RAY ELECTRIC OUTBOARDS, INC.

ELECTRICAL REPAIR MANUAL
Model E2 (Variable Speed)
Applicable to Serial #400 and greater

Ray Electric Outboards, Inc.
908 NE 24th Lane Cape
Coral, FL 33909
(239) 574-1948
FAX (239) 574-8359
Email: info@rayeo.com

5/08

SAFETY

ALWAYS OBSERVE THESE SAFETY PRECAUTIONS WHEN TROUBLE SHOOTING THE RAY MOTOR

1. BEFORE REMOVING THE TOP COVER, BE SURE KEY SWITCH IS OFF TO AVOID POSSIBLY SHORTING TERMINALS INSIDE THE MOTOR AS A METAL TOP IS REMOVED. STRONG ARCS CAN RESULT IN DAMAGING EQUIPMENT AND POSSIBLY CAUSING INJURY. (IF YOU HAVE A NEWER MODEL MOTOR WITH PLASTIC TOP, TOP MAY BE REMOVED WITHOUT TURNING THE KEY SWITCH OFF.)

2. TO AVOID INJURY, UNPLUG POWER FROM MOTOR WHENEVER MAKING REPAIRS INSIDE THE MOTOR COWL. SHORTS CAN BE CAUSED BY METAL TOOLS OR LOOSE WIRES CAUSING ELECTRICAL ARCS. WHEN NECESSARY TO TAKE VOLT METER READING WITH POWER ON, USE CAUTION! AN EXPERIENCED MECHANIC WOULD BE A PREFERRED TECHNICIAN.

Trouble Shooting

First, keep in mind that breakdowns are few and these are usually minor and almost always electrical. Don't suspect something catastrophic -- it rarely happens.

If, even with this guide, you are having a hard time finding the trouble, call us, and call before you disassemble something or replace parts based on assumptions.

Give us all the symptoms and, chances are, together we can solve the problem. It may take some tests and more calls, but we have been successful many times.

When you need a part to fix the trouble, look it up in the Parts Manual and order giving part number and name.

The Most Likely Problems

Battery Problems:

Batteries cause by far the most trouble, usually due to neglect, but occasionally due to defects. Batteries may simply be discharged or a cell in one battery may be dead. One dead cell will cause a significant slowing of the motor.

Also, terminals corrode after several years and can easily cause an open circuit. An open at any battery terminal will cause the motor not to run and charger not to charge. Greasing the terminals will prevent corrosion for a long time. A toothbrush and ordinary chassis grease works well. See Trouble Shooting Chart for other battery troubles. See Operating and Maintenance Instructions for maintenance of batteries.

Charger Problems:

Closely related to battery problems are charger problems. The most likely is a blown diode due to overheating (these can be easily replaced). As soon as a diode goes the fuse goes. If you replace the fuse without replacing the diode the fuse will blow again – replace both at the same time. The charger will not overheat if it has adequate ventilation. If it is stored in a seat, the seat lid should be open or the charger should be removed from the seat when charging.

The charger also will not charge ("0" current on charger ammeter) if there is an open anywhere in the primary battery circuit. An open can occur at a loose or corroded wire terminal at the batteries.

If batteries show only ¾ voltage, due to defects, age, or over-discharge, the Lester Automatic Charger will not turn on when plugged in. Check voltage with voltmeter and if below ¾ voltage, (example 36V for a 48V system) see Trouble Shooting Chart for correction or call your dealer.

Key Switch:

If moisture gets into the key switch the contacts may corrode and fail. The console should be covered with a canvas or vinyl captain's stand cover (pontoon boats) when not in use. WD40 is recommended. Apply liberally to keyhole so WD40 penetrates to bottom of switch. This is a good preventative measure and may even revive a failed switch.

Electrolysis:

Experience has shown that if any part of an aluminum boat is grounded to any battery terminal, electrolysis will occur on parts of the motor left underwater in areas where paint has been chipped off (exposed metal). Electrolysis is indicated by what appears to be very rapid corrosion of these areas. Rapid corrosion never takes place without electrolysis. Grounding of the boat can occur when automotive type lights with one connection through the base are installed. Even some marine running lights have one side of the circuit connected to the metal base of the light. If the base is mounted directly on a metal part of the boat, grounding occurs.

It is important to know that the boat is not grounded when installing a Ray system. If the offending light or other device cannot be insulated from the boat -- remove it.

If you discover electrolysis actually taking place, keep the motor out of water when not in use and find the cause of the grounded condition and eliminate it as soon as possible. If the boat is not grounded electrolysis will not happen, but if the boat is grounded it invariably does.

