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AN ELECTRONIC, AUTOMATICALLY OPENING RAIN COLLECTOR

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ABSTRACT

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Improvements in an automatically uncovering rain collector are described. The most important modification was insertion of a voltage sensing circuit that increased sensitivity and dependability of operation. A larger motor with increased torque was substituted for the original component to provide greater mechanical strength during rains with high winds. Other modifications are described that will make this collector useful in many areas of pollution research.

KEYWORDS: chemical analysis, composition measurement, electronic control, rainfall collection, rain gage, sampling, water analysis.

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AN ELECTRONIC, AUTOMATICALLY OPENING RAIN COLLECTOR

By Henry A. Schreiber, Loel R. Cooper, and F. Leland Payne[1]

INTRODUCTION

Studies in many areas of water chemistry require a knowledge of the contributions of dissolved and particulate matter in rainwater. The sampling of rainwater for quality is often difficult because of contamination of the collector caused by particulate matter falling into the rain gage between storm events. Some commercially available rain gages or rain gage modifications minimize these contaminations, but they are relatively expensive, often costing in excess of $500. This report describes the modifications that will convert a recording rain gage to an automatically opening rain collector by the insertion of a current sensing circuit to increase sensitivity and dependability of operation. These modifications are relatively inexpensive and can be performed by most machinists with a limited electronics background.

MODIFICATIONS

The reader is referred to Bentz[2] for general principles of an automatic opening rain gage. He constructed stainless steel shells to the dimensions of the Standard Weather Bureau copper gage. The rain gage lid, an aluminum cake pan, was lifted by an alternating current electric motor upon receipt of a signal from a rainfall sensing grid whose conductivity changed when moistened by rain. A paste of a wetting agent and a reservoir with a wetting agent were used to increase conductivity to achieve a more positive action of his "rain switch."

Our collector was made from a Friez-type gage (fig. 1). The weighing and recording mechanisms were removed, and the internal base plate for these components was lowered. The orifice, cone, tube, and storage container bag were coated with a plastic casting resin to eliminate metallic contamination. The Bentz-typed lid was added to the collector. The sensing circuit was modified to function in the absence of the wetting agent by introducing a Schmitt trigger circuit between the sensing grid and the low voltage relay coil, as shown in block SA1 of the circuit diagram (fig. 2).

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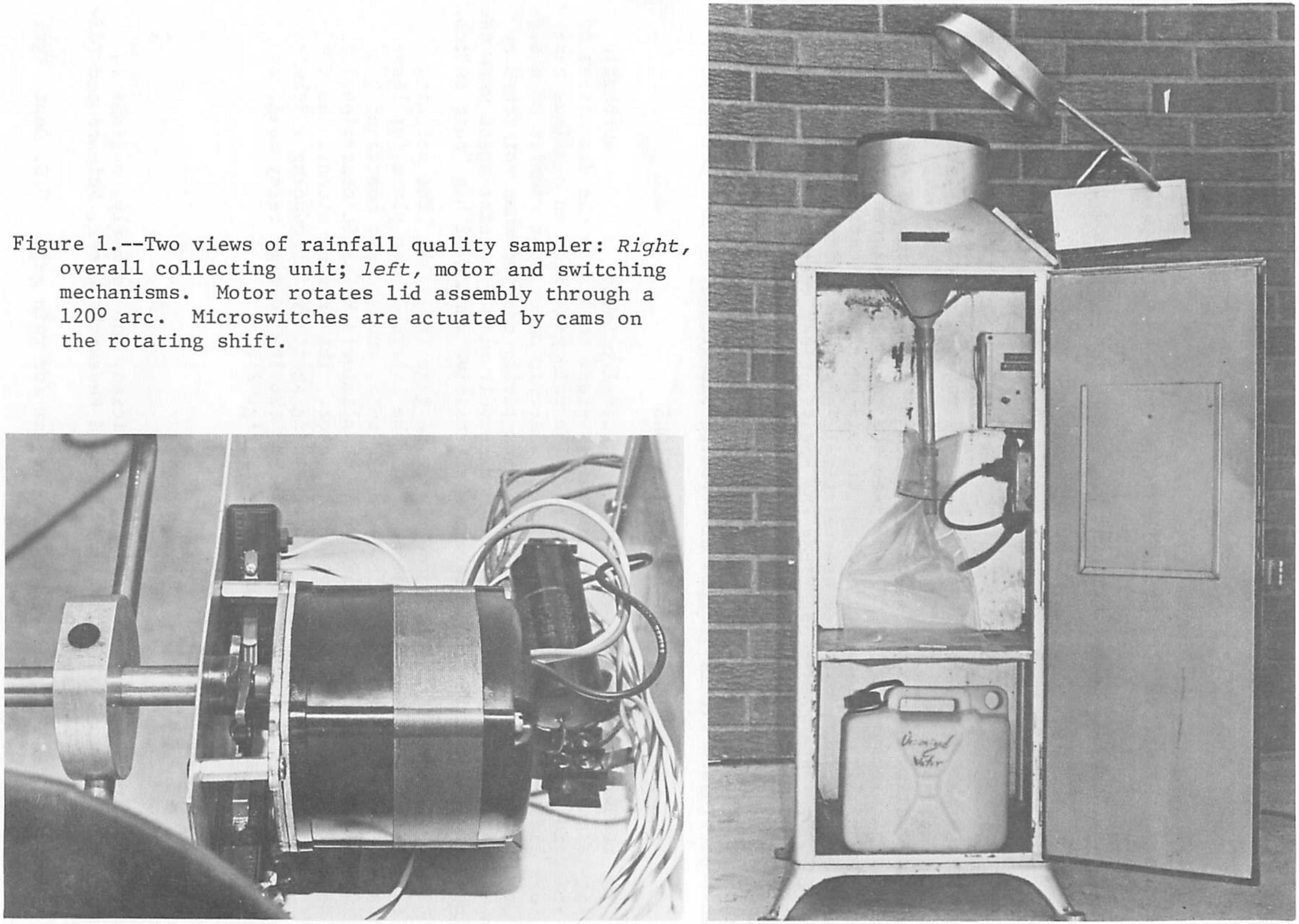
[2] Bentz, W. W. Inexpensive automatic cover for rain gage. U.S. Dept. Agr., Agr. Res. Serv. ARS-41-146, 8 pp. 1968.

