Electronic Measurement and Recording of Evaporation Loss

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Abstract

An entirely new system, electronically controlled, is described for the measurement and recording of evaporation loss on a weekly or monthly chart. The tank water level is kept constant by the addition of quantums from a flow-meter calibrated to record them on a counter and chart. Rainfall can also be recorded in the same units on the chart by using an automatic raingauge. Loss and gain in water can thus be accurately recorded over time.

Introduction

The standard practice adopted by the South African Weather Bureau and the Directorate of Water Affairs in Symons tanks and A pans, is to make daily readings on an inclined scale calibrated in 0,5 mm in depth, to record total loss over 24 h. Variations in the rate of evaporation are not recorded when read daily. In order to obtain more detailed rates over a longer period, the tank can be fitted with an electronic recording system to give a continuous trace on a chart in direct readings of 0,1 mm of evaporation which is equivalent to 1 m^3 of water per hectare.

Principle of Measurement

As evaporation takes place in the tank and the water level falls, a sensitive probe point in a still-well switches on the supply of water to a flow-meter. This in turn measures and delivers calibrated quantums directly to the still-well, where the rising water level touches the probe to switch off the control circuit and allows the added water to level out in the tank, until the next unit is evaporated (Fig. 1).

If the quantum is delivered directly into the tank, several units will be delivered one after the other unnecessarily and lengthen the time between quantums to give an inaccurate rate of evaporation.

In order to even out fluctuations in water level inside the still-well, it is fitted with a long tube slipped over the brass connecting pipe inside the tank, terminating in the middle of the tank where minimum variations in water level take place.

In the design of the control probe point in the still-well, surface tension is utilized to provide a quick break in contact when the water surface suddenly falls away. If it was not for surface tension it is doubtful whether this probe would function as efficiently as it does. The distance between the probe point and water surface will depend upon the area of the point and as the required sensitivity is 0,1 mm in depth, it is essential to have a needle-like point. Tests have been conducted at the greater sensitivity of 0,01 mm in depth and interesting results were obtained, but it was decided to use one tenth of the standard unit of evaporation instead, since 0,1 mm is a more practical proposition.

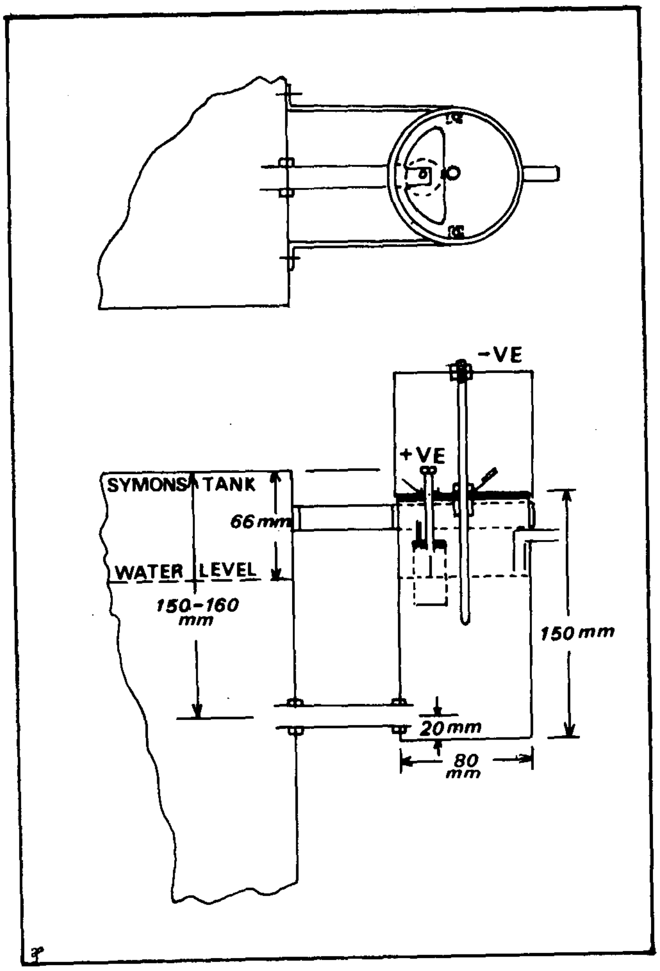

Figure 1
Symons tank still-well

To counter the effects of rain in the tank another still-well is fitted on the opposite side with another probe of platinum with a needle-like point which, when touched by rising water, opens a small solenoid-operated drain cock to allow incoming

