INSTRUCTIONS FOR
TRI-METRIC ™
BATTERY MONITOR-WITH 7 DATA MONITORING FUNCTIONS

For the following 2 models:
TM-1B: 3-1/8 in. x 4-3/4 in. panel supplied with back cover.
TM-2B: 4-1/2 x 4-3/4 in. panel for use with "double gang" electrical box (not supplied).
(version 1.01)
revised May 6, 1997

PART 1: INSTALLATION AND BASIC FUNCTIONS: VOLTS, AMPS, AMP HOURS, AND OPERATION OF "CHARGED" LAMP.

Note: The instructions come in two parts. Please first install meter and refer to these PART 1 instructions and become familiar with the basic TriMetric functions: volts/amps/amp hours according these instructions. PART2 contains optional instructions on the use of the additional data monitoring functions for those that wish to use them.

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Note: additional TriMetric information including beginning user's guide, troubleshooting, shunt information and more is available on the internet at: http://www.bogartengineering.com

Limited warranty. Meter is warranted for 1 year against any manufacturing defects. Any meter not meeting the specification or performance description will be replaced or repaired within one year of purchase, provided it has not been subject to abuse or misapplication, and provided the defective unit is shipped to us if we request it. Contact your dealer or us before shipping.

A: METER INSTALLATION--PRELIMINARY: What you need to know before installing the TriMetric meter.

Follow instructions closely. Failure to follow instructions could result in meter failure if the connections are made wrongly. Also, substantial "Amps" reading inaccuracy could result. Please refer to wiring diagram on last page of instructions.

Choosing meter location and some battery monitoring philosophy: To make best use of this monitor, we recommend that it be located where it can be readily observed in the living area where the electrical power is used, such as a kitchen or living room. (It is designed to be located up to hundreds of feet away from the battery bank using 4 wires.) One important use is to learn how much electrical power various appliances draw by looking at the "amps" readout first with the appliance off, and then observing how much the current increases when you turn it on. This is inconvenient if the meter is located away from the living area. After a while you will become instinctively familiar with the electrical usage of your appliances, so you won't need to refer to the meter. Also, you can become familiar with "normal" electrical usage, and occasionally check that it is not excessive, which would indicate some appliance has been unknowingly left on. Using the Amp-hours readout you will be able to see approximately how much energy you've withdrawn from the battery bank. If you have "lead acid" batteries--the most commonly used type--the "Volts" readout gives useful information about the "extreme" cases, when your batteries have gotten a nearly full charge, (which, while *charging* a 12 volt lead-acid battery will typically show voltage above 14.3 volts) or on the other hand when they are in a low charge state (which, while *discharging* a 12 volt lead acid battery will typically show voltage 10.8 to 11.6 volts depending on how many "amps" are being withdrawn)--but is not too informative when the batteries are between 20%-90% charged, since in this case exact voltage depends on several factors, including: *whether* the batteries are being charged or discharged, *how fast* they are being charged or discharged, temperature of the battery, and the recent past history of charge/discharge (in other words, if they are charged hard for a while, the voltage will gradually rise, due to what are called "polarization" effects.) This meter, therefore, uses the battery voltage as an indicator for when the batteries are "charged". Then--when discharging the batteries from there, the "amp-hours" reading is a better guide for determining intermediate battery state of charge. Voltage can again be useful for seeing that the batteries are in a state of near discharge--this is useful since it is not good for lead-acid batteries to be too often, or too long discharged. (Multiply voltages above by 2 for 24 volt systems or 4 for 48 volt systems).

Permissible battery voltage: This meter is suitable for battery systems with nominal voltage from 8 to 30 volts. It should not be connected to systems which will ever exceed 35 volts. A special adapter, model TM-48A, is available for 32-48 volt systems which will allow operation up to a maximum of 70 volts, and in addition will provide substantial protection from lightning for use in 12-48 volt systems.

