INSTRUCTION MANUAL

Kalyx-RG Tipping Bucket Rain Gauge

Issued: 17.1.17

CSL 1194

Guarantee

This equipment is guaranteed against defects in materials and workmanship. We will repair or replace products which prove to be defective during the guarantee period as detailed on your invoice, provided they are returned to us prepaid. The guarantee will not apply to:

- Equipment which has been modified or altered in any way without the written permission of Campbell Scientific
- Batteries
- Any product which has been subjected to misuse, neglect, acts of God or damage in transit.

Campbell Scientific will return guaranteed equipment by surface carrier prepaid. Campbell Scientific will not reimburse the claimant for costs incurred in removing and/or reinstalling equipment. This guarantee and the Company's obligation thereunder is in lieu of all other guarantees, expressed or implied, including those of suitability and fitness for a particular purpose. Campbell Scientific is not liable for consequential damage.

Please inform us before returning equipment and obtain a Repair Reference Number whether the repair is under guarantee or not. Please state the faults as clearly as possible, and if the product is out of the guarantee period it should be accompanied by a purchase order. Quotations for repairs can be given on request. It is the policy of Campbell Scientific to protect the health of its employees and provide a safe working environment, in support of this policy a "Declaration of Hazardous Material and Decontamination" form will be issued for completion.

When returning equipment, the Repair Reference Number must be clearly marked on the outside of the package. Complete the "Declaration of Hazardous Material and Decontamination" form and ensure a completed copy is returned with your goods. Please note your Repair may not be processed if you do not include a copy of this form and Campbell Scientific Ltd reserves the right to return goods at the customers' expense.

Note that goods sent air freight are subject to Customs clearance fees which Campbell Scientific will charge to customers. In many cases, these charges are greater than the cost of the repair.

CAMPBELL SCIENTIFIC
WHEN MEASUREMENTS MATTER

Campbell Scientific Ltd,
80 Hathern Road,
Shepshed, Loughborough, LE12 9GX, UK
Tel: +44 (0) 1509 601141
Fax: +44 (0) 1509 601091

Email: support@campbellsci.co.uk
www.campbellsci.co.uk

PLEASE READ FIRST

About this manual

Some useful conversion factors:

Area: 1 in^2 (square inch) = 645 mm^2

Length: 1 in. (inch) = 25.4 mm
1 ft (foot) = 304.8 mm
1 yard = 0.914 m
1 mile = 1.609 km

Mass: 1 oz. (ounce) = 28.35 g
1 lb (pound weight) = 0.454 kg

Pressure: 1 psi (lb/in^2) = 68.95 mb

Volume: 1 UK pint = 568.3 ml
1 UK gallon = 4.546 litres
1 US gallon = 3.785 litres

Recycling information

At the end of this product's life it should not be put in commercial or domestic refuse but sent for recycling. Any batteries contained within the product or used during the products life should be removed from the product and also be sent to an appropriate recycling facility.

Campbell Scientific Ltd can advise on the recycling of the equipment and in some cases arrange collection and the correct disposal of it, although charges may apply for some items or territories.

For further advice or support, please contact Campbell Scientific Ltd, or your local agent.

CAMPBELL SCIENTIFIC
WHEN MEASUREMENTS MATTER

Campbell Scientific Ltd, Campbell Park, 80 Hathern Road, Shepshed, Loughborough, LE12 9GX, UK
Tel: +44 (0) 1509 601141   Fax: +44 (0) 1509 601091
Email: support@campbellsci.co.uk
www.campbellsci.co.uk

