Model 444A Tipping Bucket Rain Gauge

User's Guide version 1.1

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Vaisala Inc. — Boulder Operations
Hydromet Solutions
194 South Taylor Avenue
Louisville, Colorado 80027
Toll free: 877 VAISALA (824 7252)
Facsimile: 303 499 1767

444-9005

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11/04

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The Vaisala Customer Service group provides after-sale support for users of Vaisala products. A telephone call during normal business hours (7:30 AM to 5:00 PM Mountain Time, Monday through Friday) places you in contact with a customer service representative who will advise you about using Vaisala equipment, interfacing sensors and data collection platforms, and troubleshooting.

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The Customer Service group provides repair service for Vaisala equipment. Before returning any equipment, call the toll-free number below, ask for Customer Service, and explain the problem. You will be asked for the model number(s) and serial number(s) of the equipment you are returning and the purchase date, if the equipment is still within the warranty period. Vaisala will give you a Returned Material Authorization (RMA) number that ensures the repair request will be acted upon promptly and you will be informed about the repair rates for equipment not under warranty.

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The Customer Service group also provides training in programming, installing, and maintaining Vaisala products. Training can be at the factory in Boulder, Colorado or at your facility.

Vaisala Customer Service

Vaisala Inc. — Boulder Operations
Hydromet Solutions
194 South Taylor Avenue
Louisville, CO 80027
Sales and Customer Service (7:30 – 5:00 MST)
Toll free: 1 877 VAISALA (824 7252)
Direct: 1 303 499 1701
Facsimile: 1 303 499 1767

Web Site: vaisala.com

Model 444A Tipping Bucket Rain Gauge

User's Guide

Table of Contents

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Preface: Applicability and organization

0.1 Applicability and update information

This *Users Guide* is current as of the date shown at the bottom of this page. If some pages of the document have older dates, the information on those pages has not changed up to the date shown on this page. See "Organization of the Manual set" for further information on the Guide.

0.2 Organization of the Manual set

The Model 555 series of Data Acquisition Systems (DASs) includes a number of products with different features and applications. In addition, the use of each product involves a number of distinct types of steps which, for greater convenience, are documented in three separate volumes of the *Model 555 User's Manual*. These volumes are:

- *Installation and Operation* (vol. 1) covers connection of sensors and other external devices, field installation, operating procedures, maintenance, and troubleshooting.
- *Programming* (vol. 2) includes complete instructions for creating the program to run in the data acquisition system. It has a tutorial to help the beginner learn the procedures, examples of applications, and a complete reference to programming and operating commands.
- *Software Library Reference* (vol. 3) provides documentation for the software modules that are available for constructing operating programs.

Volume 1 does not cover the installation, operation, or troubleshooting of options such as sensors, modems and radio telemetry systems nor does Volume 2 cover the programming of these devices. A separate *User's Guide* for each option provides information on the installation, operation, programming maintenance, and troubleshooting of the option. Volume 3 covers all software modules including those for programming optional devices.

This document is the *User's Guide* for the Model 444A Tipping Bucket Rain Gauge.

Table 0–A lists the part numbers of all of the *Model 555 User's Manual* volumes. The part number in the column headed "Set" is a master number applying to the whole manual set. The part numbers of the individual volumes in the set are in the remaining columns. You should receive a complete set of three volumes on a CD ROM with your Model 555.

Table 0–A Manual Part Numbers

Models	Set	Installation & Operation, vol. 1	Programming, vol. 2	Software Library, vol. 3
All models	555-9034	555-9001	555-9032	555-9033

0.3 Conventions used in this document

This guide uses consistent formats and conventions to improve clarity.

Sections, subsections, and topics

Section headings are numbered and in boldface type centered on the top of a right-hand page. Subsection headings are in boldface type beginning at the left of the page, going across the page, and are numbered with the section heading, a decimal, and a subsection number. Only two levels of outline are used in this User's Guide. References in the text to subject matter found elsewhere in the document use the section and page numbers.

Tables and figures

Tables and figures are titled with numbers that represent the section number and specific table or figure in the section; for example, Table 2-A, Table 2-B, Figure 2-A, Figure 2-B, and so forth.

Computers

Keys on the keyboard of a computer are indicated by key labels in square brackets, for example:

[A] [Enter] = [↵] [Ctrl] [Esc] [F1]

This User's Guide assumes the use of IBM-PC compatible computer keyboards. Output from a computer or data acquisition system displayed on the computer screen is printed in a special type face with fixed letter spacing:

```
Press any key to continue
```

When instructions to type on the keyboard are given, the characters typed are underlined:

```
C:>install
```

When the instruction says "type" or "press", just press the keys indicated. When the instruction says "enter," press the keys and then press [↵] (the [Enter] or [Return] key).

Cross references

Cross references to other parts of this document or to other documents included in the Handar CD ROM manual set are hypertext-linked and flagged with blue type. When reading this document on-line, click the mouse on the blue type to transfer to the referenced location.

1 Introduction

1.1 Description

The Model 444A Tipping Bucket Rain Gauge consists of a funnel with a 200 mm (approximately 8 inch) diameter opening which feeds rainfall into a tipping collection bucket. The opening has a knife-edge contour to ensure that only rain falling within the 200-mm circle is collected. When the accumulated rain in the bucket reaches the standard amount, the mechanism tips, closing a magnetically-operated reed switch, discharging the liquid, and presenting a second bucket to the outlet of the funnel. The amount of rainfall which is required to tip the bucket is 0.25 mm, which is equal to 0.010 inch to within the accuracy of the device. Tips of the bucket may be counted by a Model 555-series Data Acquisition System or any other device which can reliably count switch closures. The Model 555 DASs may be programmed to report the accumulated rainfall in any desired units. The accuracy of measurement, taking into account evaporation, internal splashing, and other effects is ±3%. Since the liquid is discharged after measurement, the gauge capacity is unlimited.

Figure 2–A on page 12 is a cutaway drawing of the Model 444A Rain Gauge with the components labeled.

The Rain Gauge is a simple and reliable device which requires no regular servicing other than cleaning. It uses no electrical power itself; the counting device must supply an electrical potential to the switch terminals. It is equipped with a bulls-eye spirit level to aid in levelling during installation, and with screens to keep out debris and animals.

The Model 444A is intended for measuring liquid rain only; it will not be damaged by water freezing in the collection bucket, but it will not operate under freezing conditions. If measurement under such conditions is required and AC power is available, the Model 444C Heated Tipping Bucket may be used; it differs from the Model 444A principally in having electric heating elements strategically located to melt incoming precipitation and keep it liquid until it is discharged from the unit.

