CRUISING EQUIPMENT Co.

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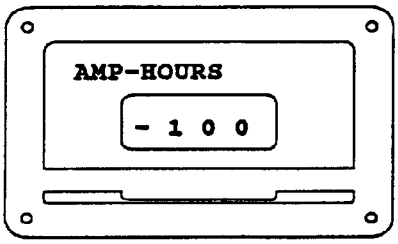
AMP-HOUR METER INSTALLATION MANUAL 15 April 1992

FUNCTIONS and FEATURES



AMP-HOUR meter counts Amp-hours (Ahrs) used from the battery and displays them with a minus sign. When charging begins, Ahrs are added until the display reads 0 when the battery is fully charged. Overcharging will continue to add Ahrs and they will be displayed as a positive number. When discharging begins from the overcharge state, AMP-HOUR meter automatically resets to 0 and starts counting down as Ahrs are used.

AMP-HOUR meter automatically compensates for efficiency during charging. The charge efficiency of every battery is a little different, but if 1Amp-hour is removed from a battery it must be charged with 1.1 to 1.2 Ahrs to replace it. AMP-HOUR meter is factory calibrated with this standard efficiency, but may be field adjusted to your exact requirements if required.

BASIC BATTERY FACTS

1) An Amp-hour is 1 Amp for one hour, or 2Amps for 1/2 hour, or 4 Amps for 1/4 hour, etc. 2) Batteries for cycling service are normally rated with a 20 hour rate which means a 100 Ahr battery will sustain 5 amps for 20 hours. 3) Our Mid-Capacity Rule says that discharge below 50% shortens life and charging more than 85% takes too long with an engine driven charging system. So 35% of the battery capacity is all that is normally available.

SYNCHRONIZING AMP-HOUR METER TO A CHARGED BATTERY

A charged battery has zero Ahrs removed. Synchronizing AMP-HOUR meter to read zero when the battery is charged insures that you always know the net number of Ahrs removed. The following charge parameters indicate when a charging system has put as much energy into a battery as it normally can. Your AMP-HOUR meter must be synchronized to the battery according to these parameters.

CHARGED PARAMETERS

If you charge your batteries differently on shore power than when away from it, you may have to resynchronize when changing charging methods.

QUAD-CYCLE Charging Systems

If you are using The QUAD-CYCLE charging Method (see page #6), the battery is charged when QUAD-CYCLE switches to the Float cycle. If properly adjusted, this will be when the charging current at the Acceptance Voltage (142V to 14AV) drops to about 2%-2.5% of the battery capacity.

Constant Voltage Charging Systems . -

Constant voltage charging systems have restored as much charge to a battery as they can when the voltage reaches the maximum regulation point (typical 12V system is set at 13.8V) and the charging current drops to less than 1% of the battery capacity. It can take more than 8 hours for a battery to reach this state of charge. If you are using an engine driven charging system and trying to limit engine running, you probably will only charge until the current drops to 3%or 10% of capacity. AMP-HOUR meter should be synchronized to whichever of these charge levels reached in normal operation.

Using Specific Gravity

Accurate battery current measurement is necessary to determine the charged parameters in the two previous methods. Specific gravity of the battery can also be used to determine the charge level of a battery. Regardless of the charging system a battery is charged when the specific gravity shows no increase for three hours, when measured at 1/2 hour intervals.

There are two ways to initially synchronize your AMP-HOUR meter to a battery that has met the above parameters: 1) If AMP-HOUR meter is installed on a charged battery, it is in sync as soon as power is supplied to the meter. 2) If AMP-HOUR meter is installed on a partially charged battery, simply charge until the charged parameter: are met. AMP-HOUR meter will begin counting up and will display charging Ahrs as positive. When the battery is charged, turn off the charging source. As soon as discharging begins AMP-HOUR meter resets to zero, begins counting down, and is in sync.

If AMP-HOUR meter should ever get out of sync with the battery state of charge it may be resynchronized by either of the above methods. If you must manually reset AMP-HOUR meter to zero you may do so by turning off the 12V supply. This is easily accomplished by briefly removing the 2 Amp fuse shown in the installation manual.

