Tipping Bucket Rain Gage (TBRG)

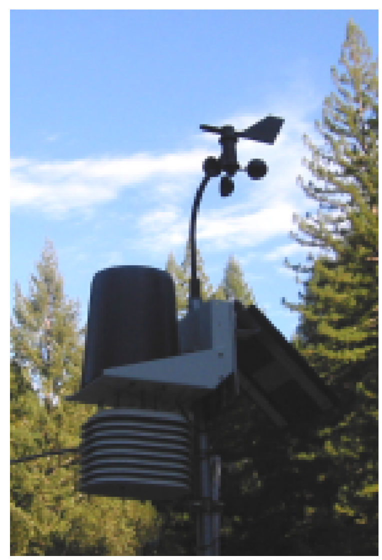
The tipping bucket rain gage measures rainfall amounts simply and accurately. Rainfall is funneled into a mechanism that tips back and forth and closes a reed switch briefly for each 0.01 inch or 0.2mm of rainfall. This signal can be input into a data logger, such as the EME Systems OWL2pe, to gather data on the rate of rainfall, and/or cumulative rainfall, from minutes to seasons.

The TBRG come from the factory set to measure in units of 0.01 inch per tip, but it can be easily configured by the user to metric units of 0.2 mm per tip. The standard model includes a 40 foot (12 m) telephone cable. It comes with an RJ11 connector, but for use with the OWL data logger we cut that off and use the bare wire ends.

The TBRG needs to be mounted on a stable horizontal surface with provision for good drainage.

Specifications:

Resolution: 0.01" (default), 0.2 mm (user configurable)
Accuracy: ± 4% (per Davis Instruments specifications) at rainfall rate up to 2" per hour.
Output pulse length: approximately 30 milliseconds switch closure
Dimensions: 9.5" h x 8" at base to 6.5" diameter at top. (24cm x 20cm to 16.5cm)
Collecting Area: 33.2 square inches (214 square cm)
Output Cable (Standard Models): 40 foot (12 m) telephone cable, RJ11 connector.
Or with bare ends for OWL2pe systems.



Ordering Information:

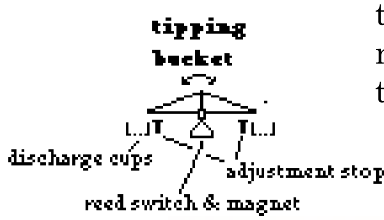
Item Part Number	Description	Price Each (USD)
D7852 TBRG,	Standard Model, 0.01 inches/tip	75.00