HOW IT WORKS

(Refer to wiring diagrams)

Plus 48 (example voltage) volts are picked up from the primary (power) wire system for operation of the control circuits at the rear terminal of the cut off contactor and run via the fuse and white 20 ga. wire to the terminal strip where the white wire of the motor cable carries the 48 volts through the plug/socket to the control cable and the terminal strip of the control console and then to the input of the key switch (white wire).

Turn key on:	Plus 48V are applied to the meter, the rotary switch (red) and through the control cable red wire, cable plug and socket and motor cable and terminal strip to PMC small terminal (rear one) and to the cut off contactor which turns on and applies plus 48V to the B+ term of the PMC. (To determine plug & socket prong assignments--see page 7.)
Push lever Forward:	The rotary switch puts 48V to the forward contactor via the control cable and motor cable green wire. The forward contactor turns on and completes the primary power circuit to the electric motor.
Push lever forward slightly more:	The potentiometer raises the control resistance to the PMC sufficiently for the PMC to start turning the motor. This operation uses the blue and brown wires of the control cable/motor cable.
Push lever forward more:	Motor speeds up because pot rotates further and the resistance to PMC (across the blue and brown wires) further increases.
Pull lever back:	The motor slows down because the pot decreases resistance to the PMC over the blue & brown wires. (The motor can be stopped by the PMC before the forward contactor cuts off.)
Pull lever back to past the forward contactor turn on point:	Plus 48V is dropped from the green control wire, turning off the forward contactor and breaking the output of the PMC to the motor.
Pull lever back (reverse):	The rotary switch puts 48V on the orange wire, reverse contactor is turned on, connecting the motor to the PMC output with the fields reversed i.e. the current flows in the opposite direction in the field coils.

Pull lever back further:	The motor speeds up in an identical way as forward using same brown & blue wires, however the other half of the center tapped pot is automatically used.

The contactor coils are supplied minus 48V via a 20 ga. black wire harness attached to the B- terminal of the PMC. This harness also runs to the terminal strip where the motor cable and control cable carry it through the console terminal strip and to the meter so the meter can measure the battery voltage.

Each contactor has a diode across the coil for purposes of diminishing arcing on the rotary switch. These diodes must be installed with the silver band end toward the plus, the colored control wire, not toward the black negative wire. Otherwise, the fuse will blow and the diode itself may also blow. (Unexplained repeated fuse blowing may be a reversed or bad diode.)

A short anywhere in the control circuits will cause the 10-amp fuse to blow. Without the fuse complete motor and control cables are at risk.

The diode just below the fuse prevents damage from reversed battery polarity by preventing the cut off contactor from operating; otherwise, connecting 48V in reverse to the outboard would destroy the PMC when the key is turned on.