OVER-CHARGE AMP-HOURS

If the battery is charged, AMP-HOUR meter is in sync, and calibrated with the appropriate charge efficiency, over-charge Ahrs are displayed as positive. Some accumulation of over-charge Ahrs is normal with all systems that are continuously connected to a charger. A system that maintains a 100 Ahr battery at the Float voltage will probably have less than 100 A flowing into the battery. This means that 2.4 Ahrs of over-charge would accumulate in a 24 hour period. If the charging system is a constant voltage type set at 14.2 volts, 1 Amp of current may be flowing all the time after the battery has reached the charged parameters. The battery will probably be gassing and you may see an accumulation of 24 Ahrs or more per day. This is a clear indication that you are destroying your battery by overcharging. Check your AMP-HOUR meter before turning off a charging source that has been connected for several days to see that you have not accumulated too many over-charge Ahrs. Over-charge Ahrs are erased and AMP-HOUR meter resets to zero when discharge begins.

Systems that use QUAD-CYCLE Regulators will accumulate a few over-charge Ahrs during Conditioning. This is normal and insures that AMP-HOUR meter stays in sync with the battery state of charge.

HOW TO USE AMP-HOUR METER

MANAGEMENT PHILOSOPHY

AMP-HOUR meter is a guide to the battery's state of charge. An amp-hour allocation that may be used from the battery should be established. When that allocation has been used you should begin charging. The Mid-Capacity Rule says you should begin charging when AMP-HOUR meter shows that 33% to 50% of the battery capacity has been used. If the battery is normally only charged to the 85% level then only 35% is available. This is the most common case for Marine and RV installations that are trying to minimize engine time. If the battery is normally 100% charged you may use 50% of the capacity. The Mid-Capacity rule is a very conservative approach to battery use. Occasionally discharging a battery more deeply and not recharging until the AMP-HOUR meter reaches zero is perfectly acceptable. The Mid-Capacity rule is intended as a design and operating guide line not an inviolable law which must be obeyed without exception.

MANAGING CHARGING WITH A SINGLE BATTERY SYSTEM

Using AMP-HOUR meter with a single battery system is simple. The Mid-Capacity Rule says that 35% of the battery capacity is all that is really available for use, if minimum charging time and maximum life is desired. If the battery has a maximum of 100 Ahrs capacity and is charged to the normal charge level of 85% the optimum way to use your AMP-HOUR meter is to discharge until the display reads -35. You should never allow it to go below -50. When you charge, do so until the meter reads zero. If charging is terminated before AMP-HOUR meter reads zero you will have less than 35% of your capacity available. For example if the display reads -10 when you terminate charging you have only 23 Ahrs to use.

MANAGING CHARGING WITH A TWO BATTERY SYSTEM

With a two battery system, the same basic rules apply. For example: Suppose you had two 200Ahr batteries for a total system capacity of 400 Ahrs and that they were normally charged to the 85% level. You should charge when AMP-HOUR meter shows that you have used 35% of 400 Ahrs or when the display reads about -140. You should never allow it to go below 30% or -200 Ahrs.

In the ideal system you would use battery #1 until the display read -70 and then switch to battery #2 and use it until AMP-HOUR meter displayed -140. You would then charge both batteries until AMP-HOUR meter read zero.

If charging is terminated before AMP-HOUR meter reaches zero the optimum number to switch batteries may be calculated by dividing the number in the display by two and adding it to the allocation available from one battery. In the example system, if charging was terminated when AMP-HOUR meter reached -40 you would use battery #1 until the display read -90 and then use battery #2 until the display read -140.

If cost is not a factor, an AMP-HOUR meter per battery is the best way to know the state of each battery.

BATTERY CAPACITY TESTING

Your AMP-HOUR meter can be used to conduct periodic capacity tests that tell you the actual amount of energy your batteries can store. A capacity test should start with a battery that has been properly charged and conditioned. The objective is to find the maximum available capacity.

Deep cycle battery capacity is usually stated as a 20 hour discharge rate. A 100 Ahr battery will provide 5 amps for 20 hours. At discharge rates above 5 amps, the battery will not supply 100 Ahr. If you are drawing 100 amps out of the battery it will last less than one half hour. Listed below are approximate capacities at different discharge rates.