1.2 Specifications

Table 1–A Model 444A Tipping Bucket Rain Gauge — Specifications

Event Resolution	0.25 mm (0.010 inch)
Accuracy	At rainfall rate < 2 inches (50 mm) /hr
<1 inch of rain	±0.02 in
<20 mm of rain	±0.5 mm
>1 inch of rain	±3% of total
>20 mm of rain	±3% of total
Contact Closure	Mercury-wetted reed switch, activated by magnet.
Capacity	Unlimited
Output	Switch closure (pulse width > 0.1 sec) each 0.25 mm (0.010 inch) rain.
Gauge Orifice Diameter	200 mm (7.87 inch)
Temperature Range	Operating: 0° to +50°C (liquid precipitation only)
	Survival: -40° to +50°C
Gauge Height	450 mm (17.7 -inch) including mounting legs.
Gauge Weight	3.9 kg (8.6 lb)
Mounting	Three L-shaped legs with 12 mm (0.47 inch) bolt holes; bull's-eye level on instrument base
Materials	
Outer shell	Painted Steel
Funnel, bucket and inner structure	Non-corrosive plastic
Screws, shaft, bearings	Stainless Steel

1.3 Accessories

Table 1–B lists optional accessories for the Model 444A Rain Gauge. The list of cables provided in the table is not complete; consult your Vaisala representative with regard to your application.

Table 1–B Accessories for the Model 444A Rain Gauge

Part no.	Item
444A-4001	Refurbish Kit (screens, reed switch, Users Guide)
444-8002	Pedestal, 4 ft (1.2 m) height
444-1	Pedestal hardware kit (for AWOS installation)
444-2	Hardware/Earth Grounding Kit (for AWOS installation)
444-3002	AWOS Cable Assembly, Precipitation Signal
530-3711	Tipping Bucket Cable, 11 ft, shielded, 555B
530-3711N	Tipping Bucket Cable, 11 ft unshielded, 555B
530-37XX	Tipping Bucket Cable, 555B (specify length)
570-3711NP	Tipping Bucket Cable, 11 ft unshielded, 555A/C/C-1
570-379XNP	Tipping Bucket Cable, unshielded,555A/C/C-1 (specify length)

2 Calibration and installation

2.1 Unpacking

Tool required: No. 2 Phillips screwdriver

Before unpacking the equipment, check the shipping carton for damage. If the carton appears damaged and the equipment is dented or damaged, contact the shipping company and Customer Service (see page 3). Check all components of the instrument for apparent damage as you unpack. If any problems with the equipment arise which are not related to shipping damage, call Customer Service only.

The Rain Gauge is packed in a plastic bag inside the shipping carton. Remove the plastic bag, and take the foam pad out of the orifice. The upper screen is located under the foam pad. Remove the screen and take the second foam pad out of the funnel. Remove the small screen located at the bottom of the funnel. The upper screen is flat, and the lower, curved; the lower screen is normally installed with the rim upward and the curved screen downward in the bottom of the funnel.

Set the Rain Gauge on a clean table surface, and remove the three Phillips screws at the bottom of the outer cylinder. Carefully lift the cylinder upward off the base of the unit and clear of the tipping bucket mechanism. The upper funnel should be attached firmly to the outer cylinder. Figure 2–A gives a sketch of the internal structure of the Rain Gauge.

The tipping bucket mechanism is secured for shipment by a block of foam in one of the drain tubes. Remove the foam, and check that the tipping bucket moves freely on its shaft. You may now perform the electrical test described in section 2.2.

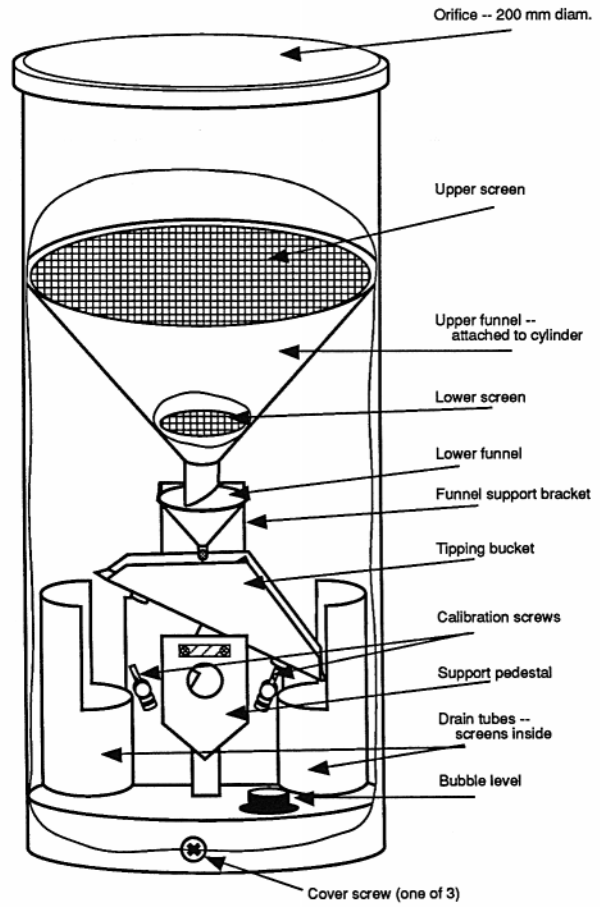

Figure 2–A Cutaway drawing of the Model 444A Tipping Bucket Rain Gauge

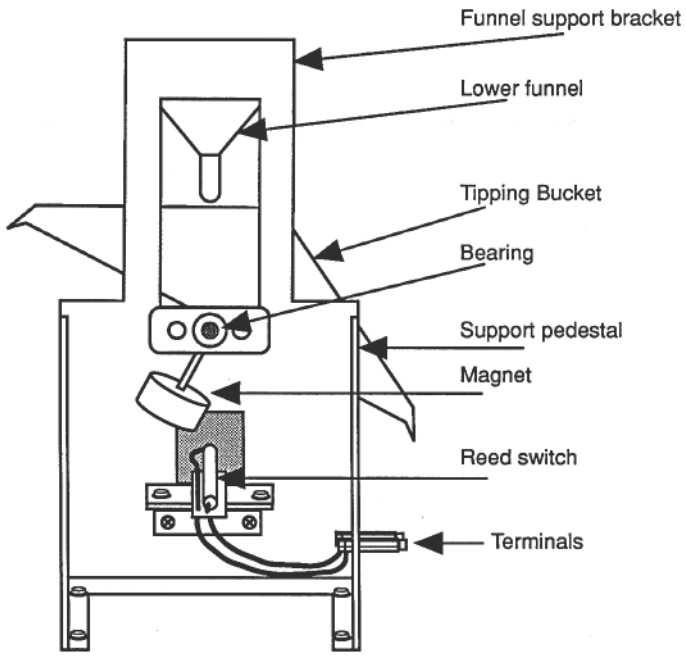

Figure 2–B View of back of the tipping bucket support pedestal, showing moving magnet and reed switch, In operation, the magnet and switch are covered by an aluminum box.

2.2 Operational Test

Tool required: Ohmmeter or continuity tester

Optional: No. 1 Phillips screwdriver

Figure 2–B shows the switch mechanism, which is located on the opposite side of the instrument from that shown in Figure 2–A. The bearing, magnet, and reed switch are covered by an aluminum box which is secured by two Phillips screws. It is not necessary to remove the box to carry out the following test, but you may do so if you wish to inspect the condition of the covered components.

