Your ETgage is fully assembled and ready to use. It was shipped with a Style # _____ cover mounted on the evaporator. Other covers are in the can.

See instructions starting on page 1 for filling, priming and field installation.

Use Distilled Water Only
Protect From Freezing

Do not use tap water or mineral water

Diffusion Covers

The ETgage uses three different top covers to provide appropriate resistance to water vapor as it leaves the instrument. These covers are identified as Style #30, Style #54 and Style #C2 You will find the number stamped on the edge of the cover.

The green-colored covers rest on top of disposable "wafers". The cover/wafer combination sits on top of the ceramic evaporator cup. The cover receives energy from sunlight and air and provides appropriate vapor diffusion resistance. The wafer keeps rainwater from entering the instrument. Cover and wafer simulate a canopy of leaves.

Canvas Covers

Use the canvas covers when you mount the ETgage in an open area or above the plant canopy of leaves.

Use the #30 for turf grass. An ETgage with #30 cover simulates grass reference evapotranspiration (ETo).

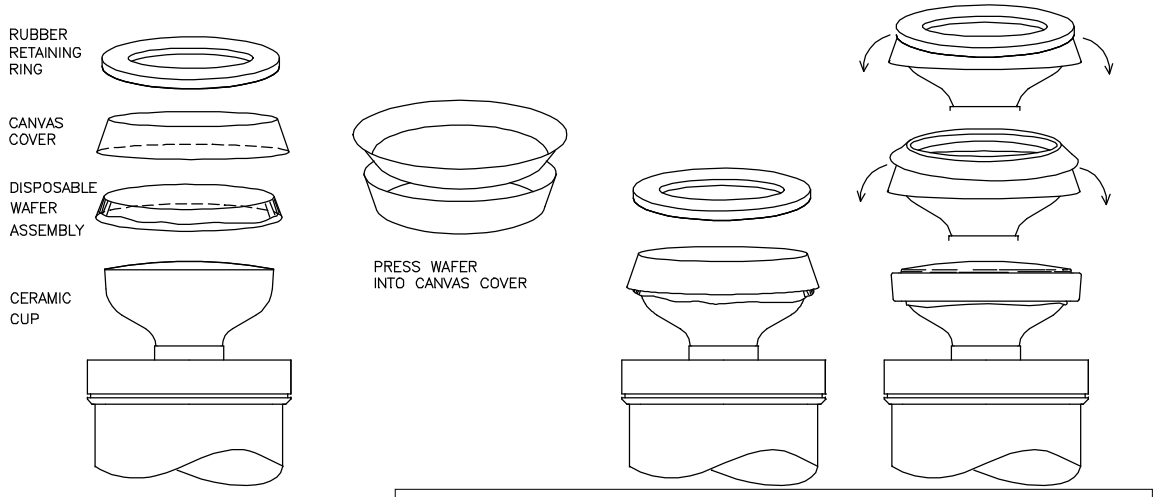
Use the Style #54 canvas cover for agricultural crops. An ETgage with #54 cover simulates alfalfa reference ET (ETr). (ET readings with a #54 cover will be in the range of 10% to 15% greater than that of a #30 cover.)

Thin Polyester Cloth Cover, Style #C2[1]

Use the #C2 cover when you mount the ETgage *within* the plant canopy. The top of the ETgage must be level with the top of the plants. #C2 will fade in sunlight, but that will not affect your results. You can turn the #C2 cover inside out without affecting performance. Use #C2 to simulate the plant canopy ET of any crop.

[1] Style #C2 replaces the ETgage Style #G2 cover. It has the same characteristics as #G2. Use with a wafer.

“Wafer” Evaporation Element (for use with all covers)



With both hands on the rubber ring, use your fingers to spread the ring in all directions, moving it out to the edge, and down the sides. The top of the rubber ring should be a little below the top edge of the ceramic. Keep the fabric tight; there must be no air space below it.

For low maintenance, use a disposable ETgage "wafer" between the green fabric cover and the ceramic evaporator surface.[1] The wafer will protect the ceramic from accumulated contamination. When you remove a wafer, the ceramic should look wet.

