Rain Correction Modification for a Non-Shielded Net Radiometer[1]

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1. Introduction

One of the principal sources of error in the readings of an unshielded ventilated net radiometer is caused by the evaporative cooling effect of rain on the sensing element as shown in Fig. 1. This cooling simulates an erratic net negative radiation balance. It has been our experience that snow, unless it is wet and heavy, does not affect the operation of an unshielded and ventilated net radiometer. Attempts have been made to approximate the true net radiation by the time consuming process of removing the erroneous data from the radiation charts. When it is difficult or impossible to approximate the net radiation during the period of rain, it is assumed that the net radiation balance is zero. This is a reasonable assumption when the sky is completely overcast because the radiating characteristics of the earth's surface and the cloud cover are similar (Frankenberger, 1958). Others have attempted to eliminate this error by temporarily covering the thermopile with a polyethylene plastic sleeve. This arrangement is unsatisfactory for the following reasons: both the polyethylene cover and the water film will partially absorb certain wavelengths, and it is necessary for an observer to be present to place the sleeve over the thermopile

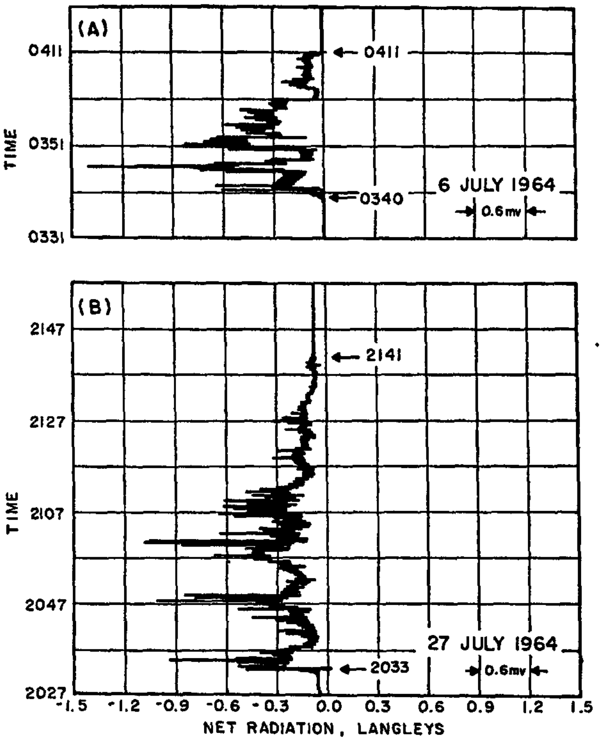

FIG. 1. Traces of two net radiation strip charts during periods of rain indicated by arrows, (A) when recorder indicates net zero radiation before and after the rain, and (B) when recorder indicates net negative radiation before and after the rain.

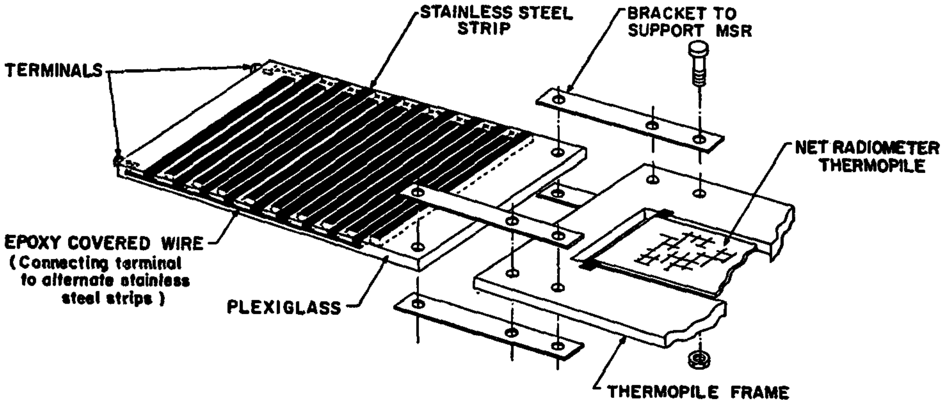

FIG. 2. Sensing unit of moisture sensitive resistor shown attached to the thermopile frame of an unshielded, net radiometer.

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when it begins to rain and to remove it when the rain ceases.