Connect the ohmmeter or continuity tester to the two terminals indicated in Figure 2–B. When the tipping bucket is at either end of its travel, there should be an open circuit between the two terminals. Move the tipping bucket by hand from one side to the other. The tester should show a closed circuit (no more than a few ohms resistance) except when the bucket is near the ends of its travel.

If the switch does not appear to be working normally, remove the cover from the switch area and inspect for obvious problems. Then call Customer Service (see page 3) for further instructions. Section 4.3 on page 28 provides instructions for replacing the reed switch.

When you are satisfied that the Rain Gauge is working properly, it is a good idea to connect it to the DAS that you are going to use or to an equivalent one. See section 2.4 on page 16 and the Model 555 *Manual, Volume 1*. Program the DAS (see section 3 on page 20), and test the whole system including the cable before installing it in the field.

Use the ONLINE menu of the *555 See 'n Select* software and the ALTER PARAMETERS command to inspect the accumulator value and watch it change as you tip the bucket by hand. The DAS must be in RUN mode. See section 7.4.8 of the *Manual*, Volume 2 for the details. You may also use the FORCE SCAN command of the ONLINE menu; see section 7.4.4 of the *Manual*, Volume 2.

If you do not get a signal, check the cable for continuity and double-check your programming. Call Customer Service (see page 3) for assistance if necessary.

2.3 Calibration Procedure

The Model 444A Tipping Bucket Rain Gauge is adjusted at the factory to tip each 0.25 mm of rainfall. If you wish to check and readjust the calibration, use the procedure described below. The method used is simply to allow a measured amount of water to flow slowly through the instrument and count tips; if the number of tips is not within tolerance, adjust the calibration screws and repeat the operation until the correct number of tips is obtained.

The calibration procedure is described below as it would be done in a laboratory or shop. It can also be done in the field without removing the gauge from its mounting.

Note that the nominal factory calibration is 0.25 mm per tip, or.009843 inch, not 0.0100 inch. The difference of 1.6% is smaller than the specified accuracy of the gauge (3%), but if you want to reset the calibration closer to 0.0100 inch, you may use the procedure below for that purpose.

One run of the calibration procedure below requires one to two hours. It is essential the water be allowed to flow slowly, otherwise internal splashing will destroy the validity of the calibration. Do not try to count the tips by hand; use a DAS or other automatic counter to avoid errors.

Tools required:

- Calibrated 1000 ml measuring beaker or graduate.
- Clean plastic bottle, larger than 1 liter ($1\ ^1/_2$ or 2 liter beverage container will do).
- Common straight pin
- DAS or other device that will count switch closures (see section 2.2 on page 13).
- If adjustment of the calibration screws is required, two pieces of #47 drill rod (0.078 in = 2 mm diameter)

1. Set up the rain gauge on a table top over a pan which will catch the water discharged from the drain tubes. Place shims under the feet to level the gauge; refer to the bubble level. If the calibration test is made with the gauge installed in the field, just check the levelling.
2. Connect a properly programmed DAS or other counting device to the Rain Gauge. See page 18 regarding connecting the DAS, and section 3 on page 20 for programming. Bring the cable in through the cable hole in the bottom just below the terminals and connect the two wires of the cable to the terminals. Polarity does not matter.
3. Pour enough water into the lower funnel to fill it to the point at which water flows through the outlet into the tipping bucket. If any water runs into the tipping bucket during this operation, tip the bucket manually to discharge the water. Be sure to rezero the counter.
4. Install the outer cylinder on the base of the Rain Gauge. Note that there is a key in the side of the base near the reed switch which mates with a slot in the bottom edge of the cylinder. If the calibration is done indoors, you need not install the three screws at the bottom of the cylinder.
5. Be sure that the counter is ready to operate and is set to zero.
6. Puncture a small hole in the bottom of the plastic bottle with a common pin to produce a slow flow of water from the bottle. The bucket should not tip more than once in 20 sec for an accurate calibration. Remove the upper screen and place the bottle in the upper funnel.
7. Check the calibration by the procedure below. The method generates about 100 tips of the bucket; do not try to shorten the procedure by recording fewer tips because you will not be able to calibrate to the specified accuracy with fewer.

The calibration procedure runs a measured amount of water (1000 ml) through the system and determines the total number of counts recorded. With the plastic bottle empty and in place in the funnel, proceed as follows.

1. Measure 1000 ml of water into the plastic bottle. The accuracy of the calibration depends on the accuracy of this measurement. Do not cap the bottle.
2. When the flow stops, be sure that the bottle is empty. If a little water remains, simply invert the bottle and pour it *slowly* into the funnel.
3. Based on a 200 mm orifice and **0.25 mm per tip** , each 7.85 ml of water produces one tip. Therefore, 1000 ml of water should produce **127 ± 4 tips** . The 4 tips tolerance is based on the stated 3% accuracy.
4. If the bucket is to be recalibrated to **0.0100 inch per tip** , 7.98 ml of water are required per tip, and 1000 ml of water will produce **125 tips**. Note that the instrument is not specified to be able to reliably distinguish between.0100 inch and 0.25 mm.

If the count of tips is not within tolerance, you may proceed according to *either* a) *or* b) below. In b) you compute an exact amount of rainfall per tip to use in place of the nominal 0.01 inch or 0.25 mm; your DAS program and data handling procedure must allow you to enter the value. If you can use the exact value, you may want to use it even if the calibration is within the 3% tolerance.

a) Adjust the calibration screws which act as stops for the tipping bucket travel using the two pieces of drill rod. Increasing the height of the stop will increase the number of counts per liter, and decreasing the height of the stop will decrease the number of counts. One-half turn of the screw will change the number of counts per liter by approximately one count. *Always adjust both screws by the same amount in the same direction.* After adjusting the calibration screws, repeat the above test and readjust until the number of counts is within tolerance.

or

b) Leave the calibration screws alone and use the data from the above test to calculate the true rainfall for each tip of the bucket. In making the calibration test, you have determined the number of tips corresponding to a volume in milliliters of water poured through the gauge. The volume in milliliters per tip is

$$v = \frac{V}{N} \text{ ml}$$

where **V** is the measured volume in milliliters, and **N** is the number of tips.

The corresponding depth of precipitation is then the true rainfall per tip:

$$R = \frac{v}{314.2} \text{ cm or } R = \frac{v}{798.0} \text{ inch}$$

The Model 555 DAS software (see section 3 on page 20) allows you to select one of the nominal values for *tip units*, but you may correct the accumulated rainfall by the multiplying by the true value divided by the nominal:

$$TR(\text{corrected}) = TR(\text{nominal}) \bullet \frac{R}{\text{Tip units}}$$

Here **TR** is the total accumulated rainfall, and **R** is the true rainfall per tip from the previous equation.

2.4 Field Installation

If the Model 444A Tipping Bucket Rain Gauge has been unpacked for inspection and testing in the laboratory or shop, carefully repack it with all foam pads in place before taking to the installation site.