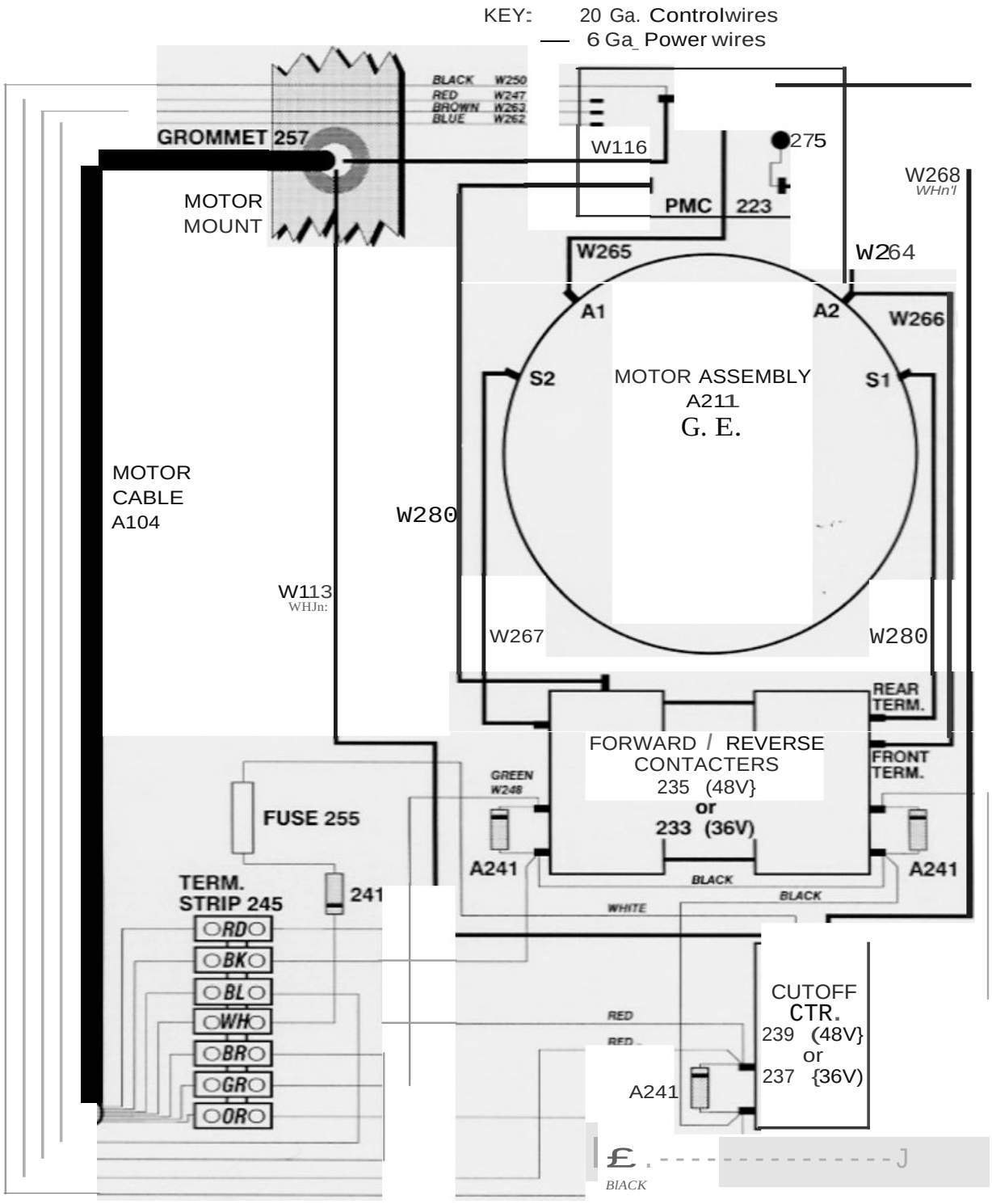
The varistor (275) is for protecting the plugging diode in the PMC from voltage spikes, such as from nearby lightening. The plugging diode makes reversing smoother (essential on tiller models). PMC will work without the plugging diode.

NOTE: The wiring diagram shows the GE motor. We have also used an Advanced DC brand motor. The only difference is the location of the terminals on the motor. (This requires some wires of different lengths.) The electrical connections are the same. With the Advanced DC motor, to facilitate wiring, we usually flip the lower front terminal (the terminal to which A2 is connected) to the other side of the Forward/Reverse contactor set. (This terminal is on a bar which goes across, so electrically there is no change.)

Ray Electric Outboards, Inc.

Wiring diagram - Motor Group

Model #E-2, including Serial #400 & on.