Precautions

DANGER — MANY HAZARDS ARE ASSOCIATED WITH INSTALLING, USING, MAINTAINING, AND WORKING ON OR AROUND **TRIPODS, TOWERS, AND ANY ATTACHMENTS TO TRIPODS AND TOWERS SUCH AS SENSORS, CROSSARMS, ENCLOSURES, ANTENNAS, ETC**. FAILURE TO PROPERLY AND COMPLETELY ASSEMBLE, INSTALL, OPERATE, USE, AND MAINTAIN TRIPODS, TOWERS, AND ATTACHMENTS, AND FAILURE TO HEED WARNINGS, INCREASES THE RISK OF DEATH, ACCIDENT, SERIOUS INJURY, PROPERTY DAMAGE, AND PRODUCT FAILURE. TAKE ALL REASONABLE PRECAUTIONS TO AVOID THESE HAZARDS. CHECK WITH YOUR ORGANIZATION'S SAFETY COORDINATOR (OR POLICY) FOR PROCEDURES AND REQUIRED PROTECTIVE EQUIPMENT PRIOR TO PERFORMING ANY WORK.

Use tripods, towers, and attachments to tripods and towers only for purposes for which they are designed. Do not exceed design limits. Be familiar and comply with all instructions provided in product manuals. Manuals are available at www.campbellsci.eu or by telephoning +44(0) 1509 828 888 (UK). You are responsible for conformance with governing codes and regulations, including safety regulations, and the integrity and location of structures or land to which towers, tripods, and any attachments are attached. Installation sites should be evaluated and approved by a qualified engineer. If questions or concerns arise regarding installation, use, or maintenance of tripods, towers, attachments, or electrical connections, consult with a licensed and qualified engineer or electrician.

General

- Prior to performing site or installation work, obtain required approvals and permits. Comply with all governing structure-height regulations, such as those of the FAA in the USA.
- Use only qualified personnel for installation, use, and maintenance of tripods and towers, and any attachments to tripods and towers. The use of licensed and qualified contractors is highly recommended.
- Read all applicable instructions carefully and understand procedures thoroughly before beginning work.
- Wear a **hardhat** and **eye protection**, and take **other appropriate safety precautions** while working on or around tripods and towers.
- **Do not climb** tripods or towers at any time, and prohibit climbing by other persons. Take reasonable precautions to secure tripod and tower sites from trespassers.
- Use only manufacturer recommended parts, materials, and tools.

Utility and Electrical

- **You can be killed** or sustain serious bodily injury if the tripod, tower, or attachments you are installing, constructing, using, or maintaining, or a tool, stake, or anchor, come in **contact with overhead or underground utility lines**.
- Maintain a distance of at least one-and-one-half times structure height, or 20 feet, or the distance required by applicable law, **whichever is greater**, between overhead utility lines and the structure (tripod, tower, attachments, or tools).
- Prior to performing site or installation work, inform all utility companies and have all underground utilities marked.
- Comply with all electrical codes. Electrical equipment and related grounding devices should be installed by a licensed and qualified electrician.

Elevated Work and Weather

- Exercise extreme caution when performing elevated work.
- Use appropriate equipment and safety practices.
- During installation and maintenance, keep tower and tripod sites clear of un-trained or non-essential personnel. Take precautions to prevent elevated tools and objects from dropping.
- Do not perform any work in inclement weather, including wind, rain, snow, lightning, etc.

Maintenance

- Periodically (at least yearly) check for wear and damage, including corrosion, stress cracks, frayed cables, loose cable clamps, cable tightness, etc. and take necessary corrective actions.
- Periodically (at least yearly) check electrical ground connections.

WHILE EVERY ATTEMPT IS MADE TO EMBODY THE HIGHEST DEGREE OF SAFETY IN ALL CAMPBELL SCIENTIFIC PRODUCTS, THE CUSTOMER ASSUMES ALL RISK FROM ANY INJURY RESULTING FROM IMPROPER INSTALLATION, USE, OR MAINTENANCE OF TRIPODS, TOWERS, OR ATTACHMENTS TO TRIPODS AND TOWERS SUCH AS SENSORS, CROSSARMS, ENCLOSURES, ANTENNAS, ETC.

Contents

PDF viewers note: These page numbers refer to the printed version of this document. Use the Adobe Acrobat® bookmarks tab for links to specific sections.

