COLORADO AGRICULTURAL EXPERIMENT STATION

AND

AGRICULTURAL RESEARCH SERVICE

Progress Report No. 1

Colorado Contributing Project

Study of Evaporation from Soil Surfaces in Terms of Soil and Micrometeorological Factors Using a Wind Tunnel

of the

Western Regional Research Project W-32

Basic Hydrological Factors Relating to Water Conservation

November 15, 1955

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This research project is a comprehensive study of the transfer of moisture from a soil column to the atmosphere under controlled and/or measurable conditions. Two soil columns, under the influence of a controlled water table and wind velocity, have been installed in the test section of a 6-ft x 6-ft wind tunnel. Data will be collected with the water table at different elevations, with different types of soil, with different conditions of surface soil, and with different wind velocities varying from 3 fps to 50 fps. Observations will include the ambient air temperature, ambient air velocity, turbulence and humidity of the ambient air passing over the surface of the soil columns, soil temperature, volume of moisture lost from the soil, and capillary tension existing at various elevations in the soil column.

It has been demonstrated in previous research on evaporation at Colorado A and M that the "moisture demand" of the atmosphere depends upon the wind structure or characteristics of the boundary layer passing over an evaporation surface. This is anticipated to be of special importance in evaporation from soils where the air not only moves across the soil surface but also circulates within the pores of the soil.

Although at present only one soil type is under investigation it is intended to vary the soil types to study the influence of different soil characteristics upon the movement of water through the soil and evaporation at its surface under different ambient atmospheric conditions and ground water elevations. It is also hoped to study the influence of heat input at the soil surface through radiation as well as through forced convection.

Work accomplished to date has been development and construction of the equipment and instrumentation. The tanks are now constructed and installed, and the tensiometers, thermocouples, manometers, and water inlet conduits have been installed. The height and rate of capillary rise of the soil have been investigated for the sandy soil to be used initially. Wind tunnel studies are expected to begin in the near future.

Soil and Preliminary Test

The type of soil being considered for the initial experimental runs is a fine natural granulated uniform sand. Sieve analysis for this sand has shown that the 50-per cent size is 0.15mm and the standard deviation is 1.5. The purpose for using a sandy soil is to maintain simplicity in the experiment until further knowledge is obtained from this investigation.

A preliminary test was conducted on this sand material in an effort to gain some knowledge of its capillary rise characteristics and the amount of water adsorbed by the soil. It was learned that most of the capillary rise occurred during the first forty-eight hours. Data will be obtained to determine certain soil characteristics such as variation of moisture content with capillary rise, and the variations of unsaturated permeability with moisture content.

Soil Columns

The soil column consists of a 46-in. length of 12-in. diameter, 14-gauge, straight seam, welded, black steel pipe welded onto a

steel dolly. Eight tensiometers have been installed in the column at the approximate distances from the top of 8 cm, 18 cm, 28 cm, 38 cm, 48 cm, 58 cm, 78 cm, and 98 cm. The tensiometer cups, located in the center of the pipe, are attached to a $\frac{1}{2}$-in. O D brass tube which protrudes through the wall of the pipe at an 11-degree tilt with the horizontal so the air may accumulate in the glass air trap on the end. Below the air trap, the 1/8-in. O D capillary line, which leads to the mercury manometer board, is attached to the brass tubing. The columns are wrapped with 3/4-in. glass wool insulating material and a sheet of aluminum foil to produce a more uniform cross-sectional temperature gradient in the soil.

Jack screws on the dolly are used for adjusting the soil column to the floor level of the wind tunnel.

Conduits for the water and the thermocouple leads into the columns are located near the bottom. The water conduit is tapped into the wall of the pipe and the thermocouple conduit is silver soldered.

Thermocouples

The thermocouples are made of 32-15, No. 30 B and S gauge copper wire and 42-3, No. 30 B and S gauge constantan wire, both of 1938 calibration and with enamel insulation. In addition to the enamel insulation, the two wires, twisted together and soldered at the ends, have been threaded through a 14-gauge plastic tubing for further protection. The ten thermocouple leads from each soil column are connected to a multiple switch box and then to a Leeds-Northrup potentiometer.

The proposed location at the present for the thermocouples are 1 in., 2 in., 4 in., 7 in., 11 in., 16 in., 22 in., and 29 in. below the soil surface with three being located at the 1 in. position.

Manometer Board for Tensiometers

The manometer board has a 1/8-in. O D capillary line connected to the 5/16-in. O D glass sight tube. The mercury reservoir is $18\frac{1}{2}$ in. above the floor of the wind tunnel. The scales beside the glass sight tubes are calibrated to read in inches of mercury and inches of water with a range of O to 850.

