COMBINER +

12V Battery Combiner and System Monitor
West Marine MODEL 288508

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- **THREE BANK 130 AMP BATTERY COMBINER**
  - Automatically puts battery banks in parallel for charging
  - Adjustable cut-in and drop-out combining voltages
- **THREE DIGITAL VOLTMETERS**
  - Resolution to 0.01 volts
  - Adjustable high and low voltage audio alarms
- **COMMON AMMETER**
  - Reads 0.01 to 1000 amps, charge or discharge
- **WATTMETER**
- **AMP-HOUR METER**
  - 0.01 to 1999 amp-hours discharge range
  - Adjustable amp-hour discharge and overcharge alarms
  - Amp-hours can be monitored when shut off
- **TIME REMAINING UNTIL CHARGED OR DISCHARGED DISPLAY**
- **ADJUSTABLE "END OF CHARGE ACCEPTANCE" ALARM**
  - Reduces inefficient engine running time
- **AUTOMATIC CHARGE EFFICIENCY MONITOR**
- **RESETTABLE CHARGE CYCLE COUNTER**
- **MANUAL COMBINE FOR ENGINE STARTING ASSISTANCE**
- **CUSTOM ALARM FEATURES**
  - Global alarm disable control
  - Individual alarm enable/disable controls
  - Time delays prevent false triggering on transients
  - All enabled alarms are active even if not displayed
  - Distinctive Morse code "B" audio battery alarm
- **REMOTE LCD DISPLAY IN A FLUSH MOUNT PANEL**
  - Back light for night viewing
  - Scan mode sequences through displays
  - Waterproof front panel with touch switches
- **50 mV SHUNT FOR MINIMUM HEATING AND POWER LOSS**
- **VERY LOW POWER CONSUMPTION**
- **SPLASHPROOF CONTACTOR BOX**
- **SIMPLE INSTALLATION - ONLY 5 CONNECTIONS**

WARNINGS

WARNING - Use only water based cleaning aids on the display. Do not use strong solvents to clean the display panel as they may soften the protective surface and damage the art work.

WARNING - the display head and control box are a matched set with the calibration data for the control box stored in the display head memory. If you need to return a defective unit, both parts must be processed together. An identical serial number is attached to each part for identification.

WARNING - avoid unplugging the data cable from the back of the display head while the Combiner + is operating. Although it is well protected, the electrical noise may corrupt data in the memory. Turn the Combiner + completely off (no lights on) or disconnect all power before unplugging.

WARNING - On alternators with an external voltage sense input, no switch, fuse or circuit breaker should be able to disconnect the sense wire from the output of the alternator under any circumstance.

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DESCRIPTION

The COMBINER+ connects to the positive side of one, two or three battery banks. When the voltage on any bank rises above 13.1 volts, the contactors close and put the battery banks in parallel so all share the source of charging power with no diode losses and all can receive a full charge. When the source of charging is removed and the voltage drops to 12.8 volts, the contactors open, separating the battery banks so that if one bank is discharged there is still power available to start an engine. The closing and opening voltage settings are user adjustable (CO mode). Time delays of fifteen seconds prevent false operation on transient voltage changes.

A digital VOLTMETER can be set to monitor any of the three battery banks. It reads from 1.00 to 19.99 volts. An averaging process provides a steady display, updated once per second, to give a non-jiggle reading with intermittent loads such as inverters or SCR type battery chargers.

Each battery bank has an individual LOW VOLTAGE ALARM and HIGH VOLTAGE ALARM. The low and high voltage alarms help provide protection against permanent damage to your batteries due to accidental loads or faulty charging. The alarms have 30 second time delays so that a momentary load, such as starting an engine, does not cause a false alarm due to the temporary drop in voltage The high and low settings for each bank are individually adjustable. Each alarm setting can be viewed, and enabled or disabled without altering its value. When an alarm is violated the display switches to the corresponding voltage display of the alarm and a distinctive Morse code "B" is sounded. The audio alarm can be cleared by pressing any button on the panel. The alarm will remain cleared until the voltage has remained within specifications continuously for a minimum of 30 seconds.

A digital AMMETER is provided which uses a shunt that is wired in series with the negative return of the bank or banks which you wish to monitor for discharge. The ammeter is very useful for monitoring your level of power use and especially when leaving the boat, or retiring for the night, to check for forgotten loads which could discharge your battery. It would typically be connected to monitor the "house" bank which is supplying the long term loads while the charging source is off. If the starting bank is included, the current and amp-hour readings will be the arithmetic total of the banks. The charging or discharging current can be read from 0.01 amps to 500 amps continuously, and 1000 amps intermittently. As with the voltages, the current is averaged over a one second period to give a steady understandable reading. The "CHARGE" or "DISCHARGE" lights indicate the direction of current flow when AMPS are displayed.

A WATTMETER tells you how many watts are being removed from (or added to) your battery bank(s). The wattage is calculated by multiplying the current by the voltage of the battery bank supplying the load. You can select which battery bank is used for the voltage parameter in the calculation and the display shows which bank is selected.

A digital AMP-HOUR METER, multiplies the current flowing in or out of the battery, by the time it has been flowing, to act as a monitor of how much charge has been taken out. To track even small instrument loads, it has an internal resolution of 0.000001 amp-hours, although the display can only show two decimal places. Maximum battery display capacity is 1999 amp-hours. A zero reading indicates fully charged. Readings with the "DISCHARGE" light on show how much power has been ***taken out*** of the battery. Readings with the "CHARGE" light show the amount of over-charge, above full. The amp-hour consumption can be monitored even with the Combiner + turned off.

An adjustable amp-hour DISCHARGE ALARM can be set to warn you that the batteries are getting low and need charging. This can be set to what you consider a safe discharge level for maximizing the life of your batteries. This also sets the level of discharge for calculating the time remaining. During a discharge alarm, the DISCHARGE light will flash and AMP-HOURS will be displayed.

An adjustable amp-hour OVERCHARGE ALARM can be set to warn you if too much energy has been replaced in the batteries after the amp-hour meter got back to zero (fully charged). This can also be useful as a "conditioning" monitor for lead-acid batteries being intentionally overcharged. The CHARGE light will flash.

A TIME REMAINING DISPLAY shows the hours of running time that are left when DISCHARGING. This meter subtracts the actual amp-hours removed from the battery from the capacity defined by the discharge alarm setting to get the remaining capacity, and then divides this by the amperage flowing to calculate how many hours are left. The display alternates between showing the abbreviation "Hr." for hours and the numerical value. The DISCHARGE light will flash to identify which time is displayed. The numerical value shows hours and *decimals of an hour*, so 10.2 would be equivalent to 10 hours and 12 minutes. If the load is so low that the number of hours is greater than 1999, the readout will show "2HI" for “too high” to display. If you typically set the discharge alarm to

half the battery capacity, the time remaining will be until this half capacity level is reached. Beyond this point the time remaining will read zero. The time remaining display must be interpreted with an understanding of the variation of load on the battery. If you have a steady load, the reading will be quite accurate, however, if you have intermittent loads such as a 12 volt refrigeration system, the reading will read a lower value while the load is on and a higher value when it is off. The true value will depend on the ratio of on/off time of the loads and will have to be estimated.