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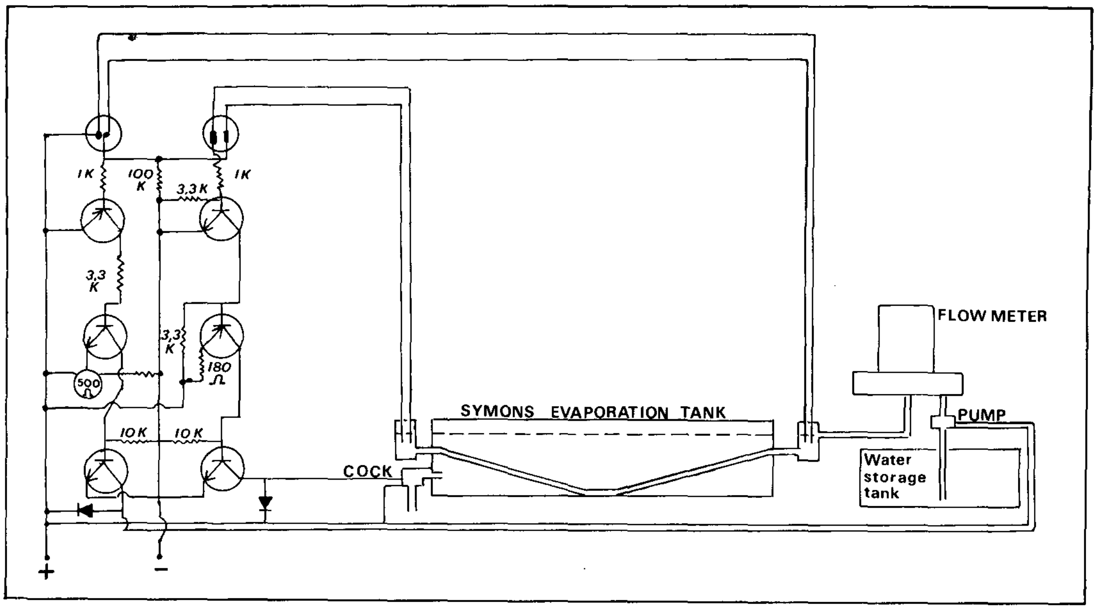

Figure 2
Evapo system only

rain to flow to waste (Fig. 2). This "rain" probe is about 0,5 mm higher than the "evapo" probe so as to prevent hunting in the system; i.e. additions of water by the flow-meter followed by the immediate release of water just added. When carefully adjusted the "rain" probe will take care of sudden showers and enable "evapo" measurements to continue after a short time. The two controls therefore operate initially in a different manner; the "evapo" control switches on when the water contact is broken and the "rain" control switches on when the contact is made.

Materials, Methods and Discussion

Two small still-wells, 80 mm in diameter, and 150 mm deep are fitted to the exterior of the tank on opposite sides with 10 mm bore brass connecting pipes (Fig. 1). Two probes, one of platinum wire in a nylon filter and the other of brass in the centre, are screwed through the perspex cover on the top of each still-well. The nylon filters are those used in diesel fuel lines to prevent dirt from clogging injection jets.

The filters are essential because any small particles on the end of the platinum probe can introduce irregularities in the successful operation of the system, and therefore no dirt, hair or insects of any kind can be tolerated.

In the "evapo" still-well, the platinum probe is connected to the positive side of the input control circuit, so that the oxygen released at the point touching the water oxidizes very small particles of carbonaceous matter and disperses them. The brass electrode is connected to the negative side of the circuit so that released hydrogen will keep it clean and free from oxidation. In the "rain" still-well the platinum probe is connected to the base of the first "rain" control transistor so that rising water can trigger off the drain cock. A series resistor of two to three ohms resistance should be connected in one leg of the 12 V or more feed to the cock. This is done to prevent the cock solenoid from burning out should water supply be impeded and the coil remain switched on for any length of time. The actual resistance to be used will depend on that of the cock solenoid itself and the "rest" operating current when the system becomes inoperative through lack of water. The growth of green algae in the system is prevented by using a suitable germicide.

Probe construction

Platinum wire S.W.G. 24, 12 mm long, is soldered into a small hole drilled in the end of a 50 mm long 5 BA cheesehead brass screw (Fig. 1). The platinum wire is filed to a needle point. The top of the nylon filter is removed and neatly fitted with a 5 mm thick disc of clear perspex tapped 5 BA in its centre. The probe is screwed into this until the platinum point is about half-way down in the filter.