Any residues left as water evaporates will accumulate in the wafer instead of on the ceramic; but you must still use distilled water to minimize contamination. Tap water or mineral water will damage the wafer.

The wafer will last about a growing season. Eventually you will see hard crusty areas on the top of the wafer. These areas block evaporation, and they will reduce the evaporation rate by an amount proportional to their size, which leads to error.

Replacing the wafer will bring evaporation back to the correct rate.

The top layer of the wafer sheds any rainwater that gets through the canvas. At the same time, it allows water *vapor* to pass freely.

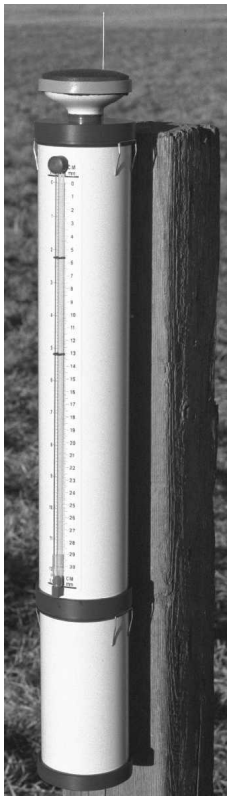
If the fabric cover becomes very dirty, remove and wash it in warm water (not hot water). If you use soap, rinse thoroughly.

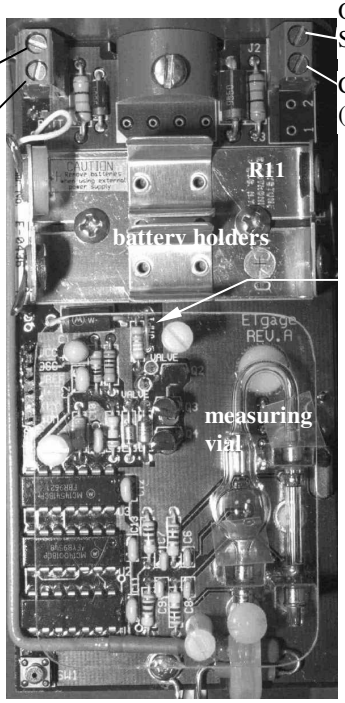
For the Style #C2 cover, install a wafer on the ceramic cup first, then center the cover on top of it and install the rubber retaining ring.

Do not clean the porous ceramic surface or the wafer with soap or detergent. This would interfere with their water wicking properties.

[1] The evaporation rate will be the same if you do not use a wafer, but without it, the ceramic surface will slowly become contaminated, and it will require vigorous sanding about every 4 months (use a medium grit silicon carbide abrasive paper under running water). Also without the wafer, rainwater will seep through the canvas cover and be pulled into the instrument’s reservoir.

ETgage Model E Instructions





EXTERNAL WIRING

Unclip and drop down the bottom compartment of the instrument to expose the circuit board. At the top of the circuit board there are two terminal blocks for external wire connections. The terminal block in the upper right corner connects to the output signal wire. A wire from the upper terminal of this block should go to the positive input terminal of your data logger. The bottom terminal provides a common, negative return path for the signal. The upper left terminal block is for external power, if used. The upper terminal of this block is positive, the lower terminal is the common negative. See the appendix for additional information about using an external power source. The Model E ships with a four-foot cable already installed and connected to the terminal blocks. This cable has three conductors: yellow, black and red. Yellow is the signal wire. Black is the common negative wire for both signal and external power. Red is the positive wire for external power. If you use external power instead of internal batteries, connect this red wire to the positive terminal of the external power source. Do not use both external power and internal batteries because the batteries will charge and burst.

Signal: After each 0.01-inch of evaporation, the ETgage's circuit pulls the signal line low for 2.3 ±0.7 seconds. Normally this line appears as an open-circuit, with infinite impedance. During an output pulse it falls to 35 ohms[1]. The receiving equipment must supply voltage through a pull-up resistor, or other means. Maximum voltage supplied to the signal line should not exceed 30 VDC since larger values will cause an over-voltage current to flow.