The scales are adjusted by charging the tensiometers with boiling water and then driving out the air by raising and lowering the water table in rapid succession with a movable water container connected to the air traps on each tensiometer. The water table is brought to a stationary position at the elevation of the wind tunnel floor after all of the air has been removed from the system. The zero mark of the scale is then adjusted to the height of the mercury column in the glass sight tubes.

Water Measuring and Water Table Control Apparatus

The water measuring and water table control apparatus was constructed so that a constant water table can be maintained in the soil column. The whole system is on a vertical slide so that the water table for the soil column can be adjusted to any height.

Ambient Air Measurements

A hot-wire anemometer and a dry-bulb and a wet-bulb thermocouple are to be mounted on the traverse mechanism in the wind tunnel for the measurements of the velocity, turbulence, temperature, and humidity profiles of the ambient air.

Personnel

Project leader (begin 15 Jan., 1956)	Arthur T. Corey
Acting project leader	Maurice L. Albertson
Graduate fellow	Robert W. Staley
Graduate fellow (begin 1 Feb., 1956)	Richard A. Schleusener
Advisors	Dean F. Peterson, Jr.
	Austin W. Zingg
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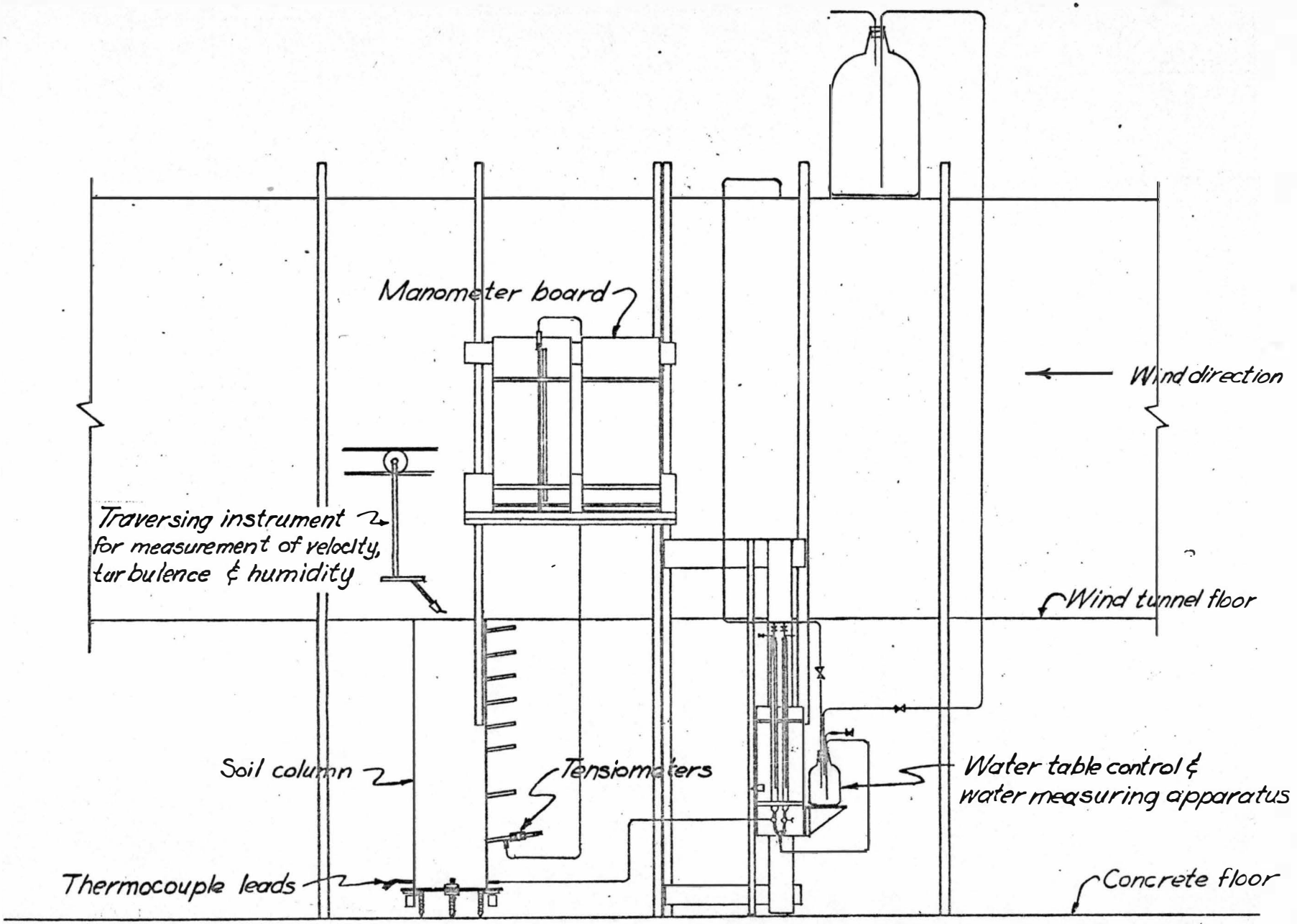