The top of the still-well is fitted with a larger perspex disc cut out as per drawing and tapped as indicated. Two 20 mm brass angle pieces 10 mm wide are drilled and tapped 3 BA and fitted to the top of the still-well on opposite sides. The large top disc is fitted to these after marking and drilling with 3 BA screws. The central brass probe can be a length of 2 BA screwed rod. The platinum probe is fitted with a male "quick" connector, and the central brass probe with a female one.

Flow-meter details

The flow-meter consists of two plastic bottles which are filled alternately through a sliding valve operated by 12 V (TMS 37) solenoids actuated by the "evapo" control circuit (Fig. 3). The brass hexagon valve body (Fig. 4) is drilled lengthwise just under the required diameter and then reamed to size after the inlet and outlet holes have been drilled, tapped and fitted with the short inlet and outlet pipes which are sweated into place. A slight leak from this valve will not affect operation as the calibrated volume is released immediately into the still-well when the probe is contacted by the rising water. The inner valve

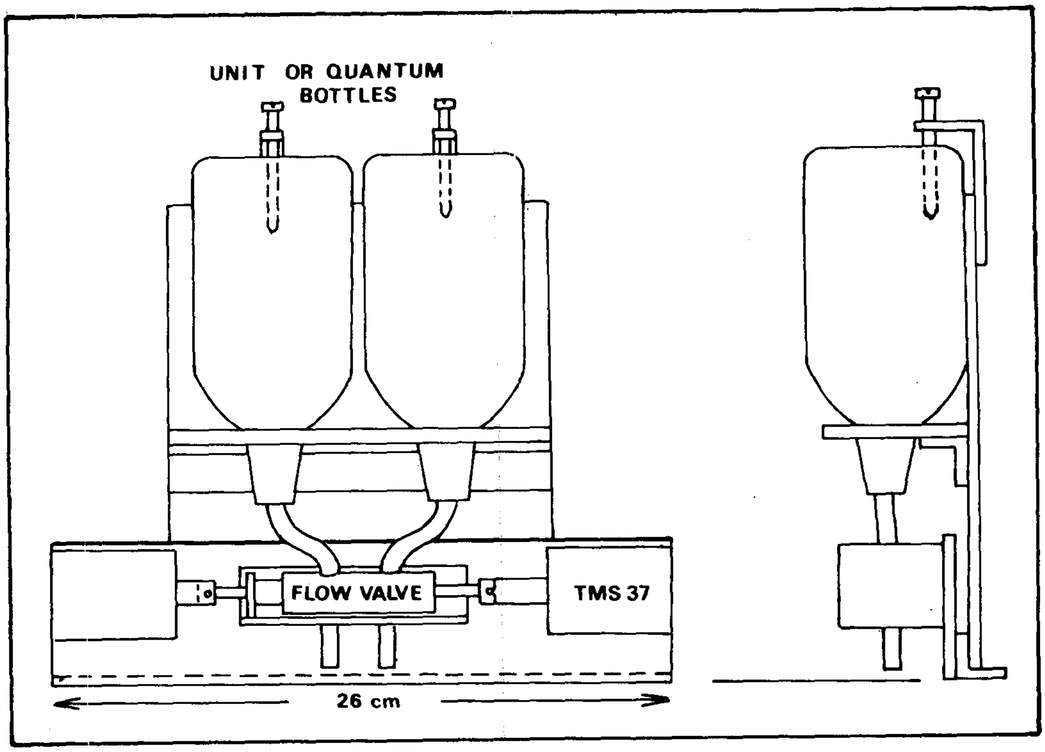

Figure 3
Flow-meter

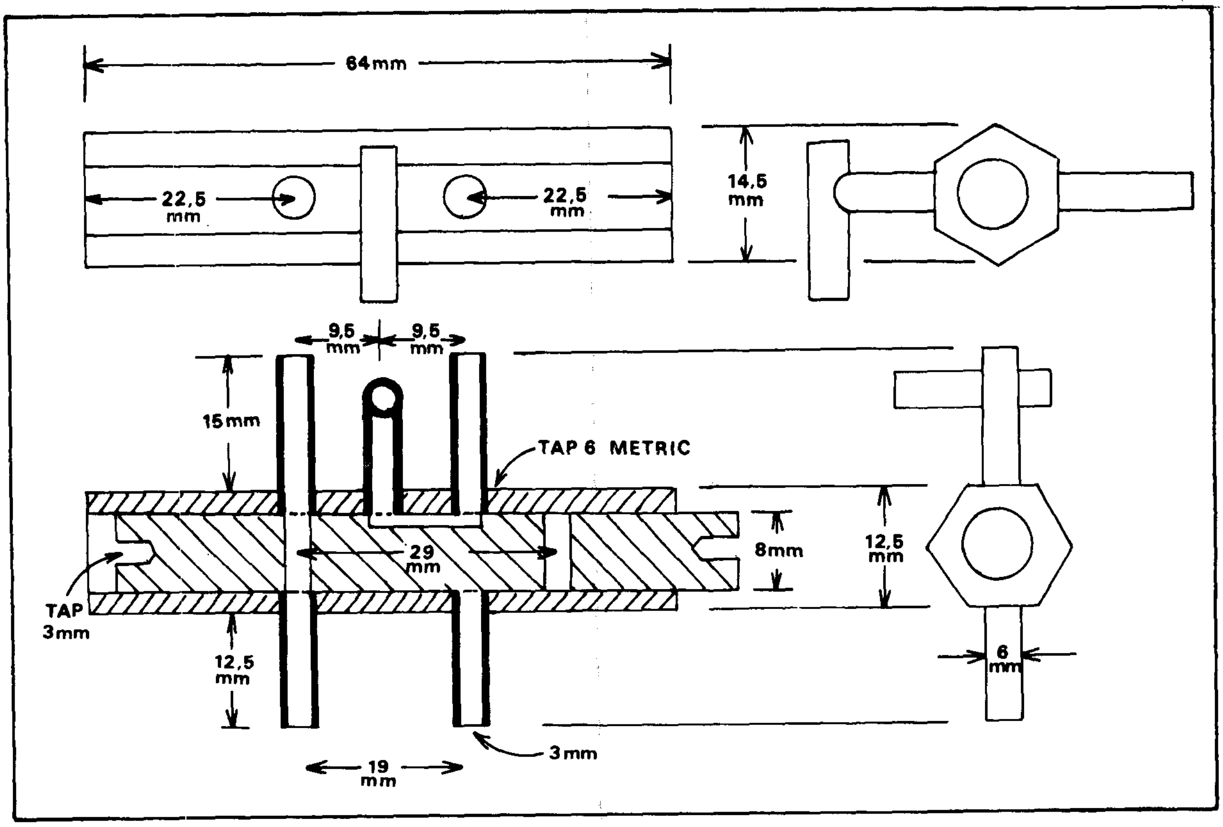

Figure 4
Flow-meter valve

can be made of brass or polyethylene which is light-weight and has excellent non-stick properties.

The travel of the valve should not exceed 10 mm as the plunger will be too far away from the magnetic pull of the solenoid. The inlet and outlet pipes are made from 6 mm brass rod threaded O BA, and drilled 3,5 mm. Suitable plastic bottles can be used as measuring vessels. The two solenoids are bolted to a 5 mm thick perspex panel