1. Description 1

2. Specifications 2

3. Installation and Siting 3

3.1 Choice of Site 3
3.2 Unpacking 3
3.3 Mounting 4
3.4 Levelling 4

4. Wiring 5

4.1 Wiring to a Pulse Channel 5
4.2 Wiring to a Control Port 6

5. Datalogger Programming 6

5.1 Pulse Channel Example Programs 7
5.1.1 CR1000 Example Program 7
5.1.2 CR200(X) Series Example Program 7
5.2 Control Port Example 8
5.2.1 CR1000 Example Program 8

6. Maintenance 9

7. Calibration 9

7.1 Static Adjustment and Calibration 9
7.2 Dynamic Calibration 10

8. Advantages and Limitations of a Tipping Bucket Gauge 11

9. References 11

Tables

4-1. Datalogger connection when using a pulse count port 6
4-2. Datalogger connection when using a control port 6
5-1. Multipliers 7

Figures

1. Side view of the Kalyx-RG fully assembled..1
2. Internal view of the Kalyx showing the tipping bucket mechanism and level indicator...2
3. The Kalyx gauge fitted on the ground mounted baseplate that is held down with pegs/stakes 4
4. Wiring Diagram for Kalyx-RG...5
5. Arrangement for Setting and Calibrating the Rain Gauge.....................10

Kalyx-RG Tipping Bucket Rain Gauge

The Kalyx-RG is a small tipping bucket rain gauge which combines durable construction with very reasonable cost. The gauge offers less resistance to air flow than most previous designs, which helps to reduce the sampling errors that inevitably occur during wind-driven rain. The gauge is manufactured for Campbell Scientific by Environmental Measurements Ltd and will provide many years of reliable operation when carefully sited and installed.

1. Description

Figure 1. Side view of the Kalyx-RG fully assembled.

The Kalyx-RG rain gauge is constructed from UV-resistant, plastic and consists of a base and an upper collecting funnel assembly. This gauge is based on the physical size of the traditional 5 inch Met Office rain gauge but with a unique aerodynamic profile.

The tipping bucket arrangement is similar to most other gauges of this type; precipitation is collected by the funnel and is passed to one of the two buckets situated at either end of a short balance arm. The balance arm tips when the first bucket is full, emptying this bucket and positioning the second under the funnel. The tipping process repeats indefinitely as long as rain continues to fall, with each tip corresponding to a fixed quantity of rainfall. At each tip, the moving balance arm forces a magnet to pass a reed switch, causing contact to be made for a few milliseconds. A two-core cable is used to connect the gauge to the datalogger where the switch closures are counted.

Figure 2. Internal view of the Kalyx showing the tipping bucket mechanism and level indicator.

The Kalyx-RG is adjusted at manufacture to tip once for each 0.2 mm of rain. Unlike more expensive sensors in this range, no detailed calibration certificate is provided with each gauge showing variation from the 0.2 calibration.

2. Specifications

Dimensions	Height (no baseplate) = 225 mm Height (max) (with baseplate) = 245 mm Funnel diameter = 127 mm (5”) Funnel Area = 12,668 mm^2
Tip Sensitivity	0.2 mm rain per tip
Output	Contact closure (reed switch)
Typical accuracy	98%+ at 20 mm/hr 96%+ at 50 mm/hr 95%+ at 120 mm/hr (above 120 mm/hr please contact Campbell Scientific for details of possible mathematical corrections)
Rainfall Intensity	Up to 1000 mm/hr (with a mathematical correction)
Weight	700g (without baseplate), 1Kg (with baseplate)

3. Installation and Siting

3.1 Choice of Site

Site the gauge carefully, avoiding obvious sources of error such as nearby trees or buildings. A useful 'rule of thumb' is that the distance between the gauge and any obstruction should be at least as great as twice the height of the obstruction above the ground. For standard meteorological sites in the UK, the Meteorological Office specify the height at which the rim of a rain gauge should be above a short grass surface, and the Kalyx-RG should be exposed similarly if measurements are required for comparison with those from agrometeorological or synoptic sites.

