

OTIS S-71 GOLF CART

TECHNICAL INFORMATION



Jim Kaness

Revised November 2015

OTIS GOLF CART S-71 TECHNICAL INFORMATION

This manual was written without the knowledge, consent, or participation of the Otis Elevator Company, and it does NOT have their endorsement. This manual is my own work on my own initiative and the responsibility for its content is mine alone.

Except for the sales brochure excerpt on page 5, the text, drawings, and photographs in this document are my own work from my own reverse engineering done on my own S-71, and comparison with other S-71's available for inspection. Despite 40-odd years of electronics engineering and construction, technical writing, and "jack of all trades" it is still possible for me to err. I reserve the right to update and correct this document as new information becomes available. Comments, suggestions, and corrections are welcomed.

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<http://www.jimkaness.com/engineering/s71.pdf>

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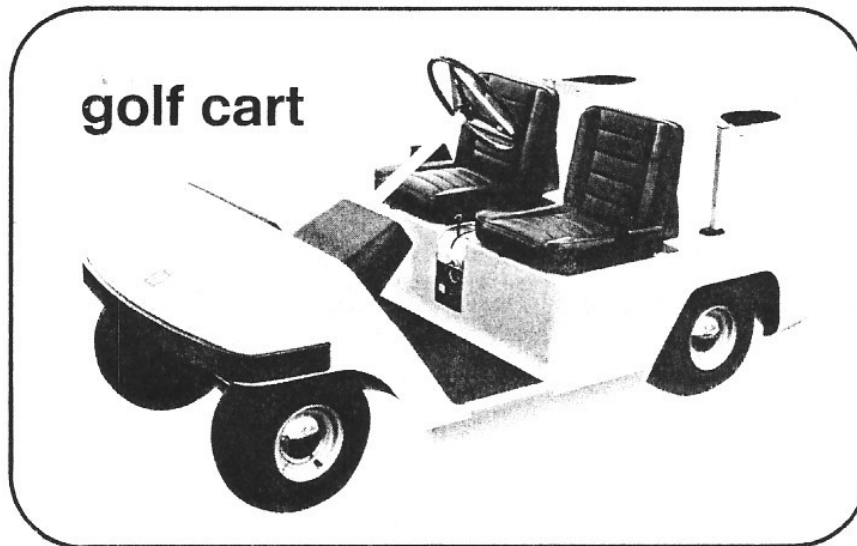
NOTE: John Triolo of Mountain Golf Cars, Inc. generously provided me with a copy of the original Otis Model S-71 Parts and Service Manual and Operators Manual after my own manual was written. It shows exploded drawings, original part numbers, and wiring diagrams. I have scanned the manual and it is available from me as a PDF file on CD-R at no cost to you. The file is too large to email.

OTIS S-71 HISTORY

The Otis S-71 golf cart was produced between 1970 and 1976 by Westcoaster, a subsidiary of Otis Elevator Company, and may be branded either “Otis” or “Westcoaster”. In 1970 Otis Elevator Company acquired West Coast Machinery Company of Stockton, CA who manufactured a full line of electric and gasoline powered vehicles under the brand name ‘Westcoaster’ for use off the public roads- on airports, factories, farms, ranches and golf courses. In 1976 Otis sold the Westcoaster / Otis product line to EVA-Chloride, who was then engaged in development of electric vehicles for highway use. In 2015 many of these S-71 golf carts are still in use.

EXCERPT FROM WESTCOASTER SALES BROCHURE [1]

**The photo and text below are Copyright © 1971
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model S-71

The most modern, sophisticated Golf Cart ever! Four wheel stability, automotive steering, hypoid rear axle, heavy duty vinyl seats, an exceptionally low profile and contemporary fiberglass body all make the new S-71 the epitome of the industry. A vacuum formed plastic canopy is optional.