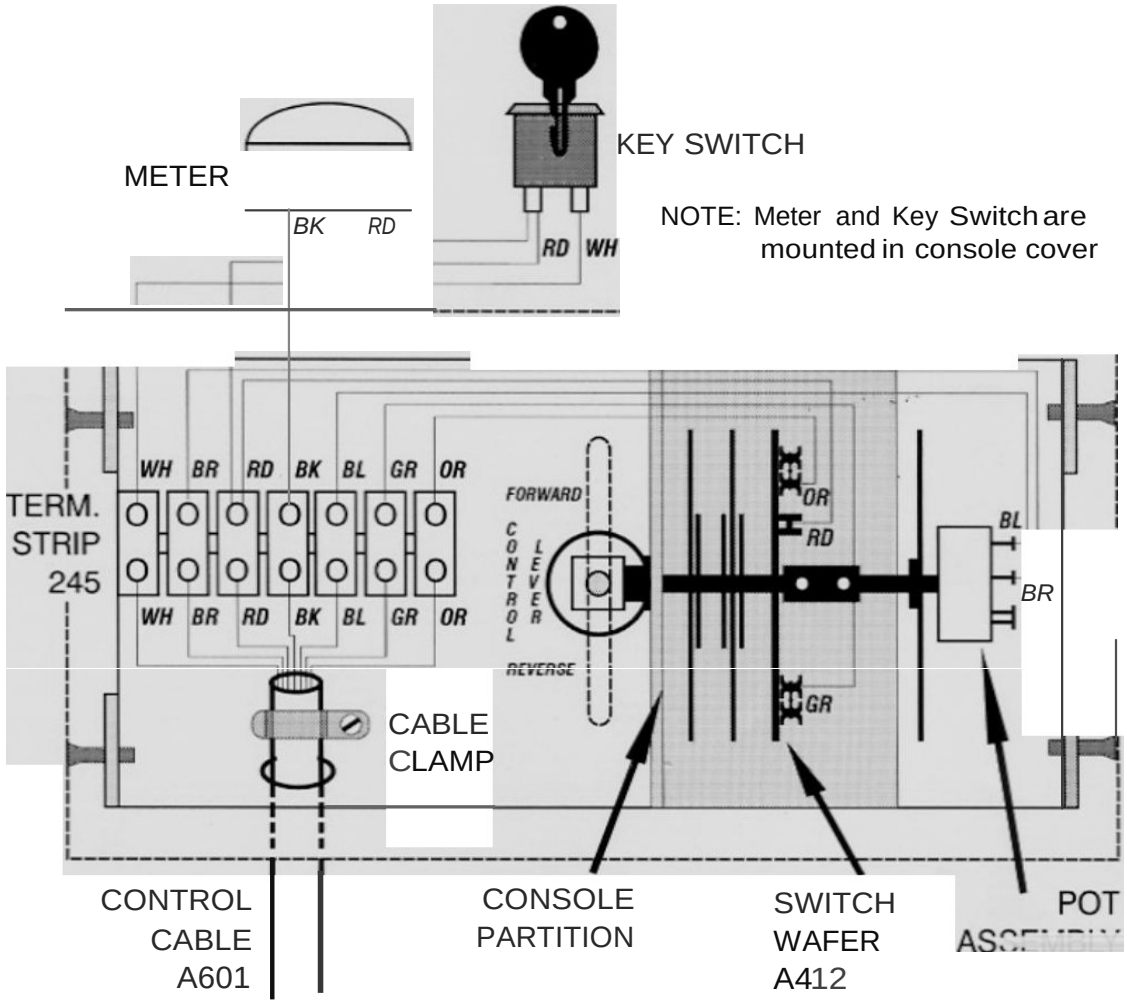
WIRE COLOR CODE

Red (RD), Orange (OR), Green (GR), Blue {BL), Brown (BR), Black (BK), White (WH)

Ray Electric Outboards, Inc.

Wiring diagram - Console Group

Model #E-2, including Serial #400 & on.



WIRE COLOR CODE

Red (RD), Orange (OR), Green (GR), Blue (BL), Brown (BR), Black (BK), White (WH)

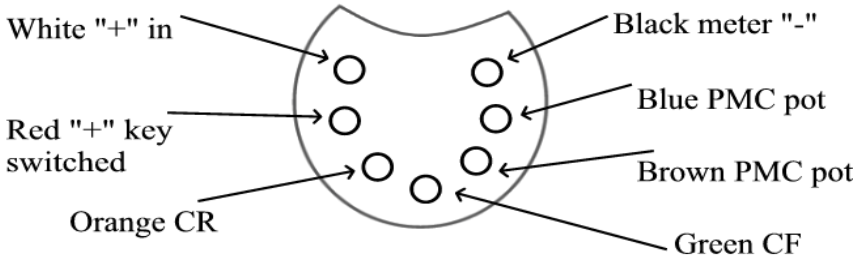
Contactor Functions

CONTACTOR LOCATION	FUNCTION	DESIGNATION	COLOR OF CONTROL WIRE
Upper Left Front (looking at front of outboard)	On: Forward Off: Lower contacts function in reverse circuit	Forward (CF)	Green
Upper Right Front	On: Reverse Off: Lower contacts function in forward circuit	Reverse (CR)	Orange
Lower Right Front	On: PMC on Off: PMC off	Cutoff (Cp)	Red