supported on a length of 20 mm brass angle. The body of the sliding valve is held in place on another 20 mm brass angle (9 cm long) which in turn is bolted to the perspex panel with suitable spacers. The inner valve is drilled and tapped in its ends to take brass extension screws which are connected to the solenoid plungers via a flat brass end-piece, silver-soldered onto the screws.

In a Symons tank with a surface area of 3,24 m^2; 0,1 mm in depth evaporated is equivalent to 324 cm^3 to which the flow-meter bottles are calibrated. Delivered water is measured in a glass graduated cylinder and probe adjustments made accordingly. The supply of water to the flow-meter should preferably be done by gravity feed with a head of not more than five or six feet. Water fed by pump from underground tanks can introduce wave action and turbulence in the bottles causing more than one unit to be recorded when only one is fed to the tank. It is possible to nullify pumping impulses by using a steady-head bottle in the feed pipe. Further tests will have to be made to prove this.

The control system and solenoids normally operate at 12 V, but to ensure more positive operation an additional 2 V cell in series will bring the total voltage to 15 when fully charged. A trickle-charger or solar cell that can deliver 1 A will keep the batteries fully charged.

The cost of components for the control circuit is not excessive. The most expensive item will be the chart recorder followed by the flow-meter which has to be specially made by an instrument maker. The still-well is made from a 150 mm length of 80 mm diameter plastic rain-water down-pipe closed at the bottom with a similar disc cemented all round.