Lightning considerations: The meter is not well protected against lightning. The TM-48V adapter mentioned in the paragraph above will greatly increase the resistance to lightning damage in areas where this threat is frequent. Note that if the adapter is to be used in the "double-gang" box with the TM-2B, be sure to insure that the box is sufficiently large to accommodate the adapter. (See next page under **Mounting the meter--**where is says: **The TM-2B model...**)

How current (amps) are measured by this meter: A shunt (a very low resistance, accurate, high power resistor) must be used with this meter. The shunt must be wired in series with the negative terminal of the battery, through which all current to the load and charging system must pass. The shunt is usually located near the batteries, but outside of the battery compartment. The TriMetric measures the current ("amps") by measuring the very small voltage drop across this shunt.

Amp-hour measurement: The meter reads up to ±167,000 amp hours. *When the value exceeds 999 amp hours the decimal point will flash. This means that the value shown should be multiplied by 1000.* For example, if the meter shows -1.02 with flashing decimal point, this means -1020 amp hours.

Meter to shunt cable requirements: The meter may be located up to hundreds of feet away from the shunt if desired, in an indoor location, with four power and control wires connecting between the shunt and the meter. (These 4 wires are labeled on the connector on the circuit board inside the TriMetric: "G1", "G2", "SIG" and "+".) The meter can be connected to the shunt with 4 wires, or a cable with 4 conductors. It would be advisable to use twisted pair wires in the cable if any other power wires are being run near and parallel with these, however it should not be necessary otherwise. If twisted pair wire is used, it should be connected as shown in the drawing. The simplest way to connect the meter is to use wire size large enough, as shown by the following:

Maximum cable length from meter to shunt for the following wire sizes are: #26 gauge: 22 feet. #24 gauge: 35 feet. #22 gauge: 55 feet. #20 gauge: 90 feet. #18 gauge: 150 feet. #16 gauge: 220 feet. #14 gauge :375 feet. (These represent distances for approximately one ohm wire resistance.)

For unusual cases-the more technical description of cable requirements: Use wire resistance less than 1 ohm total for the G1 wire. The G2 and SIG wires can each be over ten times higher than this with no problem. If the single wire connecting from the meter + and M+ terminals to the battery is over 1 ohm, the "volts" will read slightly less than true. (If the wire is less than 1 ohm, the meter "volts" error will be less than 0.03 volts--almost negligible). However, wires of *ten times* this resistance may be used with no "volts" error if a separate (additional) wire is run for the M+ terminal: Disconnect the short wire between the + and M+ terminals at the meter terminal block, and connect two *separate* (long) wires to the fuse at the battery + terminal--and run one of these to the + terminal of the meter, and the other to M+ terminal.

Shunt requirements: The shunt used must be either a 500 amp-50 mv. or else a 100 amp-100 mv. type. Whichever you select, you must tell the TriMetric which you are using in order that the meter will display the AMPS and AMP-HOURS correctly--i.e. with the decimal point in the proper position. This is done by properly programming the TriMetric, as described below in section D under HOW TO SET EFFICIENCY FACTOR and SHUNT TYPE. **Incidentally, it is only the shunt *ratio* between amps to mv. which is important to the meter**--so, for example, a 200 amp-200 mv. shunt can, from the meter's point of view, be considered equivalent to the 100 amp-100 mv shunt. The implication, when a shunt is rated at "100 amps-100 mv." is that it may safely carry *up to* 100 amps maximum--however unfortunately in many cases so-called "100 amp" shunts will not carry this much without overheating--especially some of the "mini" shunts of this type. For more information, request Technical Note #7: "Information on Shunts" from Bogart Engineering, or get it from the internet address shown on page 1.

Which shunt should you use?

The short answer: If you anticipate that you will not use more than 75 amps except for short surges (800 watts for 12 system, or 1600 watts for 24 volt system) use a 100 A, 100 mv shunt. If you anticipate sometimes using more than 100 amps (for more than a minute at a time) use the 500A, 50 mv shunt.

