TABLE OF CONTENTS

Specifications

Nominal calibration factors:	
for positive values	9.3 W m^{-2} mV^{-1}
for negative values	11.6 W m^{-2} mV^{-1}
Nominal resistance:	4 ohms
Spectral response:	0.25 to 60 μm
Time constant:	Approx. 30 seconds
Wind Effect: Positive	Up to 5.9% reduction @ 7 m/s
Negative	Up to 1% reduction @ 7 m/s
Power required:	None
Size:	57 x 72 x 177 mm (H x W x L)
Windshields:	0.25mm thick polyethylene
Support arm:	0.02 x 0.75 m (D x L)
Desiccant supply:	2.4 x 10^{-6} m^3
Standard Cable:	shielded 2-conductor, 7.6 m long

Introduction

Incoming shortwave radiation consists of direct beam and diffuse solar radiation. Shortwave radiation is defined as wavelengths from 0.25 to 4 micrometers (μm). Incoming longwave radiation consists mainly of longwave atmospheric radiation. Longwave radiation is defined as wavelengths from 4 to 100 μm. The sum of incoming shortwave and longwave radiation is ***incoming total hemispherical radiation***.

Outgoing shortwave radiation consists of *reflected solar radiation*. Outgoing longwave radiation consists of *terrestrial longwave radiation*. The sum of outgoing shortwave and longwave radiation is ***outgoing total hemispherical radiation***.

Net solar radiation is the sum of the incoming direct beam and diffuse solar radiation minus reflected solar radiation. ***Albedo*** is the ratio of outgoing solar radiation over incoming solar radiation.

Net radiation is *incoming total hemispherical radiation* minus *outgoing total hemispherical radiation*. Net radiation is the energy retained by the surface for heating soil and air, plant growth and evaporation of water. Evaporation of water is the largest heat sink when water is available. Evapotranspiration (water evaporated from surface vegetation and soil) is closely related to net radiation in humid conditions. Therefore, net radiation is the most useful radiative term in evapotranspiration research. In arid regions, advection (the transference of heat by horizontal currents of air) is more pronounced and net radiation measurements alone are not sufficient to determine water use. They must be combined with other variables for good estimates of evapotranspiration .

Radiation and Energy Balance Systems, Inc. (REBS) manufactures three different instruments for measuring radiation quantities discussed above:

- REBS' **Net Radiometer (Q*7.1)** measures only net radiation and is sensitive to wavelengths from 0.25 to 60 µm.
- REBS' **Double Sided Total Hemispherical Radiometer (THRDS7.1)** is a double sided pyrradiometer that simultaneously measures incoming and outgoing total hemispherical radiation and net radiation. It too is sensitive to wavelengths from 0.25 to 60 µm.
- REBS' **Double Sided Pyranometer (PDS7.1)** simultaneously measures incoming and outgoing shortwave radiation. The PDS7 is sensitive to wavelengths from 0.35 to 2.8 µm.

Comparisons With Other Radiometers

Net radiation values determined by REBS' Q*7.1 may not compare well with those calculated using pyranometer and pyrgeometer combinations if these other radiometers do not include proper windshield temperature correction algorithms. Also, net radiation measurements made with the Q*7.1 may not compare well with those of net radiometers from other manufacturers if these other radiometers have design and/or calibrations problems. Extensive research has been conducted at REBS to better understand the effects of windshield temperatures on radiation measurements. REBS radiometers that are of the 7.1 version are designed and calibrated to minimize errors caused by windshield temperatures.

Net Radiometer Description

REBS' Q*7.1 net radiometer contains a high output 60 junction thermopile with a nominal resistance of 4 ohms and linear calibration. It generates a millivolt signal proportional to the net radiation level. The thermopile is mounted in a glass reinforced plastic frame with a built-in level. A ball joint is supplied on the stem to facilitate leveling. Thermopile surfaces (or sensor surfaces) and surrounding surfaces are flat black and the frame is black to reduce internal reflections within the instrument thus providing more uniform performance over reflective and non-reflective surfaces. The black paint used on 7.1 versions of REBS' radiometers has far superior absorption properties and durability than that used on previous versions. Sensor surfaces are protected from excessive convective cooling by hemispherical polyethylene windshields. Polyethylene is used for the windshield material because it is transparent to both long and shortwave energy. These windshields are heavy duty and are self supporting so no pressurization is required. O-ring seals are included to enhance windshield replacement. A desiccant supply is contained in the support arm to keep air spaces inside windshields dry. The support arm has a breather port. A mounting bracket is supplied for mounting to horizontal or vertical pipes.