A TIME REMAINING until fully CHARGED display shows how many hours it will take ***at the present current*** to reach full charge. End Of Charge (EOC) is defined as reaching 14.0 volts and less than 10 amps charging current, however the user can modify these settings to suit a particular installation. The CHARGE light will flash to indicate that it displays time until CHARGED. In addition to the factors in the Time to Discharge description above, it should be noted that as the charging current reduces in the early stages, the time remaining may actually get longer. The change of current with time is a function of the charger characteristics and the battery condition. Experience will let you interpret the display and estimate how much time will be required.

A CHARGE ACCEPTANCE ALARM (ACC) can be activated to alert you to the end of the efficient charging cycle. Towards the end of the charging process, the rate of acceptance of energy by the battery drops off considerably and the last few percent can take quite some time to be absorbed. Although it is nice to have 100% charged batteries, it doesn't make sense to add long hours of running time on an engine just to put a few amp-hours on the top of a charge. By setting a current and voltage threshold to values appropriate to your battery installation, you can decide to terminate the charge at say 95% instead of fully charged and reduce inefficient engine running time.

An EFFICIENCY METER (EFF) displays the charging efficiency of your batteries. Some energy is wasted in the charge/discharge process. The efficiency meter shows the percentage of charging energy which is recovered from the battery. This value is updated automatically after each charge cycle. A value of 97.5% is pre-loaded in your meter during manufacture but it rapidly adjusts to your installation. It can also be adjusted manually if desired. The efficiency factor can be turned OFF if desired in which case it uses a value of 100%. This feature is advantageous if you have to charge someone else's battery for them and do not want to have your accumulated efficiency factor corrupted.

A CHARGE COUNTER displays the number of charge cycles since installation. The charge counter is resettable so that you can start fresh if you install a new set of batteries. A charge is counted any time the End Of Charge conditions are met or when the charge reaches about 95% after discharging at least 20 amp-hours.

A MANUAL COMBINE control allows you to put all the battery banks in parallel to get an extra boost for engine starting. You should note that if the regular starting battery is too low to start the engine, it might be more productive to use your manual selector switch to select another bank for starting, especially if the starting battery is faulty. Allow the batteries to remain combined for a while to bring up the starting battery as the contactors are not designed to carry starting currents and should be used just as you would use a jumper cable. See the notes on page 11 regarding the contactor relays cycling on and off.

An END OF CHARGE (EOC) adjustment mode is available to customize this setting to your installation. The residual current flowing into a fully charged bank will be a function of the type of batteries, their size and age. A large bank may receive a maintenance trickle of 15 amps when fully charged, whereas a small, single battery may drop to less than 0.25 amps. You can use the EOC mode to customize the setting to your installation. The voltage can also be set although it is less significant. Factory settings are 10 amps and 14 volts so if the current is *less* than 10 amps while the voltage is *greater* than 14.0 volts, the charge is defined as completed.

A SCAN MODE will automatically cycle the display through the first seven display modes.

DISPLAY SEQUENCE

The table below lists the sequence of display modes. When you first turn the Combiner + ON, the display goes to BANK 1 VOLTAGE, as shown on line # 1. Once the display is on, pressing UP moves you to a higher number display, and pressing DOWN moves you to a lower display. The mode numbers are for reference, they are not displayed.

The SCAN column indicates which display modes are cycled when the SCAN mode is operating, (started by pressing the UP and DOWN buttons at the same time).

✱The VIEW MODE is displayed by pressing the ON button so the display changes to indicate the parameter shown in the view mode column. In the VIEW MODE, you can switch between the HIGH and LOW alarm setting, and disable/enable the displayed alarm or function.

†The SET MODE is entered by pressing the SET button. In the SET MODE, you can select either the HIGH or LOW alarm or set point for adjustment.

#	SCAN MODE	HIGH ALARM	LOW ALARM	✱VIEW MODE	†SET MODE	DESCRIPTION
13		HIGH IS VOLTS	LOW IS AMPS	View EOC	Adjust EOC settings	END OF CHARGE SETTING
12						CHARGE COUNTER
11					Adjust A-H	PRESET AMP-HOURS
10				View voltages	Adjust voltages	COMBINER CUT-IN, DROP-OUT VOLTAGE
9				View %	Adjust %	CHARGE EFFICIENCY
8		HIGH IS VOLTS	LOW IS AMPS	View settings	Adjust alarm settings	ACCEPTANCE ALARM
7	YES					TIME REMAINING
6	YES	OVER CHARGE	DISCHG ALARM	Alarms	Alarms	AMP-HOURS
5	YES	No alarm	No alarm	N.A.	SET B#	WATTS
4	YES	No alarm	No alarm	N.A.	(Re-zero)	AMPS
3	YES	YES	YES	Alarms	Alarms	VOLTAGE, BANK 3
2	YES	YES	YES	Alarms	Alarms	VOLTAGE, BANK 2
1	YES	YES	YES	Alarms	Alarms	VOLTAGE, BANK 1

If you are not sure what buttons have been pushed and do not know what display mode you are in, hold the ON button for 5 seconds to turn the display off. When you turn back on you will be in the normal display mode, showing Voltage on Bank 1.

READING THE DISPLAY

ON light:

Is on continuously when the COMBINER + is in operation. There is an 8 second delay before the light comes on after power-up while the amplifier stabilizes. The ON will flash during this warm-up and amps will not be displayed.

Blinks once per second when the COMBINER + is OFF but it is still monitoring and accumulating amp-hours. The combiner and alarm functions are disabled in this mode.

Is off all the time when SHUTDOWN, and no longer monitoring amp-hours.

HIGH, LOW & ALARM lights:

When HIGH or LOW flashes alternately with ALARM, they indicate which parameter on the current display has violated its alarm setting. (Lower than a LOW alarm, or higher than a HIGH alarm setting.) When viewing or setting an alarm, they indicate which alarm is being processed. If the ALARM light is flickering it indicates that all alarms have been temporarily disabled.

COMBINED:

Comes on when the batteries are combined manually or automatically. See the notes on page 11 for problems with the contactor cycling on and off.

CHARGE/DISCHARGE lights:

AMPS — When reading AMPS they show the direction of energy flow, into or out of the battery.

AMP-HRS — When reading amp-hours, DISCHARGE indicates that the reading shows how many amp-hours have been removed from the battery. CHARGE will only show when displaying amp-hours if the battery has been charged beyond 100% and is really the OVERCHARGE.

TIME — On Time To Go display, they indicate time to CHARGE, or time to DISCHARGE depending on the direction of current.

SET AH — When setting AMP-HOUR alarms they indicate which alarm is being processed.

COUNT If alternating, you are viewing the CHARGE COUNTER.

"SET" Indicates that the displayed parameter is in a manual adjustment mode, and not indicating an actual reading.

"B1", "B2","B3" Indicate which battery bank voltage is on display or which bank is used for the Wattage calculation.

"VOLTS", "AMPS", "WATTS", "AMP-HOURS"
Indicate the units of measurement of the display.