CAPACITY AT VARIOUS DISCHARGE RATES
(percentage of 20 hour rate)

Hours to Discharge	Capacity (percent of rating)
20	100%
10	89%
S	78%
3	66%
1	45%

To determine capacity, turn on a load that draws approximately 3% of the declared batter capacity. Measure the current with an ammeter. The load should be constant, such as incandescent lighting. When the battery voltage reaches 10.5 volts, hopefully about 20 hours later, turn off the load and look at your AMP-HOUR meter. The number displayed is the capacity at the test current. If it was less than 20 hours you can determine the capacity with some arithmetic. For example: Assume a battery rated at 100 Ahr and apply a 5 amp load. Suppose it took 10 hours for the voltage to reach 10.50 volts. AMP-HOUR meter would display -50 Ahr. This is the 10 hour capacity. Dividing 50 by 89% (10 hour rate) from the table above, you determine that actual 20 hour capacity is 56 Ahr.

To verify that, you could repeat the test at 2.8 Amps, the 20 hour discharge current, and see if it will sustain it.

NOTE: Large intermittent loads like engine starting, or limited inverter use, do not significantly affect the average discharge rate. In a well designed system the average discharge rate should be less than the 20 hour discharge rate (i.e. 5% of capacity).

REQUIRED READING

Before connecting the wiring for the AMP-HOUR Meter, install the shunt as indicated. All wiring should be done before installing the fuse.

GENERAL NOTES

1) All wiring to the AMP-HOUR meter should be #18 AWG. Marine installations should use #16 AWG.

2) Shunt Sense leads should be a twisted pair.

3) If your starter draws more than 200 amps please see #2 and #3 Tips and Tricks on following page.

AMP-HOUR METER INSTALLATION TIPS AND TRICKS

1) Battery current is sensed with a shunt which is a very precise, very small, resistance which can be inserted in series (in line) in the wire whose current flow you wish to measure. The current is measured by sensing the voltage drop across this very small, but exact resistance. The AMP-HOUR meter normally uses a 100 mV, 100 amp shunt. That means that when 100 amps flows through the shunt there is a 100 mV drop across it. Thus l amp equals 1 mV. (The meter may also be ordered in a 500Amp 50mV version. This version should be used if there are frequent discharge currents above 150 Amps.)

2) Typically, the AMP-HOUR meter is installed to measure the total Ahrs consumed from the battery system. In a two battery installation both batteries' negatives are connected to one side of the battery shunt and the negative feed to the engine and all the rest of the load is connected to the other.

3) If starter current exceeds 200 amps, the starter negative must be connected to the battery side (BSHB) of the battery shunt so that starter current does not flow through it. If your alternator is of the grounded case type this means that the alternator current will not be flowing through the shunt. The alternator ground must be isolated from the engine and run to the load side (BSHG) of the battery shunt to be able to measure the current going into the battery from the alternator. Isolated negative output alternators are available and we strongly recommend them. With isolated negative output alternators remember that instrumentation and other loads grounded directly to the engine block will not be measured unless their negatives are relocated to the load side of the Battery Shunt. Special high current shunts are also a solution and may be ordered from us. A separate engine starting battery whose negative is connected directly to the engine also solves the problem.

4) We have shown several wires connected to the load side of the battery shunt in the wiring diagram. If more than a few wires need to be connected here, it is best to use a 2/0 jumper from the shunt to a good negative bus. We recommend that the only connections actually made on the shunt, besides the sense leads, are the two batteries, the negative for the engine, and the the feed to the negative bus. The negative bus should be a solid copper or brass bar with many threaded screws under which the negatives for all of the loads on the boat may be secured. It should be fed with a conductor of sufficient size so that there is no appreciable voltage drop even under full load.

WIRE BY WIRE INSTRUCTIONS

There are five wires in the cable for the AMP-HOUR meter.

The BLACK WIRE is the ground. It must have a good connection to the big bolt of the battery shunt. It should be connected on the side of the shunt farthest from the negative battery terminals (referred to as the BSHG (Grounded) side of the shunt). If you also have a QUAD-CYCLE, connect this wire to terminal #1 AGND on the Monitor Terminal Block.