The Rain Gauge should be installed at a site away from buildings, trees, cliffs, or other obstructions which might prevent the gauge from receiving a fair sample of rain with the wind blowing from any direction. It must be accurately level so that the gauge tips when the calibrated amount of water has collected. Cable length from the Rain Gauge to the DCP will not affect the signal, but long cables may pick up electric surges from nearby

lightning strikes which could damage the DAS. Long signal cables should be grounded at both ends through MOVs; instructions are provided in the *555 Manual*, volume 1.

For installation of the Model 444A Rain Gauge as part of AWOS systems, see the *AWOS System Manual*. For other installations, proceed as follows:

Tools and materials required:

- No. 1 and No. 2 Phillips screw drivers.
- Wrench to fit mounting bolts
- Ohmmeter or continuity tester
- 3 each 10 mm or 3/8 inch bolts to secure Rain Gauge to mounting surface, with nuts and washers as required.
- Additional flat washers or shims to fit around mounting bolts for levelling.
- Silicone caulk
- Cable ties

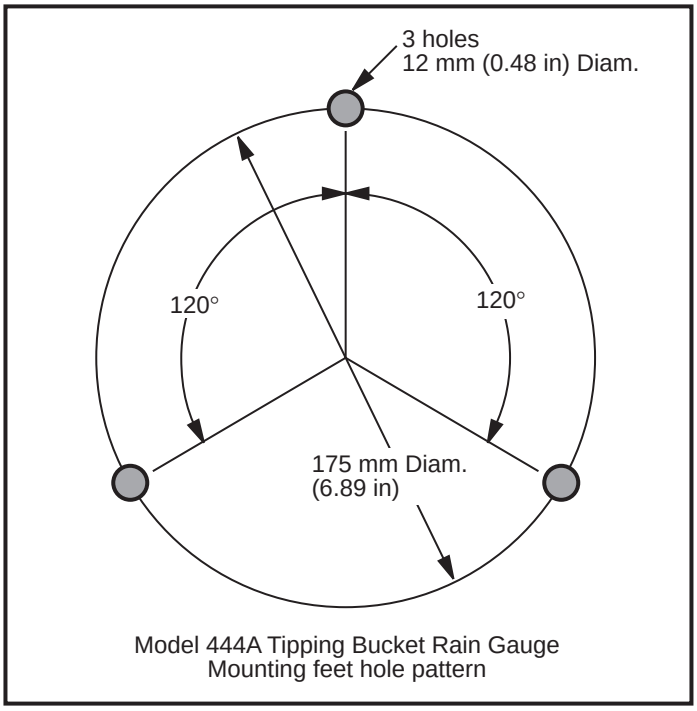

Figure 2–C Mounting hole pattern for the Model 444A Tipping Bucket Rain Gauge

1. The Rain Gauge stands on three L-shaped feet with 12 mm (0.47 inch) bolt holes drilled on a diameter of 175 mm (6.89 inch) (see Figure 2–C). Prepare a level surface at the chosen site with

matching bolt or screw holes or bolts set in concrete. Screws or bolts 3/8 inch or 10 mm in diameter may be used to secure the gauge to the mounting surface.

A mounting pedestal, part no. 444-8002, is available for mounting the Rain Gauge approximately 4 ft (1.2 m) above a concrete pad. The upper plate of the pedestal is predrilled with holes to match the mounting feet of the Rain Gauge.

2. Unpack the Rain Gauge and remove the outer cylindrical cover with the attached upper funnel as described in section 2.1 on page 11. Remove all foam padding.
3. Place the Rain Gauge on the prepared mounting surface or pedestal with the feet over the points where they are to be attached. Check the bubble level on the instrument base. If necessary, place flat washers or shims under the feet until the gauge is level.
4. Secure the gauge to the mounting surface or pedestal with 3/8 inch or 10 mm bolts, nuts, and lock washers. Stainless steel hardware is recommended near salt water.
5. Bring the signal cable through the hole in the base of the instrument near the terminals, which are located on the side of the support pedestal behind the tipping bucket (see Figure 2–B on page 13). Using a no. 1 Phillips screw driver, back out the terminal screws and attach the terminal lugs on the end of a standard cable. Other cables may end in tinned leads, which can be looped around the terminal screws. Since the Rain Gauge signal is simply a switch closure, there is no polarity to be observed in attaching the signal cable. Tighten the terminal screws to secure the leads.

   The terminal screws should not be expected to support the weight of a signal cable or mechanical shocks transmitted by the cable. Secure the cable to a suitable support outside the Rain Gauge to minimize the strain on the terminals.
6. As noted above, cables may pick up induced surge voltages from nearby lightning strikes. See the *Model 555 Manual*, volume 1,or Applications Notes available from Vaisala for instructions regarding grounding and surge protection.
7. Connect the signal cable to the Switch input (marked “TB”) on the Model 555 DAS and program the unit as required to read the signals from the Rain Gauge (see section 3 on page 20). Tip the bucket several times (not more rapidly than once per second) and be sure that the DAS has recorded the tips.

   If the DAS does not record the tips, check the cables for continuity and proper installation. Proper operation of the Rain Gauge may be checked as described in section 2.2 on page 13. Proper operation of the DAS may be checked by disconnecting the cable from the rain gauge, and simulating the rain gauge switch by any manual momentary-contact switch, or even by touching the two signal wires together briefly. The simulation may be applied both at the end of the cable and at the connector on the DAS to isolate problems to the cable or the DAS. If you need help, call Customer Service (see page 3).

8. Install the cylindrical cover and upper funnel on the gauge. Note the key in the base of the instrument above the mounting foot located behind the tipping bucket (nearest the reed switch). This key mates with a slot in the bottom of the cylinder. Secure the cylinder to the base with the three stainless steel screws using a no. 2 Phillips screwdriver. This completes installation of the Rain Gauge.

3 Programming

The Model 444A Tipping Bucket Rain Gauge can be used with any of the Data Acquisition Systems (DAS) of the Model 555 series. It can also be used with an AWOS weather system.

In AWOS systems, all of the programming parameters are fixed in firmware, and the user has no programming to do. An AWOS system reports only the accumulated rainfall within the present hour.

ALERT weather systems use the Model 555F ALERT Transmitter and Data Logger. Normally, a tipping bucket that signals each 1 mm of rainfall is used with an ALERT system, rather than the Model 444A. However, you can use the Model 444A Tipping Bucket with the Model 555F TDL; programming is as described below.

General programming instructions for the Model 555 series are given in the *Model 555 User's Manual*, volume 2. A general tutorial on programming, including programming a tipping bucket sensor, is given in section 4. ALERT system program is discussed in section 5.

This section provides brief instructions for programming the Model 444A Tipping Bucket sensor, which can be used as either an *event* sensor, or as an *interval* sensor. In the event mode, each tip of the bucket results in logging the accumulated rainfall. In the interval mode, the accumulated rainfall is logged or transmitted at a regular interval, regardless of whether any rain falls during the interval.

The instructions provided here cover only logging the sensor data to memory. The use of the sensor definitions will apply also when a telemetry system is used to transmit data, either in addition to or in place of logging the data to memory. Further programming instructions are provided in the *User's Guides* for the telemetry systems.