Calibration

Each finished radiometer is calibrated in REBS' temperature controlled black body cavity calibration chamber by comparison to a transfer standard prior to shipment. The chamber uses a tungsten-halide light source. The transfer standard was calibrated both in a temperature controlled black body cavity calibration chamber and by outside comparison to a precision pyranometer using REBS' partial shading technique. Data from the precision pyranometer was corrected using REBS' temperature correction algorithm for that radiometer. The transfer standard was also calibrated in REBS' constant radiation/variable wind chamber to determine the wind effect on a radiometer of its design. Transfer standards were ventilated during outside calibrations and resulting wind effects removed mathematically using the wind function determined for that radiometer type.

Installation

Install the radiometer in an area where it will not be hit with spray from irrigation or fertilization sprinkler systems. Water or chemicals from these systems will leave deposits on the windshields and outer mounting rings thus affecting the radiometer's performance. In the northern hemisphere, install the radiometer so that its head is towards the south and its support arm is towards the north. In the southern hemisphere, install the radiometer so that its head is towards the north and its support arm is towards the south.

The instrument can be installed on an existing frame-work of pipes or rods. Attach the mounting plate to a horizontal or vertical pipe or rod [38 mm in diameter (1 inch) or less] with the two larger U-bolts. Next attach the support arm to the mounting plate with the two smaller U-bolts. Tighten all the U-bolts so the support arm is locked in a horizontal position. Fasten the lead wire to the frame-work with plastic wire ties to prevent strain on wires and instrument damage.

Make sure the hole in the one rectangular side of the support arm end plug is facing towards one side or the other, not up nor down. You must remove the vinyl cap to check this. When reinstalling the vinyl cap, orient it so the small separation between the two holes is facing directly downward. This will prevent rain from getting into it.

Place a 0.19 m (7.5 inches) long black wire tie on the support arm just beyond the ball joint. Do not cut off the excess, instead, orient it so it is pointing straight up. Place another 0.19 m long black wire tie on the support arm about 8 cm from the first also with its tail pointing straight up. Do not strap these wire ties around the radiometer wire as they must be pulled very tight to stay in position which could damage the wire. These wire ties are to help prevent birds from landing on the support arm and pecking at the radiometer windshield. Black wire ties are recommended because they do not degrade as fast as clear nylon ones when exposed to ultraviolet light.

Leveling

The radiometer must be level. An error of 5 degrees in leveling can cause a cosine response error of 6% under normal conditions and greater errors under other conditions (e.g. sunrise, sunset, and wintertime use with low sun angles). The radiometer contains a 1-degree level for leveling.

Level the instrument by bending the ball joint at its stem until the level's bubble is centered in the bull's-eye. Place a 3/4 inch wrench on the hex coupling nut located on the instrument frame to bend the ball joint. If the instrument does not stay in position, slightly tighten the coupling **on the support arm** (not the one on the instrument's frame) with a pipe wrench (or a 15/16 inch wrench where applicable). This compresses a rubber washer against the ball inside the coupling to provide more resistance. Do not attempt to bend the ball joint by grabbing the instrument, as this could break the frame.

Wiring

The net radiometer wire is a twisted pair of wires with a shield and a drain wire. The wire insulation is polypropylene. The red wire is positive, black is negative, when the net radiometer is mounted with the level facing up and there is more incoming than outgoing radiation. (On some older versions of REBS' net radiometers the positive wire was white or clear. It should be noted that the black is always considered to be the negative wire.)

Connect the positive radiometer wire to the high side and the negative wire to the low side of an input channel on the measuring device. Connect the drain wire to a good earth ground. This will ground the shield and to help prevent electrical noise from contaminating the radiometer signal.

Measurements

Monitor the radiometer output with a high impedance voltmeter or datalogger which has a 10 microvolt resolution and a range of at least -25 to +100 millivolts. [If the measuring device does not have a large enough range, the radiometer signal may be reduced with an appropriate voltage divider.]

Expected millivolt signals from a Q*7.1 net radiometer will vary depending upon geographical location and the surface over which measurements are made. The instrument's calibration factors and estimated net radiation levels can be used to determine expected millivolt signals. For example, if the instrument's positive calibration factor (F_p) is 9.5 (W m^{-2} mV^{-1}) and the estimated net radiation level is 600 (W m^{-2}), then the expected millivolt signal would be 600/9.5 or 63 (mV). If the instrument's negative calibration factor (F_n) is 12 (W m^{-2} mV^{-1}) and the estimated net radiation level is -150 (W m^{-2}), then the expected millivolt signal would be -150/12 or -12.5 (mV).

