APPENDIX — TECHNICAL NOTE

A new device for the study of water vapour condensation and gaseous deposition to plant surfaces and particle samples

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Abstract—This note describes the construction and application possibilities of newly developed surface wetness sensors. At the present state of sensor development the absolute values are not reproducible. However, even the relative conductance measurements allow the detection of non-visible water films on samples in the laboratory as well as in the open field. Applications to spruce needles and to aerosol samples deposited on artificial collecting surfaces are presented. Using special experimental conditions, the sensors are also suited for the determination of gas deposition to surfaces.

Key word index: Aerosols, dew, dry deposition, gas scavenging, surface wetness.

INTRODUCTION

The duration of leaf wetness on environmental surfaces is important in various fields of interest: in agrometeorology, wetness duration affects plant infections by pathogens and fungi (Wallin, 1967). The dissolution of soluble particles on the surface by small water amounts may lead to high ionic concentrations, which will possibly lead to strong chemical reactions. This is the case on plant surfaces, where high concentrations lead to leaching and uptake of ions, but it is almost a matter of investigation in building deterioration (Spiker *et al.*, 1992; Haneef *et al.*, 1992).

Wetness of surfaces also increases the deposition velocity of water soluble trace gases. In a similar way, the dissolution (scavenging) of trace gases in airborne particulate matter increases with increasing water/solids ratio of the particles (Chameides and Stelson, 1992).

Various techniques have been used in the past for the determination of surface wetness on plants (Noffsinger, 1965). Besides various measurements of the electrical resistance of surrogate surfaces (Davis and Hughes, 1970; Gillespie and Kidd, 1978; Weiss and Hagen, 1983), three direct principles have been used for the determination of leaf wetness in the past. These are the electrical resistance measurements directly on the plant surface (Häckel, 1984; van Eimern, 1985; Weiss *et al.*, 1988; Katz, 1991), the radiometric determination by β-ray absorption (Bunnenberg and Kühn, 1977; Barthakur, 1983), and weighing lysimeters (Fritschen and Doraiswamy, 1973; Trautner and Eiden, 1988).

Weighing devices have been used even for tall trees (Fritschen and Doraiswamy, 1973), but are restricted usually to smaller entities. The gain in weight by deposition of rain, fog or dew is superimposed by evaporational weight loss. Only sparse reports exists for the use of β-ray gauges for outdoor measurements (Barthakur, 1985), and their application to cylindrical surfaces such as coniferous needles seems uncertain; however, they have the advantage of non-contact measurement. Electrical resistance measurements have been used until now to determine whether a surface is wetted, indicated by an electrical resistance below a certain threshold value, the reference being visually observable wetness of the surface.

Water absorption by aerosols has been measured with balances. Mechanical microbalances were used (Winkler and Junge, 1972; Winkler, 1973) for particle samples obtained by an impactor. Electrodynamic balances allow the determination of water absorption even by single particles (Tang and Munkelwitz, 1993, and references therein). To our knowledge, an electrical resistance measurement on surfaces covered with particles has not been done until now.

In this paper we present new devices designed to measure wetness and water vapour absorption on several kinds of environmental surfaces, based on electrical resistance measurements. Furthermore, the strong dependence of surface wetness on relative humidity and the sensitivity of the device allows its application for the direct detection of gaseous deposition to these surfaces.

DESCRIPTION OF THE MEASURING DEVICES

The measuring devices consist of two different sensors and an electronic circuit, the latter being shown in the lower part of Fig. A1. In the upper part of Fig. A1, views of the sensors for aerosol samples and for vegetation are shown. The vegetation sensor was designed specifically for the application to coniferous needles, but is also applicable to other plant surfaces. It is not yet possible with this device to get absolute comparable results. There is a strong dependence on the pressure applied to the needles by the sensors and the touched needle area, a situation that is still irreproducible. However, the vegetation sensors are adapted for relative measurements during continuous extended-time applications, even outdoors and, for instance, in the upper part of higher trees. They usually do not visually damage the needles even after several weeks of attachment.