Where snow is likely or it is the local convention to mount gauges above ground level higher a pole/mast mount is available.

Research has shown that a rain gauge obstructs the flow of air and that the flow accelerates and turbulence increases over the top of the funnel. This can cause less rain to be collected in the funnel than otherwise would have fallen on the ground.

The body of the Kalyx-RG has a profile which has been designed to reduce drag and turbulence and it can therefore be sited conventionally on exposed sites or above the ground on a pole with some confidence. Further details on the exposure of rain gauges are given in HMSO (1956, 1982) and by Rodda (1967). Another useful text on exposure and associated errors is Painter (1976).

NOTE No two rain gauge designs are ever likely to produce identical results, and identical rain gauges can give slightly different catches even when sited within a metre of each other.

3.2 Unpacking

Unpack the Kalyx-RG carefully. The tipping mechanism is immobilised before shipping to prevent damage in transit. To release the mechanism:

1. Remove the funnel of the gauge from its base after unscrewing the three nylon thumbscrews.
2. Remove the small piece of foam from underneath the bucket mechanism which prevents the bucket tipping in transit. Check the bucket mechanism for freedom of movement.
3. Leave the funnel off during installation to allow visibility of the bubble-level indicator in the base of the sensor.
4. Once installed the funnel mechanism can be mounted back on the base, but first check the filter mechanism and drip tube in the funnel are clear of any blockage, e.g. loose packing materials.

3.3 Mounting

The Kalyx-RG is a light-weight instrument and it must therefore be bolted down securely. Three mounting holes are provided on the outside of the gauge, which are normally used with 5 mm bolts. Three bolts are also fitted in adjacent threaded holes to act as the feet of the sensor, these bolts are used to level the sensor and can be locked in position using the nuts provided on the bolt.

If you need to mount the Kalyx-RG on a pre-existing concrete surface, we recommend the use of M5 Rawlbolts where a hole is drilled in the concrete and a bolt is screwed through the corner holes to hold the gauge down. Alternatively, a concrete paving slab may be more convenient as a base, in which case through-bolts or screws are suitable.

For fast, semi-permanent installations the optional Kalyx-RG baseplate can be used with tent pegs to hold the plate to the ground.

Figure 3. The Kalyx gauge fitted on the ground mounted baseplate that is held down with pegs/stakes.

A pole or mast mount version is also available. The mast mount comprises a simple arm which is mounted to a vertical upright of the mast using the supplied U-bolt. The plate (identical to the ground plate) is then fitted to the arm using two screws.

3.4 Levelling

If the rain gauge is tilted by more than a few degrees, the bucket mechanism may be thrown out of balance, significantly affecting its calibration. Furthermore, during wind-driven rain the response of a gauge with a tilted funnel collector will vary with wind direction.

Where a concrete slab is used, adding sand underneath the slab to level the gauge after it is fixed to the slab is often the easiest approach to levelling it. If the gauge is mounted on a concrete base using Rawlbolts, adjust the bolts that act as feet before tightening the Rawbolts to hold the gauge down. With the funnel removed use the internal bubble to check that the gauge is level; as an additional check, place a spirit level across the rim of the assembled Kalyx-RG.

When the sensor is mounted on a fixed plate (either the ground plate or pole mount) the mounting plate should first be fixed in place trying to ensure the plate is reasonably but not precisely level. The nuts on the bolts that hold the sensor down to the plate can then be loosened and the corner feet used to level the gauge whilst observing the bubble level inside the gauge. Then lock the feet and tighten the bolts which hold the gauge to plate. Double check the gauge is level before refitting the funnel.

4. Wiring

The rain gauge is supplied with a 6 m cable which may be extended if required. For most applications the Kalyx-RG may be connected directly to a pulse counting input on the datalogger as shown in Figure 1. For a long cable, a significant capacitance can exist between the conductors, which discharges across the reed switch as it closes. As well as shortening the life of the switch, a voltage transient may be induced in any other wires which run close to the rain gauge cable each time the gauge tips. A 100Ω resistor is fitted inside the gauge to protect the switch from arcing and prevent transients.