PRIMING

1. Use grocery store quality distilled water to prevent mineral build-up on the evaporation surface.
2. Unclip the top assembly from the reservoir. Remove the stopper, and fill the ceramic cup with water. If the ceramic is dry, allow a little time for it to soak up, and re-fill to the top. Push and twist the rubber stopper firmly into the cup.
3. Fill the reservoir with water (this is the main body section). For models with a sight tube on the side of the reservoir, excess water may be drained to bring the level to the zero mark by

[1] The 35-ohm impedance can be reduced to about 2-ohms by shorting out R11 on the printed circuit board. This will reduce the circuit's ability to withstand lightning damage, but may be necessary for *directly* driving some older types of electromagnetic recording equipment. Current should be limited to under 0.2 amperes. The 33-ohm resistor, R11, is located next to the green terminal block for the signal at the upper right hand corner of the board. See appendix, and circuit schematic diagram.

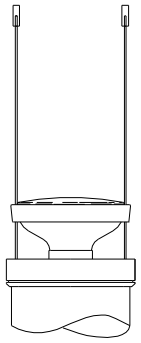
pulling the sight tube downwards, slipping it out of the upper fitting. The two sliding red markers on the glass sight tube provide visual tracking of water use

4. Install batteries *only if an external power supply is not to be used.* Unclip the lower compartment enclosure and install four (4) "AA" alkaline batteries. Positive (+) battery ends must be installed at the battery holder locations marked by red plastic bands. Insert the negative end of each battery first and press the positive end in at the red band. If batteries are installed, ***and*** external power is used, the external supply will try to charge the dry-cell batteries. This will rupture the batteries causing them to leak corrosive fluid on the circuit board and damage it. Always remove batteries when using external power.
5. Press the button switch at the lower left corner of the circuit board to activate the valve, and allow water to run through the glass vial until it is clear of bubbles. This water is coming from the reservoir.
6. Attach a syringe to the upper end of the rubber tube that leads to the ceramic cup (where it would normally connect to the cup's stopper.) With power to the circuit, use the syringe to draw water through the system. Water will cycle through the glass measuring vial, moving in pulses. When the tube is full and free of bubbles, pinch it closed with the plastic clamp located just below the end of the tube.
7. Attach the tube to the stoppered cup. Both the tube and the ceramic cup should be full of water, and the stopper should be firmly in place to prevent air leaks (the water in the cup is under a small vacuum). Air in the cup will not affect accuracy since water makes its way to the top evaporation surface through the porous ceramic sides (but air will expand and contract with changing temperatures and that will affect short-term results, but not long-term results.) If the ceramic cup becomes dry because of air leaks, the system will stop.
8. Priming is now complete. Remember to release the tube clamp. Snap the top assembly onto the reservoir.

FIELD INSTALLATION

1. Protect from freezing. Install after the last spring frost, and remove the ETgage before the first fall frost.
2. Mount the instrument in an irrigated location where wind and sunlight are unobstructed. Placing the ETgage in a dry, fallow field or near hot pavement will give high evaporation readings.
3. Do not put the ETgage under a sprinkler because minerals in the water could contaminate the canvas cover. Instead, place it at the edge of a sprinkler-irrigated field.
4. Secure the stainless steel mounting bracket to the side of a post with the two screws provided. The top of the post must be below the top of the instrument. The canvas covered evaporation surface – which is at the top of the instrument – should be one meter (39 inches) above ground level.
5. Use only distilled water for filling the ETgage. If the canvas becomes very dirty, remove and wash it in warm water (not hot water). Rinse thoroughly to remove any soap. The covering must fit snuggly so that there is no air between it and the evaporation surface.

6. To keep birds from perching on the instrument, and fouling its evaporation surface, mount the two 6 inch long "bird wires" as shown in the figure. There are two opposing holes in the top of the gray plastic top. Insert each wire under the silicone rubber band, and into a hole.



7. For models with a sight tube on the side of the reservoir, the glass tube shows water level change in the reservoir. One-inch change in water level corresponds to one inch of reference ET. The scale under the sight tube is calibrated in tenths of inches and millimeters. Note the short flexible connecting tube at the bottom of the sight tube. *Squeeze this tube several times to force the water to rise and fall, allowing the water in the sight tube to find its natural level.* Using this method, you can make repeatable readings to about .02 inch.