Figure 1.--Two views of rainfall quality sampler: *Right*, overall collecting unit; *left*, motor and switching mechanisms. Motor rotates lid assembly through a 120° arc. Microswitches are actuated by cams on the rotating shift.



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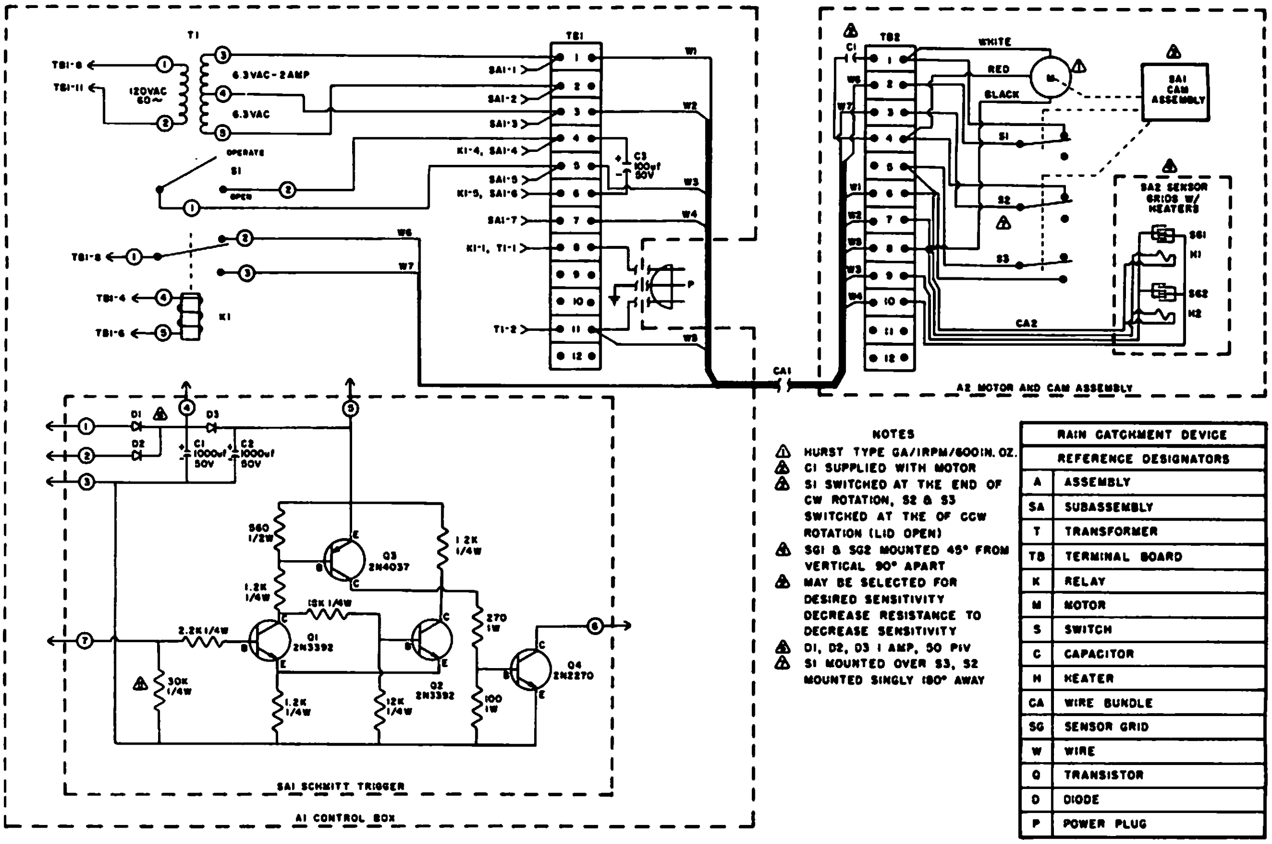