Computing Net Radiation

Nomenclature for the net radiometer is as follows:

Parameter	Symbol
Thermopile Voltage	V_t
Positive Calibration Factor	F_p
Negative Calibration Factor	F_n
Net Radiation Level	Q*

Net radiation (not corrected for wind effects) is computed from the thermopile voltage and appropriate calibration factor as follows:

If $V_t > 0$, $$Q^* = V_t F_p \tag{1a}$$

If $V_t < 0$, $$Q^* = V_t F_n \tag{1b}$$

Units for the above are: $[\text{W m}^{-2}] = [\text{mV}] * [\text{W m}^{-2}\ \text{mV}^{-1}]$

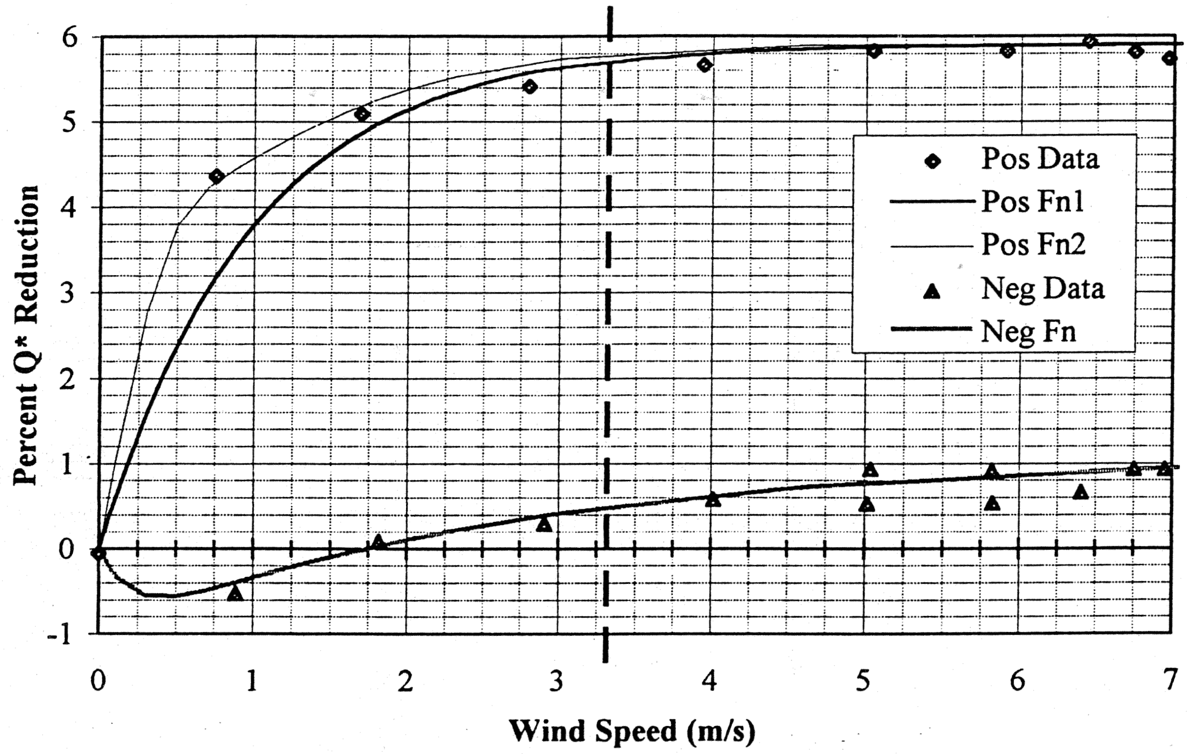
Labels on the bottom side of the instrument's frame list the serial number and calibration factors.

Wind Effect

The outputs from all radiometers that are not temperature controlled are somewhat affected by wind. The Q*7.1 has been tested in REBS' constant radiation/variable wind speed chamber to determine its wind effect. Q*7.1 wind testing results are shown in Figure 1. Symbols in these Figures are actual test data points and the curves are results of wind correction equations developed to fit the data. Note that the curves tend to stay to the high side of the data, this is because the change with wind is expected to be slightly larger outside than it was in the test chamber. The test chamber is configured to prevent light from shining directly on its lower inner surface. In order to accomplish this, the spot of light allowed to enter the chamber had to be sized slightly smaller than the radiometer mounting ring outer diameter. Therefore, the radiometer is expected to heat a very small amount more during the same net flux conditions outside than it did in the chamber causing a slightly larger wind effect. For this reason, the curves were intentionally made to stay to the high side of the data. Two curves are provided for the positive net flux condition. The one providing a better fit to the data is the result of a more complex algorithm. Only one curve is provided for the negative flux condition.

