement of the damper across the wick, so that the wick is fully exposed at 32°F and about three-quarters covered at 45°F. This achieves a melt rate of about 0.25 in. per hour, and eliminates noticeable convection updraught at the gauge funnel. It also reduces the number of ignition/damping cycles during snowstorms, and so prolongs battery life.

Damping

The receiving pan rises on the mounting spring as melted snow drains away, until the second pair of points in the flame damper circuit (DP$_1$) close. This energizes an 8-ohm solenoid which snuffs the flame by drawing a small 28-gauge copper vane (DV) across the wick. The bimetal strip Bm$_1$ then cools and straightens, disconnects the damper circuit and, as heat in the strip is dissipated, reconnects the ignition relay circuit at IP$_3$. The cycle is repeated when more snow accumulates in the pan.

Ambient Temperature Compensator

As shown in Fig. 3, the two terminals IP$_3$ and DP$_2$ which oppose the double-faced point connected to battery negative are also mounted on a bimetal strip (Bm$_2$). Both strips are set to bend away from the flame on heating. This arrangement keeps the ignition circuit closed at IP$_3$, and prevents the damper control point DP$_2$ being connected during hot weather.

1965 RESULTS

Calibration of the Gauge

Quantities of rain collected in the heated gauge and the adjacent 5-inch rain gauge were recorded for 28 convenient periods during which 0.04 in. to 17.67 in. of rain were recorded in the 5-inch gauge. Linear correlation of the catches was extremely close ($P < 0.001$), with the heated-gauge catch (Y) differing from the simultaneous 5-inch-gauge catches (X) by only 2.9% ($Y = 0.971X$). Catches recorded in the heated gauge throughout 1965 were therefore multiplied by 1.029 to convert them to estimates of precipitation in a 5-inch gauge for the full year.

1965 Estimate

A total of 117 in. (corrected by regression equation) was recorded in the heated gauge during 1965 over all months except July. Judging from the similarity of the patterns of recruitment in

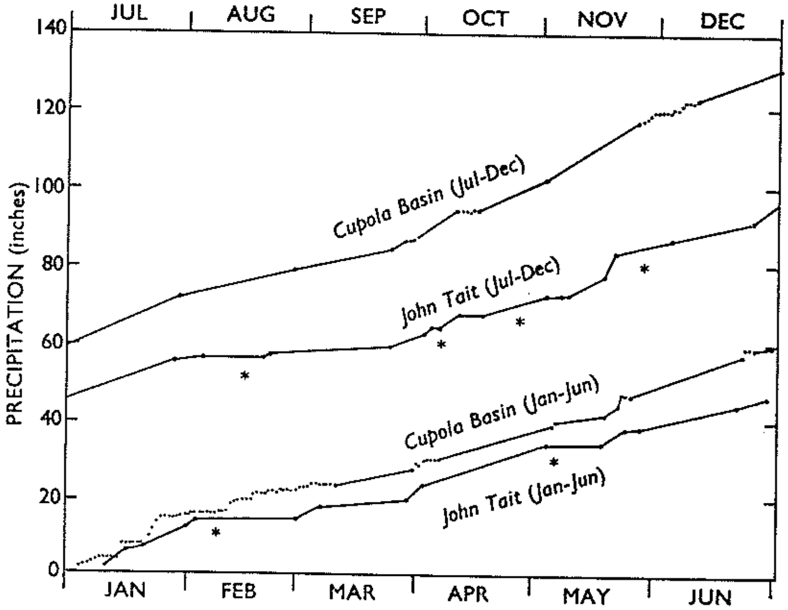

FIG. 4 — Accumulated total precipitation at Cupola Basin and John Tait stations from January to June and July to December, 1965. Marked points are totals obtained by addition. Asterisks indicate possible errors in recording the John Tait gauge when it was emptied, or when successive readings by visitors were found to be inconsistent.

a C-type gauge at John Tait Hut (at 2,600 ft altitude, 1¾ miles down river) and at Cupola Basin, this estimate seemed to be reasonable (Fig. 4). But for July, when the heated gauge failed because of an electrical defect, an estimate was made on the basis of the catch recorded in the gauge at the John Tait Hut. Over the period January to June, the low-altitude gauge collected 45 in., while 1.28 times this, i.e. 57.8 in. (corrected), was collected in the heated gauge. For July, 11 in. were recorded at low altitude, so the catch in the heated gauge was estimated proportionately at 14.1 in. As shown in Fig. 4, these data and estimates brought the catches to 96 in. in the low-altitude gauge, and 131 in. at Cupola Basin.