The RED WIRE is +12V. It is the +12V supply. It may be supplied from the common of the battery switch, or directly from one of the batteries. There are advantages to each.

Option #1: Supplied from the common of the battery switch ensures that the power that it takes to run the AMP HOUR meter is being supplied from the battery that is being used. If, however, the battery switch is turned off, AMP-HOUR meter resets to zero. If the batteries are on a charger during the time that the battery switch is off and are fully charged when the battery switch is turned on again this is not a problem since the batteries and AMP-HOUR meter arc in sync. Likewise if the battery switch is never turned to the off position this is no problem. It, however, the batteries are switched off and then switched back on in a partially charged state AMP-HOUR meter will reset to zero but will be out of sync with the battery state of charge. You will need to charge the battery to re~synchronize the AMP-HOUR meter.

Option #2: If AMP-hour meter is wired directly to one of the batteries the problem of accidentally de~powering the meter and resetting it to zero is totally avoided. Be aware, however, that AMP-HOUR meter uses a small amount of current (-.04 A) and it is always being supplied from the battery to which it is connected. In either case this wire should be protected with a 2 Amp in-line fuse.

The GREEN WIRE is connected to the SMALL SCREW ON THE BATTERY SIDE of the battery shunt (BSHB). This wire should be located exactly as described to ensure accuracy in current measurements. The two wires that run from the Battery shunt sense terminals to the GREEN AND ORANGE wires should be a twisted pair. If you also have a QUAD-CYCLE this wire should be connected to terminal #7 BSHB on the Monitor terminal block.

The ORANGE WIRE is connected to the small screw on the Grounded or load side of the battery shunt (BSHG). This wire should be located exactly as described to ensure accuracy in current measurements. If you also have a QUAD-CYCLE this wire should be connected to terminal #8 BSHG on the Monitor terminal block.

The WHITE WIRE supplies the AMP-HOUR meter display backlighting. It should be supplied from a switch that controls other instrument lighting. It may be connected to +12 V along with the red wire if you wish the lighting to be on all the time.

Note: You may make your own twisted pair wire by chucking up two wires in an electric drill motor and twisting them by running the drill motor until there is a twist every inch. A wrap of tape every 16" will keep the wires together and make them easier to pull through the raceway.

ADJUSTING CHARGE EFFICIENCY

Please do not adjust the Charge Efficiency until you have gone through at least ten discharge/charge cycles and observed the behavior of your system with your AMP-HOUR meter. Extensive experience in many different systems has proven that the factory adjustment is conservative enough to ensure a fully charged battery when AMP-HOUR meter reads zero and yet not accumulate an excessive negative number. If possible we encourage you to remove any accumulated negative Ahrs by periodically thoroughly charging the battery. AMP-HOUR meter does not affect the charge efficiency of the charging system. Adjusting the Charge Efficiency Pot only calibrates AMP-HOUR meter to properly count the charging Ahrs returned by the charging system.

ADJUSTMENT RULE

If your charging system meets the charged parameters, and when it does, consistently leaves AN INCREASING NEGATIVE NUMBER IN THE DISPLAY, IT MEANS THAT THE CHARGE EFFICIENCY IS UNDER-ESTIMATED. SLOWLY TURN THE POT COUNTER-CLOCKWISE. If your charging system meets the charged parameters, and when it does, consistently shows A POSITIVE NUMBER IN THE DISPLAY, IT MEANS THAT THE CHARGE EFFICIENCY IS OVERESTIMATED. SLOWLY TURN THE POT CLOCKWISE.

The Charge Efficiency adjustment is on the left side of the back box. A very small screwdriver is required to adjust the potentiometer (pot) located behind the access hole. Turning the pot clockwise decreases the Charge Efficiency and counter-clockwise increases the Charge Efficiency. The pot has 280 degrees of rotation and allows adjustment between 55% and 100% efficiency. This means that an adjustment of one percent of efficiency is only 5 degrees of pot rotation. Please be very careful when adjusting Charge Efficiency, you should never turn the pot more than 15 degrees in a single adjustment. After making an adjustment do not make another until you have gone through several discharge/charge cycles and have observed a consistent over or under estimation of charge efficiency.