The effect of wind on the Q*7.1 during positive net flux conditions is a reduction in the calculated net radiation with increasing wind speeds. This reduction increases asymptotically from 0% at a wind speed of 0 m/s to approximately 5.9% at 7 m/s. During negative net flux conditions wind speeds below approximately 1.7 m/s can increase the calculated net radiation (from 0% at 0 and 1.7 m/s to approximately 0.5% between 0.5 and 0.9 m/s) and wind speeds above 1.7 m/s reduce the calculated net radiation (from 0% at 1.7 m/s to approximately 1% at 7 m/s).

Figure 1: Q*7.1 Wind Affect



To use this information to correct for wind effects on the Q*7.1, the measured Q* values must be multiplied by the quantity [1 divided by the quantity (1 minus the (appropriate *percent* reduction divided by 100))]. Table 1 provides the quantity in the [ ] brackets of the last sentence for several methods of correcting Q* for wind effects. This quantity is referred to as "Multiplier" in Table 1. The column to the right of the Multiplier column shows how well each method corrects for wind effects. The column labeled Curve refers to the corresponding curve in Figure 1. The column "Net Flux Condition" refers to the period when V_n is either ≥ 0 (positive) or < 0 (negative). The column labeled "Ventilator Present?" refers to whether or not a REBS' RV2 Ventilator is being used. (This ventilator supplies an effective continuous wind speed of approximately 3.3 m/s. Note that the vertical bold dashed line across the chart of Figure 1 indicates the effective wind speed of this ventilator.) The column labeled "Monitoring Wind?" refers to whether wind speed data is being recorded and is available for use in the correction algorithms.

The best method of correcting wind effect errors depends upon the user's individual situation. Questions that need to be answered are: Is wind speed being monitored? Is power available at the research site to operate a ventilator? Is the programming capability and space available on the data system for the correction algorithms? Is the data to be processed on a computer at a later date? What precision is required for the data in the current project?

Table 1: Wind Correction Options For Q*

Note: "*ws*" in this Table refers to wind speed in m/s.

Ventilator Present?	Monitoring Wind?	Net Flux Condition	Curve	Multiplier	Approximate Error for Fit to Data
No	No	Positive	None	$1/(1-.043)$ or 1.0449	+ 4.3 to -1.6%
No	Yes	Positive	Fn1	$\dfrac{1}{1-.059\left[1-2.8^{-ws}\right]}$	+ 0.2 to -1.5%
No	Yes	Positive	Fn2	$\dfrac{1}{1-.059\left[1-2.8^{-ws}\right]-\dfrac{.0096ws}{(.216+ws^3)}}$	+ 0.3 to -0.1%
Yes	No	Positive	None	$1/(1-.059)$ or 1.0627	± 0.2%
No	No	Negative	None	1	+ 0.5 to -1.0%
No	Yes	Negative	Fn	$\dfrac{1}{1.01-.021\left[1-1.45^{-ws}\right]-\dfrac{2^{(-7ws)}}{100}}$	± 0.15%
Yes	No	Negative	None	$1/(1-.0078)$ or 1.0079	± 0.25%

Wind Correction Examples

For this example, assume that wind data is not available and a RV2 ventilator is being used. Then Eqs. 2 would be used to correct Q* for wind effect:

For $V_n \geq 0$ Wind Corrected Q* = 1.0627 Q* [W m^{-2}] (2a)

For $V_n < 0$ Wind Corrected Q* = 1.0079 Q* [W m^{-2}] (2b)

The above procedure is also recommended when a RV2 ventilator is used and wind data is available as associated errors are not significantly reduced by using a wind function multiplier (like in the following example) with the minimum wind speed of the ventilator. This is because the noise in data above the ventilator wind speed causes most of the error.