3.1 Event-type Data Logging

The sensor definitions that control the Model 444A Tipping Bucket Rain Gauge are found in the library of the *555 See 'n Select* software (program *555*) in the category *Precipitation*. If you wish to log data only when the bucket tips, select the sensor definition *Tipping Bucket Event*. Details are provided in the *Model 555 User's Manual*, Volume 3.

The sensor definition monitors the sensor continuously, and when a tip of the mechanism occurs, the sensor definition "wakes" the DAS and provides a data value to the controlling process (see below), which adds the data value to an accumulator that records the total rainfall, and then logs the accumulator value to memory.

Figure 3–A below illustrates the parameter window for the *Tipping Bucket Event* sensor definition. Only a few parameters are required.

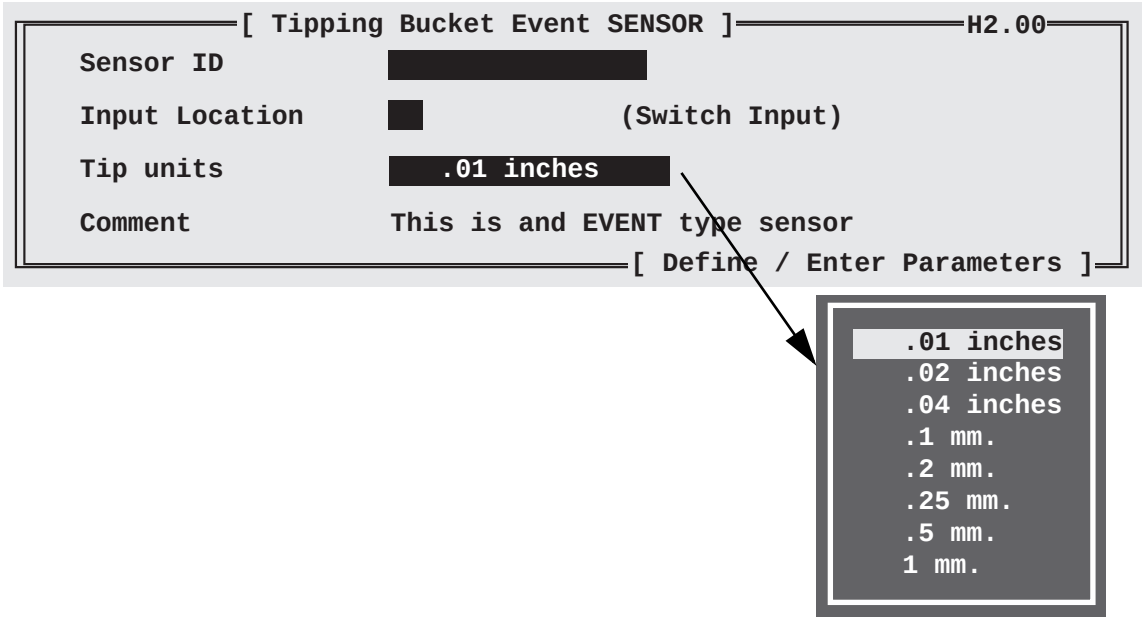

Figure 3–A Parameter window for sensor definition Tipping Bucket Event.

Sensor ID: Enter a name of up to 16 characters that uniquely identifies the sensor during programming and after loading the program into the Model 555 DAS.

Input Location: The pop-up window (not illustrated) displays only one choice — the switch enclosure input labeled "TB". Press [↵] or the left mouse button to continue. Volume 1, section 5.1, of the *Model 555 User's Manual*, describes this input.

Tip units: The pop-up window displays a list of possible values and units that correspond to the rainfall for one tip of the bucket. For the Model 444A, move the highlight to either ".01 inches" or ".25 mm". The other choices apply to other tipping bucket models. Press [↵] to continue.

The prompt "Is this information correct?" then appears. After checking your parameter selections, press [Y] or [↵].

In addition to the above sensor definition, you need a process to maintain an accumulator to collect the tip values into a number for the total rainfall, and to log the rainfall to memory. The process required is *Time Stamp Accum. Precip* from the category *Event Driven Processes.*

Figure 3–B below illustrates the parameter entry window for Time Stamp Accum. Precip. Answer the prompts as follows:

Process ID: Enter a name of up to 16 characters that uniquely identifies the process during programming and after loading the program into the Model 555 DAS.

Storage size: Enter the number of bytes of data storage to set aside for the data to be generated. Each tip of the bucket results in storing six bytes — two bytes for the accumulator value and four bytes for the time

stamp. If you leave this parameter at the default value of zero, the storage size is automatically assigned. Refer to Volume 2, section 4.2, of the *Model 555 User's Manual.*

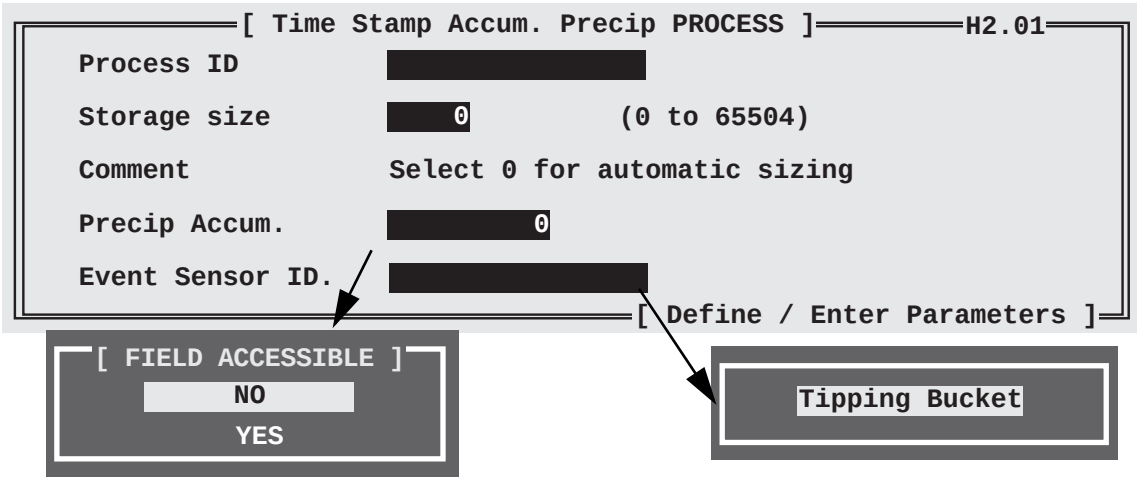

Figure 3–B Parameter entry window for the process Time Stamp Accum. Precip

Precip Accum. : Enter the current value of the accumulated rainfall. If you wish to be able to reset the accumulated rainfall value without reprogramming the DAS, make this value field accessible.

When you do so, set the minimum to "0.00" and the maximum to be larger than the most rainfall you expect before it is time to reset the accumulator to zero, for example, "100.00". Be sure to include two decimal places in both values to match the two decimals in the **Tip units** selected in the sensor definition.

For more information on field accessible values, see Volume 2, section 7.3.10, of the *Model 555 User's Manual.*

Event Sensor ID. : The pop-up window displays all event-type sensor definitions in the current program. Select the tipping bucket connected the switch input by moving the highlight and pressing [↵] or the left mouse button.

