Orientation page for TriMetric model 2020
Please read this first:

(A) INSTALL: A qualified person should install the TriMetric.

STEP 1: Read (or at least quickly review) section **A**, pages 2-3 of the manual "**METER INSTALLATION-PRELIMINARY**":

STEP 2: Study the wiring diagram on last page of manual.

STEP 3: Install according to section **B: METER INSTALLATION.**

(B) ENTER DATA: To get the TriMetric working the first time, particularly the "**Battery % Full**" and "**Amp-Hours from full**", you need to enter some system data. For "**Battery % Full**" to work properly, data in Step 2, Step 3 Step 4 and Step 5 (below) must be entered correctly. For "**Amp-Hours from full**" and "**days since charged**" to work properly, data in Step 2, Step 3 and Step 4 must be correct. For "**Amps**" to read correctly (not off by a factor of 10) Step 4, shunt type, must be specified correctly.

STEP 1: Refer to table 1 on page 13 of the instructions, which summarizes the TriMetric programmed data that may be changed, and shows how to change it. To get started enter the data shown below (steps 2 thru 5); later read the references to the instructions shown on table 1, the last column to "fine-tune" the data.

STEP 2: Enter the "charged setpoint voltage" (refer to first item of table 1, p. 13)**:** Setting all other programmed data is done in a very similar manner, so once you've done this one, changing the others should be easy.

2.1 Push **SELECT** until the display shows **volts**.

2.2 Press and hold down **SELECT**--then (quickly!) press **RESET**. Release both and the **volts** light should flash and a number will show in the display -- the "charged setpoint" voltage. (If you hold **SELECT** too long before pushing **RESET** the meter will show "Ahr" and you will have to push **SELECT** a number of times to display **volts** again, and try this again.)

2.3 This displayed number must be set to the correct value. Push **RESET** a few times to change the numbers. As you do so notice that the numbers increase by .1 with each push. Holding **RESET** down scrolls the display. (After the numbers go above 65.0, they cycle back to 10.0 again.) If you have wet cell lead acid batteries, start by entering **14.3** if you have a 12 volt system, or **28.7** if you have a 24 V system. (More detail on choosing charged setpoints may be found in section C1, pages 4-5 of the manual.) Put in the number you desire and press **SELECT** again to get out of the program mode.

STEP 3: Enter the "charged setpoint amps": Programming this is similar to STEP 2 except that instead of starting from the "volts" display, you start from the "Amps" display. Start by programming "**OFF**". This appears just after 100, and before 1. "OFF" means that the TriMetric will not use the "amps" data when determining whether the batteries are charged. If you charge with a generator or other high powered source you should eventually change this or the TriMetric will declare your batteries are "charged" before they really are. See section C1, pages 4-5 of the manual.

STEP 4: Enter the "charge efficiency factor and shunt type": Programming this is similar to STEP 2 except that instead of starting from the "volts" display, you start from the "Battery % Full" display. If you have a 500A/50 mV shunt (the most common) enter "**H**" (which is the factory default). If you have a 100A/100 mV shunt, enter "**L**". Use "94" for the efficiency factor for either **H** or **L**. You should end up seeing either "**H94**" or "**L94**" displayed. More detail on setting "shunt type" and "efficiency factor" may be found in section "C2" of the instructions.

STEP 5: Enter "battery capacity": To give a correct **"% BATTERY FULL"** display the TriMetric must know how large a capacity your battery system has. Determine your "battery capacity", that is, the total amp-hours which your *battery system* can hold when full. Refer to section C4, p.6 of instructions for information about capacity, or ask your dealer who sold you the batteries what this value is. If you do not plan to discharge your batteries very far we suggest that you enter a *smaller* value than calculated capacity--this will expand the scale of your "Batt% ful" display, so that the display will go down more rapidly as you discharge your batteries. (Alternatively you can have the "%BATTERY FULL" display show in 1% increments instead of the normal 5% increments: refer to instructions, see section C3.) **Please note: entering the "battery capacity" is a little different from the ones you've just done** (some people have had problems with this one!)**: Follow these steps: (1)** while displaying "volts", "amps" or "battery % full", push and hold "**SELECT**" down for a few seconds until you see "AH" appear in the display, then release. Now you should

observe the "**AH**" in the display alternating every few seconds with the number: ("amp-hours from full"). **If not,** repeat this step until this happens. **(2)** Next go to the program mode (in the usual way) as follows: Hold "**SELECT**" down--then (quickly!!!) push "**RESET**" then release both. Now you should observe a number in the display, and the 3 lights (volts, amps, batt % full) should be simultaneously flashing. If not push the "**SELECT**" button to start from step 1 again. **(3)**Enter the desired "battery capacity" value using the **RESET** button. You can enter a number from 10 to 2550 amp hours. Start by entering a value that is 50-75% of your actual battery capacity. Note that while showing the data, **if the decimal point is flashing,** that means multiply the number by 1000. For example, 1.20 with flashing decimal point means 1200 amp-hours. When you are finished push the "**SELECT**" button again to revert to the display mode.

(C) Read the one-page summary of TriMetric operation (page 12 of instructions). Note that "Battery % Full" or "amp-hours from full" will not be correct until the system is fully charged at least once. To understand these in more detail, read section D6 in the instructions. **The factory default setting on your meter has been set so that all three functions which would illuminate the "battery reminder" light are selected "off"** To activate them, read sections C 5, C6 & C8 of instructions.

(D) Afterwards Read the instruction manual to become more familiar with the TriMetric. Review section C to check and "fine tune" the programmed data which is entered. You may also want to read "**Using the TriMetric (or other battery system monitor) to maintain your battery system, conserve energy and troubleshoot system problems.**", written for persons with less technical background. It is available free on the internet at "www.bogartengineering.com" or by calling or writing Bogart Engineering.

Quick description of what the main numbers mean:

"AMPS" tells how fast energy is being put in or removed from the batteries: useful for conservation awareness, and checking charging systems. The "minus" sign, when lighted indicates discharging. When the minus sign is not lighted (and the "charging" lamp is lighted) indicates "charging". Turning on and off an electrical load will tell you how much current draw the load takes by comparing the difference. Turning on or off a charging source will tell you how fast it's charging.

"BATTERY % FULL" tells how full the battery is *based on the number programmed in (B) Step5, reverse. This number is not valid until the first time the batteries are charged fully. Also, it will not be meaningful if the "charged" parameters are not programmed correctly* (see section C1, instructions.) After the batteries are charged the first time causing the "charged parameters" to be attained "**FUL**" indicates a full battery. After discharging energy from the batteries for awhile, the number will show **90, 85**, etc. to show about how much battery energy is available. When the number becomes less than **30**, the display will say '**LO**"—which indicates that the batteries are getting low on energy and should be recharged. To make this display read out in 1% increments instead of 5%, see section C3 of instructions. For other information, see sections D6 and C1, of instructions.

For a more detailed explanation of how "Battery % full" is measured refer to section D6 in the instructions. This is useful for users wishing to optimize this function.