A longer answer: If you anticipate using less than 75 amps, you may use either shunt: however with the 100A/100 mv shunt you will gain an extra digit of current resolution for current readings below 10 amps. The 100 amp shunt will display currents down to 1/100 amp, (e.g., will display amps=3.42) whereas the 500 amp shunt will resolve to 1/10 amp (e.g. will display amps=3.4). However, some 100A-100 mv. shunts are designed for up to 200 amps--and the TriMetric will measure these properly up to 400 A or so--however at this current the shunt will severely overheat.

TriMetric maximum current capability: The TriMetric will measure current properly up to 999 amps with the 500 A-50 mv shunt. With the 100 A-100 mv shunt the meter measurements will be OK up to 300 amps. However, **at these currents the shunt is going to get too hot**: the 100 A shunt as described will be producing the heat of a 90 watt light bulb, and the 500 A shunt will produce heat equivalent to a 100 watt light bulb. (The heat produced by the shunt will be proportional to the **square** of the current passing through it, so each time the current is doubled the heat increases by a factor of 4.)

Mounting the meter: **The TM-1B model**, **with steel back cover**, may be mounted (if desired) in a rectangular hole 2-7/16 in. wide by 4-3/8 in. high, with 4 holes in the corners which match up with the 4 corner holes. You can also mount it against a flat (wooden) surface by removing the rear cover (by removing the 4 corner screws) and drilling several holes in the back cover, and securing the cover to the flat surface with (wood) screws placed through the drilled holes, then replacing the front panel and circuit back in the cover. **The "dual gang" electrical box mount: TM-2B model (**with 4-7/16 x 4-1/2 in. front panel), can be mounted in any standard “dual gang” electrical box (used typically to mount two standard light switches in a wall.) The box needs to be mounted 90 degrees from the usual position, so that if wall switches were mounted in the box they would go right-to-left instead of up and down. A standard metal box may be used, or a Wiremold™ surface mount “double gang” plastic box may be used, (Wiremold #2348-2, offered as an accessory) which allows flexible and easy mounting options. **Before installing any box be sure to check that the meter fits, especially if the 48 volt/lightning adapter will be used.** If a metal box is used we recommend using an oversize box that will accommodate the TM-48V lightning protector/48 volt adapter should the user wish to later retrofit this with the TriMetric. The Wiremold box mentioned will accommodate the lightning/48V adapter.

B. METER INSTALLATION- How to make connections from meter to battery and shunt:

We suggest a cable with different colored wires to reduce the probability of wiring errors. The cable wires at the TriMetric end of the cable must connect to a terminal block located on the circuit board inside the TriMetric, which requires removing the cover (if present) as described below. If cable with twisted pair wires are used, the wires labeled wires “G2” and “SIG” should be run with one twisted pair, and if another pair is used, “G1” and “+” can be run another pair. The terminal block on the circuit board accommodates wire size from 16 to 26 AWG

Connection instructions. Refer to wiring drawing on last page--please read all notes..

STEP 1: If twisted pair wires in a cable are used, clearly establish which wires in the cable are "paired" together. This often requires stripping quite a bit of insulation to see which pairs are twisted together. Then choose one twisted pair for G1 and +, and record the wire colors for that pair below in the chart. You may want to use a piece of tape at each end of the cable to tie these two together, to clearly mark the pair. Then choose a pair for G2 and SIG and record their colors. Similarly mark these with another 2 pieces of tape. If cable with non twisted pairs is used, just select any 4 wires and record the wire colors here.

	CONNECTION	WIRE COLOR
Twisted pair:	**SIG**	
	G2	
Twisted pair:	**+ and +M**	
	G1	

STEP 2: For the TM-1A model, with cover, you will first need to remove the cover by carefully removing the 4 hex nuts from the corner screws on the front panel of the meter, taking care not to damage the front label. **For both models TM-1A and TM-2A**: There will be visible a terminal block with 5 screws on the green circuit board. The five connections are labeled: G1, G2, SIG and + and +M. First connect the + and +M terminals together with a short wire. Thread the other wires through the hole in the cover (if necessary) from the outside, and strip insulation off each wire 1/4 inch or so. Use a small screwdriver to loosen the 4 screws on the connector and insert each wire in a separate connector hole using the chart above to determine which wire goes to which terminal, and tighten each screw to hold the wires securely, taking care that there is no danger of shorts between the wires.