Every time the bucket tips, the value selected with the **Tip units** prompt in the sensor definition will be added to the value in the **Precip Accum.** The accumulator total will then be logged to memory.

If you have set the **Precip Accum.** value to be field accessible, you may at any time use the programming set with the ALTER PARAMETERS command of the ONLINE menu in the *555* software to change the value — for example, back to zero at the beginning of the rainfall season. Refer to Volume 2, section 7.4.8, of the *Model 555 User's Manual.*

3.2 Interval data logging

If you wish to log rainfall data to memory, or to transmit it via a telemetry system, at regular intervals, use the sensor definition *Tipping Bucket Accumulation* from the category *Precipitation* to control the sensor.

This sensor definition monitors the tipping bucket sensor continuously, and at every tip adds the selected value to an accumulator which represents the total rainfall. A controlling process may read the sensor definition on a regular schedule and will receive the current value of the accumulator, which the process may store in memory or in a telemetry buffer.

This section will explain the program elements needed to store a total rainfall value in memory on a regular schedule; refer to your telemetry system *User's Guide* for information on telemetry programming. The sensor definition may be read by any process that stores or processes data on a regular schedule.

Figure 3–C illustrates the sensor definition parameter window. Answer the prompts as follows.

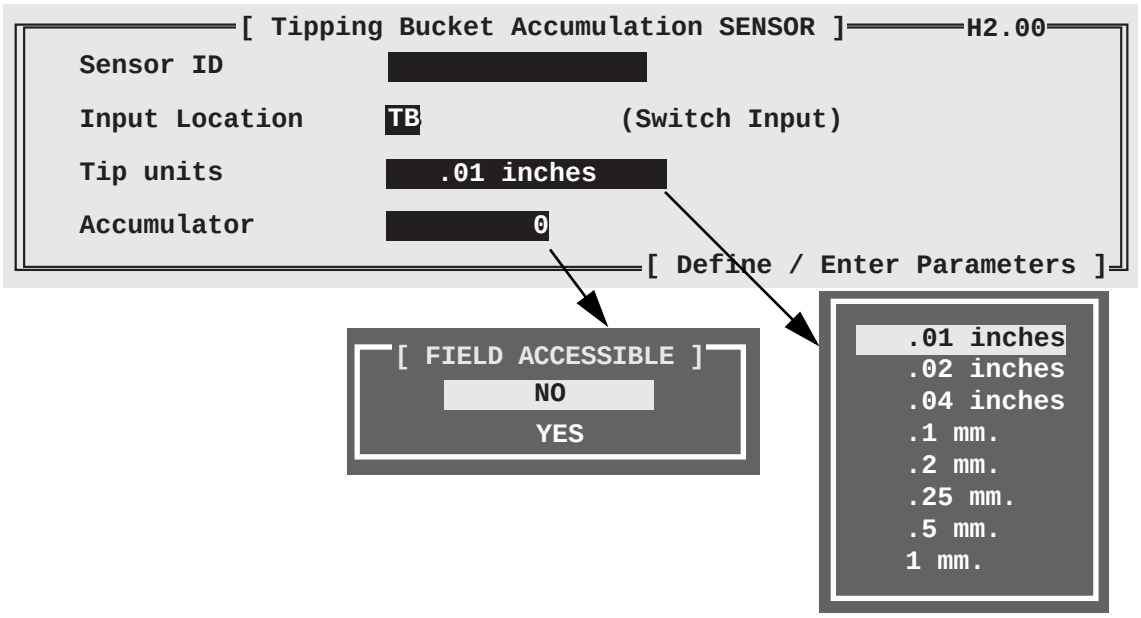

Figure 3–C Parameter window for the sensor definition Tipping Bucket Accumulation

Sensor ID: Enter a name of up to 16 characters that uniquely identifies the sensor during programming and after loading the program into the Model 555 DAS.

Input Location: The pop-up window (not illustrated) displays only one choice — the switch enclosure input labeled "TB". Press [↵] or the left mouse button to continue. Volume 1, section 5.1, of the *Model 555 User's Manual*, describes this input.

Tip units: The pop-up window displays a list of possible values and units that correspond to the rainfall for one tip of the bucket. For the Model 444A, move the highlight to either ".01 inches" or ".25 mm". The other choices apply to other tipping bucket models. Press [↵] to continue.

Accumulator: Enter the current value of the accumulated rainfall. If you wish to be able to reset the accumulated rainfall value without reprogramming the DAS, make this value field accessible.

When you do so, set the minimum to "0.00" and the maximum to be larger than the most rainfall you expect before it is time to reset the accumulator to zero, for example, "100.00". Be sure to include two decimal places in both values to match the two decimals in the **Tip units** selected in the sensor definition.

For more information on field accessible values, see Volume 2, section 7.3,10, of the *Model 555 User's Manual*.

Making the accumulator value field accessable will allow you to reset it to zero when necessary, such as at the beginning of the rainfall season.

Note that although this sensor definition reads a sensor that responds to irregular events, it is an interval-type sensor definition and appears on the lists of sources displayed by processes that read data at regular intervals.

There are several processes available to log data to memory or to transmission buffers at regular intervals. Any of these can read the above sensor definition. A simple example is illustrated in Figure 3–D — the process *Log Source Data* from the category *Interval Data Logging*.

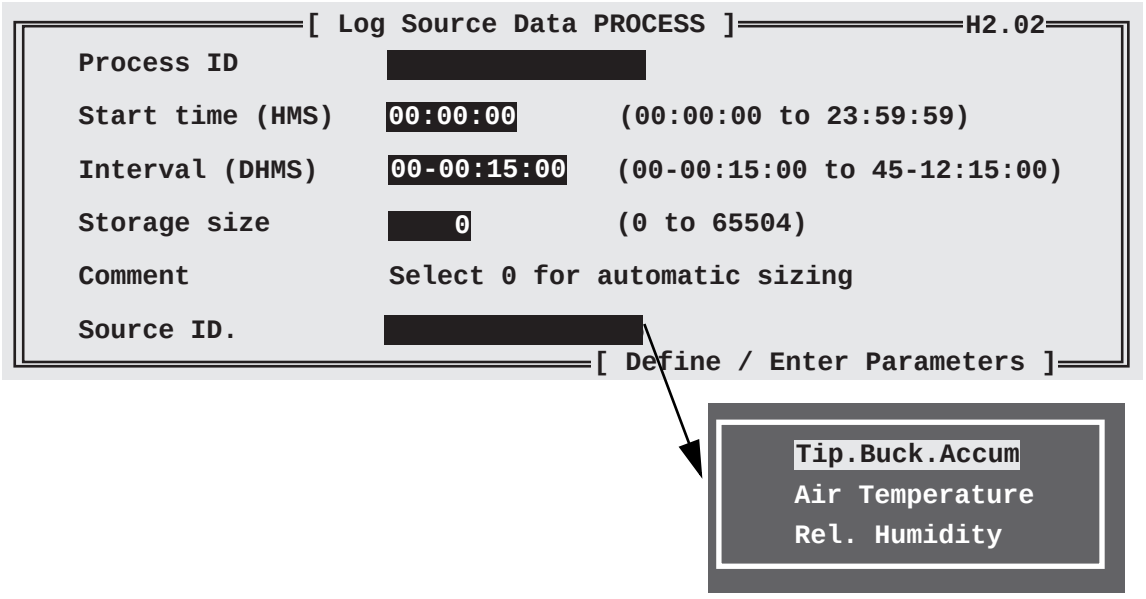

Figure 3–D Parameter window for the process Log Source Data

Process ID: Enter a name of up to 16 characters that uniquely identifies the process during programming and after loading the program into the Model 555 DAS.