"VOLTS" gives an approximation of how charged the batteries are, especially at the extremes of fully charged, and almost empty. It is an important diagnostic tool for checking charging systems and troubleshooting problems.

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INSTRUCTIONS FOR
TRI-METRIC ™
Battery system monitor, Model TM-2020

revised October 2005

INSTALLATION AND OPERATION INSTRUCTIONS (For technical users)

Note: See also the user's instructions (available from Bogart Engineering, and from the internet at www.bogartengineering.com) written for those with less technical background:
A TriMetric User's Manual: *Using the TriMetric to maintain your battery system, conserve energy and troubleshoot system problems.*

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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.

BOGART ENGINEERING

Web internet address: http://www.bogartengineering.com

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

Please 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 "BATTERY % FULL" display, (or "Amp-hours from full") 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). However "volts" 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 awhile, the voltage will gradually rise, due to what are called "polarization" effects.) The TriMetric, therefore, uses the battery voltage as an indicator for when the batteries are "charged". Then--when discharging the batteries from there, the "BATTERY % FULL" (or "amp-hours from full") 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 remain too long nearly 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 without the following adapter:* A special adapter, model TM-48VA, 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-48VA adapter mentioned in the paragraph above will greatly increase the resistance to lightning damage in areas where this threat is frequent. Also, *the warranty will extend to lightning damage too.*

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 "amps" shown on the meter measures whatever current passes through this shunt. Therefore the shunt must be wired in series with the wire which carries the current to be measured. This is usually the cable from the negative terminal of the battery to all loads and charging sources. The shunt is usually located near the batteries, since the high current carrying wires must be kept short. The TriMetric measures the current ("amps") by measuring the very small voltage drop across this shunt.

If it is desired to measure *only* total solar input current, or only total load current (and amp-hours): this can be done by wiring the shunt such that only the solar current, or load current will pass through the shunt. (The "Battery % Full" display will be meaningless in this case.)

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 with 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 then 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 FROM FULL correctly--i.e. with the decimal point in the proper position. This is done by properly programming the TriMetric, as described below in section C2. **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 : "Information on Shunts" from Bogart Engineering, or get it from the internet address shown on page 1.

Which shunt should you use? Most systems with medium and large inverters should use a 500A- 50 mV shunt, which will work for systems to 400 amps maximum (4000 watts with 12 V systems and 8000 watts for 24V systems.) With this shunt you can measure current as low as 1/10 amps. You can use a 100 A/100mV shunt with smaller systems which don't use or charge with over 75 amps, (800 watts for 12 system, or 1600 watts for 24 volt system) or if the shunt is used only for measuring solar or wind input with currents less than 75 amps. This shunt has the advantage that it will show an extra digit to the right of the decimal point, and resolve currents as low as 1/100 amp.

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: **TM-2020 model** (4-7/16 x 41/2 in. front panel), is designed 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 if surface mounting is desired 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.

<u>B.</u> METER INSTALLATION- Even momentarily connecting "+" wire from battery to meter incorrectly or backwards will destroy it. Carefully following these steps will minimize that possibility.

•**A qualified person familiar with safe electrical practices and the local electrical code should install this meter--particularly when installing the shunt.**

•**Refer to wiring drawing on last page--please read all notes.**

•**Do not install into a 32V or 48V battery system without TM-48VA adapter. The TriMetric will be damaged.**

•**A (2Amp, fast-blow) fuse shown** located *near the battery* in the wiring diagram is for safety. Such "in line" fuses are available at Radio Shack.

STEP 1: Assuming you want to use the TriMetric in the usual way to measure total "amps" in and out of your battery, the shunt must be wired in series with the negative lead of the battery system (as shown on diagram last page). You'll usually need an additional short length of the large cable of a size typically used to connect the inverter to battery, with large bolt lugs at each end to connect from the negative battery terminal to one side of the shunt.   The battery cable size must be

large enough to accommodate the maximum system charging or discharge current from the battery. Note that there should ordinarily be nothing but the (one large) cable connected to the negative of your battery systems to shunt terminal. **Please avoid this VERY common mistake: if there is a wire from the solar array and charge controller which is connected to the minus terminal of the battery be sure it is moved to the other side of the shunt, on the SAME side as the inverter is connected, as shown on the wiring diagram, otherwise solar charging current from this source will not be measured by the TriMetric**.

STEP 2 Making 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 green circuit board in the TriMetric. If cable with twisted pair wires are used, the wires labeled "G2" and "SIG" should be run with one twisted pair, and if another pair is used, "G1" and "+" can be run an another pair. The terminal block on the circuit board accommodates wire size from 16 to 26 AWG.

If twisted pair wires in a cable are used, (which is not necessary unless other power wires run near these wires) 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 piece 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 3: 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 box (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. Install meter in box.

STEP 4: 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 farthest from the minus battery terminal lead. (These two wires must join together only *right at* this terminal.) Then connect the SIG wire to the other Kelvin connection, closer to the minus battery connection.

STEP 5: 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.

STEP 6: To check that you've wired the meter and shunt properly: you can do a simple check as follows: **1.** Turn <u>all</u> charging sources and all loads off, with the inverter <u>completely</u> off (not even in "standby"). Be sure that the meter shows very near 0. (0.0 to 0.1 amps.) **2.** Turn on a load and see that it measures correctly. Turning on a 40 W light bulb should cause the "amps" reading to become more <u>negative</u> by about 3 to 4 amps (12V system) or 1.5 to 2 amps, (24V system) plus possibly a little more for the inverter power. **3.** Check charging from each charging source. As you turn each charging source on, (solar, wind, battery charger, etc) be sure that the amps become more <u>positive</u> by about the amount you would expect from that source.

C: PROGRAM MODES: entering system parameter data into the TriMetric. After

installing TriMetric you must enter data characteristic of your system into the TriMetric for some displays to show correctly.

> •First, refer to table 1 (page 13) for summary of program modes which briefly describes all data which can be entered.
>
> • **For step-by-step instructions for how to enter and change the data** see Table 1 (page 13).

The following section describes in more detail for each programmable data shown in table 1: (1) the purpose of the data, and (2) how to choose data appropriate for your system.

C.1. **"Charged" setpoint voltage** and **"charged" setpoint amps.** As mentioned above, refer to Table 1 (p. 13) for how to observe and change these data.

Purpose of data: The "charged" voltage and amp setpoints provide information the TriMetric needs to determine when your battery set is "charged". As batteries are being charged, their voltage gradually rises, and/or the charging "amps" gradually falls. The TriMetric determines that the batteries are "charged" when (1) the voltage exceeds the "charged" setpoint voltage, and (2) the amps drops *below* the "charged" setpoint amps and (3) both conditions remain true for 20 seconds. When this happens, the "CHARGED" lamp will begin to flash (as indicated on front panel). At the same time the following happens:

> •The "days since charged" display (one of the "extra data" displays shown on the lower part of the front panel) will reset to 0 days.

Also, if the "automatic reset of amp-hours" preference is selected (which is usually the case--see "Preferences" section C.3 below) as soon as the batteries begin to discharge again (i.e. the "amps" become negative)

> •The "Battery % Full" display will reset to "FUL" or 100.
> •The "Amp-hours from full" display will reset to 0.