For a different example, assume no ventilator is used, wind data is available and enough program space exists for the function corresponding to the Fn2 curve of Figure 1. Then Eqs. 3 would be used to correct Q* for wind effect:

$$\text{For } V_n \geq 0 \qquad \text{Wind Corrected Q*} = \frac{Q*}{1-.059\left[1-2.8^{-ws}\right]-\dfrac{.0096ws}{\left(.216+ws^3\right)}} \quad [\mathrm{W\ m^{-2}}] \qquad (3a)$$

$$\text{For } V_n < 0 \qquad \text{Wind Corrected Q*} = \frac{Q*}{1.01-.021\left[1-1.45^{-ws}\right]-\dfrac{2^{(-7ws)}}{100}} \quad [\mathrm{W\ m^{-2}}] \qquad (3b)$$

Maintenance

Note: The Q*7.1 net radiometer is more susceptible to damage by standing water in the instrument than older versions. This is due to the fine wire connections to the thermopile. Therefore, it is essential that preventative maintenance be conducted on a routine basis to prevent expensive damage.

Windshields

Windshields and mounting rings should be kept clean for accurate radiation measurements. They may be washed with distilled water and a fine camel's hair brush or facial tissue. (A fine camel's hair brush with approximately 2.5 cm long bristles is preferred). Remove as much dirt and dust as possible from the windshields and mounting rings by squirting them with distilled water before touching them with the fine camel's hair brush or damp facial tissue. When drying the windshields, dab them with a damp facial tissue rather than wiping. These suggestions are to help prevent scratches on the windshields and mounting rings which can affect the radiometer's performance. Do not use coarse paper or cloth as these will scratch the polyethylene.

Polyethylene deteriorates with exposure to solar radiation. Therefore, windshields should be inspected frequently (e.g. weekly or bi-weekly) and replaced as required. The inspection should include checking for condensation inside windshields and cracking, crazing, or bird pecks on windshields. Cracking typically appears first along the windshield's base. Cracking at this location may not be visible without removing the windshields as it is down between the mounting and inner rings. Condensation inside windshields may indicate a leak in them. Replace windshields if any of these conditions occur. Also, if windshields are removed for any reason after one month's use, they should be replaced with new ones. This is because the hardened polyethylene may not make a good seal after being removed. Replacing windshields with factory supplied windshields may change the calibration factor by up to 3%. Therefore, for critical tests, instruments should be recalibrated after changing windshields.

REBS recommends replacement of windshields and recalibration every 3 to 6 months depending on the climate where the instrument is used. In hotter climates, windshields degrade faster and need to be replaced closer to the 3 month frequency.

Replace windshields by removing the aluminum mounting rings and old windshields. Use a sharp number 1 Phillips screwdriver to remove and reinsert screws in the mounting rings. Use of a dull or wrong size screwdriver will cause slots in the screws to become stripped. Carefully peel the silicone sponge gaskets off of the old windshield flanges for reuse with the new windshields. [If using new silicone sponge gaskets, first remove the white protective plastic layer (if present) from both surfaces of the gaskets.] Place a silicone sponge gasket between the radiometer frame and new windshield flange on both the upper and lower radiometer surfaces. Align the holes in the windshields, gaskets, and radiometer frame. If O-rings are used, make sure they are in their grooves in the mounting rings before clamping windshields and gaskets in place. Snug the 1st, 3rd and 5th then 2nd, 4th and 6th screws until the windshields and gaskets are evenly in contact with the mounting rings and frame. Finally, alternately tighten the screws using the above sequence until both the upper and lower gaskets are compressed to approximately the thickness of the windshield flanges (i.e. 0.020") around their entire peripheries.

DO NOT ATTEMPT to dismantle the radiometer body; to do so may cause unrepairable damage. If trouble develops with the instrument, return it for repair.

Note: **Never** allow the breather port hole in the support arm end plug to be closed. Doing so will cause the windshields to collapse at night reducing their life and invalidating any data collected.

Replacement windshields are available through REBS.

Desiccant

Air spaces inside windshields are connected to a dryer filled with silica gel to prevent internal condensation. This dryer (referred to as the desiccant tube) is located in the support arm and is accessible by removing the vinyl cap and plug at the end opposite the instrument. **(When reinstalling, screw the end plug in so the hole in its one rectangular side is facing to one side or the other, not up nor down, then slide the vinyl cap over the support arm end so the small separation between the two holes is facing directly downward. This will prevent rain from getting into it.).** Silica gel should be inspected monthly to insure it is still blue and white which indicates it is dry. If it is pink and white, it is wet; replace it with dry silica gel. In rainy conditions the silica gel may have to be replaced more frequently.