Fig. 1 Arrangement of experimental equipment

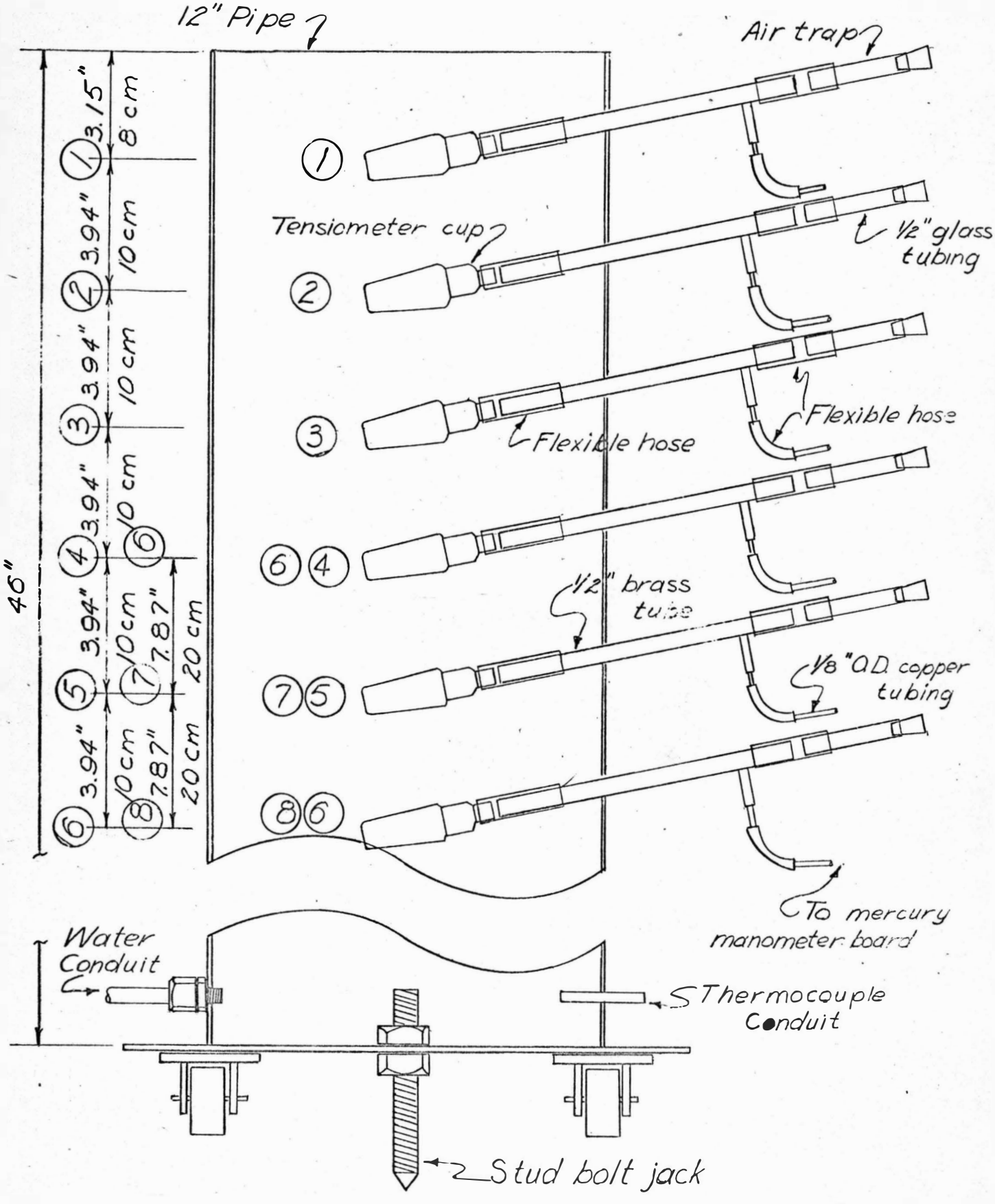

Fig. 2 Instrumentation & equipment for soil column