OTIS S-71 GENERAL INFORMATION

INTRODUCTION

The Otis S-71 Golf Cart has a fiberglass body on a tubular steel frame, and uses six 6-volt batteries to power a GE 36-volt series (the field and armature are connected in series) DC motor. Speed is controlled by adding or removing resistance in series with the motor voltage. The S-71 provides four speeds forward and reverse. The S-71 weighs 740 pounds without batteries [1] and about 1100 pounds with batteries. Top speed is 12 miles per hour [1].

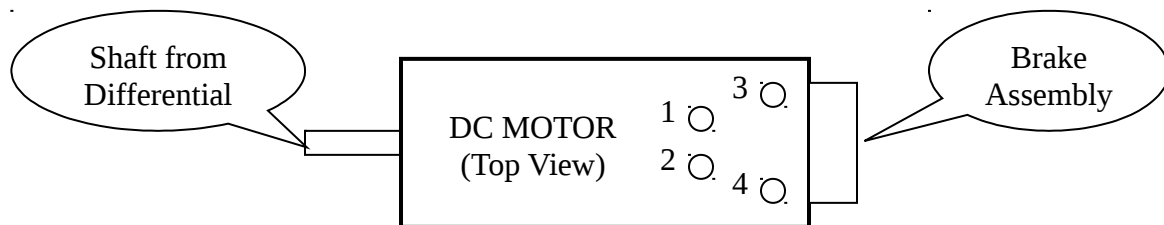
SERIAL NUMBER

One Westcoaster S-71 reported to me has an adhesive serial number label on the lower dash between the steering wheel and the glove box.

OTIS S-71 ELECTRICAL

MOTOR

The motor is a General Electric DC Motor, Model 5BC48JB517B rated on the nameplate for 55-amperes at 36-volts DC. The nominal shaft horsepower rating is 2.0. The field and armature are connected in series. The motor terminals may not be labeled- I have arbitrarily labeled them 1 through 4 for correspondence with the diagrams on the following pages. Terminals 1 and 2 go to the field winding. Terminals 3 and 4 go through brushes to the armature. Brushes are accessible by removing the rubber covers next to terminals 3 and 4.



NOTE: Most electric motors have the field and armature connected in parallel. When motors are used for propulsion, as this one is, the field and armature are usually connected in series as this provides maximum torque at low speed. However a series-connected motor **MUST** always have a load on it or its speed may rise to an unsafe value [2]. This will not be a problem unless the motor is removed from the S-71 for bench testing.

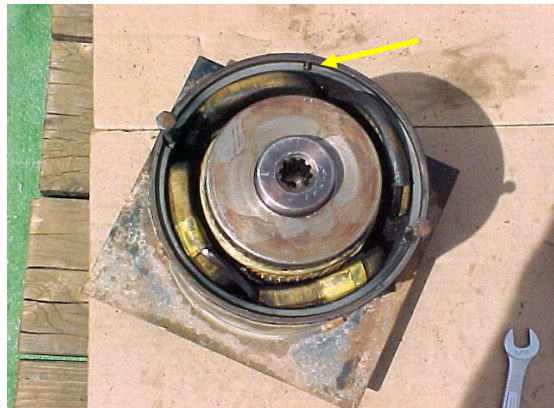
MOTOR REMOVAL

The motor mounts to the differential with two bolts and a splined shaft. Remove all electric cables from the motor **making sure that the terminal bolt does not rotate**. Use a thin 9/16" end wrench on the rear nut while removing the front nut and the cable. Then remove the brake cable assembly from the brake. Remove the two bolts at the outer perimeter of the rear motor housing from the differential end of the motor. The motor armature has a splined socket that fits over a splined shaft coming out of the differential housing. It is a tight squeeze, but the motor may be pulled away from the differential and removed from the S71.

In this condition the motor has no rear bearing so while the armature may rotate, it will rub on the stators. The motor rear housing with a rubber shaft seal is bolted to the differential with four bolts. Remove the four bolts and tap gently on the differential side of the motor rear housing. The housing will separate from the differential and come loose. A paper gasket appears to be used between the differential and the motor rear housing.



The photo upper-right shows the motor rear housing still attached to the differential, just after the motor is pulled off. The splined shaft from the differential is visible in the center of the housing. The motor is keyed to this housing with a single small finger key which should point toward the top of the cart .