STEP 3: Finally, using the chart above and the wiring drawing on the last page connect the other end of the cable. First connect the G1 and G2 wires to the correct Kelvin terminal on the shunt. (These two wires must join together only *right at* this terminal.) Then connect the SIG wire to the other Kelvin connection.

STEP 4: Connect the fuse holder to the battery + terminal, but don't yet put in the fuse. Connect the + wire from the fuse to the TriMetric + terminal. **Then please make a final check of the wiring, and then finally insert the fuse in the fuseholder.** The digits should light up on the meter and battery volts should be displayed**.**

C: BASIC OPERATING FUNCTIONS: (Volts, amps, amp-hours and "charged" indicator lamp) Description of lamps and controls.

CHARGING lamp: The "CHARGING" lamp will light whenever current is flowing INTO the battery (charging), to show at a glance that the battery is being charged, even when AMPS are not being displayed.

SELECT button: Push "SELECT" to select whether display will show VOLTS, AMPS , AMP-HOUR, or whether the digital display will be turned off . (Alternatively, instead of the "blank" display, you may show one of seven data monitoring functions, as fully described in PART 2 of the instructions). Each push will cause the display to advance through these four possibilities. Pushing "SELECT" while AMP-HOURS is being displayed will cause the display to be turned off (or show any desired data monitoring function) until SELECT is again pushed to display VOLTS. The dark display results in the minimum current being drawn by the meter of approximately 16 milliamperes. When the digits are lighted, about 22-32 milliamperes will be required, depending on the content of the numerical display.

VOLTS lamp: This lamp lights when battery VOLTS is displayed. Battery voltage as displayed is accurate to ±0.08 volts from 10 to 35 volts. (With the 48 Volt adapter it will read up to 70 volts.)

AMPS lamp: Lights when battery current (AMPS) is displayed. Current INTO the battery(charging) is displayed as positive, and OUT OF the battery as negative (with lighted minus sign). It is accurate to ±1%, ±the least significant digit. AMPS displays actual amps in or out of the battery--the reading is not affected by the "efficiency factor" setting shown below.

AMP-HR lamp: Lights when AMP-HOURS are displayed. Current INTO the battery (charging) will show as positive accumulating AMP-HOURS, and OUT of the battery (discharging) as negative accumulating up to an improbable maximum of ±167,000 AMP HOURS. The meter is ordinarily used so that when "0.00" is displayed, the batteries are approximately <u>fully</u> charged. As the batteries discharge through supplying power to a load, the numbers become more and more negative. When these numbers go negative enough to equal the total battery capacity (in amp-hours) this will indicate that the battery is discharged. When the numbers go below (or above) 999, the decimal point will flash, indicating that the reading must be multiplied by 1000. For example, if 1.02 is shown, with flashing decimal point, this means 1020 amp hours.

Efficiency factor: The meter always accumulates current out of the battery (discharging) at a 100% rate, meaning that if the measured battery discharge current is 100 amps, then AMP-HOURS will decrease by 100 every hour. It measures current INTO the battery (charging) depending on the EFFICIENCY FACTOR selected by the user. The EFFICIENCY FACTOR may be set in 1% increments from 60% to 100%. (See below, section D under How to set Efficiency Factor) For example, if 90% efficiency factor is chosen, a current of 100 amps charging will add to the AMP-HOUR reading at a 90 amp rate, so that after one hour of charging at 100 amps, the AMP-HOURS will accumulate +90 AMP-HOURS. The purpose of the efficiency factor is to try to match the battery "charge" (or "coulombaic") efficiency, since to charge a battery requires somewhat more amp hours than are recovered during discharge. **NOTE: Unlike some meters of this type, the efficiency factor must be set by the user to match the battery efficiency--the meter does not re-adjust this value by itself.** Section E, below suggests some reasonable values to use.