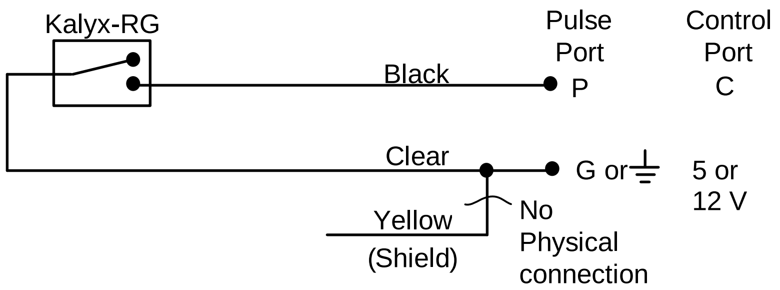

Figure 4. Wiring Diagram for Kalyx-RG

4.1 Wiring to a Pulse Channel

NOTE When Short cut software is used to generate the datalogger program, the sensor should be wired to the channels shown on the wiring diagram created by Short Cut.

The Kalyx-RG is typically wired to a datalogger's pulse channel (see Table 4-1).

Table 4-1. Datalogger connection when using a pulse count port

Colour	Description	CR800 CR1000 CR3000 CR5000	CR6	CR200(X) and CR300 Series
Black	Signal	Pulse Channel	U Channel	P_SW
Clear	Signal Return	⏚	⏚	⏚
Yellow	Shield			

4.2 Wiring to a Control Port

Dataloggers listed in Table 4-2 have the capability of counting switch closures on some of their control ports. When a control port is used, the return from the rain gauge switch must be connected to 5 or 12 volts on the datalogger sometimes using a resistor – see below.

Table 4-2. Datalogger connection when using a control port

Colour	Description	CR800 CR1000 CR3000	CR6	CR200(X) and CR300 Series
Black	Signal	Control Port	Control Port	Control Port
Clear	Signal Return	5 V	⏚	12V via 100k user supplied resistor
Yellow	Shield			

5. Datalogger Programming

NOTE This section is for users who write their own programs. A datalogger program to measure this sensor can be generated using Campbell Scientific's Short Cut Program Builder software. If using Short Cut please select the ARG100 gauge as it is identical in wiring and programming to the new Kalyx-RG, but please note that the ARG100 correction for high rainfall rates is not applicable to the Kalyx. You do not need to read this section to use Short Cut.

Precipitation is measured using a Pulse Count with a switch closure configuration code. The multiplier used in the Pulse Count instruction determines the units in which rainfall is reported (see Table 5-1).

Table 5-1. Multipliers	
Rain Gauge	**Multiplier**
Kalyx-RG	0.2

5.1 Pulse Channel Example Programs

The following example programs use a pulse channel to read the output from the precipitation gauge. The CR1000 example will also work with the CR6, CR300 series, CR800, CR850, CR3000, and CR5000. CR9000(X) programming and wiring is similar to the CR1000 except it has an additional parameter in the PulseCount instruction to specify the pulse module's slot.

5.1.1 CR1000 Example Program

```
'CR1000

'Kalyx-RG Tipping    Blk > P1
'                    Clr > ground

Public Rain_mm
Units Rain_mm=mm
DataTable(Rain,True,-1)
    DataInterval(0,60,Min,0)
    Totalize(1,Rain_mm,FP2,0)
EndTable

BeginProg
    Scan(1,Sec,1,0)
        PulseCount(Rain_mm,1,1,2,0,0.2,0)
        CallTable(Rain)
    NextScan
EndProg
```

5.1.2 CR200(X) Series Example Program

```
'CR200(X) Series

'Kalyx-RG Tipping    Blk > P_SW
'                    Clr > ground

'Declare Variables and Units

Public Rain_mm

Units Rain_mm=mm

'Define Data Tables
DataTable(Rain,True,-1)
    DataInterval(0,60,Min)
    Totalize(1,Rain_mm,0)
EndTable
```

```
'Main Program
BeginProg
    Scan(1,Sec)

        'Kalyx-RG Rain Gauge measurement Rain_mm:
        PulseCount(Rain_mm,P_SW,2,0,0.2,0)

        'Call Data Tables and Store Data
        CallTable(Rain)
    NextScan
EndProg
```

5.2 Control Port Example

The following example programs use a control port to read the output from the precipitation gauge. The CR1000 example will also work with the CR6, CR300, CR800, CR850, and CR3000.