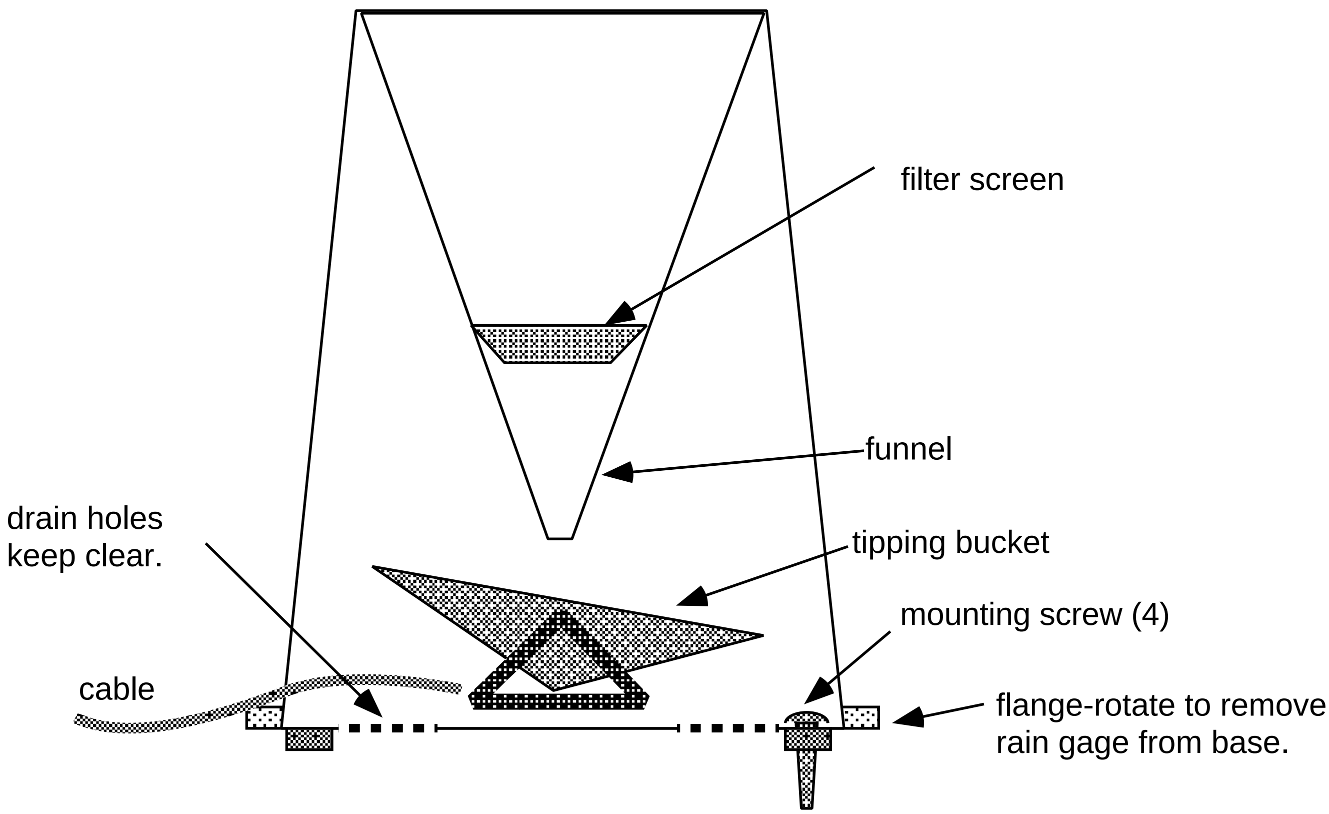
To order, email info@emesystems.com, call (510) 848-5725, or fax (510) 848-5748.

Tipping bucket ran gage, operating principle

The rain gage registers the duration and intensity of rainfall, which are parameters of first importance in irrigation, crop selection, and management of erosion, drought, flood, fire, frost and pests.

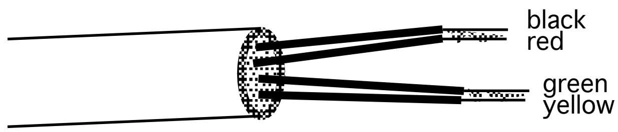
The TBRG is a tipping bucket type of rain gage. A funnel feeds water through a small hole into the tipping bucket mechanism, which is a two sided scoop with a partition in the middle. The scoop is mounted on a pivot, so that slight pressure will cause it to see-saw about sixty degrees, and it is balanced so that once in either direction, it stays there, unless something changes the balance. The rain gage funnel is positioned so that water coming into the chamber will be fed into whichever side of the scoop happens to be up at the moment. The weight of the water in the upper scoop becomes heavy enough to tip the bucket over to the other side, which dumps it and also brings the other scoop into the upper position, where it fills up, dumps, tips, and so on. A magnet is mounted on the tipping bucket, and the magnet passes by a magnetic reed switch and briefly activates the switch each time the bucket tips. Simple but very effective.





•The rain gage is manufactured by Davis Instruments of Hayward CA. It signals either 0.01 inch of rain per tip, or alternatively, 0.2mm per tip. You will find instructions in the Davis manual about how to convert the gage from inch to metric units, by installation of a small weight. Ignore the instructions about how to hook the rain gage up to the Davis recording and display instruments.

• For use with the OWL2pe, you will probably remove the RJ11 connector from the end of the cable and cut back the cable to a convenient length, or we may already have done that for you while configuring your system. Remove the jacket material back 1" to 4" from the end, as illustrated below, and strip the insulation from each of the four wires, 1/4" off the end of each wire. Twist together the outer two wires on each side, black with red and green with yellow. Tin the twisted ends with solder. The cable now fits through a cord grip into the OWL2c, and the wires attach to the OWL2c input terminals. For best results with the cord grip, add a layer of heat-shrink tubing on the outside of the cable where it passes through the grip. Tie down the cable with tie wraps to keep it from whipping in the wind. Run wire in protective tubing if there is danger from animal bites or abrasion. Run the cable inside a metal shield or the mounting tower if there is danger from ESD or lightning.



