NEW INSTRUMENTS FOR AGRICULTURAL RESEARCH ¹⁾

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SUMMARY

Documentatie

The following instruments have been developed and are briefly described :

- 1 A mechanical ground-water level recorder.
- 2 A resistance bridge for field work.
- 3 An oscillating micropsychrometer.
- 4 Two field apparatus for rapid determination of the moisture content of the soil.
- 5 An electronic heart beat recorder.

INTRODUCTION

Some new instruments for agricultural research have recently been developed or improved by the present authors as a part of the program of the Agricultural Physico Technical Service at Wageningen. This service acts as a consulting body for agricultural research in problems involving physics and gives advices in questions concerning the construction or purchase of apparatus. The new instruments were developed for special investigations but in view of their applicability for other agricultural researches they are briefly described in this paper. They are :

THE INSTRUMENTS

A mechanical ground-water level recorder

Detailed knowledge pertaining to the fluctuation of the water-level in open water and in the phreatic table in soils is obtained with recording instruments. Most instruments for field use are equipped with a float connected by means of a wire to a pen. In order to overcome unavoidable friction, floats with diameters of at least 10 centimetres are necessary. However, in groundwater tubes with such large diameters the course of the phreatic level is often measured with a considerable time lag. In order to avoid adhesion of the float to the wall of the tube, the wall and the float must be kept apart and the tube must be placed vertically in the soil. Moreover with such instruments it is not possible to transmit the movements of the float to a horizontal plane without a considerable increase of friction or by complicating the instrument.

The principle of an instrument which does not suffer from these disadvantages is explained in fig. 1.

A mercury manometer system (M) is connected by means of a rubber tube (R) to a rubber bag (B) which is immersed in the ground-water. Rubberbag and tube and the right leg of the manometer are filled with a non-freezing liquid.

An iron float (F), directly connected to a writingpen (W) is mounted in the left hand leg.

It is evident that the relationship between the displacement of the waterlevel (h_w) and the mercury level in the left hand leg (h_m) is represented by the following relationship :

$$h_m = \frac{d_r^2}{13.6(d_3^2 + d_1^2)} h_w$$

in which 13.6 represents the density of mercury and d_1 and d_r the diameters of the left and right legs of the manometer. In the present apparatus these diameters are 1.7 and 5.3 cm respectively. The ratio is therefore 1 : 15. Since the length of the left leg is about 15 cm fluctuations of 225 cm of the waterlevel can be recorded. The depth range of the waterlevel to be recorded can be chosen by moving the right leg up or down in relation to the left leg.

¹⁾ Received for publication June 16, 1954.

FIG. 1. PRINCIPLE OF THE MECHANICAL GROUND-WATER LEVEL RECORDERS.

FIG. 2. A MECHANICAL GROUND-WATER LEVEL RECORDER.

A photograph of an apparatus by which three waterlevels in the vicinity of each other can be recorded on one drum is given in fig. 2.

A resistance bridge for field work

A universal bridge has been developed to be used for the determination of:

- 1 The salinity of soil and water (e.g. in canals) by means of conductivity measurements.
- 2 The soil-moisture by measuring the conductivity of plaster of paris or nylon-blocks.
- 3 The soil temperature. The temperature in places where fruits are stored etc. (Thermistors are used).

FIG. 3. A WHEATSTONE BRIDGE FOR FIELD WORK.

In Western Europe no suitable WHEATSTONE bridge can be purchased. The constructed bridge (fig. 3) has the following features:

- a A small energy consumption (batteries are used).
- b A builtin 1000 HERZ oscillator (Negative Resistance type) to avoid polarisation by conductivity-measurements.
- c Capacity compensation in order to obtain a sharp minimum of the bridge when using plaster of paris or nylon-blocks.
- d The accuracy is about 1%, the range is 10 Ohm — 10 Megohms. Temperatures can be determined with an accuracy of 0.2° C.