About voltage and current "charged" setpoints: Of these two setpoints, the "voltage" setpoint is the most critical, and the "current" setpoint less so. If you have only low current charging sources you can set the current setpoint to "OFF"— however both should be used if at least one of your chargers is a high current charging source such as a generator charger or inverter/charger. More specifics follow.

Choosing "charged setpoint volts":. 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. This is particularly simple with PWM solar controllers such as the Trace C-40, which charges up to a certain voltage (such as 14.4) and then limit the voltage to that value by gradually reducing the charging current. With this type you should set the TriMetric voltage setpoint to just below the charger's voltage setpoint. If you have two or more chargers, such as solar and generator, both chargers would normally be set to charge to approximately the same voltage, and the TriMetric should be set with the voltage low enough for either one to reach when the batteries approach full charge.

If you have an older "on/off" relay type charge controller that charges to 14.7 volts, and then stops charging, set the TriMetric for slightly below this voltage, say 14.6 or 14.5 volts

Choosing the "charged setpoint amps": If you have generator or other charger that has high charging current capability it becomes important to also set the "charged setpoint amps" in the TriMetric. This is because a high current charging source can force the battery voltage to rise and meet the "charged voltage" setpoint even though the batteries are not yet well charged. With such a charger, once the voltage reaches its maximum"bulk voltage" the charging current (amps) will start out high, then *gradually reduce* as the batteries become more charged. Proper adjustment of the "current setpoint" will insure that the TriMetric will not consider the batteries "charged" until the charging current goes below the setpoint amps. The lower you set this value, the more "charged" the battery must be before the TriMetric will declare the battery to be "charged". To set this value you must know the amp-hour capacity of your battery system. A reasonable value for the "current setpoint" setting would be C÷50 to C÷20 where C=battery system capacity in amp-hours. For example if your battery set has a capacity =700 amp hours, then amps setting=14-35 or so. Some experts recommend a setting as low as C÷90 for the battery to be really charged—however it may require extra charging hours to reach this lower value. After you enter the current setpoint the TriMetric will require that both the voltage setpoint be *exceeded*, and the current (amps) value be *less* than the current setpoint (for a continuous 20 seconds) before the TriMetric will indicate that the batteries are "charged".

Usually in float mode? Another possibility we should address is if your charging system stays much of the time in "float" mode, which may be true for a "line tied" systems. With a lead-acid liquid electrolyte battery the "float" voltage may be 13.4 volts (for 12V system) For a system that is usually in "float" mode, the TriMetric voltage setting can be just below 13.4, (or whatever the float voltage is) and the "amps" setting can be for some low value, such as C÷90 or so, or to a value which the "amps" would only go below during the "float" condition. Then the TriMetric will reset only after the "float" condition is attained.

Important: When the voltage setpoint is above 34.9 volts the TriMetric will go into the "48V mode", which requires the 48V adapter (TM-48V). Otherwise the voltage will read twice its correct value.

C.2. **Shunt type and charge efficiency factor:**

Purpose of data "Shunt type": This must be set according to the shunt type you have. This determines the sensitivity of the "amp" input to the TriMetric, so that it reads correctly for the shunt you have. If your "amps" readings appear to be off by a factor of 10, the most likely cause is this is not set correctly for your shunt.

Choosing value of "shunt type". If you have a 500A/50 mV shunt enter "**H**" ("**H**igh current shunt"). If you have a "100A/100 mV" shunt, you should enter "**L**" ("**L**ow current shunt"). Only the *ratio* shown is important to the TriMetric, so that from the TriMetric's point of view a 200A/200 mV or 300A/300 mV shunt is equivalent to a 100A/100mV shunt.

Changing the data: Note that when adjusting this data, each push of "reset" button causes the shunt type to change. (**H** to **L** to **H** to **L**, etc) Every other push changes the efficiency factor by 1%. Once you get the efficiency factor you desire, you may or may not need to push one more time to set in the correct shunt type.

Purpose of data: "charge efficiency factor" The purpose of the "Charge efficiency factor" is to compensate for the fact that you don't get as quite as much energy out of the battery as you put in; it causes the "amp-hours from full" display to discount the charging "amps" slightly compared with discharging amps. The "amp-hours from full" display becomes gradually more negative when the batteries are discharging, i.e. whenever the "amps" display is negative. For example if the batteries are discharging with "amps"= minus 10.0, the "amp-hours from full" display always gradually *decreases* by exactly 10 for every hour that goes by. Similarly, when amps are *positive* 10 amps (charging) the "amp-hours from full" display gradually increases by *almost* 10 amps for every hour. The "almost" has to do with "charge efficiency factor". If the efficiency factor is set to 100%, the amp-hours will go up by *exactly* 10 per hour (in this case), however if the efficiency factor is 90%, the "amp-hours from full" display goes up by only 90% of 10, or 9 amp-hours for every hour. The purpose of this is to account for the fact that you don't get as many amp-hours out of the battery as you put in, so that the TriMetric "amp-hours from full" display will give a reading of amp-hours which reasonably closely estimates your battery amp-hours.

Choosing values of "charge 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 from full"-- that is the meter will generally slightly over-estimates the actual amp-hours removed from 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.

<u>C.3.</u> **"Preferences"-changing the way "Battery % Full" is displayed, and "auto reset on/off."**
   Purpose of data: The "Preferences" allows you to make two (separate) choices as described here:
   (1) You can choose the way the "Battery % Full" display shows data: The "Battery % Full" is determined by dividing the "amp-hours from full" display by the "battery capacity" programmed data (see C.4), and the result is calculated internally in the TriMetric to 1%. However, realistically the accuracy in an actual battery system is not as good as 1%, especially as days pass since the batteries have been "charged" resulting in gradual loss of synchronization of "amp-hours from full" with the battery. That is the reason that the "normal" display for "Battery % Full" shows "FUL" when the internally calculated percent is between 92-100% (and over), and "LO" when the internal percent value is less than 27%, and in other cases it shows percent value in 5% increments, for example: 80, 85, 90%. If, however, you wish to show the data in its raw "1%" form, you can do this by selecting this preference, which will show the data to 1%. The "normal" display is recommended because it gives a more "honest" view of the accuracy to be expected from the "Battery % Full" display--and which is normally quite adequate for practical use.
   (2) You can turn "auto reset" on or off. Normally the "amp-hours from full" automatically resets its value to 0 whenever the batteries are "charged", i.e, the "charged" criteria are met (as described in full detail in section C1 above). In fact this is *necessary* in order that the "BATTERY % FULL" display read correctly. However it is possible to turn off this feature if you do not want the "amp-hours from full" display to automatically reset. For example if the TriMetric is being used to measure total load amp-hours for some period, or total solar input amp hours you may not want this number to reset to 0 by itself. (You can still *manually* reset this by using the "reset" button while displaying "amp-hours from full".)
   After deciding choices for (1) and (2) above, choose P0, P1, P2 or P3 according to this table:
   P00= "Battery % full" display mode ="**normal**" mode.   Automatic reset = **on** (normal)
   P01= "Battery % full" display mode ="**1%**" mode.   Automatic reset = **on** (normal)
   P02 = "Battery % full" display mode ="**normal**" mode   Automatic reset = **off**
   P03 = "Battery % full" display mode ="**1%**" mode.   Automatic reset = **off**.