The sensor for particle samples is used for the resistance measurement on impactor samples. The collected aerosol

Position	Vegetation sensor	Particle sample sensor
1	Miniature alligator clip (metal)	Insulator plate (Plexiglas)
2	Distance- and insulator-plate (epoxy resin)	Distance screw (metal)
3		Nut (metal)
4	Brass extension	Spring (metal)
5	Vegetation surface	Metal syringe needles
6	—	Particle sample on polyethylene foil

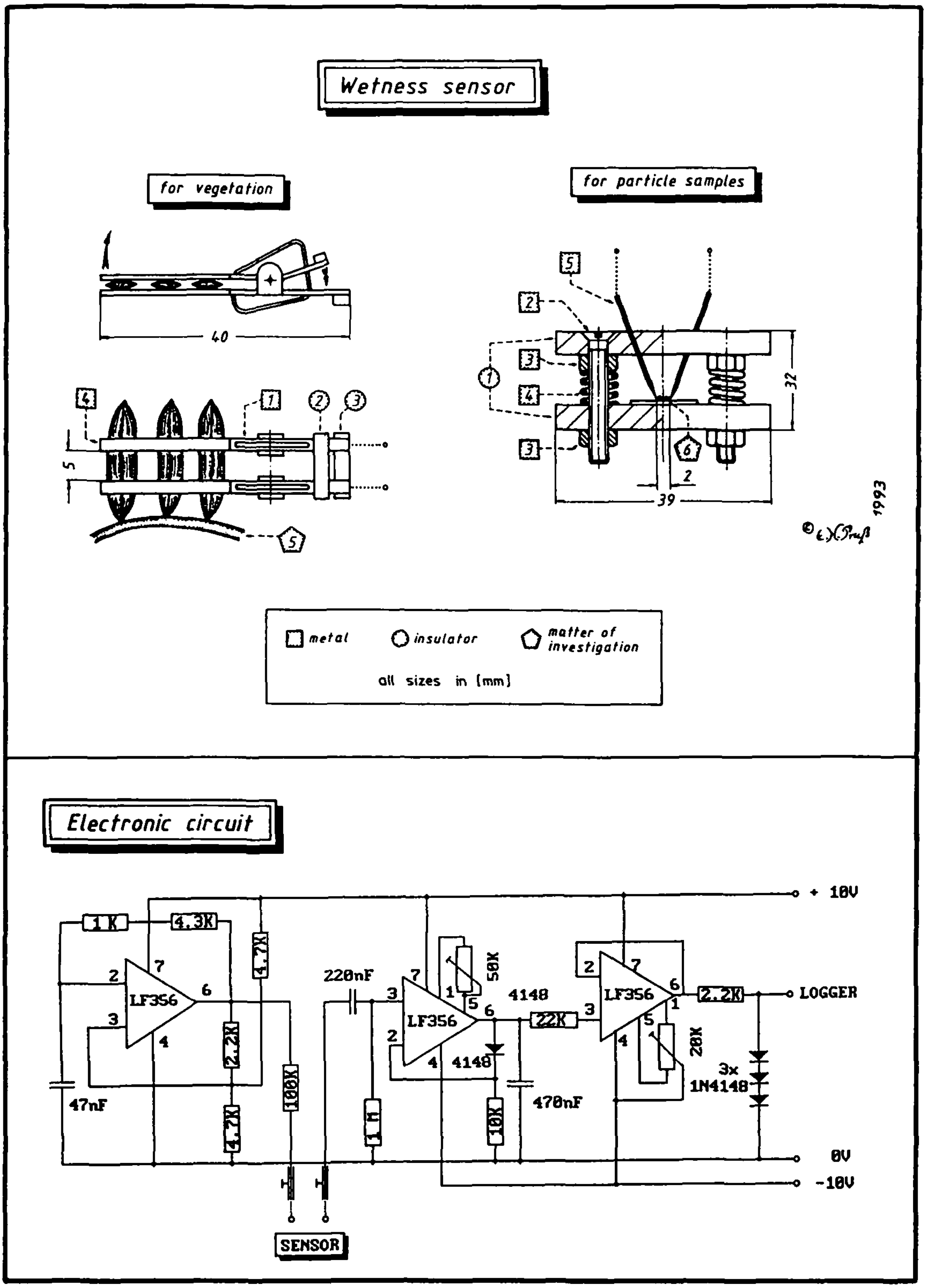

Fig. A1. Schematical design of the wetness sensors for detection of leaf wetness and for particle samples, and electronic circuit. Framed numbers are position numbers, explained in table, numbers without frame indicate the size of the devices in mm