   Because all water to the evaporation cup must pass through the electrically operated valve on the circuit board, the Model E must be turned on and operating. For accurate sight tube measurements, eliminate any bubbles in the glass tube or its bottom fitting. If there are bubbles, remove them by first slipping the sight tube down and out of its top fitting, and then blowing into the tube to force water back into the reservoir. The water will come back into the tube without bubbles. The two sliding red markers on the sight tube can help you keep track of water use, or mark limits for allowable soil water depletion.

8. During heavy rainfalls, canvas covers may absorb rainwater. The absorbed water delays resumption of evaporation from the ceramic cup. This absorption can result in lower readings (an error of -0.02 to -0.05 inch).

Turf Grass

For landscape irrigation, use the ETgage with a Style #30 canvas cover for estimating grass ET. The best landscape location is an open area of turf not shaded by buildings. The location should represent the turf being managed. Landscape settings are composites of many irrigation zones of turf and shrubs. The water use or evaporation from these various micro climates may be different from evaporation at the ETgage site. Use the ETgage as a reference to help in setting the sprinkler controllers. For example, a turf island in the middle of a hot parking lot will have a higher multiplier than a large open area of turf grass that is not influenced by hot asphalt. Factors can be determined by trial and error: try a multiplier and see if the grass looks good without wasting water. This will become the factor for that area and will also include the efficiency of the irrigation system.

Agricultural Crops

An example of a good location for the ETgage in an agricultural setting is a border ridge in an alfalfa field. However, it may also be located for easy access alongside a dirt road if surrounded by low-growing irrigated crops. The location of the ETgage should represent the irrigated acreage, and should not be shaded or blocked by tall crops. Placing the instrument in a dry, fallow field, near farmstead buildings or near hot pavement generally will give high readings.

If used within a cornfield, the ETgage should always be mounted at least 1-foot above the canopy of the crop when using the Style #54 canvas cover. This is necessary for adequate

exposure to sun and wind in the tall crop. When corn is at least 1-meter high, the Style #C2 cover may be used. This diffusion cover is a good simulator of the canopy; but for Style #C2, the top of the ETgage must be maintained at a level even with the top of the canopy.

Do not put the ETgage under a sprinkler because minerals in the water could plug the evaporating surface. Instead, place it at the edge of a sprinkler-irrigated field.

A *rain gauge* can be set under the sprinkler, on a separate post. This will allow the application amount to be compared to crop water loss. Use the comparison to find application efficiency.

With a style #54 canvas cover, the ETgage will estimate the evapotranspiration of a green well-irrigated crop. This alfalfa reference evapotranspiration, or ETr, assumes the crop covers or shades at least 75 percent of the ground surface. For row crops early in the season, the canopy of leaves will not shade 75 percent of the soil, and a crop coefficient, Kc, should be used to multiply the ETgage reading. For a typical alfalfa stand, a nine-inch crop height corresponds to about 75 percent ground cover. For small grains, 75 percent cover comes at about mid-boot stage, two weeks before heading. For corn, it is about two weeks before tasseling. For ground covers below 75 percent, use the following table to find a crop coefficient multiplier:

Percent ground cover	Kc
Above 75%	1
50%	0.8
25%	0.5
Below 10%	0.3

LOW BATTERY VOLTAGE

The first component that will fail to operate due to falling battery voltage will be the solenoid valve. The glass vial will not refill and the valve will not respond to the push-button switch. This will happen at about 4 volts. To avoid data loss and the need to re-prime the system with water, replace batteries before the voltage gets too low. An indication of low voltage is sluggish valve response when you press the pushbutton switch at the lower left corner of the circuit board. (Pushing this button will not transmit a signal pulse, but it will add water to the glass vial. The unrecorded amount will generally be minimal since a full vial is equivalent to .01 inch ET.) Battery life for continuous operation is about six months.

DRAINING FOR STORAGE

1) Remove the ceramic cup, detach the rubber tube, remove the rubber stopper, and drain the cup. Use a twisting motion, or pry from side to side to remove the stopper. Pour water out of the reservoir.