<u>C.4</u> **"Battery capacity"**
   Purpose of data: This programmed data calibrates the "Battery % Full" display. For the "Battery % Full" display to work, the TriMetric must know how many amp-hours the battery holds when full. (called "battery capacity"). The "Battery % full" display shows "FUL" or 100 when the when the "amp-hours from full" equals 0. The "Battery % full" display shows "0" or "LO" when the "amp-hours from full" equals the "battery capacity" entered.
   Choosing battery capacity: The "battery capacity" means the number of amp-hours that your battery system holds when it is full. A value of battery capacity should usually be selected that is equal or *lower* than the actual capacity. It's recommended that you use a conservative (low) value for the TriMetric—50-75% of their factory rated value--considering that the stated capacity numbers for batteries tend to be optimistic. They are also usually measured at 77 degrees F, and capacity will decrease somewhat at lower temperatures. Furthermore, they are rated from when they are completely and utterly charged, which probably won't happen often in a real system.
   Computing battery system capacity: The battery capacity of a set of batteries in series and parallel can be computed if the capacity (in amp-hours) of each individual battery in the system is known. There are two simple rules: If several batteries are connected in series, the capacity of the series string is equal to the value (amp-hours) of the *least* capacity battery in the series. (This is like a chain whose strength is determined by its weakest link.) After figuring this for each series string you have, if the battery system has several series strings which are placed in parallel, then add up the capacity of each series string to get the total for the system.
   Measuring battery capacity: Another way to determine actual capacity is to use the TriMetric to measure it directly. First charge the batteries until they are "charged" according to the "charged" criteria. This means, in reality that they are "pretty well" charged--perhaps to 90% or so--because to get batteries really fully charged they need to absorb charge slowly (or equalized) for many hours. When they are charged, reset the "amp-hours from full" to 0. Then discharge by putting some loads on your system so it is discharging at an "amps" rate of C÷10 or C÷20, where C=approximate rated capacity of your battery system in amp-hours. For example, if your battery system is about 500 amp-hours, C÷20 is 25 amps (the exact value isn't important at these low discharge rates) until the voltage declines to a "low battery voltage" of about 11.0 volts. At that time read the "amp-hours from full" which indicates the approximate capacity. You'll need to be carefully watching the voltage from time to time to be able to catch the system when it is about this voltage. The capacity is affected by temperature, so you should note the temperature as well--the capacity declines with lower temperature. You will want to enter a capacity that represents the capacity at the lowest temperature you expect, since you won't usually know in advance the temperature when the battery is nearly empty. A lead acid battery at 32° F (0° C.) has about 70% the capacity at 77° F (25° C). It should also be noted that the effective capacity of the battery is less

at high current draw--although this is not a significant factor for the "typical" rates in a renewable energy system--it becomes more significant at rates exceeding C÷5 amperes.

C.5. **Days before "time to charge full" reminder,** or **"recharge interval"**

   Purpose of data: Every day which elapses in which the batteries are not fully charged will cause the "days since charged" display, (an "extra data" function) to increase by one. When "days since charged" equals or exceeds this "**recharge interval**" the "Time to charge full" ("**Ch.F"**) battery reminder will flash, to tell the user that the batteries haven't been fully charged during that interval. This reminds you to fully recharge the batteries periodically. There are two reasons to recharge your battery system frequently:

  (1) it is good for lead-acid batteries to be periodically recharged to completely reconvert the chemistry back to its "charged" state. (Lead-sulfate back to lead and sulfuric acid) If this is not done the battery reaction products become gradually more difficult to convert to the "charged" state, which is termed "sulfation". See also below for dis cussion of "equalization", section C.6.

  (2) For the TriMetric to show a realistic value of "Battery % Full" or "amp -hours from full" it must be occasionally fully charged sufficiently to reach the "charged" criteria so that the meter synchronizes with the battery. The "Battery % Full" and "amp -hours from full" will be most accurate right after this synchronization takes place--and will gradually lose accuracy after many days of use. The reminder will indicate that the "% BATTERY FULL" may be becoming less accurate.

   Choosing "days before recharge" time. 1-63 days or "OFF" **.** We recommend a number from 5 days to 14 days--with 5-7 days being better. Some conservative users will prefer a lower number--however if one tries to charge the batteries fully very often it may be good for batteries, but may make the system less practical.

   If you do not want to have the "battery reminder" feature activate, put "OFF" as the number of days**.**

C.6. **Days between "Time to equalize" reminder**

   Purpose of data: This causes the "Time to equalize" (**Ch.E**) battery reminder to flash after this number of days has elapsed since "equalizing" your batteries--i.e., when this programmed number equals or exceeds the "**days since equalized**" display, shown in the "extra data" display group on the bottom front panel. It reminds you when to perform a periodic "equalization" charge. **"Equalization" refers to a process of occasionally overcharging your batteries**-- which is usually recommended by manufacturers of "wet cell" lead acid batteries--but, however is *usually not recommended for sealed lead acid batteries, and can seriously damage these types.* The Trojan battery company, for example, recommends that their wet-cell batteries be equalized every 1-2 months. This helps to completely recharge the battery--which helps maintain the battery capacity. Some charge controllers, or battery chargers have an "equalize" mode which is controlled either manually or automatically. This TriMetric function is intended for use primarily for systems that require manual equalization--and reminds you to perform this after the programmed time. Placing the charger in "equalize" mode involves extra charging *after* the batteries have reached the "charged" criteria which allows the voltage to rise extra high for a period of time--for example the Trojen Battery Co. recommends charging to 15.5 volts (for 12V systems--double this for 24V systems) and keeping the batteries at that level for 2 hours. Other manufacturers may have different recommendations. It is usually advisable to check water levels in the batteries after equalization, as it causes some water loss. **After equalization has taken place you must manually reset the "days since equalized" display** (by pushing "reset" when the "days since equalized" extra data is displayed)**--this does not take place automatically.** This will turn off the "time to equalize" reminder, which will reactivate only after another equalization period has elapsed.

   Choosing "days between equalization" time. Enter 1-255, or "OFF" The time generally recommended is between 1-2 months--or 30-60 days. Check with the supplier of your batteries. **To prevent this reminder from coming on**, put "OFF."

C.7: **Reinstall all factory values.**

   Purpose of this function: This enables you to reinstall all factory values in the programmable values, and will overwrite any values previously installed. The factory values are shown in column 3 of table 1. To reset all values, first enter the program mode (from the "maximum voltage" function, as described in table 1.) You will see "FAC" in the display. Push the reset button until "ALL" flashes 3 times.