Since it does not appear feasible to alter the thermopile behavior, a device was designed to eliminate the incorrect values obtained with the recorder, integrator, and timer used in conjunction with the net radiometer. The integrator-timer was developed especially for the net radiometer in order to eliminate the time consuming and laborious job of hand integrating the strip chart containing the net radiation trace.

2. Design of MSR sensing surface and circuitry

The sensing surface of this moisture sensitive resistor (MSR) consists of a grating of stainless steel strips embedded in plexiglass to make a weather resistant unit. The plexiglass was first milled with $\frac{1}{16}$ inch grooves that were $\frac{1}{32}$ inch apart; then sheared, stainless steel strips $\frac{1}{16}\times\frac{1}{16}\times2\frac{1}{2}$ inches were fitted into these grooves so that the stainless steel strips were flush with the plexiglass surface. Alternate stainless steel strips were soldered to one connecting terminal and the remaining strips were soldered to the other terminal. The sensing unit was then attached to the frame which supports the thermopile so that both the MSR sensing surface and the thermopile were in the same environment (Fig. 2).

Current will flow across the terminals of this sensing surface when the gap between adjacent stainless steel strips is bridged. Thus, this sensing unit can act as a switch in any circuit connected across its terminals. For example, the circuit is open when the sensing surface is dry and closed when the gaps are bridged by moisture. The current carrying capacity of the sensing surface, for a given potential difference, is a complex function of the number of stainless steel strips, their distance apart, and the electrical characteristics of the rain water. In general the MSR is more sensitive if it is designed with many stainless steel strips very close together.

One consideration in the original design of the sensing surface was raindrop sizes. Since raindrops generally vary from 0.02 to 0.1 inch (Fleagle and Businger, 1963), a $\frac{1}{32}$ inch gap should be sufficiently small to detect any rain that would affect the ventilated thermopile of the net radiometer.

When the sensing surface gets sufficiently wet to conduct a current, the activated relay short circuits the thermopile input leads of the net radiometer recorder causing the recorder to read zero net radiation. When the MSR surface dries, which normally occurs within several minutes of the cessation of rain, the relay releases and the thermopile is again connected across the input of the recorder (Fig. 3).

The power supply for the circuit in Fig. 3 is any 115-ac outlet, the proper full-wave silicon bridge rectifier, and a 300-μF capacitor filter. The relay is a dc, single pole, double throw relay with a coil rating of 9 mA and 2500 Ω, and a contact rating of 5 A. The 15,000-Ω variable resistor can be used to adjust the sensitivity of the circuit; in general, lowering the resistance increases the sensitivity.

The MSR was tested by sprinkling deionized water on the sensing surface; with 17,500 Ω in the circuit there was sufficient current to operate the 9-mA relay. During the testing period it was noted that if the 120-V wires were too close to the input wires from the thermopile to the recorder under wet conditions, leakage from

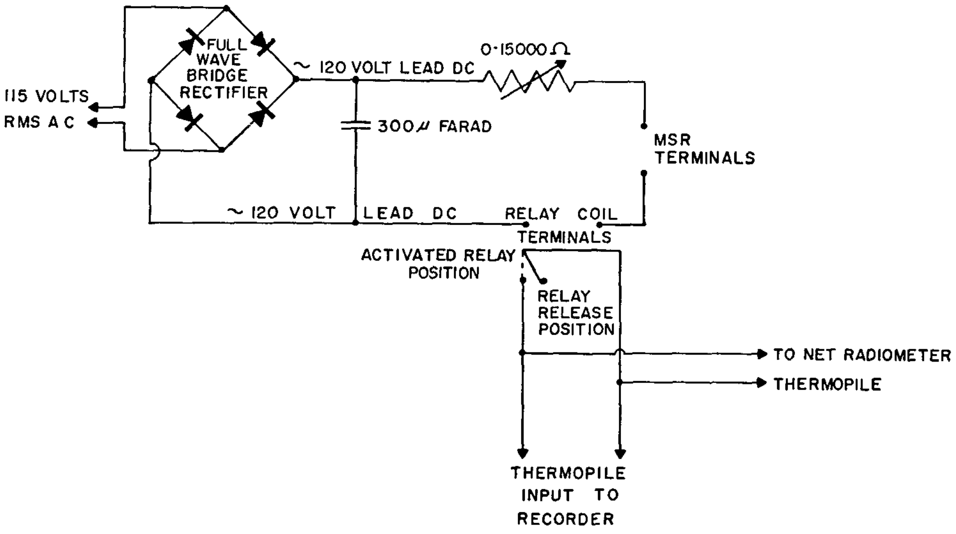

FIG. 3. Circuitry of the moisture sensitive resistor.

the 120-V leads caused erratic behavior of the recorder. Therefore, all leads to the recorder were made with shielded wire and kept sufficiently far from the 120-V leads.