2) Attach the syringe to the rubber tube and apply suction. If the circuit is still under battery power, the valve will block the flow for 15 seconds while trying to refill the glass vial. After this "time-out" period, the syringe can be used to completely remove water from the vial. Under freezing conditions, a vial full of water will freeze and break.

3) Remove batteries when not in use.

APPENDIX

1. **External Power Supply**: Terminal blocks for an external supply are located at the top left corner of the printed circuit board. They are marked EXT. SUP. "+" and "-" on the back of the circuit board. 5-VDC to 16-VDC may be supplied from an external source. The jumper wire at R12 labeled JMP1 should be cut if using an external power supply greater than 10 volts (but must be in place for the internal battery power). This will prevent wasting current on the solenoid valve, although no harm would result with a higher voltage since the duty cycle is low. If using an external supply, do not install batteries on the circuit board since they would be driven by the external supply. The circuit is protected against accidental reverse voltage.
2. **Timeout Circuit**: A "timeout" circuit keeps the solenoid valve from staying on more than 15 seconds. This prevents battery drawdown if the reservoir runs dry. Normal priming by filling the glass vial with the push-button switch will reset the timer. If, during priming, the system seems unresponsive, wait fifteen seconds: the timeout may have tripped.
3. **Circuit Board and Vial Replacement**:

To remove the circuit board:

1. Unclip lower compartment enclosure.
2. Remove the two silicone rubber tubes from the barbed fittings on the solenoid valve.
3. Remove the single slotted-head screw at the top of the board.

To replace the Pyrex glass vial:

1) Remove batteries from the front side of the circuit board.
2) Remove the clear plastic cover plate (3 screws).
3) Slip the silicone rubber tube off the inlet end of the vial. Silicone can weld itself onto glass; it may be necessary to cut the tube off with a razor blade.
4) Loosen the Nylon clamp screw at the inlet end of the vial.
5) Slide the old vial straight up, into battery space, and out.

6) Slide in the new vial. Adjust its position to bring the red lines on the glass tubes into alignment with the two bottom shields which are mounted upright on the circuit board. (Three "shields" support the vial.) The red lines will be centered in the holes where the glass tubes pass through these two shields. To allow for the slight over-shoot when the vial fills (due to the 0.004 seconds the valve takes to close), you can slide the vial down 1/32 inch to bring the red mark (under the bulb) into the gap below the shield. Over-shoot error without the adjustment is only 0.5%.