C.8. **"Low battery" setpoint voltage.**

   Purpose of data: When the value of "volts" equals or is below this programmed value, the battery reminder lamp will flash indicating "Batt. volts low". If the battery voltage drops too low this indicates that little energy is left in the battery. Obviously that means that power could go off soon thereafter. In addition, keeping the battery at low voltage condition for a long time is not good for a lead-acid battery. These are the reasons for the "low voltage" reminder. Low voltage is a good indicator of when the battery is nearly out of power (in contrast to the usual case when the battery is

30-90% charged, where the "BATTERY % FULL" is usually more reliable.) If you see that your batteries are at low voltage when your "BATTERY % FULL" indicator shows otherwise, you may want to check that your entered "battery capacity" (section C 4) above is correct.

Choosing value of "low battery" voltage. A 12 volt lead acid battery system could use from 10.5-11.5 volts. (24V system 21-23V)   A reasonable value could be 11.2 volts, for a 12V system. (Double this for 24V systems). **To turn off reminder about low voltage**, put in 10.0 volts.

D: TriMetric OPERATING INSTRUCTIONS: Most questions on TriMetric indicators and controls will be answered on **"TriMetric operation summary"** on page 12. The section below contains more detailed information.

D.1. VOLTS: 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.)

D.2. AMPS: This gives an instantaneous picture of energy entering or leaving your battery system. Use this to check that your charging system is working properly, and to see how much electricity your loads draw from the batteries. Current into the battery (charging) is displayed as positive, and discharge current is negative (with lighted minus sign). It is accurate to ±1%, ±the least significant digit. **The CHARGING lamp will be lighted whenever this value is positive.**

D.3. How to display the 6 "EXTRA DATA" functions, which are shown on the bottom of the front label: While displaying "Volts", "Amps" or "Battery % Full", push the "SELECT" button for several seconds, until you see "AH" in the display. Release "SELECT" and you will find that the letters "AH" will alternate in the display with the actual value of "amp-hours from full".   These will alternate in the display until you push and release "SELECT" again, which will show "dSC" in the display, which will alternate with the "days since batteries were charged". Likewise, successive pushing of SELECT will allow you to progress through the remaining 4 "EXTRA DATA" functions, after which the "Volts", "Amps" or "Battery % Full" displays will reappear.

D.4. Reset functions: Each "EXTRA DATA" display function shown (not "volts", "amps" or "Battery % Full") has a reset function. These are explained on the front panel below the RESET button. **In all cases you need to hold the RESET button long enough to flash the data 2 or 3 times before the data will be actually reset.** The flashing data shows what the RESET will accomplish, before actually implementing the RESET function. The purpose of this is to avoid resetting something you didn't intend to if the reset button is accidentally pushed.

D.5. Battery reminders display: See Operation Summary, page 12**.** This function is described in more detail in sections C.5, C.6 and C.8, on pages 7-8.

D6-A. "Battery % full": Exactly how does the TriMetric do this measurement? The water tank analogy: Imagine a water tank that is closed, so you can't easily determine the level of water inside the tank-- but you can tell when it is full, because then the water flows out of the top. This is analogous to a battery, because it is difficult to sense how much energy is in a battery when it is partially full, but it is not so difficult to sense (using Volts) when it is full. Now, assuming you know the total volume of the tank, when you withdraw water from the tank you could tell how much was left if you precisely measure the volume of water that you removed from the tank, and subtract this, and when putting water back in, add that back.   This is analogous to how the TriMetric measures how full the battery is.

   The TriMetric first senses that the battery (system) is full by sensing that the "battery voltage" is sufficiently high and "battery amps" is sufficiently low. (Exactly how the TriMetric determines that the batteries are full is explained in section C1 in these instructions. Correct parameters must be programmed for your battery system, as explained there.) When this occurs the "Battery % full" is automatically reset to "FUL or 100%". Starting from that reference point, flow of energy out of the batteries is measured by "amps", analogous to "gallons per minute" flowing out of the water tank. The TriMetric totalizes the amount of energy removed, by multiplying the "amps" times the time, resulting in "amp-hours" flowing out of the batteries, which is analogous to "gallons" in the water tank analogy. This value is subtracted from the value representing "full".   To give a percentage full reading, the TriMetric must be programmed (by the user-- see section C4) with the "capacity" of the batteries, in total "amp hours", analogous to total "gallons" capacity of the water tank.

   To complete the analogy, imagine that the tank leaks a small amount of water, which is analogous to what is called "self discharge" of a battery. To be sure you don't have an over optimistic view of how full the tank is, you could count

the volume removed exactly, at 100% rate, but when adding water back count only 94% of that volume. This is analogous of the "efficiency factor" which is set at the factory at 94%, however you may set any value from 60-100% into the TriMetric. (see section C2). **A precise, more technical description of how "Battery%FULL" is measured is given in section D8.**

D6-B. You have two options about how to display "BATTERY % FULL: It can display in 5% increments (80%, 85%, 90%, etc.) which is the factory default, or in 1% increments. Refer to section C3-1 for more information.

   Keep in mind for "Battery % Full" display to work accurately several conditions must be met . These are (**1**) The "Charged setpoints" for voltage and current must be correctly programmed in the TriMetric for your system. (see section C.1, pages 4-5) (**2**) The correct "battery capacity" must be entered into the TriMetric. (see section C.4). (**3**) The battery system must be synchronized with the battery by being fully charged *at least once*—and thereafter needs to be periodically fully charged (recommended at least once a week), so as to keep the meter "in sync" with the battery. The "battery reminders" feature is useful for this. (section C.5) (**4**) A reasonable value of "EFFICIENCY FACTOR" should be entered in program memory (see section C.2), and the normal "automatic reset" feature for amp-hours must be selected (see section C.3) to allow the meter to periodically synchronize with the battery when charged.

D7. **"AMP-HOURS FROM FULL".** This is the first display shown in the "Extra" display group, shown on the bottom half of the TriMetric front panel. As indicated on the front panel, you can view this by holding the "SELECT" button down for 3 seconds (starting while viewing any normal display).

D7-A: There are two ways that this display can be used. It is most commonly used to show the "amp hours" that have been removed from a full battery: This is what happens when the TriMetric is used and wired as shown on the wiring diagram (last page). It starts at a beginning point at 0 amp hours, after the amp-hours are "fully charged", and therefore reset to 0. This reset usually happens automatically when the battery is sensed as "charged" as described in section C1 of these instructions. However this reset can also be manually accomplished by pushing (and holding for 4 seconds) the "reset" button while observing the "amp-hour from full" display. As energy, (or more precisely "charge"), is withdrawn from the battery the "amp hours from full" decreases in proportion to the "amps" and the time. For example -2 amps for 5 hours, would cause the amp hours to decrease by 10 amp-hours. When charging, the opposite happens. However when charging, the "true" amp hours is slightly discounted according to the programmed value of "Efficiency factor" programmed. So if the battery is charged by 2 amps for 5 hours, and the "Efficiency factor" is 94, then the amp hours will increase by only 94% of 10, or 9.4 amp hours. This is to compensate for the fact that you don't get quite as many amp-hours out of a battery than you put in. See section C2 "Purpose of data, charge efficiency factor" for more information. When the "amp hours from full" is equal to the amp hour "capacity" of the batteries, you are out of power. Efficiency factor may be programmed from 60-100%:

D7-B: The TriMetric "amp hours from full" can also be used to monitor only a charging input source (such as solar or wind charging) or only a load, to see how much accumulated energy (or more precisely, charge) has accumulated over some period of time. Usually the "efficiency factor" will be set to 100% in this case (see section C2). Also the shunt will be wired differently: in this case the shunt needs to be wired so that it is in series with the desired current path to be measured. For example, if it is desired to measure solar input, the shunt must be wired in series with the negative wire to the solar charge controller. In this case, it is measuring "accumulated amp hours". In these applications the "automatic reset" would be turned off (see section C3). Typically you would begin the measurement by manually reset the Amp hours to 0 by pushing and holding the "RESET" button for 3 or 4 seconds, while observing the "amp hours from full" display. After that time true amp hours will be accumulated (negative or positive) until the "RESET" button is again used.