5.2.1 CR1000 Example Program

```
'CR1000

'Kalyx-RG Tipping   Blk > C4
'                     Clr > 5v

'Declare Variables and Units
Public BattV
Public Rain_mm

Units BattV = Volts
Units Rain_mm =mm

DataTable(OneMin,True,-1)
    DataInterval(0,1,Min,10)
    Totalize (1,Rain_mm,FP2,False)
EndTable

'Define Data Tables
DataTable(OneDay,True,-1)
DataInterval(0,1440,Min,10)
    Minimum(1,BattV,FP2,False,False)
    Totalize (1,Rain_mm,FP2,False)              'Kalyx-RG tipping bucket
EndTable

'Main Program
BeginProg
    Scan(5,Sec,1,0)
        'Default Datalogger Battery Voltage measurement BattV
        PanelTemp (PTemp,_50Hz)
        Battery(BattV)

        'Kalyx-RG Rain Gauge measurement Rain_mm
        PulseCount(Rain_mm,1,14,2,0,0.2,0)

        'Call Data Tables and Store Data
        CallTable(OneMin)
```

```
        CallTable(OneDay)
    NextScan
EndProg
```

6. Maintenance

To ensure reliable and accurate measurements, we recommend that the following checks be carried out every month if possible:

1. Inspect the funnel for any damage or blockage and check the integrity of the connecting cable. At certain times of the year, leaves may accumulate in the bottom of the funnel, clogging the filter and preventing the flow to the buckets beneath, or reducing the flow rate to a slow drip. The obstruction is best cleared by inverting the funnel (after removal from the base) and pouring water back through from the spout beneath the collecting surface. Note that the plastic filter in the bottom of the funnel should not normally be removed on the Kalyx-RG.

2. Check that the gauge is still level. It is surprisingly easy for an apparently immovable gauge to become tilted as a result of small ground movements, vandalism or just inquisitive fingers.

3. Check that the balance arm is free to move. This can be done by slowly pouring a measured quantity of water (say 25 cm^3) through the gauge and counting the tips. It is worthwhile carrying this out at regular weekly intervals (for example, every Monday at 0900) while leaving the gauge connected to the datalogger. Providing a significant volume of water is used, these weekly checks can easily be identified in the logged measurements. This simple procedure confirms that the gauge is functioning, detects any marked change in the calibration and (if carried out punctually) introduces an independent time check into the records.

7. Calibration

The sensitivity of the Kalyx-RG is set at manufacture to 0.2 mm/tip. The calibration of each gauge can be checked as described in Section 7.1.

7.1 Static Adjustment and Calibration

The following procedure is carried out during manufacture and may be repeated if the calibration appears to have shifted:

1. Install the gauge over a sink unit as illustrated in Figure 5 ensuring that it is correctly levelled.
2. Adjust the two calibration screws under the tipping buckets until the balance arm tips in response to the correct amount of water dripped from a burette or pipette (2.53 cm^3 for 0.2 mm sensitivity).

It is not possible to set the screws very precisely using this method, but it should be done with as much care as possible. Due to the extremely small volume of water needed to tip this small gauge it is advisable to remove the cap on the top of the filter in the base of the funnel and drip the water down the centre of the tube to avoid the filter. Repeat this process several times until the bucket tips repeatedly in the same way. It is obviously very important to ensure that both buckets tip in response to the same amount of water.