Wet silica gel can be dried by removing it from the desiccant tube and baking it until it returns to a blue and white color. Remove the desiccant tube end cap to remove and replace the silica gel. (Use a 1/2 inch split end wrench to press the end cap off.) For remote installations it may be convenient to have a spare desiccant tube for quick replacement. If using spare desiccant tubes be sure to remove outer end caps from both tube ends before installing. Save these caps to seal the other desiccant tubes after silica gel has been dried.

Breather Port

The pipe plug at the support arms' end has a small hole in one of its rectangular sides. This hole is to allow the radiometer to breathe. Air is exhausted from this port as the radiometer heats up. As the radiometer cools, it draws air in through this port and the desiccant tube in the support arm. The volume of air that actually passes through this channel is small. This open type of system prevents expansion and collapse of the windshields during temperature and pressure variations. The pipe plug is shielded from rain by a vinyl cap with two holes on its bottom side. Inspect the holes and inner cavity of this vinyl cap frequently (e.g. weekly or bi-weekly) to insure that bugs have not crawled inside and made nests that may prevent free air flow. If this channel becomes clogged, the windshields will collapse as the radiometer cools in the evening hours.

Calibration

Although REBS' net radiometers remain stable for long periods, annual calibration checks are recommended. An instrument's calibration may be field checked by mounting another net radiometer along side and comparing results. Instruments and techniques should be questioned if results differ by more than a few percent.

REBS recommends replacement of windshields and recalibration every 3 to 6 months depending on the climate where instruments are used.

Wires

Caution: Avoid jerking or bending wires into too tight of a radius when they are at near freezing temperatures as the insulation on them becomes brittle and will break. If coiling wire in cold conditions, coil it in about a 1/2 meter diameter initially, then bring the instrument indoors to allow it to warm up. Once the wire is warm, recoil it into a smaller coil.

Trouble Shooting

Condensation

Condensation on net radiometer windshields causes incorrect radiation measurements. This is because water does not transmit longwave energy. An example of this problem can be seen by comparing measured net radiation values from two different net radiometers at night, the first on which dew is allowed to form and the second on which dew is prevented. Without dew both instruments would indicate a similar net radiation level. For this example let us assume that net radiation level is -50 ($W\ m^{-2}$). Once dew occurs on the first instrument, that instrument would indicate a much smaller negative net radiation level [i.e. near 0 (W m^{-2})]. The second instrument without dew would still indicate a level of -50 (W m^{-2}).

Condensation on windshields can have several different origins.

Condensation inside windshields

If the condensation occurs inside windshields check the following:

Windshields/O-rings

Insure the windshields and O-rings are in good condition and are properly seated against the radiometer frame (see Maintenance Section).

Desiccant

Make sure the desiccant is dry as indicated by a blue and white color. If it is pink, replace it with dry desiccant or bake it until it is dry (see Maintenance Section). If the desiccant is pink only at the tube end nearest the radiometer it may indicate a leak somewhere on the radiometer.

Leak check

Warning: Do this test only after insuring windshields and O-rings are in good condition and are properly seated (see Maintenance Section). The easiest way to locate a leak on the radiometer is to remove the desiccant tube and, while dunking the radiometer body in a container of water, blow in the open end of the support arm. A stream of bubbles will appear from the locations where leaks exist. After using this method, the instrument should be dried off with a soft facial tissue. When drying the windshields, dab them rather than wiping them to prevent scratches. If the windshield gets dented, reinflate it by blowing in the end of the support arm.

Frame leak

Insure there is not a leak in the radiometer frame (see Leak check above). If the frame has a developed leak, it can either be repaired as described below or the instrument can be returned to REBS for repair. Leaks around the wire, or from mounting ring screw holes can be repaired using super glue. When repairing a leak using this method use only small quantities of super glue and make sure the area is completely dry and free from oils or grease before applying the glue. (Note: the water from the leak check may have gone into the crack where the leak is and should be allowed to dry out completely before putting any super glue on the area.) Before sealing around the wire, scrape or remove excess build up from previous sealing then apply a thin bead of super glue around the wire and allow to dry. To seal a mounting hole leak, remove the mounting rings and put a drop of super glue in the leaky hole. Spread the super glue by rubbing the side walls of a pin against the hole wall in an orbital motion. First moving the pin clockwise then counterclockwise. During this step the pin's axis should be parallel to the axis of the hole. Continue spreading the super glue in this manner for about one to two minutes or until it becomes discolored by the dissolving plastic. Then remove any large excess of glue by wiping the pin off, then rubbing the hole wall some more, and wiping it off again. Continue this until the remaining glue will not obstruct inserting the screw. Wipe excess glue from the hole rim on both sides of the frame with a paper towel. Finally allow the glue to dry completely prior to reinstalling the windshields. **Do not put super glue around the level** as this will cause it to craze and crack.