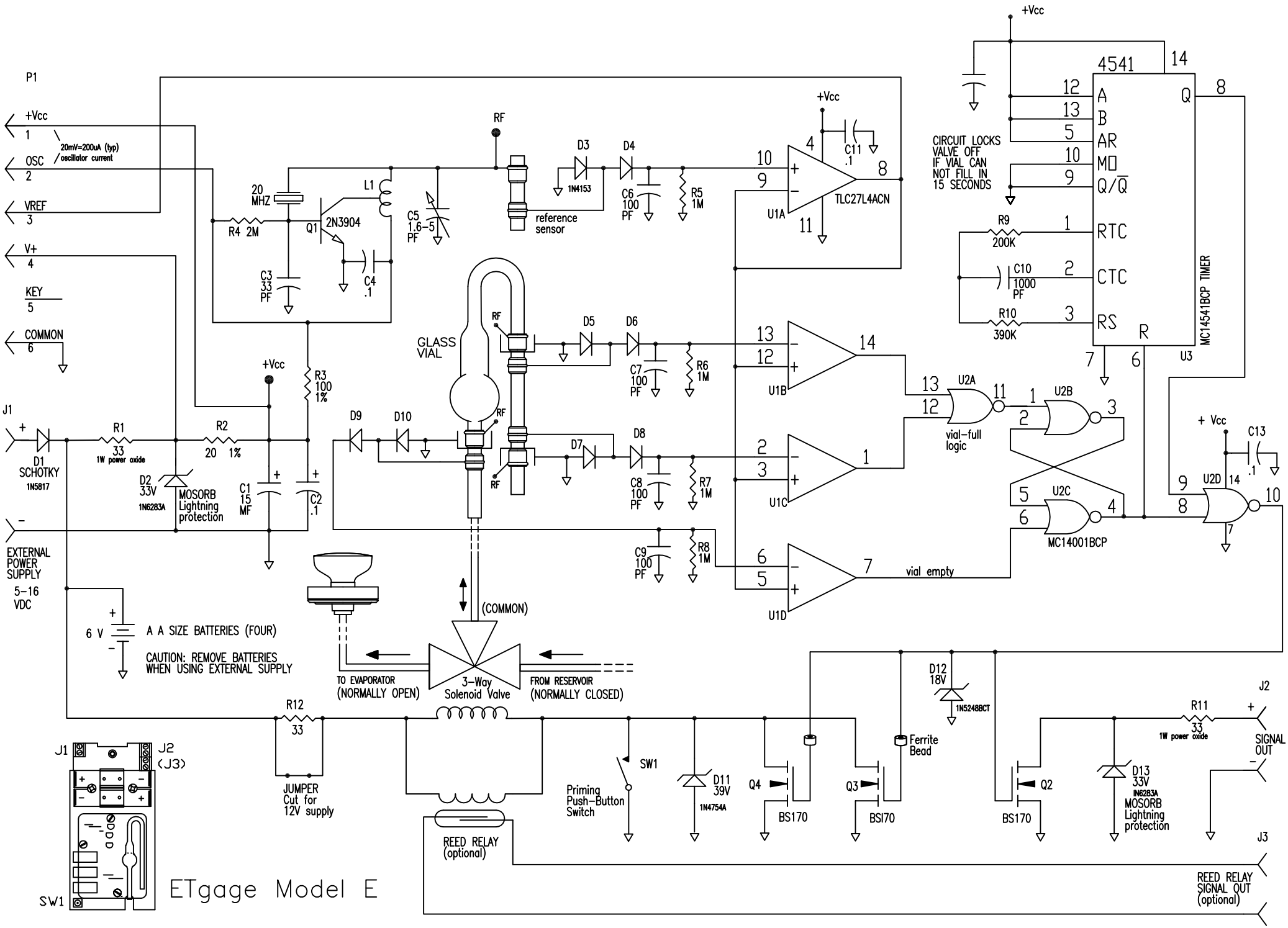
7) Tighten the Nylon clamp screw, reattach the silicone rubber tube, and replace the clear cover plate. Do not over-tighten plastic screws.

4. **Output Resistance**: On some older electromechanical data logging equipment, such as battery operated rain gauge strip chart recorders with stepping solenoids, a very low signal line resistance may be necessary. The 35 ohms of resistance in the ETgage Model E output circuit can be reduced to less than ten ohms by shorting out R11 (see figure and schematic diagram). (This will reduce lightning protection to the ETgage.) Care should be taken to limit signal current to a maximum of 200 milliamperes. Alternatives to bypassing R11 are to use the ETgage to drive an intermediate switch such as a transistor or relay, or to install an optional reed relay output in the ETgage Model E (factory option, factory retrofit or customer installed).

LIMITED WARRANTY

The reliability and accuracy of the ETgage depends on proper installation, operation, and maintenance. This product is warranted against defects in materials and workmanship for one year. During the warranty period, we will repair or, at our option, replace, without charge for parts and labor, a product that proves to be defective. This warranty does not cover transportation costs, and it does not apply if the product has been damaged by accident, or by misuse, or by modification. No other express warranty is given. The repair or replacement of a product is your exclusive remedy. Except as provided herein, we make no warranties express or implied, including warranties of merchantability and applicability for a particular situation. In no event shall we be responsible for consequential damages. Products are sold on the basis of specifications applicable at the time of manufacture.