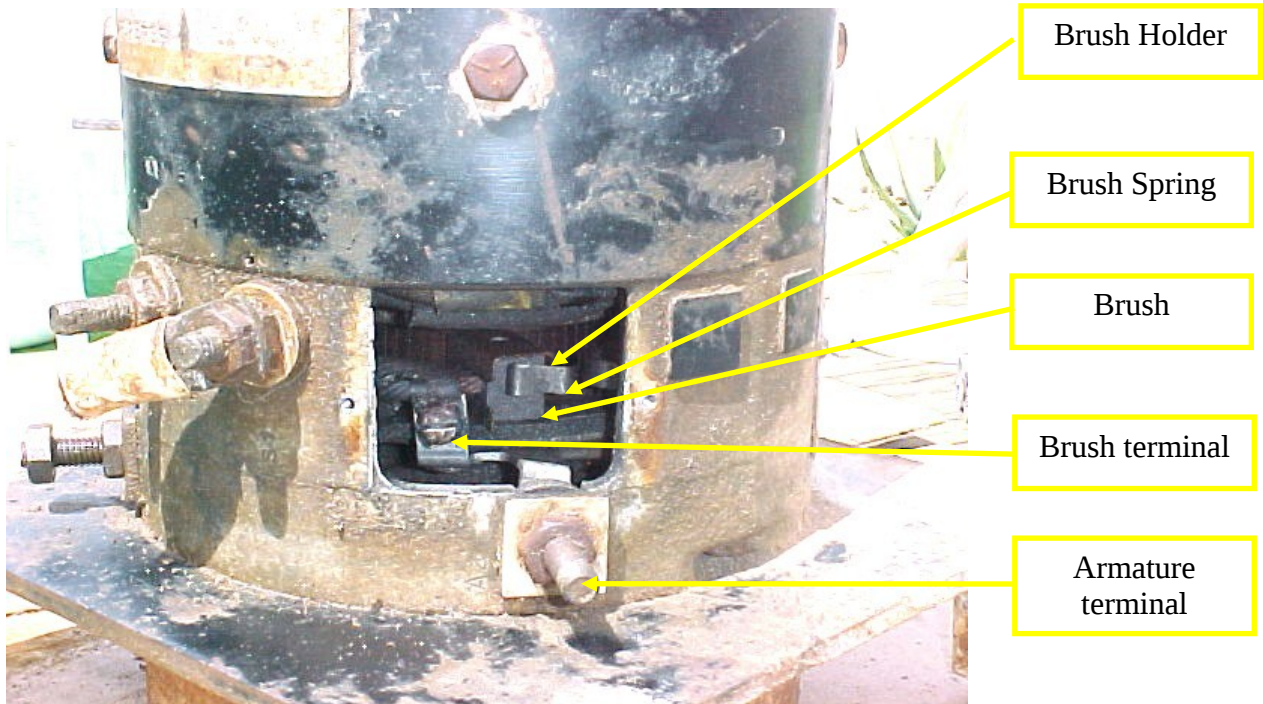


The photo to the right shows the rear of the motor with its rear housing missing, just after the motor is pulled off the differential.

The splined socket is visible in the center of the armature. The finger key may be seen as a dark spot on the outer case of the motor, near the top of the photo.

MOTOR BRUSHES

The motor has two replaceable carbon brushes. Each brush is held in its holder by a spring that may be pulled back by the fingers for brush removal. Each brush has a heavy stranded wire and lug that bolts (brush terminal) to a piece of flat steel which is spot welded to the motor armature terminal as shown in the photo below.



The armature terminal bolt is insulated from the motor housing by an inner round washer, an outer square washer, and a center bushing with a square inner hole (to fit the square shank on the bolt) and a square outer shape to fit the square hole in the motor housing. One nut holds all this together and a second nut is used to attach the electrical motor cable. I have found two of these that were over-torqued such that the center insulation (between the washers) was destroyed and the bolt could rotate in its hole, bending the metal tab attached to it. This could eventually lead to a short circuit. Both the brush and the brush terminal screw should be readily accessible through the inspection hole as shown in the photo above. If the brush terminal is not fully visible, look for bent (out of proper shape) metal between the armature terminal and the brush terminal caused by rotation of the armature terminal bolt.