It may help to remember that the factory setting for Charge Efficiency is 87% which means that it requires a charge rate of 69 Amps to cause AMP-HOUR meter to count up one Ahr per minute. If the Charge Efficiency is increased, AMP-HOUR meter will count up one Ahr in less than a minute with this charge rate. If the Charge Efficiency is decreased it will take more than one minute for AMP-HOUR meter to count up one Ahr with this charge rate.

NOTE: AMP-HOUR meters prior to Serial #1900 used a Charge Efficiency of 83%.

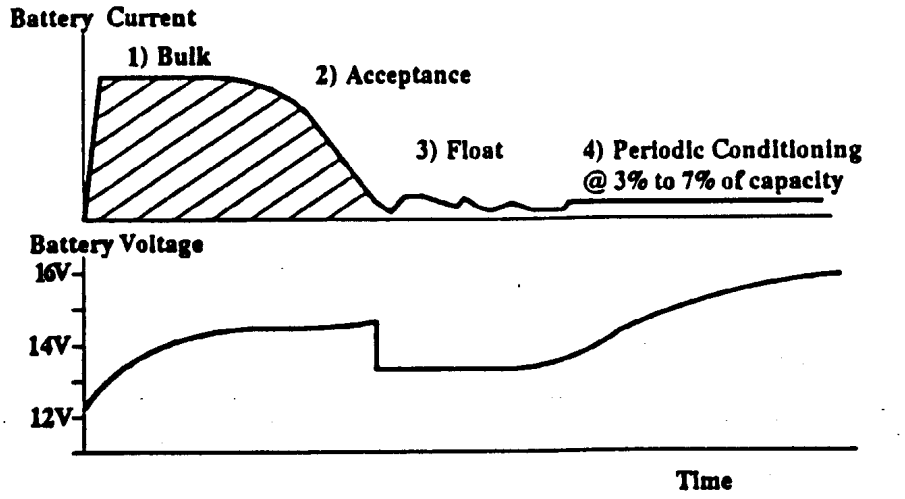
Adjusting Charge Efficiency to display a small positive number (less than 1% of battery capacity) just as the charged parameters are met insures that your AMP-HOUR meter will stay in sync with the battery state of charge. If the Charge Efficiency is adjusted so that a small negative number is displayed when the charged parameters are met, it will gradually cause the accumulation of discharge Ahrs that will periodically have to be removed by over-charging or by resynchronizing.