The transistor control circuitry should be placed inside an insulated box below ground level to shield it from changes in temperature and the flow-meter is placed close to the still-well above ground level with a suitable cover.

The unit pulse is fed to the counter and recorder through reed-switches fitted inside a low-resistance solenoid connected in series with the positive feed to the flow-meter solenoids (Fig. 5). When a quantum of water is delivered through the flow-meter, either of the two solenoids is operative for a short time to move the valve into its delivery position and, therefore, units are counted and recorded only when the positive feed is actuated together with the negative feed from either flow-meter control outputs. Diodes should be connected across all solenoids to prevent spurious pulses from recording more than one unit on the chart.

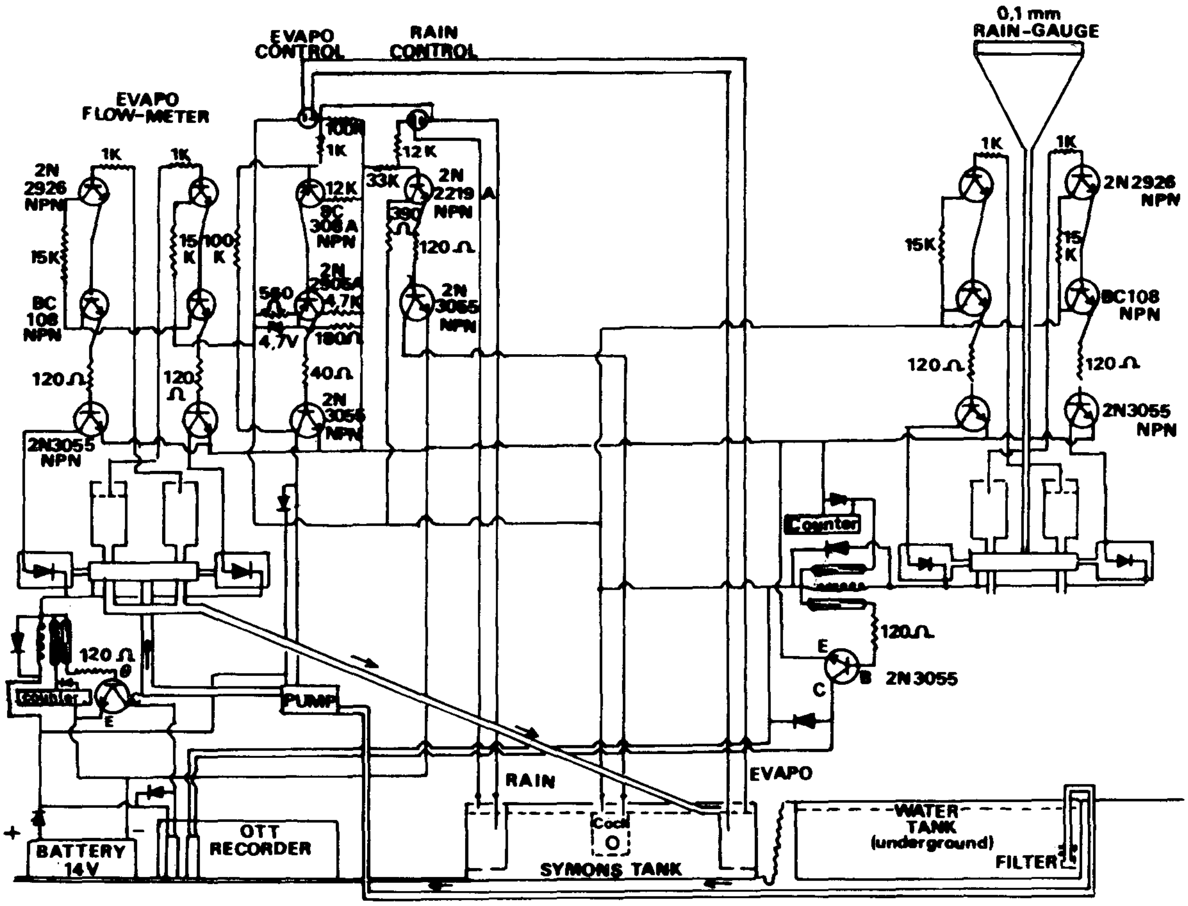

Figure 5
Evapo and rain circuits

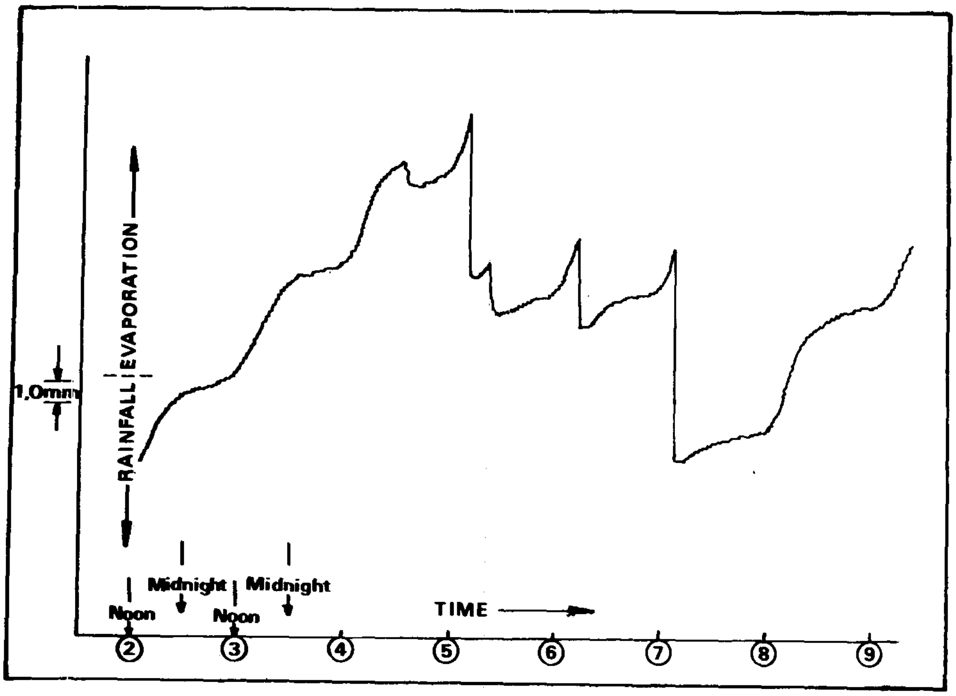

Figure 6
Typical record of evaporation-rainfall over the week 2–9/11/80

Rainfall can also be recorded together with evaporation units on the same chart by using a specially constructed rain-gauge calibrated to measure in 0,1 mm units. The loss in evaporation, and gain in similar units from rainfall can, therefore, be studied over periods of a week or a month. Unit pulses are transferred to the chart pen by using two solenoids, one on each side of a 20 tooth gear wheel on the recorder shaft. The gear wheel is spring-loaded via a small ballbearing so that only one tooth can be turned at a time by a pawl fitted to a plunger in a solenoid. By using two solenoids, pulses from "evapo" and "rain" are recorded on the chart in opposite directions.