AUDIO BEEPER Morse code "B" (**S** • • •) indicates a Battery alarm.
A continuous tone for two seconds or longer, and/or the display shows "2LO" indicates that the power supply is too low to maintain accurate operation and the computer has shut down.
A repetitive BLIP or chirping sound like a cricket indicates a memory failure, see the Troubleshooting section, page 10.

"2HI" Indicates the computed value is greater than 1999 and is "too high" to display.

"2LO" Indicates that all three battery bank voltages are "too low" to maintain accurate operation and the Combiner + is shutting down.

"OFF" Indicates that the alarm (or other function) you are viewing is off or disabled.

"Hr." Indicates you are in the Hours to charge or discharge display mode.

"ACC" Indicates you are in the CHARGE ACCEPTANCE mode.

"EFF" Indicates the mode to view (or set) the EFFICIENCY.

"CO " Indicates the COMBINER viewing or adjusting mode.

"A-H" Indicates you are in the Amp-Hour adjustment mode.

"EOC" Indicates the End Of Charge settings viewing or adjusting mode.

HOW TO:-

After each title there is an abbreviated **KEY SEQUENCE** followed by a full description. When the **&** sign is shown, it means that the key on the left must be held down like a shift key while the key on the right is pressed. They can then both be released in any order. The waterproof guide card shows flow diagrams of the following operations.

If you are not sure what buttons have been pushed and do not know what display mode you are in, the OFF control below will work at any time. When you turn back on you will be in the normal display mode, showing Voltage on Bank 1.

TURN THE COMBINER + ON

ON

It doesn't matter if the COMBINER + was SHUTDOWN (no lights) or OFF (ON light flashing) it will turn on when you press the ON button. It always starts by displaying Bank 1 Voltage, however a restoration of power continues from the condition existing prior to the power failure. If it was shutdown, or when power is re-applied, there is an 8 second delay before the ON LIGHT stays on while the amplifier is stabilizing.

TURN THE COMBINER + OFF

ON (HOLD)

Press and hold the ON button until it turns off (4 to 5 seconds).

The first time you turn it off it goes into the OFF mode - the ON light flashes once per second and the display is blank. No alarms are monitored and the combiner function is disabled, but it continues to monitor current flowing into or out of the battery and update the AMP-HOUR total in memory.

The second time you turn it off (or if you continue to hold) it goes into SHUTDOWN - with no lights on or flashing. Current in or out of the battery will now go unrecorded. Power consumption drops to 0.002 amps. There is a minimum 2.5 second shutdown time before you can turn it back on.

SELECT A PARAMETER TO VIEW

UP/DOWN

Press UP or DOWN until the item you wish to view is displayed. See the instruction card or the table of display modes under "DISPLAY SEQUENCE" on page 2.

SCAN ALL PARAMETERS

UP & DOWN

Press the UP & DOWN buttons together. The display will start cycling through all parameters, one every four seconds. Only the parameter monitoring functions as shown in the table on page 2 are scanned.

STOP SCANNING

ANY

The first time you touch any button, scanning will cease. No beep will sound, and the normal function of the button you pressed, will not be performed. Use the UP/DOWN buttons to change to the desired display.

TURN ON/OFF BACK LIGHT

ON&UP or ON&DOWN

Hold the ON button and press UP to turn the light on. Hold the ON button and press DOWN to turn the light off.

VIEW AN ALARM SETTING

ON - (DOWN/UP) - ON

There are times when you need to review the set point of an alarm or parameter. Use the UP/DOWN buttons to display the parameter (Volts, Amp-hours, etc.) you desire and then touch the ON button. The HIGH and ALARM lights will come on indicate you are VIEWING the HIGH ALARM. If you want to view the LOW alarm, press the DOWN button. If you wish to go back to the HIGH alarm, press the UP button. When you are finished viewing the alarms, press the ON button to exit back to normal viewing of the selected parameter. If there are no alarms for the selected parameter (e.g. AMPS, WATTS), the ON button will be ignored.

Most of the alarm functions are disabled while VIEWING an alarm so always return to the normal display mode as soon as you are finished. Normal mode will be restored automatically if no keys are pressed for two minutes.

ENABLE/DISABLE AN ALARM

ON - (DOWN/UP) - SET - ON

Use the ALARM VIEWING mode (above) to view the selected alarm. Press UP/DOWN as required to select the HIGH or LOW alarm. If the numeric value is showing it is enabled. If "OFF" is showing, it is disabled. Press SET to change from enabled to disabled or visa versa. Press ON to exit the VIEWING mode. Re-enabling a high or low alarm after it has been disabled, will clear any acknowledgment so if the alarm is still violated, it will go off again. Each alarm's enabled or disabled state is retained permanently in memory until you change it.

Most of the alarm functions are disabled while VIEWING an alarm so always return to the normal display mode as soon as you are finished. Normal mode will be restored automatically if no keys are pressed for two minutes.

SET THE VALUE OF AN ALARM

SET - UP/DOWN - [UP/DOWN...] - [ON ...] - SET

Press UP or DOWN to display the parameter whose alarm is to be adjusted. Press SET. The display will now show SET H-L and the parameter (e.g. VOLTS). If there are no alarms for this parameter, SET will be ignored. Press UP or DOWN only once to select the HIGH or LOW alarm to adjust. The present setting of the alarm will be displayed The HIGH or LOW light will indicate which alarm you have selected. (If the alarm was previously disabled it will not show OFF, but it will ENABLE the alarm and show its value.) Use UP/DOWN to adjust the setting. (The steps are non-linear to speed setting so use UP or DOWN to go just past the desired setting and then press ON repeatedly to do a fine adjustment and *BACKUP* to a value you have just passed.) Press SET to exit. The last value showing before you exit is the new setting. If you do not want to leave the alarm you were setting enabled, you will have to enter the VIEWING mode to turn it off.

Most of the alarm functions are disabled while setting an alarm so always return to the normal display mode as soon as you are finished. Normal mode will be restored automatically if no keys are pressed for two minutes.

CLEAR AN ALARM

ANY

When an alarm is going off, the ALARM and HIGH or LOW will be flashing and the beeper will be sounding B (**S** • • •) in Morse code. The display will have switched to the parameter which has caused the alarm. Scanning, if on, will have been terminated. Momentarily press any button and the beeper and flashing will terminate. The display will continue to show the alarmed parameter. If a second alarm event occurred while the alarm was sounding, it will be delayed for 30 seconds after clearing the first one before sounding. If, the alarmed condition corrects itself (e.g. voltage went back to normal) before you clear the alarm, it does not clear automatically, but continues to beep until you respond.

Once you clear (acknowledge) an alarm, it will not sound again even though the alarm settings is still violated. The alarm condition must be restored to normal for at least 30 seconds continuously before it will respond to a repeat alarm. You can manually re-activate an alarm which has gone off by VIEWING the (high or low) alarm, turning it OFF, then turning it back on again. If the alarm is still violated it will sound again in 30 seconds.

TEMPORARILY DISABLE ALL ALARMS

ON & SET

There may be times when you want to monitor one parameter without the interruption of an alarm sounding on another parameter, or you are busy with other problems and don't want any alarms to go off. Instead of having to VIEW each parameter in sequence and turn the alarms OFF individually, you can disable all alarms.