The electrical components of the MSR circuit described can be purchased at any electronics storehouse for about five dollars. The sensing unit may cost anywhere from a few dollars to thirty or forty dollars depending on the sophistication desired. The sensing unit described in this article was built in the University of Minnesota shops for about twenty-five dollars.

3. Design of the integrator-timer

The MSR is used with the following integrating circuit (Fig. 4) on a Honeywell continuous strip-chart recorder and a ventilated, nonshielded net radiometer

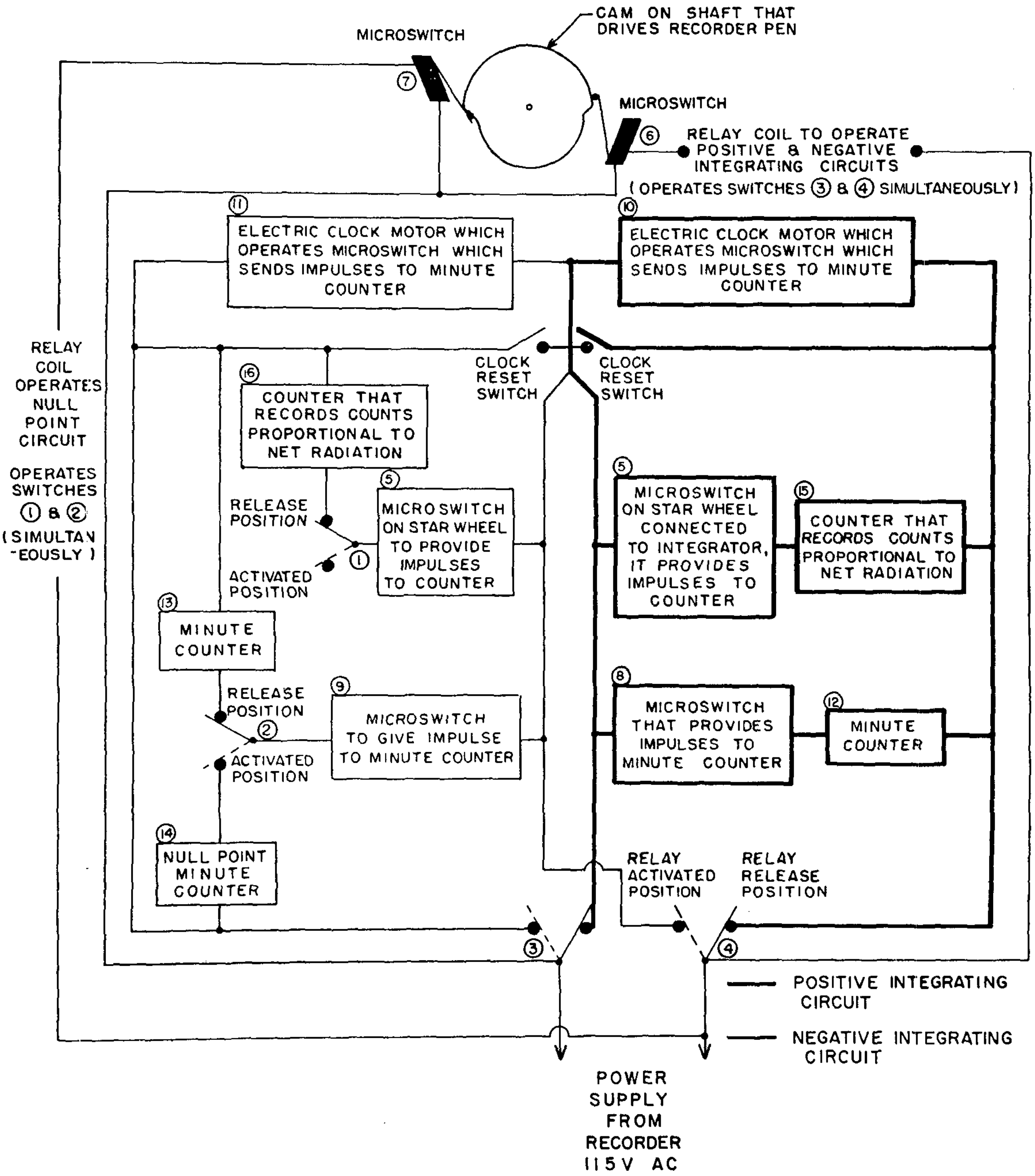

FIG. 4. Integrator-timer circuit used with the net radiation recorder.