An oscillating micropsychrometer

Psychrometers are used for determining the humidity of the air. Measurements with these meters are reliable if the dry and wet bulb of the meter are adequately ventilated. This is in most cases done by sucking air along the bulbs. This method cannot be used to determine the humidity of the air at different heights, in fields of growing crops, or in other conditions where the humidity varies in short distances. It has now been found that a good ventilation of the bulbs can be obtained by oscillating the bulbs with a frequency of about 30–40 periods per second and an amplitude of about 1.5 centimeters. The air around the bulbs is displaced only slightly by this method. One end of the steel-bar (40 cm long) is fixed to an electrically operated interruptor, the other end oscillates the thermocouples. The bulbs (b) of the psychrometer ventilated in this way are shown in fig. 4

FIG. 4. AN OSCILLATING MICropsychROMETER.

The temperature sensitive elements (wet and dry) are small copper constantan thermocouples.

The circuit diagram of fig. 5 shows that the temperature of the air and the psychrometric difference can be measured with only two thermocouples. The thermocouples are not shielded against radiation since it can be shown that the vapour pressure calculated from an irradiated dry and wet bulb is made exactly the same. This condition is sufficiently attained by using bulbs of the same dimensions and by wrapping a cotton socklet around both the dry and wet bulb.

FIG. 5. THE CIRCUIT DIAGRAM OF THE OSCILLATING PSYCHROMETER.

a. Wet bulb, b. dry bulb, c. reference point.

The psychrometric difference is measured between d and g, the temperature of the air is measured between e and g.

Thus, the relative humidity of the air can be calculated only if the true air temperature is known. This temperature can be determined separately with a shielded, not ventilated, thermocouple. As, however, the temperature rise of the dry ventilated bulb, caused by direct radiation from the sun, is in most cases less than 0.5°C , the influence of radiation on the dry bulb temperature may be neglected.

The same ventilation principle can be used to eliminate the influence of radiation in the case of temperature measurements. The thermocouples are fixed 10 cm apart on a vertical steel rod 150 centimeters long which is moved rapidly up and down by an electrical motor, so that the average speed of the couples is 2.5 metres/sec.

More detailed information on the construction of the psychrometer and the influence of radiation is given in Appl. Sci. Res. A4 : 120-126.

Two field apparatus for rapid determination of the moisture content of soil

The first apparatus is based on the distillation of xylol and water from a mixture of soil and xylol.

A sample of the soil (100 cc) and xylol (300 cc) are heated in a still connected to an air cooled condensor.

The condensate flows into a tube mounted below the condensor. Since xylol and water are immiscible and water has a higher density the latter is accumulated in the lower part of the tube. In order to prevent overheating of the soil a part of the xylol is recirculated.

FIG. 6. A DISTILLATION APPARATUS FOR DETERMINATION OF THE MOISTURE CONTENT OF SOIL.

After 20 min. all of the water has been removed from the soil. The amount of water dissolved can be measured by discharging the tube into a calibrated cylinder of glass. A photograph of the instrument is shown in fig. 6.

The second apparatus is based on the evaporation of water from a mixture of soil and a non volatile oil (vegetable).

Within 15–20 min. the mixture is heated to 130°C . The loss of weight after the heating is the amount of water in the soil. The oil must be boiled before use in order to avoid foaming.

By estimating the density of the soil the pore space can be calculated.

In both methods the results are the same as those obtained by drying the soil at 110°C for three hours. A photograph of the instrument is shown in fig. 7.

An electronic heart-beat-recorder

In physiological studies it is sometimes valuable to be continuously informed of the heart-beat-frequency of working men.

The heart-beats can be detected by a photo-electric pick-up which is placed on both sides of the earlobe. This method has been published by MÜLLER and REEH, but their amplifier proved to be unstable. In the apparatus described here the electrical pulses are amplified with a differential amplifier with symmetrical input and feed-back.

The electrical pulses (which correspond with the heart-beats) are counted with a SIEMENS telephone-counter 67 c. The coil is rewound to adapt it to the electrical circuit (2000 Ohm resistance).

It has been found that sudden movement of the working person, especially with the head, causes mistakes, owing to a surge of blood in the ear. A photograph of the apparatus and a working person is given in fig. 8. More details of the apparatus have been published in *Appl. Sci. Res. B* 3, 293–296.

FIG. 7. AN APPARATUS BASED ON EVAPORATION FOR DETERMINATION OF THE MOISTURE CONTENT OF SOIL.

FIG. 8. AN ELECTRONIC HEART-BEAT-RECORDER.