Reset of AMP-HOURS to 0. Occasionally it is necessary to reset the "amp hours" to synchronize with the battery--since a real battery will never track **exactly** a fixed efficiency setting. (For one example, when the battery is close to fully charged it will have lower efficiency than when it is 50% charged, since at near full charge some of the energy put in will go to convert water to oxygen and hydrogen rather than go into electrical energy.) With the TriMetric, you may reset the meter to "000" manually when you decide that the batteries are charged, or automatically, as described below, when the batteries reach a predetermined charge voltage and current, indicating that they are charged.

Manual reset of AMP-HOURS to zero: If you know your batteries are charged, you may wish to reset AMP-HOURS to zero as follows: first select AMP-HOURS using the SELECT button. Then push SELECT again, and while holding the SELECT button down, push the RESET button. This will reset AMP-HOURS (without resetting "battery charged" lamp). After being reset to zero, the "amp hours" will accumulate as described above. (In addition, the meter will reset itself to zero when it is initially connected up to your system.) *However, usually the meter is set to automatically reset the amp hours as described as follows*.

Automatic reset and the "reached CHARGED setpoint" lamp. As batteries are charged by a charging system, their voltage gradually rises and/or the charging current gradually decreases until they are fully charged. For example, when a solar array (or other "constant current" charging source) is charging the batteries, one way to determine that the batteries are charged is to monitor this voltage. When the voltage rises above a certain point, the batteries are fully charged. The TriMetric, upon meeting a predetermined battery voltage/current charge point (which you may select) will light the "reached CHARGED setpoint" lamp on the panel. For this to occur the voltage must be *above* the voltage setpoint, and the current *below* the amps setpoint--and this condition must exist for a minimum of 20 seconds. **The "reached CHARGED setpoint" lamp will then remain lighted forever until the user turns it off by pushing the "reset" button next to the lamp**. After you have seen that it has reached its charged setpoint by observing that the lamp is on, you will typically want to reset the lamp off so you can tell the next time it is fully charged.

In addition, if the **"auto reset"** option is chosen, (which is recommended unless for some reason you don't want the meter to reset by itself) the AMP-HOUR display will automatically reset to zero after the batteries have caused the "CHARGED" lamp to illuminate, but only after the battery starts DISCHARGING again. In other words, AMP-HOURS will not go to "000" at the moment this lamp lights, but will wait afterwards until the battery begins discharging before it resets to zero, typically just after the charging system has stopped charging--(but also possibly when a load large enough to require more current than the charging system can supply is turned on.)

Properly cared for batteries need to be occasionally fully charged. The "charged" lamp informs you that this has happened, and (assuming you have chosen the "auto reset" option) also notifies you that the amp-hours have been again resynchronized to the battery. For example, if you are out during the day while a solar array is charging your batteries, when you come home in the evening you can see if your batteries reached a full charge at some point during the day.

To adjust the voltage and current setpoints see below in section D under "HOW TO SET THE VOLTAGE AND CURRENT CHARGED SETPOINTS." For guidance on selecting appropriate values, see section E**:** CHOOSING VALUES OF EFFICIENCY FACTOR AND CHARGE POINT SETTINGS.

D: CHANGING <u>BASIC</u> USER ADJUSTABLE PARAMETERS: How to adjust the charge point settings, turn on/off auto reset, setting up for the correct shunt, and changing efficiency factor settings. (Besides these, there are other parameters which may be set relating to the data monitoring functions. These are described in PART 2 of the instructions.)

GENERAL INFORMATION ON ENTERING DATA IN THE TriMetric PROGRAM MODES: Each TriMetric display mode, (including the "Data monitoring display functions" described in PART 2 of TriMetric instructions) can have its own program mode (but not all do) that allow you to adjust data. Follow this four step process: (1)First select the desired display mode. (2)Hold down SELECT and while holding momentarily push RESET. You'll then see *flashing* "volt/amp/amp-hour" lamp(s). (3) Adjust data showing in display by pushing the "RESET" button. (4) Leave program modes by pushing "SELECT". Data in program modes stays even if power is disconnected from the meter.