Start time (HMS): Enter the time in hours: minutes: seconds for making the first measurement. You can make this quantity field accessible.

Interval (DHMS): Enter the interval in days– hours: minutes: seconds between readings of the source. You may make this quantity field assessable.

Storage size: Enter the number of bytes of data storage to set aside for the data to be generated. Each reading of the source results in storing the accumulator value, which is usually two bytes. If you leave this parameter at the default value of zero, the storage size is automatically assigned. Refer to Volume 2, section 4.2, of the *Model 555 User's Manual*.

Note that no time stamp is stored with interval data. When the DAS provides a report of stored data, it calculates the time each item was stored. Refer to Volume 2, section 7.4.6, of the *Model 555 User's Manual*.

Source ID.: The pop-up window displays the IDs of all of the data sources included in the program. Select the ID entered for the *Tipping Bucket Accumulation* sensor definition.

Note that if you log tipping bucket data on an interval basis, during a long period without rainfall the same accumulator value will be logged repeatedly. Under the same circumstances, if you use event-type logging (see section 3.1 on page 20), no data will be logged.

3.3 Logging data with calibration adjustment

If you calibrate the sensor as described in section 2.3 on page 14, and find that the calibration is not close enough to the nominal **Tip unit** value provided by the sensor definition, you may correct the data by means of a constant multiplier before logging it to memory.

You can apply this correction only if you log data on a regular interval as described in section 3.2; not if you event-type data logging as in section 3.1.

As described in section 2.3, you may use the calibration procedure to calculate a correction factor

$$f = \frac{R}{\text{Tip units}}$$

You may then apply this factor to the accumulator value by using the intermediate process *Source x Constant* from the category *Interm. Basic Math Processes*. The parameter window is illustrated in Figure 3–E.

Process ID: Enter a name of up to 16 characters that uniquely identifies the process during programming and after loading the program into the Model 555 DAS.

Source ID.: The pop-up window displays the IDs of all of the data sources included in the program. Select the ID entered for the *Tipping Bucket Accumulation* sensor definition.

Constant value: Enter the value of **f** as computed above. You must limit **f** by rounding (if necessary) so that it has no more than four decimal places and is represented by three bytes or fewer. See Volume 2, Appendix B, of the *Model 555 User's Manual* for help in estimating the number of bytes in your value. You may make this quantity field accessible so that you can change it later.

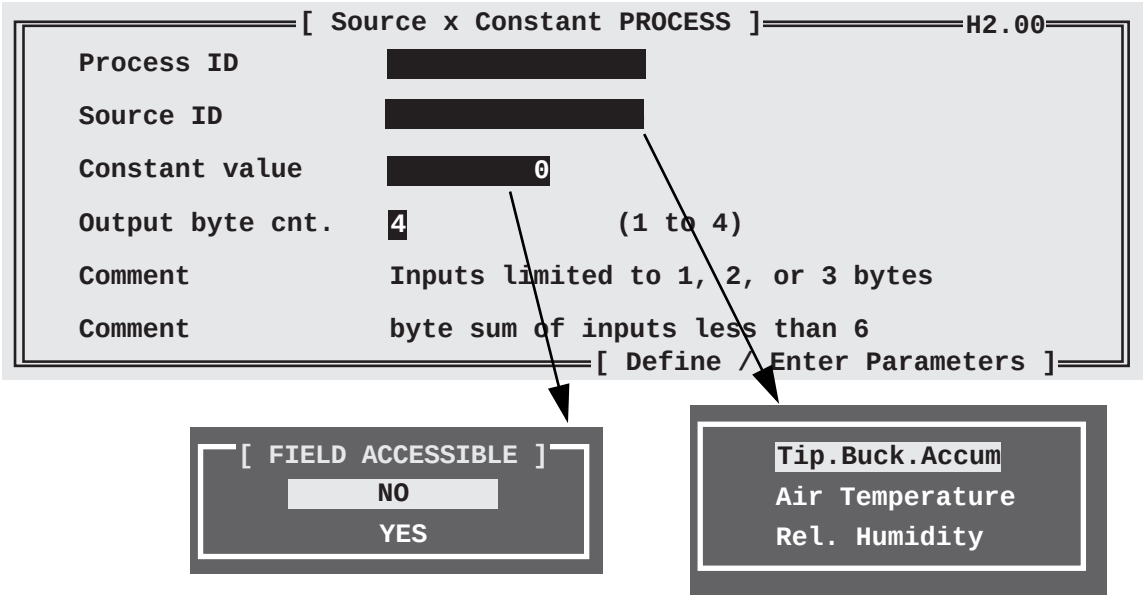

Figure 3–E Parameter screen for the intermediate process Source x Constant

Output byte cnt.: Enter the number of bytes required to represent the output. Estimate the number of bytes by multiplying the value of **f** without a decimal point by the largest accumulator value you expect, also without a decimal point, and refer to Volume 2, Appendix B, of the *Model 555 User's Manual.*

Now add to the program a data logging process, such as the example in Figure 3–D on page 24. The list in the **Source ID** pop-up window will include the ID you assigned to the *Source x Constant* process; select this as the source. Then all of the data you log will be the accumulator value from the sensor definition multiplied by the calibration factor **f**.

4 Maintenance and repair

4.1 Normal Maintenance

Tools and materials: Water (distilled or demineralized), clean rags, no. 1 and no. 2 Phillips screw drives, silicone oil.

The only maintenance normally required by the Model 444A Tipping Bucket Rain Gauge is periodic cleaning and lubrication. Local conditions will determine how frequently cleaning is required. The screens in upper funnel will keep out large items of debris such as leaves, branches, and small animals, but they will not prevent the entry of dust and insects. Small insects may also enter through the drain tubes on the bottom.

To clean the Rain Gauge, remove the outer cylinder and wash out all dirt with water under gentle pressure, such as from a plastic squeeze-bottle. Wipe up with a soft, clean cloth. Do not use solvents.

Lubricate the bearing points at the ends of the tipping bucket shaft lightly with silicone oil. To reach the bearing at the back of the shaft over the reed switch (see Figure 2-2), remove the two small Phillips-head screws holding cover box to the back of the pedestal, and lift off the cover.

When the gauge has been cleaned, check that it is still level by inspecting the bulls-eye level, and correct the leveling if necessary.

Make an operational test by connecting the gauge to the DAS and tipping by hand; see steps 7 through 9, section 2.4 on page 18. Replace the cover over the reed switch before installing the outer cylinder.