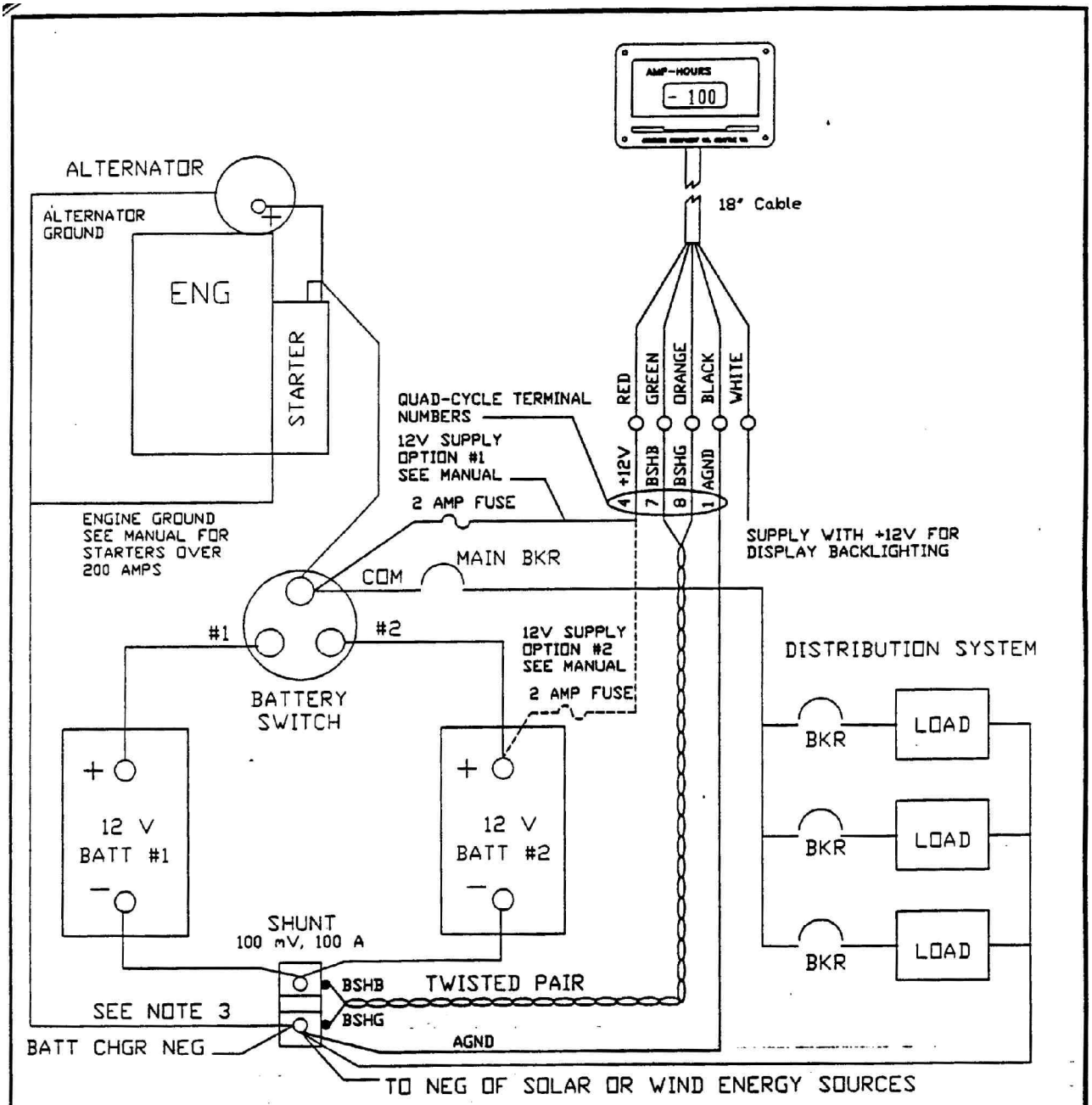
Once the charge efficiency is set the best way to be sure the batteries are charged, and AMP-HOUR meter is in sync, is to charge until the meter reads zero.

ABOUT THE QUAD-CYCLE CHARGING METHOD

The QUAD-CYCLE Regulator/Monitor combines a digital monitor and the best alternator regulator available in the same unit. The following information is given to help synchronize your AMP-HOUR meter. The QUAD-CYCLE CHARGING METHOD begins with a CHARGE CYCLE that supplies a bulk current to the batteries. (See The Ideal Charge Curve.) The CHARGE rate is limited by alternator capacity or battery capacity. The CHARGE CYCLE continues until the battery reaches 14.2 to 14.4 volts. ACCEPTANCE CHARGING now begins. The battery accepts whatever current it can, until it is accepting only 10% of the bulk CHARGE rate. At this point the battery is charged and QUAD automatically switches to the FLOAT cycle to maintain the batteries safely at about 13.2 volts without water consumption. QUAD-CYCLE's exclusive CONDITION cycle allows for constant current equalization of the batteries for maximum capacity and life. The batteries should be CONDITIONED every 30 days, particularly during deep cycling service.

QUAD-CYCLE'S IDEAL CHARGE CURVE





NOTES:

(1) Shunt 300% over-current rated.

(2) All AMP-HOUR Meter wiring #18 AWG minimum. Shunt leads are twisted pair.

(3) Starter connected to load side of shunt if less than 200 amps full load. See manual.

DWG: AMP-HOUR METER FOR TWO BATTERIES WITH ENGINE ALTERNATOR CHARGING SYSTEM

NO: AHRWIRE.DWG REV: 8/7/90

CRUISING EQUIPMENT CO.