• You may want to use an additional fine screen filter to keep detritus out of the funnel. The small plastic filter that comes with the rain gage is not very efficient. We suggest a stainless steel filter of the kind that can be purchased in hardware and variety stores for use in sink drains.

• You may want to apply insulating varnish to the electrical connections inside the rain gage, to insulate them in case the rain gage becomes flooded. Better yet, be sure the rain gage has good drainage.

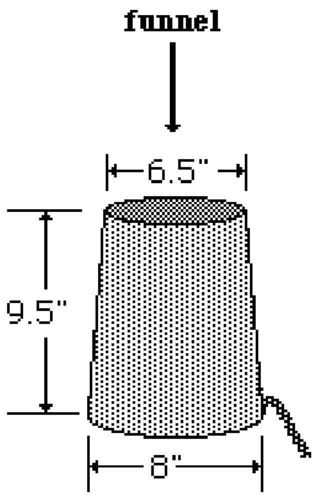
• The tipping bucket is held in place for shipping by a tie-wrap. YOU MUST CUT AND REMOVE THAT TIE-WRAP TO MAKE THE GAGE OPERATIONAL. The top of the rain gage twists off of the bottom, and this is most easily done when the bottom is held firmly on a surface.

• You should screw the gage down to a solid, level base using the stainless steel screws provided. There are channels in the base of the rain gage you can fill with water for approximate leveling, or use a bubble level. Observe the drain holes on the bottom of the gage. Be sure they are free for water to run out.

• Position the gage away from walls and other large objects. Some installations do best with a wind screen in a circle some distance from the gage and about 30° above the rim, or with a circle of trees or bushes subtending the 30° angle above the horizon.

• Check the rain gage from time to time to clean the filters and to be sure no detritus is blocking the funnel. From time to time remove the top to inspect the bucket, and remove detritus and insects.

TBRG--calibration



This rain gage as it comes from the factory records cumulative rainfall within 4% of the correct value for moderate rainfall rates, up to 50mm per hour rate (2 inches). The accuracy falls off in very low rates due to evaporation and due to the small amounts of water in relation to the bucket size. And accuracy falls off in heavy rainfall due to limitations of the mechanism.

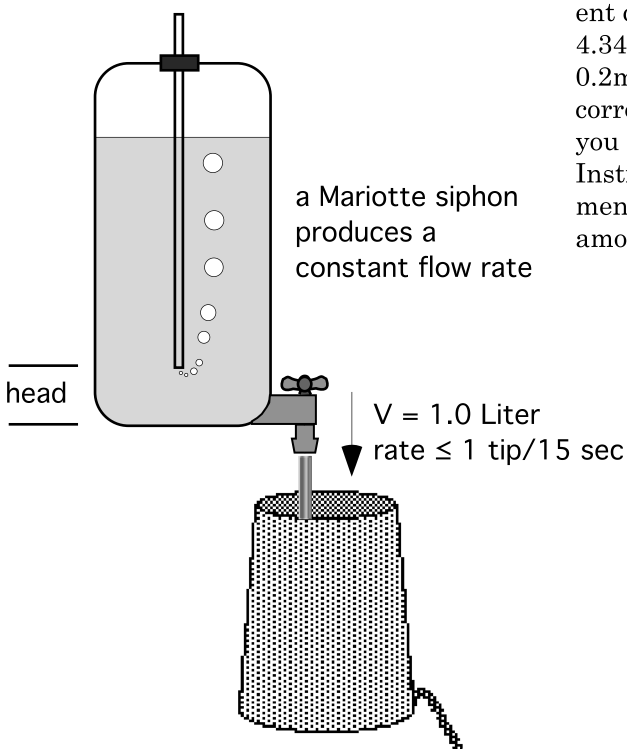
Wind across the gage can be the most important factors in gage accuracy. Proper placement and a natural or improvised wind shield are important.