(Suomi et al., 1954). Mr. R. K. Maxwell[2] constructed the original integrator-timer, and it was later simplified by Mr. A. R. Harris.[2] The present integrator-timer is a modification of the Maxwell-Harris design. This circuit integrates independently the actual net positive and net negative radiation by assigning a given counting rate to a given thermopile input. This is accomplished with a heart shaped cam mounted on the drive shaft of the recorder pen. A Librascope ball and disc integrator rides on the cam. Impulses are provided to the integrating circuit counters (15 and 16, Fig. 4) by the switching action of a microswitch riding on a star wheel (5, Fig. 4). The Librascope ball and disc integrator varies the angular speed of the star wheel as the heart shaped cam rotates; thus, a given counting rate is assigned to any deflection of the recorder pen. (The microswitch that is mounted on the star wheel (5, Fig. 4) is shown in each integrating circuit; this is for diagrammatic purpose only and in actuality there is only one star wheel.) When the net radiation balance is zero the recorder pen is in the center of the chart and the heart shaped cam is positioned so that the counting rate is zero. As the net radiation increases in either the positive or negative direction, the drive shaft of the recorder pen rotates the heart shaped cam in the appropriate direction, increasing the counting rate linearly with the thermopile input voltage.

The positive and negative integrating circuits shown in Fig. 4 are controlled by a second cam mounted on the shaft assembly (see top of Fig. 4). When the net radiation balance is zero the cam and microswitches are synchronized so that both microswitches are closed. When this occurs the coils of both the null point relay and negative integrating circuit relay are activated. From Fig. 4 it is evident that if both relays are activated the only counter operating is the null point minute counter. If the net radiation balance is positive, microswitch 6 is closed and microswitch 7 is open so that only relay contacts 3 and 4 are in the activated position. This starts the positive integrating circuit. If the net radiation balance is negative, switch 6 is open and switch 7 is closed so that the contacts of all relays are in the release position. This starts the operation of the negative integrating circuit.

The duration in minutes is also separately recorded for the net positive radiation, net negative radiation and the null period. Each integrating circuit (Fig. 4) contains an electric timer motor (10 and 11, Fig. 4) geared to 1 rpm. Once per minute a microswitch is activated by a cam mounted on the shaft of this motor. These microswitches (8 and 9, Fig. 4) provide impulses for the appropriate minute counter (12, 13 or 14, Fig. 4).

The electrical components of the integrator-timer circuit shown in Fig. 4 can be purchased for approximately $120 exclusive of the ball and disc integrator.

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Frankenberger, E., 1958: Über die Anwendung von Strahlungsbilanzmessern verschiedener Bauart bei Wärmehaushaltsuntersuchungern. *Ann. Meteor.*, **8**, No. 5/6, 163–166.

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Low-Level Jet Winds at Green River, Utah

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1. Introduction

The vertical profile of horizontal wind speed sometimes shows a relatively sharp peak or "nose" within the lowest 5000 ft of the atmosphere. Such low-level maxima apparently achieve greatest development and occur more frequently in parts of the central and southern plains area of the United States during the summertime between midnight and sunrise and at about 1500–2500 ft above ground level.

During 1963, a considerable number of nighttime and early morning radiosonde soundings were made at Green River, Utah, and a few soundings were made during these hours in 1964 and 1965. Wind data from these soundings indicated a number of significant low-level wind maxima. It is the purpose of this note to show some evidence of low-level jets at Green River, make some comments concerning their development, and point out their importance and the need for a more thorough study of the phenomenon.

The low-level jet is of great interest from a theoretical viewpoint since its explanation must involve turbulent mass exchange within the planetary boundary layer. It also has very important practical interest. Of primary concern is the effect of such sharp low-level wind profiles and the associated wind shear upon rockets launched at Green River.

2. Discussion

Examination of 195 nighttime radiosonde soundings revealed 32 cases of low-level wind maxima considered