Plug/Socket Assignments

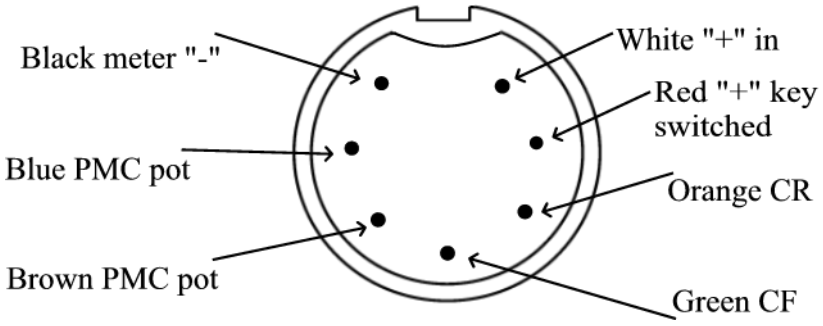
Also, see next page

Socket on Motor Cable



Looking into Socket

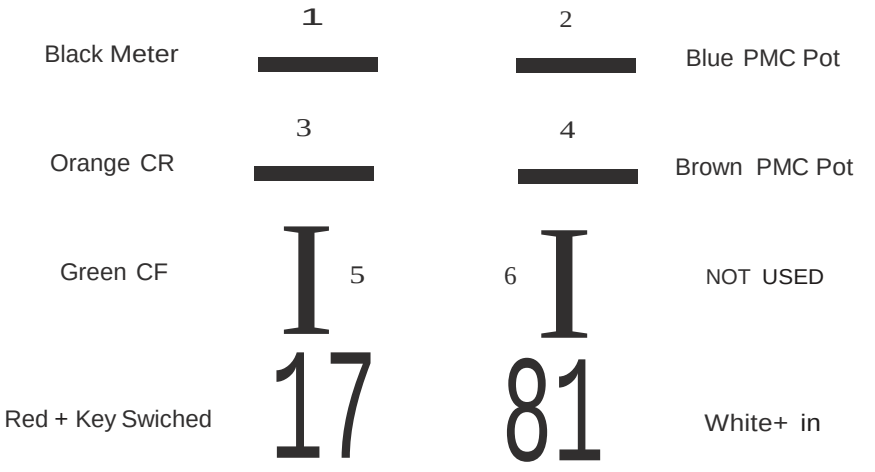
Plug on Control Cable



Looking into Plug

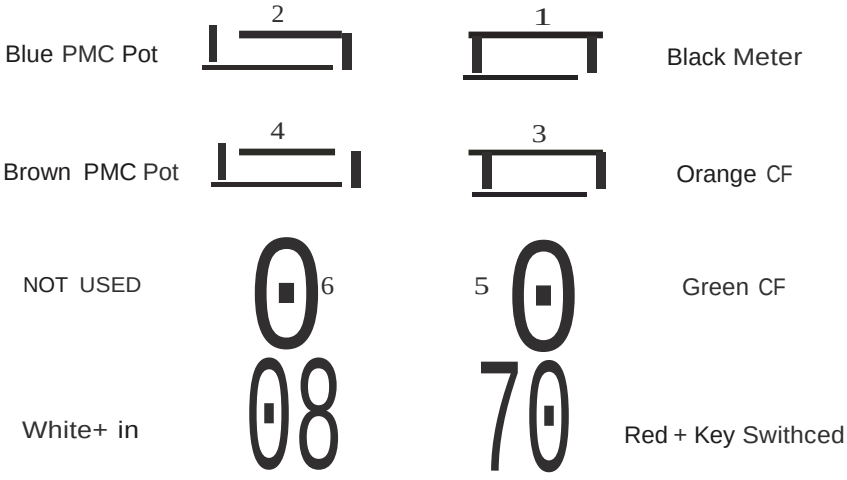
Plug/Socket Assignments

Later Motors with Covered Rectangular Plug



Looking at Ends of Prongs

Socket on Motor Cable



Looking into Socket

When a Contactor or the PMC Fails to Operate,
How Do You Find Where the Trouble Is and Correct It?

Any failure (open) in any individual contactor control circuit will cause the associated contactor to fail to turn on. The Trouble Shooting Chart (TSC) associates the symptoms with each contactor so there should be no trouble finding out which circuit is at fault.

We will take one example and follow through checking and repair procedures. By then it should be obvious that similar procedures will work for the other circuits. There are three contactor circuits (one for each contactor) plus the potentiometer circuit.

Example: Motor does not run in reverse, but runs in forward. You suspect the reverse contactor not to be picking up. (Turn key off before taking the top, if metal, off the motor.) Take off the top, put the motor in reverse, and, note that your suspicions were correct; the reverse contactor is not operating.

Start checking the trouble right at the "the horse's mouth." With the controls set at reverse low speed (Speed lever must be advanced past the point where the rotary switch turns on the reverse contactor), take a voltmeter and check for voltage right across the contactor coil terminals. If you get voltage, the coil is suspect. However, check for mechanical friction of contactor before replacing contactor. If there is no mechanical blockage or mechanical problems that can be repaired, replace the contactor.

If you do not get voltage at the coil, start checking control voltage at other points along the orange wires, proceeding from the contactor coil terminals toward the console.

First, check the negative feed to the coil. Place the positive voltmeter lead on the white primary wire on Cp. Place the negative lead on the coil negative terminal. If the reading is not battery voltage, check the black wiring harness (20 gage wire) for opens and correct. (Check the crimping of terminals on this harness if at first no broken wire is found.)

Next, check between (-) at the contactor coil and orange terminal on the motor terminal strip. If you get proper voltage, the problem (open) is in the orange wire (or crimping) between the strip and the coil. If voltage is still zero, go to next paragraph.