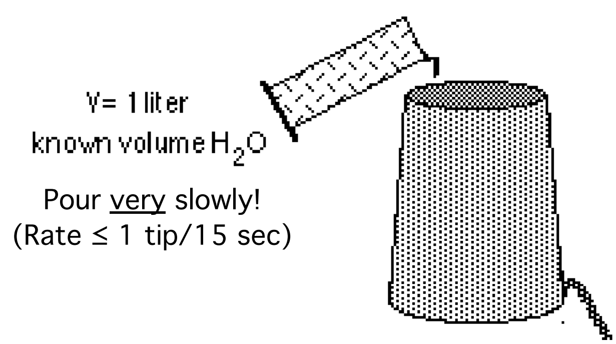
The collecting area of the funnel is 33.2 square inches (2114.1 square cm). (From 6.5" diameter at top). You can check the calibration or calibrate the gage by pouring a known volume of water slowly (4 tips per minute) into the funnel. The calibration factor is:

• 0.01" gage:—The 33.2 square inch collecting area covered 0.01" deep holds a volume of 0.332 cubic inch. This is the avoirdupois gage calibration factor.

• 0.2mm—The 214 square cm collecting area covered 0.2 mm deep holds a volume of 4.282 ml. This is the metric gage calibration factor.

Pour a known volume of water through the gage. For example, to calibrate the metric gage, use 1 liter of water. Pour very slowly, no more than 4 tips per minute. Count the number of tips. The expected number of tips is 1000ml/4.282 ml per tip = 233.5 tips, which takes about 1 hour to complete. Suppose it comes out at 230 tips instead.. The error is -1.5%. The apparent calibration of this gage is 1000/230 = 4.348 ml per tip or 4.348/2114 = 0.206 mm rainfall per tip instead of the standard 0.2mm per tip. You have two options. You can incorporate that correct calibration factor in your software as a multiplier. Or, you can adjust the hardware calibration of the gage. The Davis Instruments instruction sheet shows how to turn the adjustment screws to change the calibration mechanically by a small amount, ±2%.



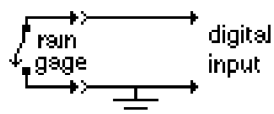


Rain gages and traffic counters with the OWL2pe & BASIC Stamp II

Tipping bucket rain gages signal each increment of rain (.01 inch or 0.2 mm) with a brief switch closure. A read switch is activated by a magnet as the bucket tips from one side to the other. The tip frequency varies from zero in dry weather, to up to one or more tips per second in torrential downpours. A rainfall rate of 2" per hour corresponds to a tip rate of about 4 per minute.   The pulse is brief, roughly 30 milliseconds in duration. Similar signals come from other kinds of event counters or traffic counters, and from flow meters and anemometers.

Neither the PULSIN nor the COUNT command in the BS2 work well with this type of signal, That is because of the wide range of times involved and the single-tasking manner of BS2 operation.

One way to deal with this is to use an external counter chip, in particular the CT515 from EME Systems.   This counter chip is installed on certain of the EME Systems topboards (TB1-1048 and TB2-1538), and it adds 4 or 5 dedicated counter channels to the OWL system. The OWL2pe simply reads the counter chip from time to time, once per 10 seconds for example, and it reports back how many events such as tips of the rain gage have occurred during the interval.   Here is the core of the program code to access the counter data. On the OWL2e topboards, rain gage would be connected to counter input “c0", simply as shown in the diagram. The CT515 provides the pullup resistor and all of the necessary switch debouncing.

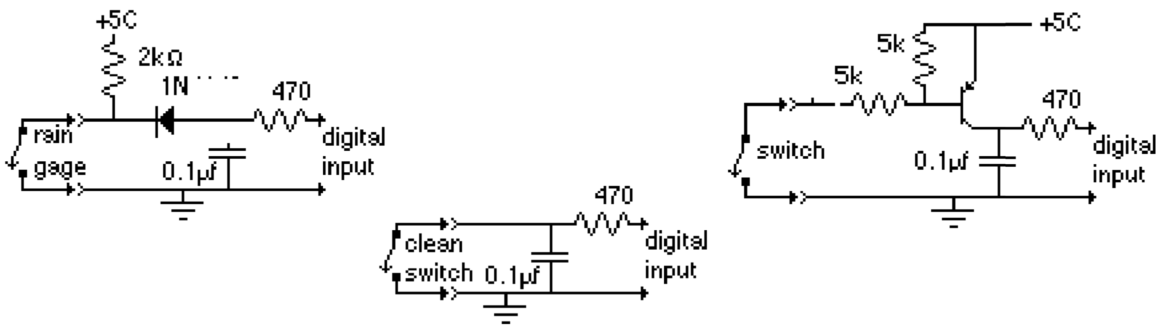



```
CT515_Acquire:
     CT515pin  PIN 9
     RainCount  VAR Word
      RainCount0 VAR RainCount.byte0
     LOW CT515pin : PAUSE 10
     INPUT CT515pin   ‘ pullup resistor pulls high
     SERIN CT515pin,$54,[WAIT ($80), SKIP 1, STR rainCount0\2]
     RETURN
```