DIRECTION CONTROL AND INTERLOCK

The Forward - Reverse lever on the control panel directly operates the high-current DC polarity reversing switch. To prevent arcing, a normally-open microswitch closes when the lever is in the full "Forward" or full "Reverse" position, allowing the solenoids to apply power to the motor.

SPEED CONTROL

The accelerator pedal operates a pushrod connected to a series of switches inside the enclosed box (under the seat) on which the solenoids are mounted. As the accelerator is pressed down, power is applied to the motor through two solenoids, and through resistors (they look like coils of heavy wire) mounted under the motor. As the accelerator pedal is pressed further other solenoids reduce the amount of resistance in the circuit. Five solenoids and two resistors (one with a tap) offer four speeds. This approach has been used in electric street railways for over a century [3].

Solenoids LT and LB are both used to apply or remove power from the motor. The S-71 uses these two solenoids with their contacts in series, apparently to guarantee that power can be removed from the motor in the event the contacts on one of these solenoids should weld closed. The other three solenoids (RT, RM, and RB) are used to short out various parts of the resistance for speed control.

Solenoid ON	Accelerator Position
LT, Left Top	A, B ,C ,D
LB, Left Bottom	A, B, C ,D
RT, Right Top	B, C, D
RM, Right Middle	C, D
RB, Right Bottom	D

The accelerator, as it is pressed, offers OFF and positions sequentially labeled (by me) A (slowest), B, C, and D (fastest). With any one of the motor wires disconnected, and key ON, you can hear the solenoids turn ON as the accelerator is depressed through its range.

The pushrod between the accelerator pedal and the switches can be adjusted in length so that, at rest, NO switches are engaged, and so just before the accelerator bottoms on the floorboard ALL switches are engaged.

The five solenoids are basically automotive starter solenoids with all four terminals isolated from the metal case and from each other. The solenoid coils are rated at 12 VDC and show a measured DC resistance of 12 to 14 ohms. In my S-71 they are each operated on 18 VDC. The solenoids are bolted to the metal box holding the accelerator switches but **the nuts inside the box are not captive** and will fall down inside the box if the bolts are removed. Sheet metal screws may be used to re-mount a solenoid.