Remove console from base and with the voltmeter check between black (negative) (If battery meter is working, negative will be good here.) and orange on the terminal strip (motor still on in reverse, low speed). If you get voltage, the problem is in the orange wire in the control cable, motor cable or the connecting plug and socket. (Control cable system) If you get no voltage, check for voltage between black and white on the terminal strip. If you get no voltage, the trouble is in the key switch, rotary switch or connecting orange wire inside the console. Check these and isolate the problem.

If problem is not found, check the cable on the motor for continuity. BE CAREFUL NOT TO SHORT THE SOCKET WITH OHMETER PROBE. (Battery voltage normally exists on the black and white terminals) Check the orange wire in the cable. With plug unplugged, check with an ohmmeter for continuity from the motor terminal strip to the socket hole corresponding to orange. (See plug/socket assignment above) If you get continuity in the motor cable and the socket appears satisfactory, the trouble is isolated to the control cable and plug.

To check the control cable on boat for continuity of the orange wire, place one probe of the voltmeter on the prong of the plug. Extend the length of the other probe, if necessary, with a piece of wire to the screw on the control console terminal strip corresponding to orange.

Other Control Circuits

You can check the other two-contactor control circuit following procedures similar to those above. Just trace the applicable colored wire from the contactor coil through to the terminal strip in the console as we did above. If necessary, make continuity checks on the motor cable to the applicable socket hole and then similar checks of the control cable on boat.

Shorts in the Control Cable

Shorts across wires in motor cable or control cable can cause various unexplained malfunctions of the system. To check for shorts in the control cable and motor cable unplug the control cable connector. Remove cable wires from the motor terminal strip and check for shorts between wires in the motor cable with an ohmmeter. There should be no shorts. Remove control cable wires from terminal strip at console and check for shorts in control cable. If shorted, applicable cable must be replaced.

The PMC (Pulse Modulated Control) and associated circuits

If the contactors are operating normally and the motor still will not function, suspect an open primary terminal inside the cowl, the PMC, the three control wires to the PMC -- blue, brown and red, or the potentiometer.

First, check for a shorted plugging diode. (See function of plugging diode at end of "How it Works" above) If this is the problem, the PMC output is shorted inside the PMC. If left on for any length of time, the PMC will get hot and additional damage will occur. The PMC will work without the plugging diode if additional damage has not occurred. Removing the A2 PMC to A2 motor wire (W264) removes the plugging diode from the circuit. If a shorted plugging diode is suspected, remove the A2 wire. If motor then runs, it means the diode is shorted. Without the plugging diode, reversing will be harsh and even dangerous on tiller models. PMC should be replaced. If plugging diode is not the problem, proceed to next step.

With the key switch on, check for battery voltage between the black and white primary wires attached to the two rearmost terminals at the top of the PMC. Check for good connections at these terminals and the two other primary terminals on the PMC. If voltage is not obtained, the trouble is in the PMC shut off contactor (Cp) or in the primary wires leading to this contactor. Check connections and contacts of the contactor. If voltage is obtained, proceed to next paragraph.

With key switch on, check for battery voltage between the red control (small) terminal on the PMC and the black primary wire (-) on the rear terminal of the PMC. If voltage is not obtained, the trouble is in the red wire between the motor terminal strip and the PMC (if problem was in the control cable or elsewhere, Cp would not be operating). If voltage is obtained, proceed.

TURN KEY OFF. CAUTION: CAPACITOR VOLTAGE (36, 48 or 60) STILL EXISTS ACROSS THE REAR PRIMARY TERMINALS OF THE PMC. Remove the blue and brown control wires from the PMC. With ohmmeter, check resistance across ends of blue and brown wires with speed lever on off. You should get approximately 0 ohms. Now, advance lever to full speed while observing ohmmeter – resistance should increase to 5000 ohms in either forward or reverse.

If resistance is correct and all voltages at the PMC are correct (as above), a bad PMC is indicated and should be replaced. If resistance is infinite, there is probably an open in the blue or brown wire. Check out these wires for continuity in the motor cable and control cable. If resistance is always zero, check for a short between blue and brown in cable system. Also, check for positive mechanical drive of the pot; that it has not slipped due to loose coupling or nut.

If no trouble can be found as above, check for operation of the potentiometer by placing ohmmeter on contacts at the console terminal strip. Resistance should vary approximately 0 to 5000 ohms when pot is rotated with speed lever in either direction. Also check for loose connections on pot and terminal strip. If pot is not providing proper resistance, it must be replaced.