DISCUSSION

There are, among the many possible lines of evidence concerning accuracy and reliability of the gauge, only three fragmentary pointers in the present information. First among these is the extremely close correlation and regression of the catches in the standard 5-inch gauge and heated snow gauge when neither was under any risk of complication due to snow. It is therefore clear that either the heated gauge gave an accurate estimate of precipitation under snow-free conditions, or that both gauges gave inaccurate figures. However, since both of these gauges collected about 1.3 times the fall recorded in the John Tait gauge — and this order of difference between low- and high-altitude stations is confirmed for summer precipitation by Morris (1965) — the totals recorded by both gauges can be presumed to be reasonably accurate.

For the winter months, the only available evidence concerning the heated gauge is the fact that, in all months except July, it continued to collect and store about 1.3 times the precipitation recorded in the John Tait gauge. This observation can only suggest that the heated gauge operated well at all times except July or, alternatively, that none of the three gauges operated accurately at any time. The latter possibility is outside the scope of this paper.

The third point of evidence was that the heating equipment of the gauge was repeatedly seen to operate during those periods in which the station was occupied.

About 37% (46 in.) of the year's precipitation was of snow, which is not much different from the one-third proportion reported by Morris and O'Loughlin (1965, unpublished) for sites above 5,000 ft in the Craigieburn Range. This figure for Cupola Basin does not include snow which fell from January to April and from October to December because during these months it melted within a few hours or days. The winter snowpack formed with a snowfall about 15 May, and after this precipitation at and above the timber line consisted of snow or (rarely) rain which froze into the snowpack. Rain again predominated in October, and the spring thaw occurred quickly.

A shield is undoubtedly necessary at the gauge funnel, as has been found by Gillies (1964) and other observers. The one developed for the heated gauge is very simple to construct, being an inverted frustrum mounted 1 inch below the horizontal line of the gauge orifice. It has a diameter of 14 in. at the top and 12 in. at the bottom, a vertical depth of 8 in., and an exterior angle of 7.2° from the vertical. During earlier observations without a shield, the catch was only half that recorded on adjacent level ground. Large quantities of snow accumulated on a Nipher shield such as shown by Middleton and Spilhaus (1953) who quote a recommendation by Brooks (1938) for an almost horizontal (80° from vertical) lip. Wet snow, falling when air temperature was about 33–35°F at the site, built up rapidly and partially bridged the funnel orifice. The shield adopted (Fig. 2) appeared to prevent development of an updraught near the orifice, yet was sufficiently far removed from the funnel to permit snow falling just outside to slide through the gap on to the cabinet. The snow cross within the funnel — the idea for which was first brought to the attention of the author by Mr P. Kemp of the N.Z. Meteorological Service (pers. comm.) — eliminated loss of snowflakes after they fell beneath the rim. Previously, much dry snow was observed to eddy within the funnel and then drift out over the lee side.

Approximately 0.25 gallon of kerosene was burned by the gauge during the year, and the four No. 6 dry-cell batteries were still in good condition by winter 1966. This type of instrument would therefore be suitable, if adequate storage were provided or a tipping-bucket or siphon recorder utilized, for alpine precipitation studies where the instrument is to be read either daily or at intervals of up to one year.

ACKNOWLEDGMENTS

I appreciate the advice and help given by Mr J. D. Coulter and Mr P. Kemp of the N.Z. Meteorological Service, Mr C. L. O'Loughlin for introducing me to relevant literature, and Mr A. J. Gillies, Otago Catchment Board, for comments on the manuscript. Miss P. M. I. Hampson assisted with calculations, and Messrs A. H. C. Christie and C. M. H. Clarke read and checked the gauges from time to time.

REFERENCES

Gillies, A. J. 1964: Review of snow survey methods, and snow surveys in the Fraser catchment, Central Otago. *J. Hydrol. (N.Z.) 3* (1): 3–16.

Middleton, W. E. K.; Spilhaus, A. F. 1953: *Meteorological instruments.* Toronto. 286 pp.

Morris, J. Y. 1965: Climate investigations in the Craigieburn Range, New Zealand. *N.Z. Jl Sci. 8* (4): 556–582.

Morris, J. Y.; O'Loughlin, C. L. 1965: *Snow investigations in Craigieburn Ranges.* N.Z. Forest Service Protection Forestry Report No. 4 (unpublished).