Press ON and while holding ON, press SET. The ALARM light (without HIGH or LOW) will flicker periodically to indicate that alarms are disabled. Repeat the above process to turn all alarms back on. Any violations will then sound after 30 seconds.

VIEW/ADJUST HIGH/LOW VOLTAGE ALARMS

See the generic alarm controls on page 5.

SET DISCHARGE/OVERCHARGE ALARMS

See the generic alarm controls in the preceding paragraphs but select UP (HIGH alarm) for the Overcharge Alarm or select DOWN (LOW alarm) for the Discharge Alarm.

VIEW THE CHARGE ACCEPTANCE ALARM
ENABLE/DISABLE THE ACCEPTANCE ALARM

ON DOWN/UP [SET] ON

You can review the function of the CHARGE ACCEPTANCE alarm in the DESCRIPTION section on page 2. There are two parameters to set for this alarm. The alarm will go off to alert you that economical charging has terminated when the VOLTAGE is greater than the ACCEPTANCE VOLTAGE and at the same time, the CURRENT has dropped to less than the ACCEPTANCE CURRENT. The voltage setting used will depend on the type of batteries. The current setting will typically be a ratio of the total amp-hour capacity of the banks being monitored.

The ACCEPTANCE ALARM display is reached by using the UP (or DOWN) button until "ACC" is displayed. VIEWING is initiated in a similar manner to alarms - press ON to view the VOLTAGE setting, press DOWN to view the CURRENT setting, press UP to go back to the VOLTAGE. Use the SET button to turn the alarm function on/off while viewing either parameter. The ON button will exit to the normal mode showing “ACC”.

Most of the alarm functions are disabled while VIEWING an alarm so always return to the normal display mode as soon as you are finished. Normal mode will be restored automatically if no keys are pressed for two minutes.

ADJUST THE ACCEPTANCE ALARM

SET UP/DOWN [UP/DOWN...] [ON...] SET

Use the UP/DOWN switches until the acceptance display is showing, "ACC". Press SET to enter the SETTING mode. The display will show "SET H-L", although in this case H means high VOLTAGE setting, and L means low CURRENT setting. Press either UP to select the VOLTAGE, or DOWN to select the CURRENT for adjustment. "VOLTS" or "AMPS" in the display will identify which one you have selected. If the alarm was previously set to "OFF" while in the viewing mode, it is automatically turned to on. When the voltage or current is displayed, use the UP/DOWN buttons to adjust to the desired value. The ON button will fine tune the value by backing up to a setting you have just passed. When the correct value is showing, press SET to exit.

Most of the alarm functions are disabled while SETTING an alarm so always return to the normal display mode as soon as you are finished. Normal mode will be restored automatically if no keys are pressed for two minutes.

VIEW THE COMBINER VOLTAGE SETTINGS
ENABLE/DISABLE COMBINER FUNCTIONS

ON - (UP/DOWN) - SET - ON

The COMBINER cut-in and drop-out voltages are originally preset to 13.1 and 12.8 volts. Use the UP and DOWN switches until you arrive at the COMBINER display mode The display will show "CO ". Use the ON button to VIEW the settings just like HIGH and LOW alarm settings. Use the SET button while viewing to turn the COMBINER functions OFF, or back on. Press ON to exit to normal mode showing “CO “ again.

Most of the alarm functions are disabled while VIEWING the combiner settings so always return to the normal display mode as soon as you are finished. Normal mode will be restored automatically if no keys are pressed for two minutes.

ADJUST THE COMBINER VOLTAGE SETTINGS

SET UP/DOWN [UP/DOWN...] [ON...] SET

This is similar to adjusting an alarm. Select the CO mode and press SET. Select either UP for High (Cut-in voltage) or DOWN for Low (Drop-out voltage) for adjustment and use the UP/DOWN (and ON) buttons to change the value. Operating with settings having less than 0.3 volts between the high and low should be monitored carefully to make sure that there is not excessive cycling of the contactors. Settings with the HIGH less than or equal to the LOW can cause continuous cycling on and off every 15 seconds and should be avoided. Cut-in settings lower than 13.0 volts may not have enough voltage to operate the solenoids on the contactors. See the notes on page 11 regarding contactor pulsing.

Most of the alarm functions are disabled while SETTING the combiner voltages so always return to the normal display mode as soon as you are finished. Normal mode will be restored automatically if no keys are pressed for two minutes.

MANUALLY COMBINE THE BATTERIES

SET - ON

Use the UP or DOWN buttons to reach the combiner mode. The display shows "CO ". Press SET so the display shows "H-L" in anticipation of setting the cut in or drop out voltages. While the "H-L" is showing, pressing ON will change the contactors from OFF to ON or visa versa. The manual control will remain effective until UP, DOWN or SET is pressed, then the normal conditions will resume in 15 seconds. Please review the description section on page 2 regarding use for emergency starting.

VIEW OR SET THE EFFICIENCY METER

ON - (UP/DOWN) - SET - ON
SET UP/DOWN [UP/DOWN...] [ON...] SET

Amp-Hours of charge put into the battery are multiplied by the efficiency setting to correct for battery losses so that the Amp-Hour meter will go back to zero when the battery is fully charged. This setting is updated automatically to adjust to your installation, however it can take about 5 charging cycles to settle down on a representative value.

Use the UP and DOWN switches until you arrive at the EFFICIENCY display mode. The display will show "EFF" to identify the efficiency meter.

Press ON to view the current value. While in the viewing mode, the SET button will toggle the efficiency function OFF or back to the current setting. When turned OFF, no correction is used during charging and a battery efficiency of 100% is assumed. While OFF, the efficiency setting stored in the computer remains stable and it is not corrected at the end of each charge cycle so this is a good way of preserving your efficiency setting while charging alternate batteries on a temporary basis. Press ON to return to the "EFF" display and normal operation.

Press SET if you want to adjust the efficiency setting manually. Use the UP and DOWN buttons (and ON for fine tuning) if desired to change the setting, keeping in mind that the computer will always update the value after each charging cycle to correct any error. If the efficiency function had been turned OFF, changing the setting will automatically force it to ON. If the setting has been corrupted due to temporarily charging another battery and you failed to turn the efficiency function OFF, this SET function would be a technique for restoring what you know to be close to the correct value. Automatic correction, however, is quite rapid.

Most of the alarm functions are disabled while VIEWING or SETTING the efficiency so always return to the normal display mode as soon as you are finished. Normal mode will be restored automatically if no keys are pressed for two minutes.

ADJUST THE AMP-HOURS READING

SET UP/DOWN SET

There are times when the AMP-HOURS displayed are not representative of the actual AMP-HOURS removed from the battery. This can occur when the Combiner + has been SHUTDOWN for an extended period, or when a battery is replaced, or charged off the boat, etc.. If you know the approximate AMP-HOURS currently discharged from the battery you can manually correct the display. After the next charge cycle, the reading will be corrected to the true value by the computer.

Keep in mind that if the setting you make is too far removed from the actual value, the efficiency setting may be temporarily disrupted and meaningless discharge or overcharge alarms may be sounded. If you do not pre-set the amp-hours, the computer will correct it and re-establish the efficiency setting within a few cycles.