Display range of "amp-hours from full". This display will show amp-hours up to ±9,999 AMP HOURS. When the number exceeds 999, a flashing decimal point means "multiply the result by 1000." When you see −1.02, with flashing decimal point this means −1020 amp-hours.

D.8. **A more precise (and technical) description of BATTERY % FULL:** The way this is displayed is influenced by the PREFERENCES which are programmed as described in section C3. This allows a choice of showing **BATTERY % FULL** in **5%** increments, or in more precise **1%** increments. The reasons for this option are explained in section C3.

   If the PREFERENCES are selected for the 1% option (see section C3) this is how the TriMetric computes "BATTERY % FULL"

        "Amp hours from full" here means displayed *Amp Hours from Full*.
        "Capacity" here means *Programmed battery capacity* in amp-hours (see section C4)
       Case1: If "AMP-HOURS FROM FULL is less than 0 (negative) but not less than "Capacity"

$$\text{then "BATTERY \% FULL"} = \frac{Capacity - AmpHoursfromfull}{Capacity} \times 100\%$$

Case2: If "AMP -HOURS FROM FULL is less than (more negative than) "Capacity"
then "BATTERY % FULL"=0%

Case 3: If "AMP -HOURS FROM FULL" is greater than 0, (positive)
then "BATTERY % FULL"=100%

If the PREFERENCES are selected for the 5% option: then this number gets "rounded" to an approximate value. If between 93-100% it will display "FUL". When between 27% to 93% it will display the closest 5% value (e.g "65", "70", "75", etc). When it is below 27% it will show "0".

OTHER EXTRA DATA FUNCTIONS:

D.9. days since charged: Lead acid batteries should not go too long without being fully charged as explained more fully in section C.5. This display shows how many days have elapsed since the batteries were last charged. It shows with resolution to .01 day (about 14 minutes) and will read up to 650 days--after which the number will roll over to 0 again. When the "charged" parameters are met, (see section C.1) this number will be reset to 0. When this number equals or exceeds the number programmed as "days before recharge time" the **Batteries Reminder** light will flash, and will show "**Ch.F**" in the display (see also section C.5). When the meter is first powered up "days since charged" begins at 0. It may be reset manually to 0 (while viewing "days since charged") by pushing and holding the RESET button until the display data flashes 3 times.

D.10. Days since equalized: Equalization is an occasional deliberate overcharge of the batteries, usually recommended for "wet-cell" lead-acid batteries (not sealed lead acid types). See section C6 for more explanation of "equalization". This function can be used to tell you *how long ago* since your batteries were equalized. It is just a simple timer with resolution to .01 day, and will read up to 650 days which can be used to see how long ago equalization of the battery set was performed. When this number equals or exceeds the number programmed as "days before equalize time" (see section C.6) the **Batteries Reminder** light will flash, and will show "**Ch.E**" in the display. When you equalize batteries the "days since equalized" function should be manually reset to 0 with the reset button by pushing and holding the RESET button until DAYS SINCE EQUALIZED flashes 3 times. This will return this display to 0 and turn off the "Time to Equalize" reminder (if activated).

D.11. Cumulative battery discharge amp-hours: **Displays how many amp-hours have been withdrawn from the battery system over its lifetime.** This number starts at 0 when manually reset which would usually be at the time of initial installation of the batteries. Every time the current is negative (charge is leaving the battery) the display counts "amp-hours" down, but doesn't count any charging current (amps=positive).. It analogous to a car odometer to tell how much service the batteries have seen. When the batteries are replaced, this number can be noted measure the total energy which your battreies have delivered in their lifetime, which can be used to evaluate performance of the batteries and the level of care which they received. In case of power interruption to the meter you will only lose a maximum of 3.2 hours of this data--because this data is automatically stored every 3.2 hours. So if power should be temporarily disconnected from the meter, the number showing here will usually be slightly less than before, representing the value that was present when it was last stored into permanent memory, and will continue from that number. This number can be displayed to -999,000 amp hours, which is longer than most batteries would be expected to last. (Should it ever reach this high it should be reset--since it does not, as of this edition of instruction, just roll over to zero by itself after 999,999.)

Often battery life of "deep cycle" batteries is rated by the number of discharge cycles it will undergo without failure-- however this always assumes a fairly complete discharge during each cycle, followed by complete recharge. The life of deep cycle batteries is increased if the discharge depth is less--in fact the number of cycles of life is inversely related to the depth of discharge of each cycle--so if one discharges only half the amount during each "cycle" the battery will last about twice as many cycles. This is really just another way of saying that the battery life is related to the number of amp-hours removed.

D.12. Maximum battery voltage: This display shows the maximum battery voltage reached since the display was last manually reset with the "reset" button. Pushing "reset" (and waiting for display to flash 3 times) resets this to the present battery voltage. One use for this function is to check that a charging system is reaching the correct voltage specified by the battery manufacturer when charging your battery system. If this voltage is too high or too low the life of batteries will be compromised.

D.13. Minimum battery voltage: This display shows the minimum battery voltage reached since the display was last manually reset with the "reset" button. Pushing "reset" (and waiting for display to flash 3 times) resets this to the present battery voltage.. This function gives some information which indicates if the battery set was discharged too low.

TriMetric (model 2020) operation Summary

General notes: A flashing decimal point in the display means "multiply the number by 1000". The "AMPS", "VOLTS" or "BATTERY % FULL" lamps flash when the TriMetric is in a program mode. See right for how to enter data in the TriMetric. (program modes)

SELECT button: Momentarily push "SELECT" to view "VOLTS", "AMPS", "BATTERY % FULL" or to "blank" the display. (Blanking the display reduces the TriMetric current draw from 30 to 16 milliamperes.) Hold the "SELECT" button down for more than 2 seconds to select the "AMP-HOURS FROM FULL" function, and the other "EXTRA DATA" functions which are shown below on the panel.

VOLTS: Shows volts across the battery.

AMPS: Shows amps charging or discharging. A positive number means "charging" and a negative number means "discharging".

CHARGING light: Shows that batteries are charging (i.e. amps are positive). Starts flashing when the battery is charged--i.e. when "charged" parameters are being met. See section C1 for information on "charged" parameters. Then remains flashing until battery first starts discharging.