Many manufacturers and users of tipping bucket gauges aim to adjust the bucket settings until exactly the correct calibration is achieved. However, a dynamic test (see below) is required to check this calibration precisely after each readjustment and the process becomes very time-consuming.

7.2 Dynamic Calibration

1. Set up the gauge as illustrated in Figure 5, carefully levelled and connected to the datalogger.
2. Fill the water container with 202.7 cm^3 of water for a 0.2 mm calibration. This is usually achieved most precisely and consistently by weighing the water on a balance capable of measuring to 0.1 g (0.1 cm^3). An alternative is to use a good quality graduated measuring cylinder.
3. Allow the water to drip slowly into the gauge (allowing approximately 100 minutes for the container to empty). This is a rate equivalent to a rainfall of 10 mm/hour, as recommended in BS7843 Section 2.1 for calibration purposes. At the end of this period approximately 80 tips will have occurred. The exact number is obtained from the datalogger, together with a visual inspection of what fraction of a ‘tip’ is left in whichever bucket is still filling as the flow of water finishes.

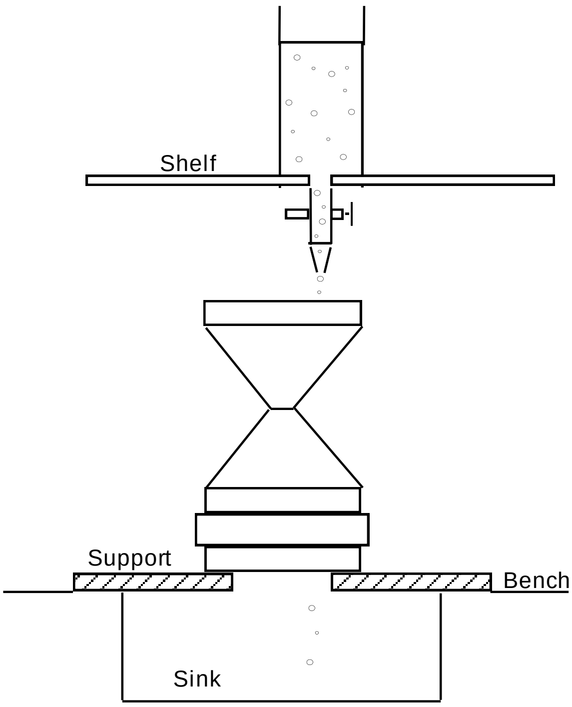

Figure 5. Arrangement for Setting and Calibrating the Rain Gauge

The true calibration of the gauge can be calculated as follows and used in place of the standard 0.2 mm calibration. If N is the number of tips (together with the fractional part left in the one bucket), the calibration factor (CF) is then

CF = 0.2 x 80/N

For example, if N = 78.8, then

CF = 0.2 x 80/78.8

= 0.203 mm/tip

The amount of rainfall in any particular interval is obtained by multiplying the number of recorded tips by the calibration factor.

This type of dynamic calibration gives repeatable results indoors, but it is not always a true representation of the gauge's sensitivity to natural precipitation. Useful results can be obtained by comparing the output from the Kalyx-RG with the catches from a standard 'Snowdon pattern' gauge (HMSO, 1956) sited nearby; if this comparison is carried out with care, a calibration factor for natural rainfall can be calculated from the slope of a graphical plot of (number of tips) against (catch from Snowdon gauge in mm).

8. Advantages and Limitations of a Tipping Bucket Gauge

Gauges which operate on the tipping bucket principle provide a digital output, which simplifies connection to a datalogger. The pulses returned during rainfall may be counted over any time interval desired allowing accurate determination of the rainfall rate (this variable, sometimes called 'intensity', is frequently used in soil erosion studies and is relevant to some aspects of crop pathology).

When the Kalyx-RG is used primarily to measure rainfall rates, the resolution of the gauge may be too coarse to detect the significant changes in rate which normally occur from minute to minute in moderately heavy rain. Alternative gauges are available with higher resolution.