Use the UP or DOWN button to get to the AMP-HOURS adjustment. The display will show "SET A-H". Press SET and the display will change to show the AMP-HOURS value. Now the UP and DOWN buttons will increase or decrease the setting

while they are pressed or held down. Holding a button down does about 5 AH per second. The DISCHARGE light will show that the display is in the DISCHARGE range. You cannot enter the OVER CHARGE range. Press SET when finished. There is no fine adjustment as the setting is only approximate.

Most of the alarm functions are disabled while adjusting amp-hours so always return to the normal display mode as soon as you are finished. WARNING: Normal mode will **NOT** be restored automatically.

VIEW THE CHARGE COUNTER

Use the UP or DOWN buttons until the CHARGE and DISCHARGE lights are alternating to suggest CHARGE/DISCHARGE cycles, and only digits are showing in the display. The numerical display shows the number of completed charge cycles since the Combiner + was installed or the counter was last reset. Ignore decimal places.

RESET THE CHARGE COUNTER

The charge counter serves as an odometer on the age of you batteries. When you replace a battery you can re-start the counter at zero. While in the charge counter mode, pass a magnet horizontally over the digital display. This technique prevents accidental clearing by pushing a wrong button.

ADJUST THE END OF CHARGE SETTINGS

Read and understand the function of the End Of Charge settings before adjusting. Do not adjust them unless you understand their function. Unrealistic settings may disrupt the operation of the Amp-hours monitoring and efficiency controls. Do not turn the function to "OFF".

The end of charge detector is used internally to correct the efficiency and zero out any amp-hours error for the next cycle. The end of charge is pre-set to 14.0 volts or more combined with 10 amps or less. If these values do not correspond to your installation, you can adjust them manually. The amps setting is much more relevant than the voltage setting.

You may want to adjust the voltage to the type of batteries installed. It should be set lower than the voltage present when charging is in progress and essentially finished (typically 14.6) but before it settles back to a "float" voltage, (typically 13.6).

The current setting should be adjusted so that it is above the residual current remaining once the batteries are fully charged which will depend on the total amp-hour capacity and the condition of your batteries. Although the residual current of a new set of batteries can be very low, you should set the value significantly higher so that End Of Charge will be recognized without undue delay and also to allow for an increase in residual charging current as the batteries age. For example a typical new set of batteries may drop to a “maintenance” charging current of only 100 milliamps, however an end of charge current setting of 3 to 5 amps would be appropriate. The charging process **does not stop** at this current, it only indicates to the computer that this can be counted as a complete cycle and not a partial re-charge so that the efficiency figures can be updated when the physical charging cycle eventually ends. Due to loads on your 12 volt supply, the current supplied by the charging source may be much higher than what is trickling into the batteries, however the current setting does not have to be corrected for these loads because the Combiner + is only measuring the actual current passing into the battery.

Use UP or DOWN until the display shows "EOC" for End Of Charge. No lights except for "ON" will be lit for this mode.

With "EOC" showing, the ON button will VIEW the volts or amps setting (UP or DOWN buttons). WARNING: Although the SET button will turn off the EOC detector, you should never leave it set it OFF as this will disable all amp-hour correction processes.

With "EOC" showing, the SET button will access the SETTING mode and allow adjustment of the voltage or the current. The display will show "H-L", although in this case H means high VOLTAGE setting, and L means low CURRENT setting. Press either UP to select the VOLTAGE or DOWN to select the CURRENT for adjustment. "VOLTS" or "AMPS" in the display will identify which one you have selected. Use the UP/DOWN buttons to adjust to the desired value. The ON button will fine tune the value by backing up to a setting you have just passed. When the correct value is showing, press SET to exit.

Most of the alarm functions are disabled while VIEWING or SETTING the EOC values so always return to the normal display mode as soon as you are finished. Normal mode will be restored automatically if no keys are pressed for two minutes.

INSTALLATION

CONTACTOR BOX

The contactor box should be located where it provides access to all battery connections. It should be a dry location. An engine compartment is acceptable but care should be taken to avoid excessive temperatures and vibration. It can mount at any angle however keeping the fins on the shunt vertical will improve cooling efficiency. Assemble the feet and mount using #12 self tapping screws provided.

The cable to the display head is approximately 15 feet and it should not be shortened or extended. If a longer cable is

required, a 25 foot extender kit may be purchased from West Marine, part # 320418. Do not exceed the 40' maximum. Although the cable itself is waterproof, the extender kit coupling connector is not.

DISPLAY/CONTROL PANEL

The panel will mount on a flat instrument panel or bulkhead. The surface must be flat so that the panel is not distorted during assembly which could affect the touch switch clearance adjustments. It is waterproof from the front, but not behind the panel so exposed locations should be avoided in case the seal to the mounting surface should leak. Mount the panel using the four #4 screws supplied and use a sealing compound if the installation has to be waterproof. Some sealing compounds may soften the front panel overlay so masking and careful application should be observed. The panel cut-out is 2 1/2" X 3 1/2". The rear cover is 1" deep but the nut requires another 5/16". Access to the panel from the rear is desirable but not necessary. If space allows, clearance should be provided to remove the connector, although it can be left assembled in a cavity. The plug on the end of the cable requires a 1/2" access hole. If required, see the notes regarding panel removal under the CALIBRATION section, page 13.

ELECTRICAL WIRING

(See example schematic on page 13.)

3 POSITIVE CONNECTIONS

Battery combiners allow you to connect your alternator directly to the battery without going through a selector switch or diode isolator. The battery which is directly connected to the alternator rapidly reaches the cut-in setting of 13.1 volts when the engine is started and the combiner then shares the charging with all other banks. To reduce load on the combiner and improve its life, the alternator should be connected to the battery bank which requires the most charging, usually the "house" bank. This way the majority of the charging current goes directly to the largest load and only the lesser charging requirements of the starting or auxiliary batteries are passed through the combiner.

If your alternator has an external voltage sense input, it should be connected to the alternator output terminal. Since there are no isolator diodes in the circuit, little is gained by connecting the sense wire to the battery. Even if there is a long cable run from the alternator to the battery little is gained by connecting the sense wire to the battery end because as the current drops towards the end of the charge, the voltage drop along the cable becomes negligible. **SAFETY WARNING:** NO SWITCH, FUSE OR CIRCUIT BREAKER SHOULD BE ABLE TO DISCONNECT THE SENSE WIRE FROM THE OUTPUT OF THE ALTERNATOR.

There are three heavy connections on the top of the contactor box, labeled B1, B2 and B3. These labels will correspond to the B1 B2 and B3 on the display. Use whatever allocation to your banks you prefer. If you only have two banks, you would typically omit BANK 3, however this is not a requirement. Each battery bank has a lead connected from its positive terminal to its corresponding terminal on the box. Good marine wiring practice requires a high current emergency switch be located at the positive terminal of each battery. Due to the heavy currents which can flow between batteries when the contactors close, it is not economical to use fuses in these cables however 500 amp fuses could be used to protect from accidental shorts to ground.

NEGATIVE CONNECTION

The shunt on the side of the combiner is a very low resistance (0.0001 ohms). When current passes through this shunt to or from the battery it produces a very low voltage which is amplified and digitized to calculate the current. The shunt is rated for 500 amps continuous and 1000 amps for short periods such as a starter overload. Persistent high loads will cause heating of the shunt.