"BATTERY % FULL" shows amp-hours expressed as a percentage of a full battery. It is the "amp-hours from full" (below) divided by the total battery capacity, in amp-hours. (The correct number of "amp-hours" battery capacity must be programmed into the TriMetric. See section C4). Also it is important to occasionally charge fully to synchronize the TriMetric with the battery (once a week or more recommended) for this number to be accurate. There is a choice of two ways to display this number. (See section C3 and D6-B.)

BATTERY REMINDERS light: lamp flashes when (1) batteries should be recharged, or (2) should be equalized, or if (3) battery voltage drops too low. When flashing, (and when VOLTS, AMPS or BATTERY %FULL is being displayed) the letters Ch.F, Ch.E, and/or b.LO-- whose meaning is explained on panel--will flash in display every 5 seconds to tell you what the reminder is:
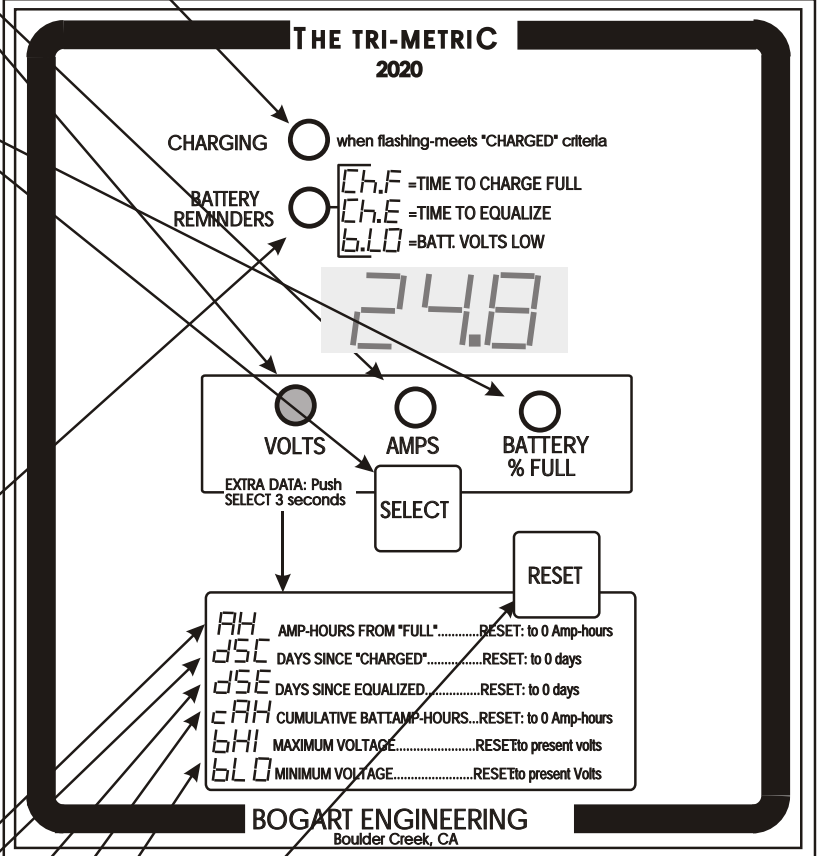**Ch.F="time to charge full"** means that too many days have passed since the batteries were last "fully charged" (i.e, since the TriMetric "charged" parameters were met-- see section C1.) You can program the desired maximum number of days. (section C5)
Ch.E="time to equalize" means that the (user programmable) equalization interval (in days) has been exceeded, and that batteries should again be equalized. *After they have been equalized, it is necessary to manually reset the "days since equalized" number to 0 to turn off this reminder.* "Equalization" is a controlled overcharge of the battery. (see section C6)
b.LO="battery low" means that the battery voltage has dropped below the (user programmable) "low battery voltage". (See section C8).
Disabling these functions: Any or all of these reminders may be disabled if they are undesired. (See sections C5, C6 C8.)

THE TRI-METRIC
2020

CHARGING ○ when flashing-meets "CHARGED" criteria

BATTERY REMINDERS ○

$Ch.F$ = TIME TO CHARGE FULL
$Ch.E$ = TIME TO EQUALIZE
$b.LO$ = BATT. VOLTS LOW

24.8

VOLTS   AMPS   BATTERY % FULL

EXTRA DATA: Push SELECT 3 seconds

SELECT   RESET

AH	AMP-HOURS FROM "FULL"	RESET: to 0 Amp-hours
dSC	DAYS SINCE "CHARGED"	RESET: to 0 days
dSE	DAYS SINCE EQUALIZED	RESET: to 0 days
cAH	CUMULATIVE BATT AMP-HOURS	RESET: to 0 Amp-hours
bHI	MAXIMUM VOLTAGE	RESET to present volts
bLO	MINIMUM VOLTAGE	RESET to present Volts

BOGART ENGINEERING
Boulder Creek, CA

AH = "Amp Hours from Full" display measures the number of amp-hours which have been removed from a full battery. It shows about how many amp-hours away from "full" that your batteries are. For an accurate number, the battery must be occasionally charged fully so the TriMetric can synchronize with the batteries--at least once a week is recommended. See section D7 for more information on this function.

RESET button: Each "EXTRA DATA" display function (as chosen by the SELECT button) has a RESET function, which is described below on the panel. The RESET button does not do anything when "VOLTS", AMPS" BATTERY % FULL" or if the the display is blanked. **To reset a function, you must hold down the reset button so this display first flashes 3 or 4 times**--to make sure you don't accidentally reset something you didn't intend to.

dSC = "Days since charged" display shows how many days ago since the batteries were fully charged--ie., how many days ago since the batteries met the TriMetric "charged" parameters. See section C5.

dSE = "Days since equalized" display keeps track of how many days ago since the batteries were equalized. When you equalize the batteries you must use the reset button to *manually* reset the "Days since equalized" to 0-this will also turn off the "time to equalize" battery reminder. See section C6.

cAH = "Cumulative battery discharge amp-hours" Shows the total amount of battery discharge that has taken place in the life of the battery. (Does not count charging--only discharging.) This number should be reset to 0 when changing the battery set--then this is the "bottom line" number showing how much service your batteries have given so far. This number is not lost if TriMetric power is disconencted. Shows to -999,000 amp-hours--a **flashing decimal point means multiply the number by 1000.** See section D11.

bLO = "minimum battery voltage" and **bHI = "maximum battery voltage"** Shows the lowest and highest battery voltage since the this function was last manually reset. See section D12-D13.

rev. 02/20/03

TriMetric Program mode summary

entering system data into the TriMetric

After installing the TriMetric, correct data relating to your system should be entered in the "program modes" of the TriMetric so that the TriMetric data shows correctly. This data is retained even if power is disconnected from the TriMetric.

Each of the **display modes** (left column of table) has a program mode which allows you to enter some **programmable data** characteristic of your system. Note that column 3 of this table has space for you to record the data you put in, and also shows the preinstalled factory values . You can reinstall these factory values: see second to the last row of table..