A tipping bucket gauge responds to discrete quanta of rainfall, and the accuracy and reproducibility of this quantum are determined not only by factors such as friction in the bearings, etc. but also by the rate of fill of the buckets. When the rainfall rate is high, a bucket may *start* to tip when the necessary volume of water has been collected, but while the bucket is moving away from the funnel outlet, an extra volume will have been collected and lost through spillage. The resulting degradation in accuracy is of the order of 4% at rainfall rates of 25 mm/hr and 8% at 133 mm/hr for most gauges (Parkin et al, 1982). This is important when results from gauges of different designs are compared. These errors worsen when gauge sensitivity is increased. It follows that gauge design is always a compromise between the need for good resolution and good overall accuracy in rainfall totals.

9. References

HMSO (1956) *Handbook of Meteorological Instruments*, Part 1, Met.0. 577.

HMSO (1982) *Observers Handbook*, Met.0. 933.

Painter, R.D. (1976) in *Methods of Plant Ecology* pp 369-410. Ed. by S.B.Chapman, Blackwell Scientific Press, Oxford

Parkin, D.A., King, W.D. and Shaw, D.E. (1982) *An automatic rain gauge network for a cloud seeding experiment* J.Appl.Meteorol. p 228.

Rodda, J.C., (1967) *The rainfall measurement problem* Proc. IAHS Gen. Ass. Bern, IAHS Pub. No. 78, 215-231

CAMPBELL SCIENTIFIC COMPANIES

Campbell Scientific, Inc. (CSI)
815 West 1800 North
Logan, Utah 84321
UNITED STATES
www.campbellsci.com • info@campbellsci.com

Campbell Scientific Africa Pty. Ltd. (CSAf)
PO Box 2450
Somerset West 7129
SOUTH AFRICA
www.csafrica.co.za • sales@csafrica.co.za

Campbell Scientific Southeast Asia Co., Ltd.
877/22 Nirvana@Work, Rama 9 Road
Suan Luang Subdistrict, Suan Luang District
Bangkok 10250
THAILAND
www.campbellsci.asia • info@campbellsci.asia

Campbell Scientific Australia Pty. Ltd. (CSA)
PO Box 8108
Garbutt Post Shop
QLD 4814 AUSTRALIA
www.campbellsci.com.au • info@campbellsci.com.au

Campbell Scientific do Brazil Ltda. (CSB)
Rua Apinagés, nbr. 2018 - Perdizes
CEP: 01258-00 São Paulo SP BRAZIL
www.campbellsci.com.br •
vendas@campbellsci.com.br

Campbell Scientific Canada Corp. (CSC)
14532 – 131 Avenue NW
Edmonton, Alberta T5L 4X4
CANADA
www.campbellsci.ca • dataloggers@campbellsci.ca

Campbell Scientific Centro Caribe S.A. (CSCC)
300N Cementerio, Edificio Breller
Santo Domingo, Heredia 40305
COSTA RICA
www.campbellsci.cc • info@campbellsci.cc

Campbell Scientific Ltd. (CSL)
80 Hathern Road, Shepshed, Loughborough LE12 9GX
UNITED KINGDOM
www.campbellsci.co.uk • sales@campbellsci.co.uk

Campbell Scientific Ltd. (France)
3 Avenue de la Division Leclerc
92160 ANTONY
FRANCE
www.campbellsci.fr • info@campbellsci.fr

Campbell Scientific Spain, S. L.
Avda. Pompeu Fabra 7-9
Local 1 - 08024 BARCELONA
SPAIN
www.campbellsci.es • info@campbellsci.es

Campbell Scientific Ltd. (Germany)
Fahrenheitstrasse13, D-28359 Bremen
GERMANY
www.campbellsci.de • info@campbellsci.de

Campbell Scientific (Beijing) Co., Ltd.
8B16, Floor 8 Tower B, Hanwei Plaza
7 Guanghua Road, Chaoyang, Beijing 100004
P.R. CHINA
www.campbellsci.com • info@campbellsci.com.cn

Please visit www.campbellsci.eu to obtain contact information for your local EU or International representative.