Figure 2.--Schematic diagram of circuitry for lower and upper control boxes, including the Schmitt trigger.

The first modification, the Schmitt trigger,[3] is a regenerative, bistable circuit useful for direct current level detection in the presence of very low current--a condition existing across the grid electrodes. With its use, grid opening reliability was increased so that one drop of deionized water initiated relay closure. If desired, the sensitivity can be altered by replacing the 30-ohm resistor with a potentiometer, as shown under note 5 in the circuit diagram. Another modification was needed to prevent winds of up to 40 miles per hour gusting against the rising cover from breaking the teeth in the motor gear assembly during opening. To eliminate this difficulty, a larger motor with 600 inch-ounces of torque was substituted for the original with 120 inch-ounces. Opening speed was lowered from 4.5 to 1.0 revolutions per minute.

The source of heat to provide for drying of the grid sensor was changed from Bentz's 8-watt, 110-volt alternating current light bulb, to 3 feet and 28-gage nichrome wire embedded in silicone rubber. This unit was then sealed underneath the grid to make a waterproof unit and was in turn fastened to the box housing the motor and upper terminal board (fig. 1). The nichrome heater uses about 9 W of alternating current power.

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[3]Cleary, J. F., Jr., ed. G. E. Transistor Manual. General Electric Company, Syracuse, N.Y. 199 pp. 1964.

FIELD MAINTENANCE AND OPERATION

Our model has been in use 9 years. During that time, there have been no electronic failures, and the motor-gear train combination has not broken. Inspection of the cams and the setscrews positioning the cams for the microswitches is recommended to prevent possible shifts. If particular cam orientations occur, damage to the gear train could result.

Surface deposits or corrosion from acidic rain on the sensing grids have not been serious problems. Approximately once a year, a combination of conductive materials and dampness (morning dew, for instance) has caused the opening circuit to malfunction, and a cyclic opening and closing of the lid may be experienced. Our grids are made of nickel-rhodium and are easily cleaned with concentrated ammonium hydroxide.

One disadvantage of this type of collector is the small volume of rain gathered from very light rains. Approximately 13 ml of water are collected per 0.01 inch (25 ml) of rain. If the chemical determinations to be performed require larger volumes, the number of determinations is limited from such typically small storms in semiarid regions. To overcome the small sample size would require using a larger collector and lid.

CONSTRUCTION

The schematic wiring diagram in figure 2 gives all the details of the electronic components. The accompanying photographs (fig. 1) show details of mechanical components and their physical placement. The building of several units at one time probably could be done at a cost of under $200 per unit, if the collector shell is available, exclusive of the rain gage shell. The most expensive component is the motor, which costs $53 at this writing. All the other parts can be obtained from electronic supply houses.

For areas with snow, a sensing grid with baffles that trap snow, permitting it to melt on the grid, is available commercially. For extremely low temperatures, a thermostatic control could be set in parallel with the existing heater switching to keep the grid sensor surface warm enough to melt ice. To allow snow or ice to pass into storage, a nichrome heating element could be incorporated into the cone and tube.

In some research studies, it may be necessary to determine the temporal distribution of the precipitation contaminants. In arid and semiarid regions, start of rain is often accompanied by large amounts of blowing dust. In urban or industrial environments, airborne materials could be dissolved or washed out in the rain near the beginning of hours-long frontal storms. These difficulties could be overcome by having two or more catchment units wired to open in sequence. In such a system, the master unit is complete as described herein. The slave unit(s) derive their power from the master through time-delay relays. These devices are available with delays of from a few minutes to 3 h and cost from $20 to $40.

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