U.S. Pats. 4,709,585 5,311,769 5,423,206 5,389,311


P1
+Vcc
1
20mV=200uA (typ)
oscillator current
OSC
2
VREF
3
V+
4
KEY
5
COMMON
6
20
MHZ
L1
R4 2M
Q1
2N3904
C3
33
PF
C4
.1
C5
1.6-5
PF
RF
reference
sensor
D3
1N4153
D4
C6
100
PF
R5
1M
+Vcc
C11
.1
10
9
U1A
TLC27L4ACN
8
11
4
GLASS
VIAL
RF
D5
D6
C7
100
PF
R6
1M
13
12
U1B
14
D9
D10
D7
D8
C8
100
PF
R7
1M
2
3
U1C
1
C9
100
PF
R8
1M
6
5
U1D
7
vial empty
R3
100
1%
+Vcc
J1
D1
SCHOTKY
1N5817
R1
33
1W power oxide
R2
20 1%
D2
33V
1N6283A
MOSORB
Lightning
protection
C1
15
MF
C2
.1
EXTERNAL
POWER
SUPPLY
5-16
VDC
6 V
A A SIZE BATTERIES (FOUR)
CAUTION: REMOVE BATTERIES
WHEN USING EXTERNAL SUPPLY
(COMMON)
TO EVAPORATOR
(NORMALLY OPEN)
3-Way
Solenoid Valve
FROM RESERVOIR
(NORMALLY CLOSED)
4541
14
12
13
5
10
9
A
B
AR
M
Q/Q
Q
8
CIRCUIT LOCKS
VALVE OFF
IF VIAL CAN
NOT FILL IN
15 SECONDS
R9
200K
1
RTC
C10
1000
PF
2
CTC
R10
390K
3
RS
R
7
6
U3
MC14541BCP TIMER
U2A
vial-full
logic
U2B
U2C
MC14001BCP
U2D
+ Vcc
C13
.1
R12
33
JUMPER
Cut for
12V supply
REED RELAY
(optional)
SW1
Priming
Push-Button
Switch
D11
39V
1N4754A
Q4
BS170
Q3
BSI70
Ferrite
Bead
D12
18V
1N5248BCT
Q2
BS170
D13
33V
IN6283A
MOSORB
Lightning
protection
R11
33
1W power oxide
J2
SIGNAL
OUT
J3
REED RELAY
SIGNAL OUT
(optional)
J1
J2
(J3)
SW1
ETgage Model E

SPECIFICATIONS
ETgage Model E

PERFORMANCE

Accuracy: ±1% of evaporated water.

Resolution: 0.01 inch

Output: Transistor switch-closure pulse generated at each 0.01 inch ET. For data loggers, use tipping-bucket rain gauge input.

Visual Readings: Sight tube with scale in inches and millimeters mounted on instrument's water reservoir.

Capacity: 12 inches ET per filling.

MAINTENANCE

Reservoir refill interval: two months typical. Fill with distilled water available at grocery stores.

Replace wafer evaporation element annually (or clean ceramic evaporator with sandpaper every four or five months). Keep from freezing.

ENVIRONMENT

Temperature: Above freezing to 70°C (158°F); 54°C (130°F) max if using batteries.

Humidity: 0 to 100% RH.

Housing: Weatherproof.

MECHANICAL

Dimensions: 22.3 inches (56.6 cm) high, 3.1 inches (7.9 cm) diameter.

Weight: 5.5 pounds (2.5 kg) with water, 3.1 pounds (1.4 kg) empty.

Mounting: Stainless steel vertical bracket.

Materials: Ceramic evaporator, green canvas diffusion covers (#30 for grass, #54 for crops), glass sight tube, PVC plastic housing, CMOS electronics. Silicone conformal coating protects circuit board.

ELECTRICAL

Output Characteristics

Output Connection: Two wire, internal screw-terminal block.

Signal: Line pulled low for 2.3 ±0.7 second pulse after each 0.01 inch ET.

Impedance: Normally open-circuit (<6 µA leakage at 30 V), 35 ohms during pulse.

Output Voltage: Voltage supplied by receiving equipment. Lightning protection circuit will not allow line to exceed 34 VDC.

Transient Protection: Fully lightning protected except for direct strike.

Power Source

Internal Supply: Four alkaline "AA" cells (6V). Replace after six months continuous use.

External Supply: 5VDC to 16VDC; 167 mA peak, 0.4 mA average current draw at 6 VDC. Internal screw-terminal block. Circuit is protected from lightning spikes on external supply line. Use only when not using internal batteries.