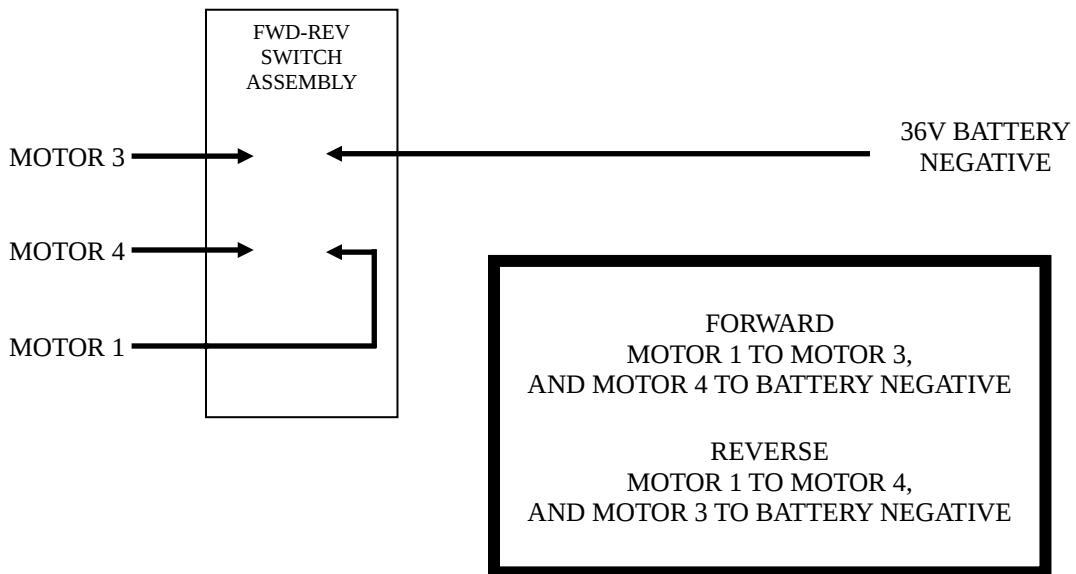
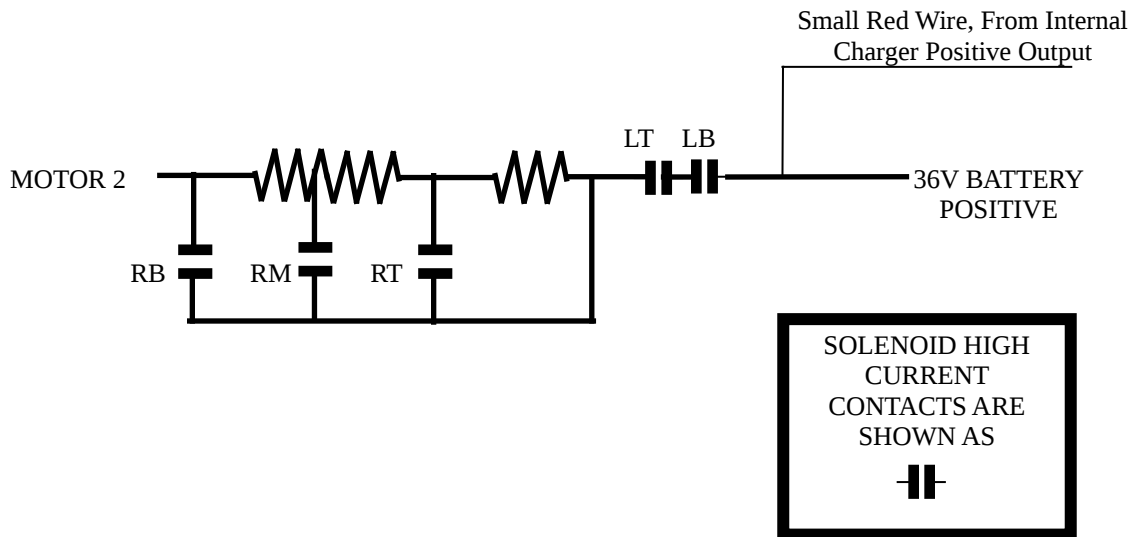
NOTE: THE S-71 MOTOR USES UP TO 55 AMPERES. FOR SATISFACTORY OPERATION IT IS VERY IMPORTANT THAT ALL CONNECTIONS TO THE MOTOR, BATTERIES, RESISTORS, AND REVERSING SWITCH BE CLEAN AND TIGHT.

HIGH CURRENT SCHEMATIC

This schematic shows the high-current connections between the batteries and the motor. MOTOR 1 and MOTOR 2 are the field winding. MOTOR 3 and MOTOR 4 are the armature winding. Except as noted, all wiring in this diagram is heavy-gauge stranded copper wire (AWG-6 or larger) or copper strap rated for not less than 55 amperes.

The Forward – Reverse switch swaps connections to the armature winding.