Residual water from previous leak

After locating and removing a leak in the radiometer, condensation inside the windshields may still occur from residual water inside the radiometer frame. (This problem usually occurs after a significant leak has been removed. If a minor leak is detected and fixed quick enough, this problem may not occur.) To remove water from a radiometer frame, remove the windshields and blow clean dry compressed air into the frame through the ball joint and in the outer gap below the rings surrounding the sensor surfaces. **[Avoid blowing air into the gap between the sensor surfaces and surrounding rings as this may deflect tiny connection wires inside causing a shorted or open circuit.]** Then leave the radiometer indoors at room temperature for 1 to 2 days before reinstalling the windshields.

Condensation outside windshields

If the condensation is occurring outside the windshields it is from dew formation. Some geographical areas are more prone to dew formation. REBS manufacturers a 12 volt radiometer ventilator to reduce the occurrence of dew on the windshields.

Collapsed Windshields

Birds pecking at and animals rubbing on or biting the radiometer, hail stones or other falling objects, and a clogged breather port are all possible causes of collapsing windshields. If windshields are found to be collapsed shortly after it happened and if they are fairly new, they can be reinflated by blowing in the breather port at the support arm end opposite the radiometer **(Warning: First check the port to insure their are no bugs or nests clogging it).** If the condition is not discovered quick enough or if the windshields are old they should be replaced as the collapse will cause kinks that can affect the performance and leak. The cause of the collapsed windshields should be isolated and eliminated. A careful inspection of the radiometer and surrounding area may aid in isolating the cause. Examples of some clues are: bird peck marks on the windshields, animal fur on the radiometer, fallen branches on the ground, and bug nests in breather port channel.

Over Ranging

If during the middle of a day the radiometer signal appears to be an open circuit or over range condition, it may be caused by too small of a range being used on the data system. Try setting the data system's range to the next higher range. (If already using the highest available range a voltage divider may be required to eliminate the problem.)

Another possible cause of this type of problem is a broken wire. Broken wires are frequently caused by people stepping on them and cutting them between their shoes and sharp objects below, or rodents chewing on them, or from pulling them through or around tight restrictions. Check along the entire length of wire for scars or cuts in the insulation. Repair any breaks that are found. If making a wire repair, be sure to also repair the shield and drain and to seal the repair from water.

Bird Problems

If birds continuously peck at and damage radiometer windshields, install the bird prevention wire ties (see Installation Section). In some regions birds are quite large and these wire ties may not be sufficient to prevent birds from landing on the support arm and pecking the domes. In these regions other methods such as, a rubber snake tied on the support arm, a row of anti-bird spikes, an ultrasonic transducer, etc. may be required to prevent bird damage. [There are companies that sell bird prevention equipment, one such company is Bird-X, 730 West Lake Street, Chicago, IL 60661, Phone: 312-648-2191. A cautionary note: When selecting bird prevention equipment and its installation, take care to insure the radiometer signal is not affected due to the view factor with the bird prevention equipment.]