Decide which bank(s) are going to have their current monitored and connect the Negative side of those battery(ies) to the end of the shunt labeled "BATTERY NEGATIVE". This is a full load carrying conductor so it should be as short as possible and as heavy a gauge as you can install. Make sure all connection are of good quality and secure. Crimped and/or soldered ring terminals are recommended. 3/8" clamping screws are provided and terminals of corresponding size should be used. The wire terminals go between the washers and the brass

IMPORTANT - READ THIS BEFORE INSTALLING

Use #6 gauge wire with matching terminals for connecting to the batteries. The small resistance of the wires from the batteries to the combiner provides protection to the contactors from the in-rush current when they first connect the batteries in parallel SO USING HEAVIER THAN #6 WIRE CAN DO MORE HARM THAN GOOD. The #6 gauge wire resistance is 0.0004 ohms per foot which has a negligible effect on the charging efficiency but provides protection from high battery-to-battery current. A MINIMUM run of 3 feet of cable to each battery from the combiner should be provided. If the installation requires any combiner-to-battery runs of over 12 feet, #4 gauge wire may be used for these. The ring terminal on the end of each wire goes under the top nut and lock washer. Do not loosen the bottom nuts. Avoid coiling unused cable which could cause magnetic interference to your compass.

No other power connections (Inverters, House breaker panel, alternator, etc.) should be connected at the combiner end of these cables and allowed to share the cable to the battery. They (especially inverters) can cause electrical interference which will deteriorate the accuracy and performance of the Combiner +.

block. Connect the wire(s) which were previously connected to the battery minus terminal, to the "LOAD NEGATIVE" end of the shunt. Any current returning to the battery(ies) through this shunt will now be monitored for Amps and Amp-hours.

If you have any other current monitoring equipment which requires a 500A, 50mV shunt, it can share this shunt by connecting its sense wires to the two spare screw terminals on the Combiner + shunt and avoid having two shunts in series.

DISPLAY HEAD

WARNING: Avoid unplugging the data cable while the display is running. Hold the ON button for 10 seconds until all lights remain off or remove all 12 volt power sources before unplugging. Inserting the plug while power is on does no harm.

Route the display head cable to the display and plug it in. Avoid sharp edges, especially on the shunt. This cable carries high frequency digital signals and it may cause some low level electrical interference to sensitive devices so it is wise to test all equipment in the vicinity and re-route the cable if problems are discovered. Avoid proximity with radio frequency power sources which could disrupt the data signals in the cable, such as VHF or SSB antennas.

Static electricity is usually not a problem in the marine environment, however if the installation is located where static discharges are possible, the control panel should be solidly grounded using the nut which secures the cover on the rear.

SETUP

1. The Combiner + comes with all three high and low voltage alarms enabled. If you only have two banks, move the display to the unused bank, and use the VIEW mode (See page 5) to turn both the high and low alarms off, otherwise they will keep sounding each time the combiner relays apply and remove power on that unused terminal during charging. During normal operation, if you select the unused bank voltage display, it will read the same as the other banks while the batteries are combined. When not combined, it will show zero or a low, unrelated voltage.
2. Adjust the Acceptance alarm to your installation's battery size. See page 6.
3. Preset the AMP-HOURS setting to the approximate discharge condition of the battery. See page 7. Remember zero amp-hours is fully charged. The display increases as amp-hours are removed from the battery.
4. Set the AMP-HOURS DISCHARGE ALARM value (accessed when viewing AMP-HOURS) to a value depending on the size of the battery and the level of discharge you want to use. Ampere hours of 50% of rated battery capacity is often recommended as giving maximum battery life, however higher settings will give a longer running time before the discharge alarm sounds. This alarm value should be set even if you decide to disable the alarm because the Combiner + uses this setting to calculate Time Remaining.
5. Check that the DISCHARGE light comes on while not charging and when you are viewing AMPS with some load on the battery. If the CHARGE light comes on you will need to reverse the connection on the shunt. See page 9.

TROUBLESHOOTING AND SERVICE

NOTE: If service is required, both the display and the contactor box must be returned together because the calibration data for the amplifier in the box is stored in the display head. If required, see the notes regarding panel removal under CALIBRATION, page 13.

WARNING: Use only water based cleaning aids on the display. Do not use strong solvents to clean the display panel as they may soften the protective surface and damage the art work.

WARNING: Avoid unplugging the data cable while the display is running. Hold the ON button for 10 seconds until all lights remain off or remove all 12 volt power sources before unplugging. You can also unplug it safely when in the switch test mode. Inserting the plug while power is on does no harm.

WARNING: Do not attempt to adjust the internal potentiometers. These set internal balance and noise rejection to optimum values but the computer will correct any misadjustment digitally so the only result of faulty adjustment is a reduction of the available range for automatic correction.

The Combiner + is polarity protected and suffers no damage from reversed power supply connection. Be especially careful using home made or 3rd party extensions for the data cable. Incorrect or reversed connection may cause permanent damage. A 25' extension kit is available from West Marine, Model # 320418. The power lead in the data cable is protected with a 0.1 amp automatic resetting thermal fuse. No other fuses are necessary.

THE BEEPER SOUNDS A CONTINUOUS TONE

If the display shows "2LO" and/or the "ON" light has extinguished after previous normal operation, it indicates that all the battery banks which are currently connected to the Combiner + are below 9 volts and the computer has shut down. Continued operation at low voltage may cause erratic behavior and garbage in the display, however all data is stored in permanent memory and normal operation will resume when the power is restored.

Otherwise, a continuous tone from the beeper indicates than the computer is not running, either due to a power supply problem or a fault condition and service may be required. Try disconnecting the data cable and re-connecting after 10 seconds.

BEEPER CHIRPS LIKE A CRICKET

The computer checks the validity of the data storage memory and if it finds an error, the beeper chirps and the display may show random segments. This is probably an indication that the unit will need to be returned for service, however, if you suspect that it may have occurred due to an electrical accident such as a short circuit, removal of the data cable during

operation or a static discharge, you can override the memory lock-out and attempt to start again. Momentarily pass a magnet horizontally just below the liquid crystal display while it is chirping, to operate the internal magnetic reed switch. If the memory is functional, operation will resume in the switch service routine so you will need pass the magnet a second time to exit this mode and return to normal. (Store the magnet with a keeper bar, away from compasses.)

If normal operation is restored, keep in mind that some of the stored data (Alarm settings, calibration settings, efficiency setting or the current amp-hour value, etc.) may have been corrupted. All of these except the calibration settings can be corrected manually through the control panel, or will correct automatically. Incorrect calibration settings would usually result in obscure values for voltage or current readings. Press SET while viewing AMPS to initiate a zero correction to see if it helps recovery. Other types of erratic behavior after restoring operation may result if operating parameters in memory have been corrupted.

THE AMP-HOUR METER JUMPS OR CHANGES VALUE

The AMP-HOUR meter uses the EFFICIENCY setting to adjust for the charge efficiency of your batteries. Some power is lost during the charging process which is not recovered when the batteries are discharged into a load. The actual efficiency is a function of the type of battery being used, their age and previous cycle history. Typical efficiency figures are in the 90 to 99% range.