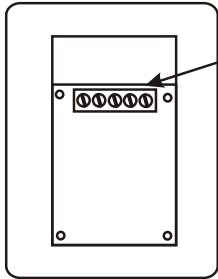**Follow the first 4 steps to change or observe <u>one</u> of the programmable data shown in the table:**

(1) Choose a PROGRAMMABLE DATA that you want to change (column 2). Use the SELECT button to select the DISPLAY MODE (column 1) corresponding to the PROGRAMMABLE DATA you wish to change.

(2) First push SELECT—then (quickly) push RESET so they are both momentarily pushed together—then release both . (If you don't do it quickly enough you'll get the "A-HR" display instead. In that case, you will have to start with step 1 again.) Flashing volts/amps/Battery % lamp(s) confirms you are in a program mode. The numerical display will now show the "programmable data" shown in table.

(3) To change data slowly, push "RESET button repeatedly. To change data faster, hold RESET down for several seconds.

(4) When desired data is shown, push SELECT to exit program mode. Now you have set that data into the TriMetric.

(5) Now, decide on the next item you wish to program, and repeat starting at step 1.

DISPLAY MODE	PROGRAMMABLE DATA and ADJUSTMENT RANGE	Factory value. Your value	WHAT IT IS FOR (SUMMARY) Where to find more information.
VOLTS	"Charged" setpoint voltage. **10.0** to **65.0** volts	**14.4**	TriMetric determines that battery is charged when actual volts is *greater* than setpoint volttage, and amps is *less* than setpoint amps, **(see section C.1)**
AMPS	"Charged" setpoint amps **1** to **100**, amps or "**OFF**"	**OFF**	**NOTE:** When voltage setpoint is greater than 35.0 Volts, TriMetric goes automatically to 48V mode
BATTERY % FULL	Charge efficiency factor, and shunt type Efficiency factor: **60** to **100**. Shunt type: "**H**" or "**L**".	**H94**	Charge efficiency factor determines discount rate for amp-hours charging. **(See section C.2 and D.7)**. Shunt type: H = 500A/50 mV. L=100A/100mV.
blank display (after "BATTERY% FULL"	Preferences: (1)BATTERY % FULL: data display: select "Normal" or "1%" (2) Auto reset of "amp-hours from full": select "on" or "off". "**P00**, **P01**, **P02** or **P03**	**P00**	P00=auto reset **on**, BATT.%FULL display = **normal.** P01=auto reset **on**, BATT.%FULL display=**-1%**. P02=auto reset **off**, BATT.%FULL display=**normal.** P03=auto reset **off**, BATT.%FULL display=**1%**. **(See section C.3)**
(AH)Amp hours from full	"Battery capacity" amp-hours **10** to **2500** amp hours. **Note: flashing decimal point means "multiply number by 1000";** so 1.02 means 1020 amp hours	**400**	Calibrates "battery % full" display. **(see section C.4 , D.6 and D.8)**
(dSC) Days since "charged"	Days before "time to recharge" reminder **1-63** days, or **OFF**	**OFF**	When Days since "charged" exceeds this, "time to recharge"(cH.F) reminder will display. **(see section C.5)**
(dSE) Days since "equilized"	Days before "time to equalize" reminder. **1-255** days, or **OFF**.	**OFF**	When Days since "equalized" exceeds this, "time to equalize (cH.E) reminder will display. **(see section C.6)**
(cAH)Cumula-tive amp hours	NONE	N/A	N/A
(bHI) Highest batt. voltage	Puts **fac**tory values: Hold RESET until "ALL" flashes 3 times.	N/A	Reinstalls factory data for all the programmable data as shown on this table, column 3. **(see section C.7)**
(bLO) Lowest batt. voltage	"Low battery" voltage point. **10.0** to **65.0** Volts	**10.0**	When "VOLTS" is less than "low battery" volts, "low batt reminder" will display. **(see section C.8)**

TABLE 1

M+ terminal must be connected to + with short wire (except as noted on page 3 of instructions "For unusual cases...").

Magnified view of 5 SCREW TERMINAL STRIP located on circuit board.

SIG

G2   +   G1

M+   SIG   G2   G1
     +

Back view of **TriMetric** battery monitor (without back cover.)

SHUNT TO METER CABLE: Can be up to 150 ft. long if cable has #18 or larger wires, or 50 feet using #22 wires. Twisted pair wire should not be necessary. However, if it is used, we recommend wiring it as shown in the diagram. Use one twisted pair for the G1 and + wires, and another twisted pair for the G2 and SIG wires (as shown). For long cable runs the M+ terminal can be connected separately as described on page 3 "For unusual cases...."

IMPORTANT NOTE: The two wires: G1, G2 must be connected to each other ONLY right at the shunt terminal at the small screw (Kelvin connection) for accurate current measurements. Don't connect them together at the meter and run one wire to the shunt. (Otherwise meter will show residual "amps" when it should be showing zero.) Also, good connections must be maintained for accuracy.

TECHNICAL NOTE: The reason the G1 and G2 wires must be connected together ONLY at the shunt, is that to measure current through the battery the TriMetric measures voltages across the shunt between the SIG and G2 wires as small as 10 microvolts. On the other hand, the voltage drop across the G1 wire from the shunt to the meter (due to current flow through the wire) can be 10,000 times this, or 100 millivolts. Only when the connections are made as shown, the G2 wire carries no current, thus there is no error causing voltage drop across it. (1 volt=1000 millivolts = 1,000,000 microvolts.)

NOTE: The SIG wire must be connected to the small screw (kelvin connection) on the shunt, not the larger bolt which connects to the battery. Otherwise "amps" measurements will be inaccurate.

FOR SAFETY: Place a **2 amp** (fast blow) fuse in series with the + wire **near the battery,** as shown. That way, if there is ever a short between this wire and the other wires, you won't melt down the wires, you will only blow the fuse.

IMPORTANT: Be sure the negative lead from your solar charge controller is NOT connected here– but to the other side of the shunt. Otherwise the TriMetric will not measure your solar amps.

KELVIN CONNECTIONS: These are the two smaller screws on the shunt which should be used for current sensing wires only. For measurement accuracy, never connect wires containing high currents to these connections.

SYSTEM GROUND (if used) Be sure the minus terminal of charge controller, inverter, and all other loads and chargers connect here (not the negative post of battery).

– TO CHARGING SYSTEM (SOLAR PANELS including controller, CHARGER, ETC.) AND ALL LOADS +(INVERTER, ETC.)

12 OR 24 VOLT BATTERY SYSTEM.

SIG   G1

           G2

SHUNT: 50 MV/500 AMP OR 100 MV/100 AMP

SHUNT NOTE: Use either a 50 mv/500 amp shunt or 100 mv/100 amp shunt. Shunt must be connected to minus side of battery. *To read correct current and amp-hours, TriMetric battery monitor must be programmed for correct shunt type being used, as described in instructions.*

TriMetric BATTERY MONITOR CONNECTIONS. Please read all notes carefully. (Technical notes optional.)   BOGART ENGINEERING   5/1/98