TROUBLE SHOOTING CHART

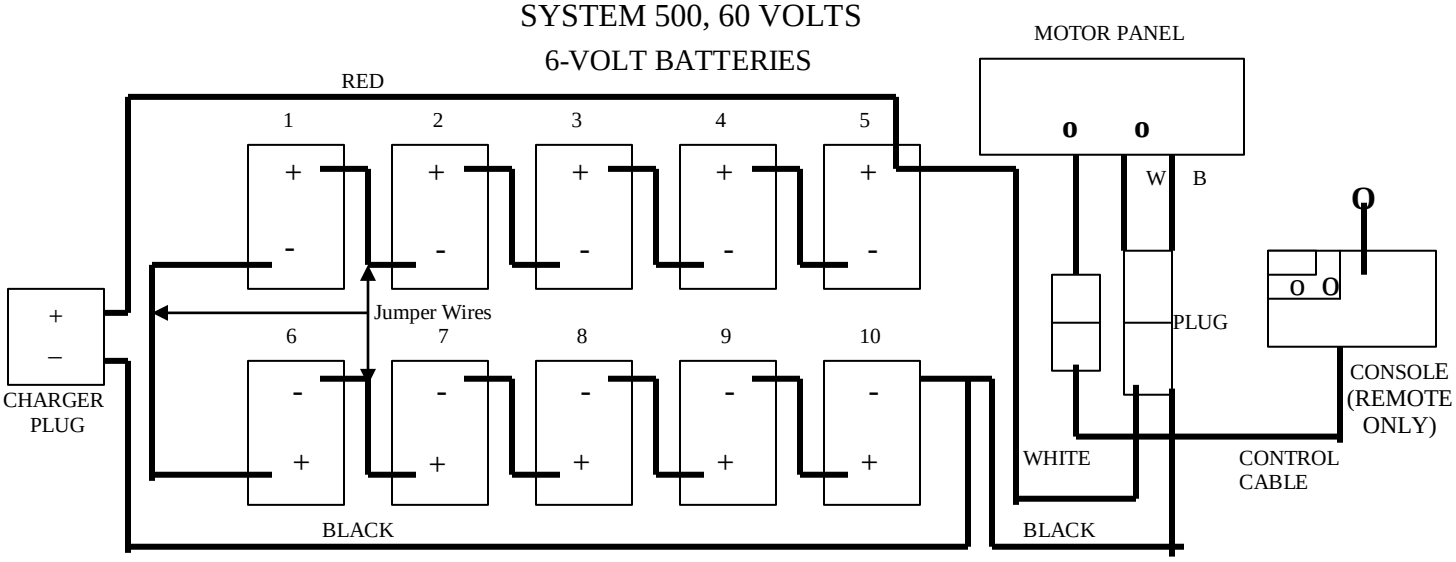
Symptoms	Cause	Correction
1. Won't run. Battery meter Registers far left "charge"	1. Batteries dead	1. Charge or replace batteries as necessary
	2. Open at a battery terminal	2. Repair terminal
	3. Key switch not operating	3. Short across switch terminals to verify. Replace switch
	4. Control cable plug/socket unplugged or damaged	4. Insert plug into socket. Replace if necessary
	5. Anderson plug un-plugged at motor or damaged	5. Plug in plug. Replace if necessary
2. Won't run. Battery meter registers "OK"	1. PMC not operating	1. See "The PMC and associated circuits"
	2. Green and orange wires shorted, causing CF & CR to be on simultaneously	2. See "Shorts in control cable"
	3. Loose primary terminal inside motor cowl	3. Inspect and repair
	4. Cp not operating or has dirty contacts See “Checking control circuits”	4. Check out Cp and red control circuit

Symptoms	Cause	Correction
3. Will not operate in Forward	1. CF not operating Control	1. Check green circuit See "Checking Circuits"
	2. CF normally open Contacts not making contact	2. Visually check contacts. UNPLUG BATTERIES. File contacts with point file. Replace contactor, if necessary.
	3. CR normally closed Contacts not making contact	3. Same as 2
4. Will not operate in Reverse	1. CR not operating	1. Check orange circuit. See "Checking Control Circuits"
	2. CR normally open Contacts not making contact	2. Visually check contacts. UNPLUG POWER TO MOTOR. File contacts with point file. Replace contactor, if necessary.
	3. CF normally closed Contacts not making contact.	3. Same as 2
5. Electrolysis -- rapid corrosion on underwater parts of motor where paint is off.	1. Boat grounded to a battery terminal -- such as through the base of an automotive type light. Some marine running lights also connected through base.	1. Eliminate ground by insulating light from boat or eliminate light. NEVER ground boat when a Ray Outboard System is installed. See Electrolysis
6. Charger will not charge ("0" ammeter	1. One or both diodes have failed due to	1. Check diodes with ohmmeter and replace