When the battery is charging, the amp-hours of charge going into it are reduced by this efficiency setting before being accumulated on the AMP-HOUR meter. If this efficiency rating is not correct, an error will accumulate by the time charging is completed, either below or above the actual charge in the battery. The computer corrects this error by changing the AMP-HOUR display to its correct value and at the same time, modifying the efficiency rating in use to get a more accurate result next time. These jumps in the reading can occur at various times. The Combiner + is specially designed to track and update efficiency even though a full charge may not have been completed so at about 10% before full charge you may see an Amp-Hour jump to a different, non zero value. The discharge level must have reached at least 20 amp-hours for this correction to be activated.

A jump to zero (IE. fully charged) can occur when full charge is first reached, and after overcharging has been completed. Full charge requires the voltage to reach a minimum of 14.2 and the charging current to drop to less than 10 amps. These settings are adjustable to suit your installation if required. See page 8.

After a few charging cycles the jumps in the amp-hour reading should become quite small and unnoticed. If they continue without diminishing in size, check the EFFICIENCY display to make sure you do not have the efficiency function turned off.

There are times when the voltage, current and amp-hours do not relate realistically and the computer will periodically reset amp-hours until they align.

THE CONTACTORS CYCLE ON AND OFF

The contactors usually pulse momentarily when power is first applied. We use 15 volt coils to reduce power consumption and heating so "Cut-In" voltage settings of less than 13.0 volts may not be high enough for the contactors to close. To reduce power consumption, the two contactor coils are placed in series after they are engaged, however once per second they are momentarily connected in parallel to make sure they remain fully closed. It is normal for the COMBINED led to pulse once per second and you may hear the solenoids pulsing as they are switched.

A. If the combiner turns on for a short period after you start charging but then turns off and repeats this cycle for a couple of minutes, it indicates that one battery is very low and causing the voltage to drop when the combiner contactors close so that it falls below the "Drop-Out" voltage. Once it drops out, the charging source rapidly brings the first battery back up to the "Cut-In" voltage and the combiner closes again. After a few cycles, the second battery will have accumulated sufficient charge that it no longer causes the combiner to drop out and charging can continue uninterrupted.

Although this is normal, it can be reduced, and the wear and tear on the contactor minimized, by connecting the charge source directly to the house battery (or the one which is usually very low). This way the low battery is brought up to the "Cut-In" voltage before the contactors close and the starting battery will then share the charging power without causing heavy cycling of the combiner.

B. If the "Drop-Out" voltage has been set higher than the "Cut-In" voltage, then once the charging voltage reaches the "Cut-In" level and the combiner turns on, it immediately starts a "Drop-Out" cycle. Each half of the cycle has a 15 second time delay so the combiner will cycle on and off continuously every 15 seconds. Eventually, sufficient voltage will be accumulated so that the voltage level is above both settings and the combiner will stay operated. This gives similar symptoms to example A, above, so you should check the settings in the "CO " view mode and make sure the High setting is higher than the Low setting. Suggested settings are 13.1 volts for "Cut-In" and 12.8 volts for "Drop-Out".

CHARGE AND DISCHARGE LIGHTS ARE REVERSED

If measuring AMPS, the connections to the current measuring shunt are reversed. See the notes NEGATIVE CONNECTION on page 9. If measuring Amp-Hours, see below.

AMP HOURS RUNS THE WRONG WAY

If the amps discharge and charge indicators are correct then all is OK. Remember that the AMP-HOURS display shows the level of ***DISCHARGE*** so a fully charged bank will show ***ZERO AMP-HOURS***, and the numbers will increase as battery discharges. If the CHARGE light is on, the display shows the OVERCHARGE, above fully charge which will return to zero when charging is ended.

DISCHARGE LIGHT IS ON WHILE BATTERIES ARE CHARGING

See the above paragraph regarding Amp-Hours display. When viewing Amp-Hours, the discharge light will remain on to show that the display shows the level of discharge (which is getting less). The charge light will only come on after the display passes through zero (fully charged) and goes into the OVERCHARGE display range.

AMP HOURS DOESN'T RECORD CHARGE

The ground return circuit to the negative side of the battery from the engine ground (and alternator) must go through the shunt and not directly to the negative battery terminal. There should be no direct connections to the battery negative terminal except the Combiner + shunt or these circuits will not be monitored for current flow.

CHARGE LIGHT IS ON WHEN NOT CHARGING

When reading AMPS, zero current flowing is regarded by the computer as a positive number so with all loads disconnected, the charge light may come on. With no other loads connected, the Combiner + itself produces about .02 amps of discharge which is included in the measured current. This current increases to about .45 amps when the contactors are closed. Usually this small current is sufficient to keep the discharge light on when no other current is flowing through the shunt. Temperature changes can offset the zero level in the amplifier, however the amplifier is re-zeroed automatically once per hour which will correct the display before any significant amp-hour errors can be accumulated. You can force a re-zero by pressing SET while AMPS are being displayed. The display will freeze for 4 seconds while the re-zero is performed.

COMBINER STAYS ON WHEN CHARGING HAS ENDED

The combiner turn off voltage is originally set to 12.80 volts. A battery at rest, immediately after charging will have a "float voltage", or artificially high voltage left over from the charging. This float does not represent any significant source of energy and just the small amount of current going into the combiner relay will slowly drop the voltage to a normal resting value where the combiner will turn off. If the voltmeter reads less than "Drop Out" setting on all three banks for more than 15 seconds without the "combined" light turning off, you should go to the CO mode, to view and confirm the setting of the turn off voltage and adjust if necessary. Setting a higher turn off voltage will turn it off sooner but avoid settings too close to the turn-on voltage which could cause increased cycling of the contactors.

COMBINER + METERS APPEAR OUT OF TOLERANCE

The meters should agree within tolerances for steady DC voltages and currents. See Page 13 of this manual for the tolerance specifications. Many waveforms, however, are not steady, especially those from automotive or SCR type battery chargers and inverter loads. The manner in which these non uniform voltages or currents are displayed varies from meter to meter. Most meters read an average value but the averaging time period is critical to the stability of the display. Even the needle on an analog meter will vibrate depending on the mechanical damping time constant of the movement, requiring the user to mentally interpolate the result.

The COMBINER + meters combine electronic and digital filtering to display an average value, averaged over a 1 second period to give a reasonably steady result without losing responsiveness. The accuracy may degrade on complex waveforms.

Unrealistic voltage or current readings may indicate a loss of calibration data and both components will need to be returned for free re-calibration. Call West Marine for shipping information.

THE TIME REMAINING RUNS TOO FAST

Please review the description section for information on accuracy. Remember, the display is decimal hours, not hours and minutes. The second decimal place digit represents 0.01 hour or 36 seconds, not 1 minute. The first decimal digit is 6 minutes. See the functional description of Time Remaining on page 1 for further information.

ADJUSTING FRONT PANEL SWITCHES

The four waterproof touch switches on the front panel only travel about 20 thousandths of an inch. If the front panel is accidentally distorted, some of the switches may fail to close, or be held closed all the time. The following procedure allows them to be tested and adjusted without removing the meter. If the panel has been damaged too severely, it may not be possible to align all the switches, in which case you can try correcting the distortion or you may need to return the display to have a new panel fitted.