In the normal course of operation, the program will call the above subroutine or a similar one at regular intervals. The above routine reads only the c0 counter channel and puts the count into the variable rainCount, and the CT515 immediately starts a new count.   The program would then process rainCount as necessary or add it to a total accumulation. Please refer to the CT515 documentation for the coding.

Here is an alternative way to deal with the rain gage, when the CT515 is not available. The rain gage switch is set up to discharge a capacitor, as shown in the diagram on the following page . The capacitor "stores" the "tip" event until the stamp gets around to looking at the input. To begin, the stamp io pin is made a high output, which charges the capacitor +5 volts. Then the stamp io pin is made an input, so that the capacitor retains the charge, and the input can be sampled to sense the capacitor voltage. When the rain gage switch closes, the capacitor discharges through the diode. When the switch opens, the capacitor is left in the discharged state.

Once the stamp input registers the discharged capacitor and increments the count, it recharges the capacitor to arm for the next tip. This takes advantage of the ease with which the stamp can switch any of its i/o pins between input and output modes. The capacitor can hold the charge for 10s of sec-



onds, due to the high input impedance of the Stamp input.

There are three circuits shown above. In the middle circuit, the switch is connected directly across the capacitor. This works fine so long as the switch itself and the wires leading up to it are clean and do have any electrical leakage paths in parallel. However, this is sometimes difficult to achieve with a rain gage that is exposed to the elements. Condensation may form on the body of the switch, along with grime or mud splashed from the bottom of the gage. For this reason, the other circuits shown have an advantage. The 2kΩ pullup resistor is in series with the reed switch in one on the left, and 5kΩ in the circuit on the right with the transistor, so leakage across the gage will not be significant. The diode or transistor, isolates the high level on the switch from the capacitor.

Here is a simple PBASIC 2.5 program for reading one rain gage using either of the circuit on the left with the diode:

```
rainpin     PIN  8    ' assume p8 is used for the rain gage
rain  VAR  byte ' for count of tips--could be made a word variable
DO:
  rain=rain+1-rainpin max 254' count advances when pin low. max at 254
  HIGH rout                 ' recharge capacitor, 200 microsecond pulse.
  INPUT rout           ' await next tip
  ‘...                 ' do other stuff
LOOP
```

Usually there will be some point in time when the rain count will be logged into a file. The rain count can be rezeroed at that time, or it can be maintained as a cumulative total. The routine recharges the capacitor each time through the loop, whether it needs it or not.

The above routine is fine if the loop is short enough to get around to check the rain gage every few seconds. Consider the rate. If one tip represents 0.2 mm of rainfall, then one tip every second represents a rainfall rate of 720mm per hour (28 inches per hour). That is to say, checking for a tip of the rain gage once every few seconds will rarely miss a tip!

There are a number of requirements that can arise when using rain gages in research settings. For example, it may be necessary to log data more often during a rainfall event. This occurs in hydrological studies, where the erosion occurs when it is raining, so data is logged most frequently when rainfall starts and continue for some time after the rainfall stops. Another such situation would be control of pumps and valves that move water or potential toxic materials to holding tanks when it is raining, Or control situations where rainfall closes greenhouse windows or inhibits a sprinkler system quantitatively. In some situations, it may be necessary to use several rain gages or event counters on one data logger. Please refer to the EME Systems web site, or call or email, for suggestions to program the data logger for those situations.
http://www.emesystems.com/OWL2rain.htm