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RESEARCH NOTE NC-123

NORTH CENTRAL FOREST EXPERIMENT STATION, FOREST SERVICE—U.S. DEPARTMENT OF AGRICULTURE

Folwell Avenue, St. Paul, Minnesota 55101

ECONOMICAL CONVERSION OF A MINIATURE NET RADIOMETER TO AN ALL-WAVE HEMISPHERIC RADIOMETER

ABSTRACT: — Describes a method of inexpensively converting a miniature net radiometer to an all-wave hemispheric radiometer that does not preclude the original use of the instrument.

OXFORD: 111.21 — 017.1 KEY WORDS: solar radiation, long-wave radiation, pyrradiometer.

INTRODUCTION

In many ecological and micro-climatic studies incoming energy is commonly measured with glass-domed radiometers (pyranometers). However, these instruments are only sensitive to short-wave or solar radiation (0.28 to 3.0 microns), and thus a substantial portion of the incoming radiant energy, long-wave or atmospheric radiation, is neglected. All-wave, hemispheric radiometers of U.S. manufacture are available. However, these are the ventilated type, and as such, require power and are subject to wind and conventional errors (Sellers, 1965). They are also fairly expensive.

A less costly, and more satisfactory, pyrradiometer can be constructed from the Fritschen, or Thornthwaite type miniature net radiometers now in common use. The conversion is easily accomplished by covering the lower surface of the net radiometer with an opaque hemisphere so that the lower surface is viewing a "black body" (Gates, 1965). When the temperature of this black body is known, the total all-wave, downcoming radiation is easily calculated. The cost of the net radiometer and the conversion is considerably less than that of the commercially available pyrradiometers, and the user then has either a pyrradiometer or a net radiometer at his disposal.

CONSTRUCTION

The conversion is easily accomplished from readily available materials. The construction details are not critical. Our hemispheric covering was made from a 1¼-inch-long piece of 2-inch diameter copper pipe coupling. A 2 3/16-inch circle was cut from 14 gauge copper sheeting and soldered to the bottom of the cylinder to form a cup. A copper constantan thermocouple was soldered to the bottom of the cup and the inside of the cup painted flat black to eliminate any light reflection. Any type thermocouple, thermistor, or thermometer could be fixed to the cup as long as good thermal contact is assured.

For ease of mounting and field operation, and to reduce temperature fluctuation, the cup was mounted in an insulated stand. This stand was constructed from two 7-inch squares of 2-inch thick styrofoam cemented together with waterproof linoleum cement to form a 7 x 7 x 4-inch square. The cup was recessed into the center of this square and a 2¼-inch (inside diameter) rubber "O-ring" glued to its rim as a light and weather seal.

For our use the stand was mounted on a simple base which provides support and facilitates leveling of the instrument (Fig. 1).

OPERATION

When covered by the cup the bottom surface of the net radiometer is viewing a black body whose radiation may be calculated by the Stefan-Boltzmann law, $R = \sigma T^4$. The total downward all-wave flux may then be computed as:

$$\text{Flux} = \text{measured net radiation} - \sigma T^4$$

where T is the temperature of the cup in degrees

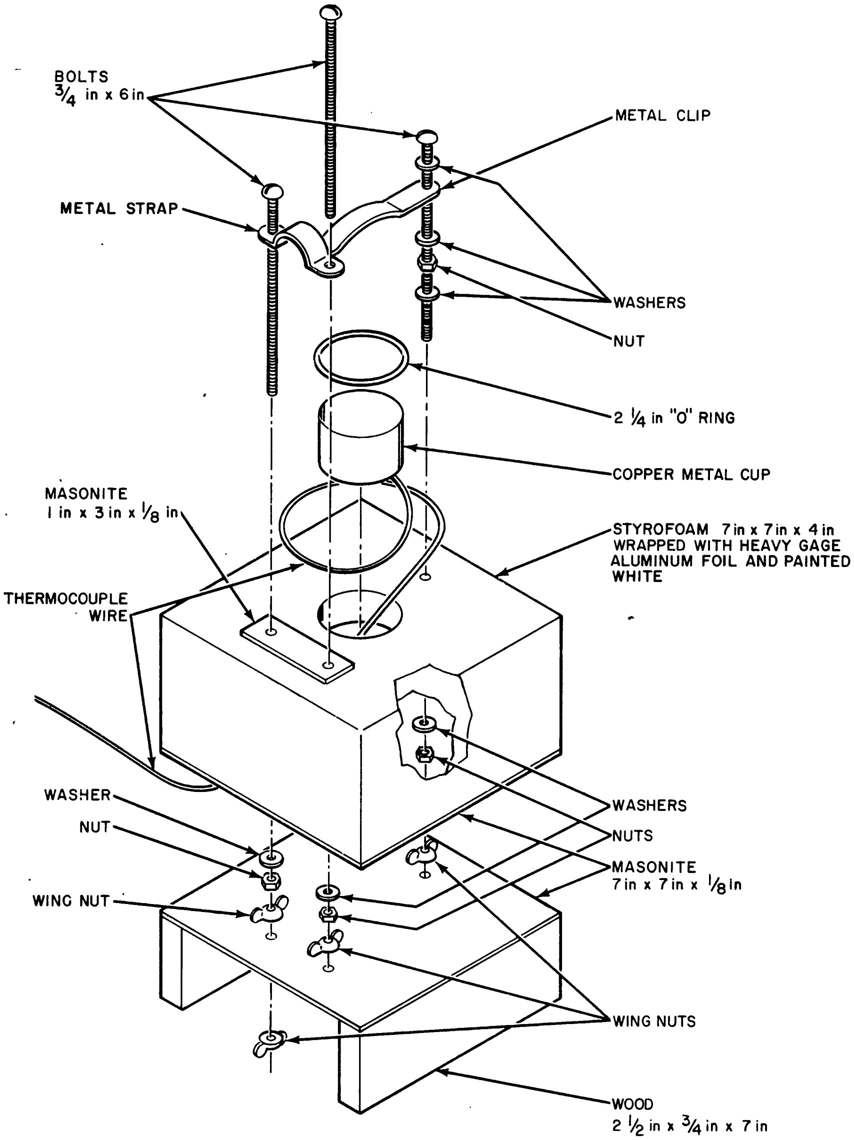

Figure 1. — *Diagram of insulated stand for mounting the radiometer.*

Kelvin. The emissivity of our cups was found to have a value closely approaching 1.0 so this factor has been neglected in the above equation.

For extended periods of pyrradiometer operation the miniature net radiometer is mounted in the stand and leveled. Both the temperature of the hemispheric cup and the net radiometer output are recorded. For short term instantaneous measurements of hemispheric all-wave radiation, the bottom surface is merely covered with a noninsulated cup and its temperature recorded. The noninsulated cup is also used in conjunction with the insulated cup for calibration purposes and in checking zero point stability.

For an approximate cost of $3 we have been able to use a miniature net radiometer to measure another important environmental factor.

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JAMES M. BROWN
Research Plant Physiologist
Grand Rapids, Minnesota
(Laboratory maintained in cooperation with the University of Minnesota)

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