When using a standard 127 mm diameter funnel on the rain-gauge, one unit of rain amounts to 1,267 cm^3 and 9,5 mm diameter perspex tubes (with probes) are calibrated to measure these units. The upper probe points on the gauge flow-meter are screwed up or down until the correct count is obtained. With 50 mℓ delivered slowly from a burette, the count should be 39 units. As a matter of interest, this particular rain-gauge is capable of recording over 300 mm of rain per hour.

The evapo-rain chart of the week 2–9 November 1980, shows five distinct showers of rain, three on the 5th and one each on the 6th and 7th (Fig. 6). The relative amounts recorded on the chart are 1,1 7,2 and 2,2 mm for the 5th; 3,9 mm for the 6th and 9,4 mm for the 7th November. It is interesting to see the evaporation rate increase just before a shower and the very slow rate at midnight and early hours of the morning.

The combined evapo and rain recording systems require regular maintenance inspections. Battery voltage and condition must be checked. Flow-meter valves should move with ease and receive lubrication with liquid silicone grease. Occasionally flow-meters should be re-calibrated to ensure accuracy. If an electric pump is used, the points require periodical cleaning and adjustment, as does the filter on the inlet side. Underground water storage tanks are filled once a month or sooner, depending on capacity. A controlled gravity feed of water to the evapo flow-meter with a solenoid operated cock requires very little maintenance and uses less current than a pump.

Conclusions

The results obtained to date have been encouraging. Further improvements to reduce maintenance and ensure greater reliability are possible. The aim has been to design control circuits that operate efficiently and yet be simply built.

Acknowledgement

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