4.2 Troubleshooting

Tools: No. 1 and no. 2 Phillips screwdrivers, ohmmeter or continuity tester.

If the gauge does not provide a signal when tipped, it is important to determine whether the problem is in the gauge itself, the cable, or the Data Acquisition System (DAS). See section 2.2 on page 13, and step 7 on page 18 for suggestions as to how to proceed.

If the problem is in the Rain Gauge, remove the Phillips-head screws holding the cover over the magnet and reed switch, and lift off the cover. Inspect the wires from the reed switch to the terminal posts (see Figure 2–B on page 13). If these wires are disconnected or broken, repair them if possible. If the wires are intact, the reed switch probably requires replacement. A Refurbish Kit is available from Vaisala, and instructions are given is section 4.3 below. You may, if you wish, return the Rain Gauge for repair.

If the cable is defective, you may make repairs yourself, or return it for repair or replacement.

If the DAS does not respond to either the tips of the Rain Gauge or to simulation by switch closure applied directly to the input terminals, check that the battery is charged, that the program is correct, and that the unit is in RUN mode. If all seems to be correct, and the DAS still does not record the tips, refer to the troubleshooting advice in Volume 1, section 11.2, of the *Model 555 User's Manual*.

For advice regarding problems or to return equipment, call Customer Service (see page 3).

4.3 Replacing the Reed Switch

The magnetically-operated mercury-wetted reed switch is subject to a minimum of mechanical stress in operation, and has a long life in service. It is, however, the part most likely to fail eventually. If the troubleshooting procedure indicates a defective switch, a new one may be installed. Obtain the Refurbish Kit, part no. 444A-4001, from Vaisala; this kit contains a new reed switch and replacement screens for the funnel.

Tools required: No. 1 and No. 2 Phillips screw drivers, 7 mm or $^{9}/_{32}$ inch end or box wrench, wrench for bolts holding gauge to pedestal, ohmmeter or continuity tester.

Refer to Figure 2–A on page 12 and Figure 2–B on page 13 for the following procedure.

1. Remove the three Phillips screws securing the outer cylinder, and remove the cylinder and upper funnel from the instrument base.
2. The reed switch assembly is fairly delicate and should not be installed with the gauge located where it cannot be worked on conveniently. If it is awkward to work on the gauge in place, remove it from its mounting pedestal and place it on a safe and convenient work surface:

   Disconnect the signal cable from the terminals on the Rain Gauge, and pull the cable out of the hole in the base.

   Remove the bolts securing the legs of the Rain Gauge to the pedestal or mounting surface, and carry the gauge to the work area.
3. Remove the Phillips-head screws holding the cover over the magnet and reed switch (behind the support for the lower funnel) and lift off the cover. The reed switch assembly will appear as shown in Figure 2–B on page 13.
4. Using the 7 mm or $^{9}/_{32}$ inch wrench, remove the nuts and washers from the inner ends of the terminal posts and disconnect the switch wires from the terminals.
5. Using the no. 1 Phillips screw driver, remove the two screws holding the metal plate on which the reed switch is mounted to the L-shaped support bracket. The two screws are in the *horizontal* leg of the L, next to the reed switch cylinder. Pull out and discard the old reed switch assembly.

6. Install the new reed switch assembly in place of the one just removed, securing it with the same screws and washers.
7. Attach the lugs at the ends of the switch wires to the terminal posts with the nuts and washers removed in step 4. It does not matter which wire goes to which post.
8. Using the ohmmeter or continuity tester connected to the terminals, check that the reed switch is open when the magnet is at the ends of its travel, and closes in the middle.
9. Replacing the reed switch should not affect the calibration; unless there is some other reason to believe that the calibration is incorrect, it is not necessary to carry out the calibration procedure suggested in section 2.3 on page 14.
10. Replace the cover over the reed switch, magnet, and rear bearing. Place the gauge back on its pedestal or mounting surface, level, and secure in place.
11. Reconnect the signal cable, carry out an operational test, and complete the installation as suggested in section 2.4 on page 16, steps 5 to 9.

4.4 Replacing the Magnet

The magnet is not subject to wear, and it is unlikely that it will need replacement, except possibly as a result of corrosion in an exceptionally hostile environment. Replacement magnets are available from Vaisala; call Customer Service (see page 3) for instructions.

5 Theory of operation

Refer to Figure 2–A on page 12 and Figure 2–B in connection with the following description.

The measuring system of the Model 444A Tipping Bucket Rain Gauge consists of two buckets with triangular profiles in the vertical plane. The two buckets are formed into a single assembly and mounted above a pivot point. Water flows through the upper funnel and the lower funnel into the upward-facing bucket. This bucket is held in position by a calibration screw acting as a stop. The center of gravity of the empty bucket is on the same side of the pivot as the stop; as the bucket fills with water, the center of gravity of the bucket plus water moves away from the stop, and when it crosses the pivot, the bucket assembly tips around the pivot until it hits the other calibration screw / stop. The water is discharged into one of the drain tubes, and the second bucket is brought into place under the funnel.

A permanent magnet is attached to the tipping bucket assembly (see Figure 2–B). When the bucket tips, the magnet swings close to the reed switch and causes the switch to close; as the bucket approaches the other end of its travel, the magnetic field felt by the switch becomes weak and the switch opens again. The switch, therefore, is closed only while the bucket is in the process of tipping, and the number of tips can be counted by any device which can sense and count switch closures.

Adjusting the active calibration screw moves the bucket which is receiving water around the pivot point, and shifts the center of gravity. Raising the screw shifts the center of gravity of the bucket assembly toward the pivot; this means that less water is required to move the center of gravity across the pivot and tip the mechanism. Lowering the screw shifts the center of gravity away from the pivot, and increases the amount of water required for a tip. Both screws should be moved together, so that both buckets measure the same amount of water.

The knife-edge contour around the orifice is intended to prevent rain which falls outside the 200 mm diameter circle from splashing into the collecting area, and to prevent rain which should be collected from splashing out. The upper funnel then channels the collected rain into the lower funnel. The outlet from the lower funnel is above the bottom of the funnel; this arrangement allows the lower part to collect sediment which might otherwise accumulate in the tipping bucket and reduce its capacity. The short drop from the lower funnel outlet to the tipping bucket reduces the possibility of water splashing out of the tipping bucket.

Measurement errors can occur during heavy rainfall if a significant amount of water runs through the system while the bucket is in the act of tipping. Some of it will flow into the bucket which has already filled and begun to tip downward; this water will not be counted. In extreme conditions, water can splash out of the lower funnel. Water will evaporate from the tipping bucket or the lower funnel when the time between rain episodes is long. Other errors result from wind shadows produced by nearby obstructions, wind turbulence in the orifice in extremely strong

winds, uneven capacity of the two buckets as the result of poor levelling, and freezing. Most of these effects will tend to reduce the amount of rain measured.

In below-freezing conditions, the water in the lower funnel and the tipping bucket will freeze, and snow will not pass through the upper funnel. The Model 444A Rain Gauge is not intended to measure precipitation in freezing conditions, but the gauge will not normally be damaged by freezing.