This section describes how to adjust **voltage** and **current "charged" set points, efficiency factor, shunt type**, how to turn on/off the **"auto reset"** feature.

HOW TO SET THE VOLTAGE AND CURRENT "CHARGED" SETPOINTS, and AUTO RESET OPTION INTO THE TriMetric: The TriMetric uses this information to decide when to light the "charged" lamp, and reset the "amp-hours" to 0. First decide on a voltage and current which will be used as a "charged" criteria. **For help in determining what values to enter here, refer below to section E: CHOOSING VALUES OF EFFICIENCY FACTOR AND CHARGE POINT SETTINGS.**. Any voltage may be used from 10.0 to 34.9, adjustable to 0.1 volt. Any current from 1-100 amps may be used, adjustable to 1 amp. Once the values of voltage and current (amps) are chosen and entered, the CHARGED lamp will illuminate when the battery *equals* or *exceeds* this voltage setpoint while the batteries absorb less (or equal) current (AMPS) than the current setpoint, and where that condition exists for at least 20 seconds. It is also possible to defeat the AMPS criterion so that only the voltage is used to determine whether the batteries are charged. In addition, decide whether you would like the AUTO RESET option, (usually you should) which means that the AMP-HOUR display will reset to zero automatically when this condition is met. However the actual reset time will occur only after the battery again begins discharging.

HOW TO ENTER VOLTAGE SETPOINT and AUTO RESET: Using the SELECT button, select VOLTS. Then hold down the SELECT button and while holding push the RESET button. After releasing both buttons, the "VOLTS" lamp will be flashing, indicating that the program mode has been entered. The display will show the **setpoint voltage**, and the "CHARGED" lamp will be illuminated if the AUTO RESET option is in effect. To change to another voltage setpoint, push the RESET button momentarily, which will turn the CHARGED lamp ON or OFF every push, and every other push will increase the display by 0.1 volts. After holding the RESET button down for one second the display will begin to increase by 1 volt every second, until finally after it reaches 35 volts it will go to 10 volts again and continue to increase. So hold the button down until you get close to the voltage you want, then give brief pushes until the correct tenths of volt appears, and finally either ILLUMINATE or DE-ILLUMINATE the charged lamp depending on whether you DO or DO NOT want the AUTO RESET feature. This should usually be turned on--meaning that you should be sure that the "charged" lamp is illuminated. After you are finished, push the SELECT button momentarily to get out of the programming mode.

HOW TO SET CHARGED CURRENT SETPOINT: Using the SELECT button, select AMPS. Then push the SELECT button again, and while holding it push the RESET button. After releasing both buttons, the AMPS lamp will flash, and the display will show the current setpoint, in AMPS. Each push of the RESET button will increase the setpoint AMPS by one. Holding the RESET button for about 1 second will cause the AMPS to increase by 10 amps every second. You may also disable the current feature, so that the charged criterion will be determined ONLY by the voltage criterion, paying no attention to the battery current.. For this, put "---" into the display, which will appear when holding the SELECT button down, just after the display goes over 100. When the correct number is in the display, push SELECT to go back out of the program mode.

HOW TO SET EFFICIENCY FACTOR and SHUNT TYPE: First blank the display, using the SELECT button. (The display blanks by pushing and releasing the SELECT button while AMP-HOURS is shown.) Then again push and hold down SELECT, and while holding, push RESET. After releasing, the 3 lamps will simultaneously flash, and the left display digit will show an "L" or "H", indicating the Low or High current shunt. The LOW CURRENT shunt selection should be used for a 100 amp/100 mv shunt, (1 milliohm) and the HIGH CURRENT shunt selection should be used with a 500 amp/50 mv (0.1 milliohm) shunt. The two right digits show the efficiency factor, in percent, where "00" refers to 100% efficiency. Repeatedly push the RESET button until the desired combination is displayed. Or, if you hold RESET down, the efficiency factor will change by 10% every second. Then push SELECT to go back out of the program mode. **Before leaving this program mode be sure that the "L" or "H" is correct for your shunt, or your "amp" and "amp-hour" readings will be off by a factor of 10.**

E. CHOOSING VALUES OF "EFFICIENCY FACTOR" AND CHARGE POINT SETTINGS. Some guidance on choosing these programmable parameters.