TESTING THE LIGHTS, SWITCHES AND LCD DISPLAY

To enter the test mode, pass a magnet horizontally over the bottom of the liquid crystal display while the Combiner + is on *but not while it is in the CHARGE COUNTER MODE*. The On, Combined and Back light lights remain unchanged but the remaining lights should come on and all the segments in the display should be on.

If you cannot make the Combiner + turn on due to faulty switch adjustment, you can force it into the test mode as follows. First, the Combiner + power must be off for 15 seconds minimum. This can be done by unplugging the data cable at the rear of the display panel (while the display is off), or by disconnecting all three 12 volt battery input connections. Hold a small magnet horizontally at the bottom of the liquid crystal display while you re-apply the power. You will enter the test mode even though some switches are inoperable.

While in the test mode, each of the four switches is connected to a display light:- CHARGE, DISCHARGE, ALARM, & LOW. As each switch is pressed, its light should go off. Only one light should go off and come on as each button is pressed and released. Alarms and amp-hours are not monitored while you are in the test mode and there is no exit timer.

Exit the test mode by passing the magnet over the display a

second time.

ADJUSTING THE SWITCHES

Enter the test mode as described above.

Remove the nut which holds the rear cover in place on the display and slide it back. There are lock nuts in the four corners of the printed circuit board which adjust the clearance of the switch contacts between the printed circuit board and the front panel. The top two nuts should never need adjusting. Tightening the bottom nuts will decrease the space to the front panel and turn switches on. Loosening them will increase the space and turn switches off. Uneven closing of the switches can be adjusted by turning the left or right hand nuts independently.

Be careful adjusting the nuts. Long nose pliers make a satisfactory tool but access may be difficult on thick panels. Remember the power is on and you don't want to short anything out with metal tools. A fraction of a revolution separates one extreme from the other so be sparing with the adjustment. Adjust the nuts for good sensitivity but so only one switch operates when pressed hard.

CHECKING THE DISPLAY SEGMENTS

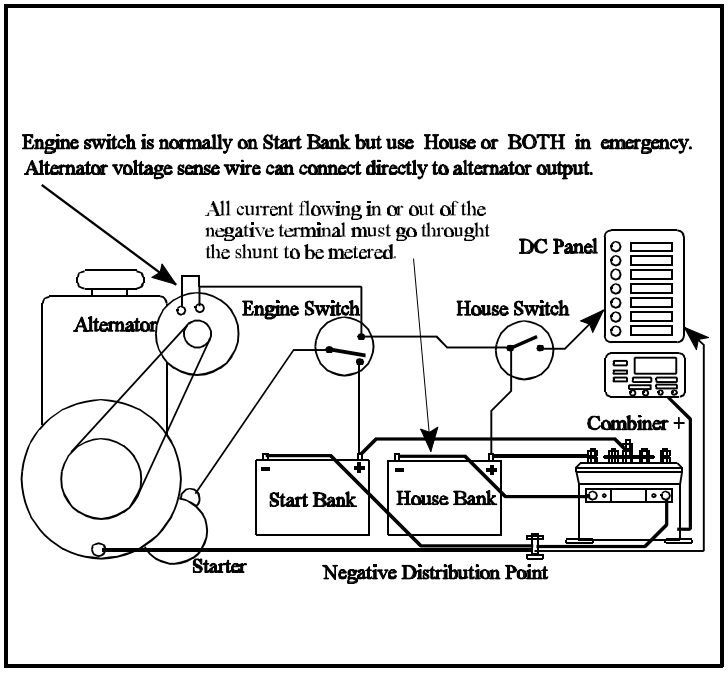
See the switch test mode above which includes the display segment test.

CALIBRATION

The zero setting of amps is corrected automatically 4 minutes after turning the Combiner + ON, and then once per hour. This corrects for temperature variations and ageing of components. You can force a zero setting even though current is flowing by pressing SET while AMPS are being displayed. Voltage and current re-calibration should not be required and must be performed on an accurate test set. Unrealistic voltage or current readings may indicate a loss of calibration data. If you suspect your calibration needs correcting, you will need to have both the display unit and the control box returned for free re-calibration. Call West Marine for instructions.

If you attached the display with a sealant, and you are concerned that removal may damage the panel, you can remove the electronic board assembly from the rear, and replace it after calibration, without removing the front panel. After removing the aluminum cover, you just unscrew all four lock nuts on the back of the display and the board will slide off to the rear. Save the four silicon rubber spacers, the nuts, nylon washers and the cover for re-assembly and just ship the circuit board with the contactor box, wrapped appropriately for protection. When re-assembling, put the four silicon rubber spacers on the studs, then attach the PC board to the panel. There is no spacer on the center stud. Tighten the top two nuts first being *very* careful not to over tighten. The glass display should be as close to the clear area in the front panel as possible without touching. Be very careful not to over tighten the nuts and force the panel to delaminate. Then follow the switch adjusting procedure on page 12 to set the bottom two nuts.

TYPICAL TWO BANK SCHEMATIC



OPERATING SPECIFICATIONS

VOLTAGE: OPERATING		9.0 to 20.0 Volts DC. Reverse polarity protected. Not suitable for 24 volt installations.
	NON-OPERATING	Down to zero volts without data loss. Overheating may occur with sustained voltages above 20 volts. Damage may occur with voltage pulses greater than 35 volts.
CURRENT IN SHUNT		0 to +/-500 amps continuous, +/-1000 amps intermittent.
COMBINING CURRENT		400 amps inrush, 130 amps holding, 100 amps interrupting.
BATTERY CAPACITY	MINIMUM	20 Amp Hour.[1]
	MAXIMUM	1999 Amp Hour.[2]
OPERATING CURRENT [3]	SHUTDOWN	0.002 amps.
	OFF	0.016 amps.
	ON	0.022 amps.

	BACK LIGHT	Add 0.005 amps.
	ALARM	Add 0.010 amps.
	COMBINER ON	0.450 amps.
VOLTAGE ACCURACY	+/- 0.02 V typical	
CURRENT ACCURACY	0 to 4A	+/- larger of 0.02A or 1% typical.
	4A to 30A	+/- larger of .1A or 1% typical.
	Over 30A	+/- 1% typical.
AMP-HOUR ACCURACY		Comparable to current accuracy.
CONTROL PANEL SIZE		4.5"W x 3"H. Mounts in panel cut-out of 2 ½" X 3 ½" with rear clearance of 1 3/8 inches minimum.
CONTACTOR BOX SIZE		8"W x 6"D x 6 ½ "H. You will need unrestricted access to the top and front for cable attachment.

[1] Batteries lower than 20 Amp Hour may be used, however a full charge must be reached each time for automatic correction of efficiency.

[2] Batteries larger than 1999 Amp Hour may be used, however when the discharge level exceeds 4000 Amp Hours, accuracy will be lost. The display will indicate "2HI" for readings or alarm settings above 1999 Amp Hours.

[3] The internal storage capacitor may cause a spark and momentary current draw when the Combiner + is first connected. This is normal and only lasts a fraction of a second. An automatic reset thermal fuse limits current supplied from the contactor box to the display head to 0.1 amps.