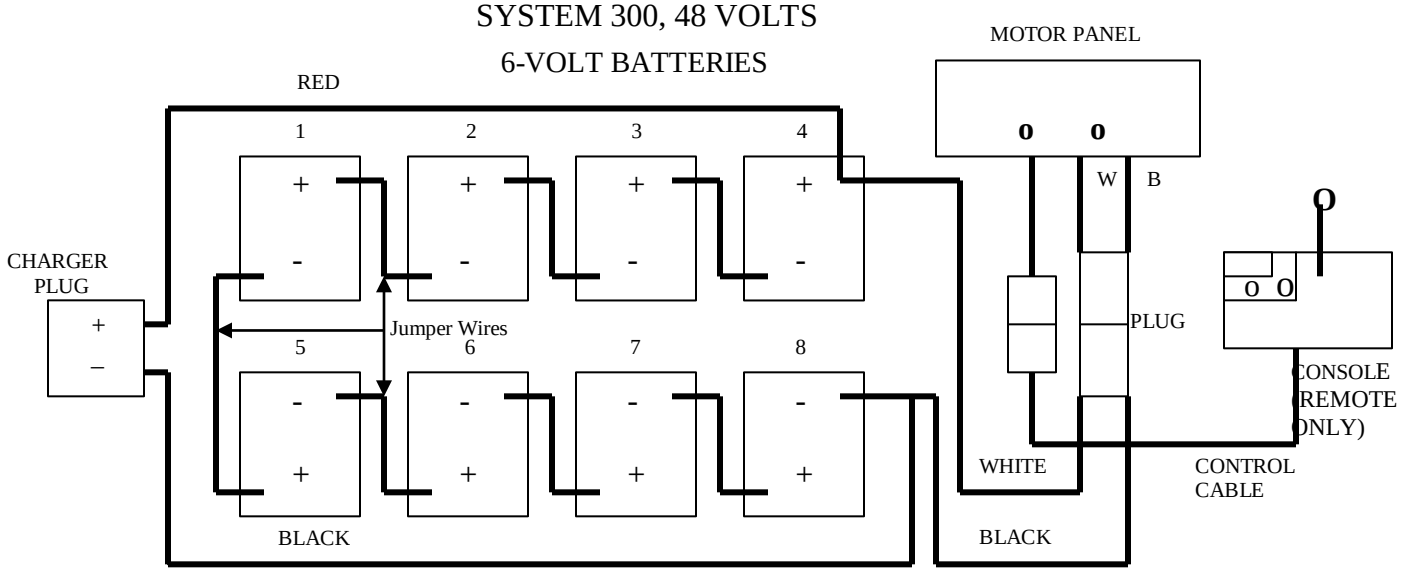
reading)	overheating or due to voltage spikes such as from lightning. Charger fuse will usually also be blown.	if bad. Replace fuse. Make sure charger has adequate ventilation when in use. See Charger Problems
Symptoms	Cause	Correction
	2. Open in charging circuit.	2. Check all battery terminals and leads for open. Check Anderson plugs at charger.
	3. Low Battery Voltage. Lester Automatic charger requires approx. ¾ of battery voltage before it will turn on.	3. Verify with voltmeter. Use a manual charger until required voltage is returned. Then use regular charger. 6V batteries can be brought up 2 at a time with a 12V charger.
7. Motor operates slower than normal or running time is shorter than it should be.	1. Bad cell in one battery.	1. Check all battery cells with a hydrometer after charging. Replace battery with bad cell.
	2. Corroded or loose battery terminal or loose primary connection anywhere in the system.	2. Locate bad connection visually and correct.
	3. Batteries not receiving a full charge.	3. Too much amperage on batteries used to power accessories. Bring these batteries up to charge with a 12 volt charger, reduce accessories (radio, spot lights, etc.). Install a 12V battery and charger when a lot of accessories are operated.

Symptoms	Cause	Correction
	4. Battery acid allowed to remain below plates (pre-mature failure).	4. Replace batteries. See Operating and Maintenance Instructions for care of batteries.
	5. Battery life expired (4 to 6 years typical for private use).	5. Replace batteries.
	6. One battery reversed (connected plus to plus instead of plus to minus.)	6. Check to see that batteries are all wired in series plus to minus. Reversed battery may have to be replaced. First, try to bring it up to charge with a 6 volt charger.

SYSTEM 500, 60 VOLTS
6-VOLT BATTERIES



SYSTEM 300, 48 VOLTS
6-VOLT BATTERIES



SYSTEM 240 & 200, 36
6-VOLT BATTERIES