CHOOSING EFFICIENCY FACTOR: If you do not know what efficiency factor to use and if you have lead-acid batteries we suggest that you start with 94%. The actual "charge efficiency" factor for lead acid batteries *while they are not at the top of charge* is generally higher than 94%, so this will usually give a *conservative* value for "amp-hours"-- that is the meter will generally slightly underestimate the actual charge in the batteries which will give a useful practical result for knowing state of charge.

Optional technical note: Some people familiar with batteries will be surprised that the suggested "efficiency factor" is as high as 94%. Without going into all the details here, there are two reasons for this: (1) The number entered in the TriMetric is not true battery efficiency, or *energy* efficiency, (which is often quoted at 70-80% for lead acid batteries) but *charge* efficiency. Charge efficiency (the ratio of total amp-hours you get out divided by total amp-hours to charge the battery) is always greater than energy efficiency. (2) What is entered in the TriMetric is not even the overall charge efficiency of the battery, but the charge efficiency while the battery is *not* at the top of charge, and not gassing. A battery is not charge efficient while at the top of charge, so if this part is excluded the battery is very charge efficient. (We have measured this to be 95-98% with Trojan wet cell batteries.)

For the perfectionist only: Practical utility doesn't demand perfection--and the reality of changing battery temperature makes this difficult. But if you wish to try and your batteries are fairly constant in temperature: the ideal is that the TriMetric amp-hours should be at 0 at the time that the *charging system* has fully charged the batteries. (This will generally be shortly after the "charged" lamp lights on the TriMetric, as explained in the next section below.) If you find that the AMP-HR reading is somewhat **below** 000 (negative) after the charging system has fully charged your batteries, then you could **increase** the efficiency factor. If you find that the numbers are going substantially **above** zero when your charging system has finished charging, then **decrease** the efficiency factor. (Note that the amp-hours should read 0 at about the time that your *charging system* has just stopped charging, not necessarily when the TriMetric "charged" lamp first comes on, provided your charging system is not over charging or equalizing your batteries.) But note that if the battery temperature went up since the last "full charge" was reached, the "amp-hours" will be somewhat negative the next time reaching "charged." And if temperature went down, they'll be somewhat positive. Real "macho techies" might also want to make an "efficiency factor" data function measurement, d. 3 to measure the efficiency directly. See "PART 2" of the TriMetric instructions for this.

CHOOSING VOLTAGE AND CURRENT CHARGED SETPOINTS: For a 12 V lead acid battery system, the **voltage setpoint** will usually be between 14.3 and 14.8 volts. Double these numbers for 24V systems. The main rule for setting the "charged" voltage and current setpoints in the TriMetric is to follow the lead of the charging system you have, so that the TriMetric "charged" lamp comes on just before the charging system decides that the batteries are charged and stops charging your batteries. If you have an "on/off" type charge controller that charges to 14.7 volts, for example, and then stops charging, set the TriMetric for slightly below this voltage, say 14.6 or 14.5 volts, and disable the current setpoint (by putting "---" in the current setpoint.) Some chargers, for example PWM solar controllers such as the Heliotrope CC, or Trace C-40 charge up to a certain voltage (such as 14.4) and then limit the voltage to that value and gradually reduces the current. With this type you can set the TriMetric voltage setpoint to just below the charger's voltage setpoint. In addition, if this type of charger has a fairly high current capability then as the batteries charge more fully the current will gradually taper down. If you have this type of charger you could also set the "current" setpoint to some value *above* where you find the current to be when the charger stops charging. A reasonable value of current setting could be C/20 where C=battery system capacity in amp-hours. (For example, if C=700 amp hours, then current setting=30-35 or so) Then the TriMetric will wait until not only the charger reaches 14.4 volts, but will delay turning on the "charged" lamp until the "amps" value declines below the current setpoint.