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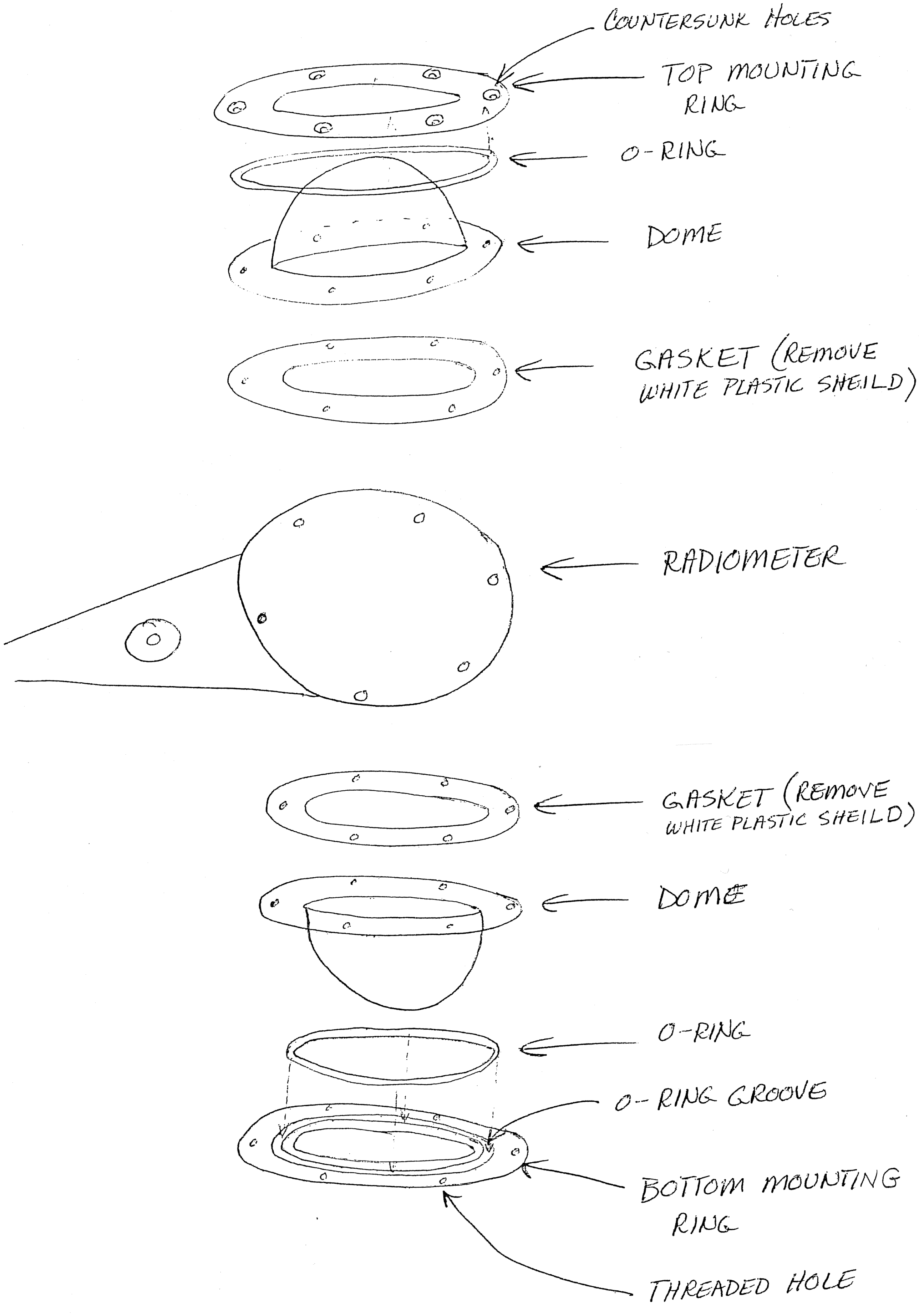
Reference: SILICONE SPONGE GASKET INSTALLATION

Install the silicone sponge gaskets and new domes by removing the aluminum mounting rings and old windshields. Use a sharp number 1 Phillips screw driver to remove and reinsert screws in the mounting rings. Dull screw drivers may result in stripping of the screw heads.

1) **Remove the thin protective plastic layer**, if present, from both sides of the silicone sponge gaskets. **Insure all sealing surfaces are clean** and free from any lint, dust, and/or other particles to prevent leaks. The sealing surfaces include both gasket surfaces, both frame surfaces and the mating surface of each windshield. A loop of masking tape can be made with the adhesive side out and used to lightly wipe these surfaces to remove any debris prior to assembly.

2) **Place the silicone sponge gaskets between the net radiometer frame and dome flange on both the upper and lower surfaces.** The gaskets must be on the radiometer frame (i.e. **under the dome**) for proper sealing. Align the holes in the domes, gaskets, and net radiometer frame.

3) If using O-rings, make sure they are in their grooves before clamping domes and silicone sponge gaskets in place. Snug the 1st, 3rd and 5th then 2nd, 4th and 6th screws until the windshields and gaskets are evenly in contact with the clamping rings and frame. Finally, alternately tighten the screws using the above sequence until both upper and lower gaskets are compressed to approximately the thickness of the dome flanges (i.e. 0.020") around their entire peripheries.



COUNTERSUNK HOLES
TOP MOUNTING RING
O-RING
DOME
GASKET (REMOVE WHITE PLASTIC SHEILD)
RADIOMETER
GASKET (REMOVE WHITE PLASTIC SHEILD)
DOME
O-RING
O-RING GROOVE
BOTTOM MOUNTING RING
THREADED HOLE