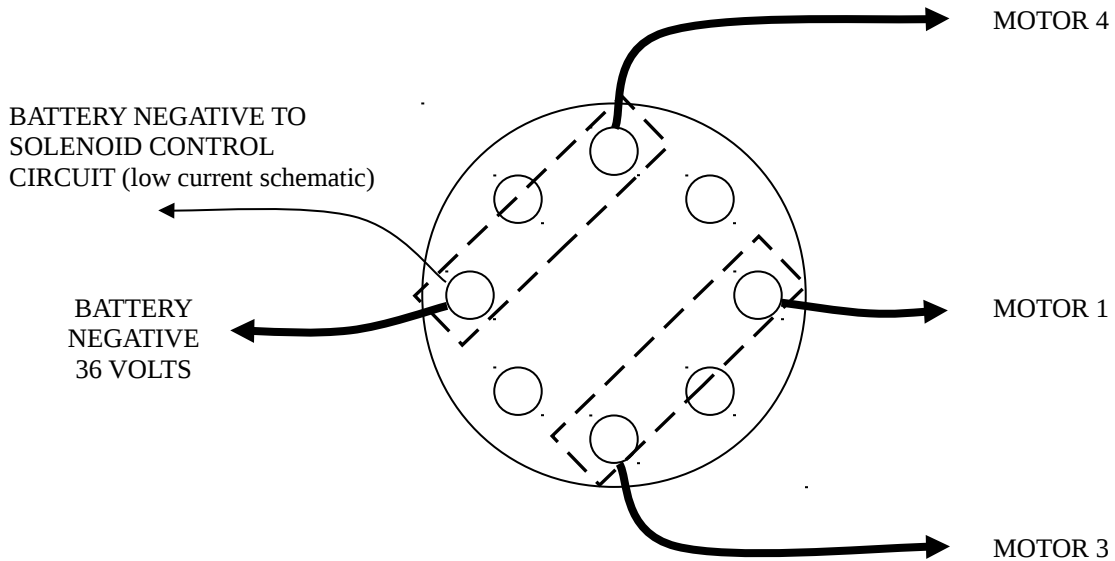
NOTE: The resistors shown are a fraction of an Ohm each and will measure zero Ohms with the usual bench multimeter.



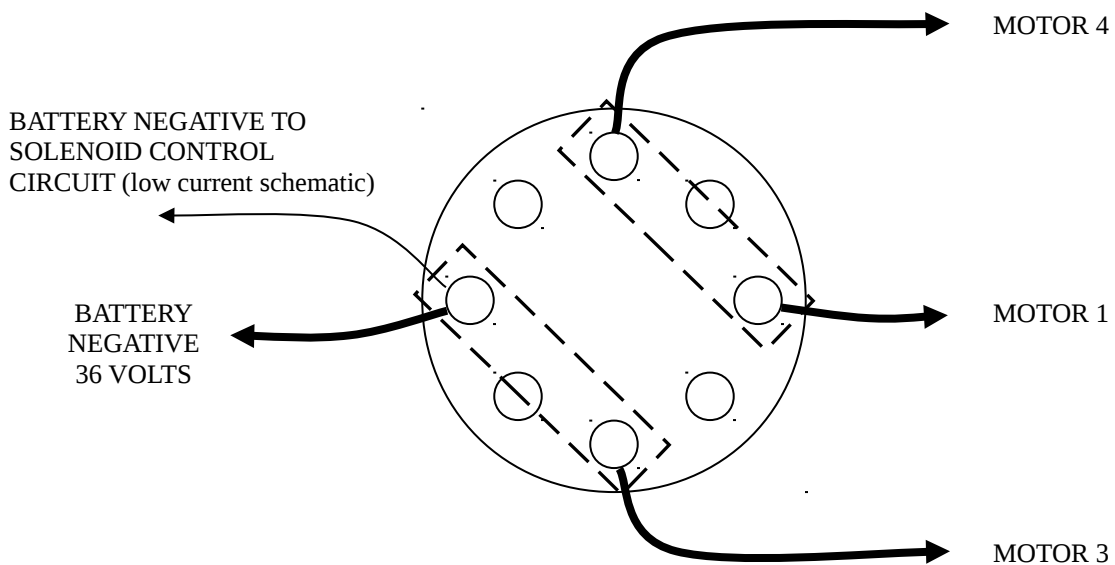
REVERSING SWITCH CONNECTIONS

Viewed from passenger side with control panel pulled forward. The MOTOR 4 connection is at the top. The dashed rectangles are the shorting bars on the reverse side of the switch assembly. The four unused bolt connections are only there to help the shorting bars slide smoothly over them to the intended connections. **The two copper shorting bars MUST be insulated from the metal spring-loaded carrier that moves them around.**

COPPER SHORTING BARS SHOWN BELOW IN 'FORWARD' POSITION.

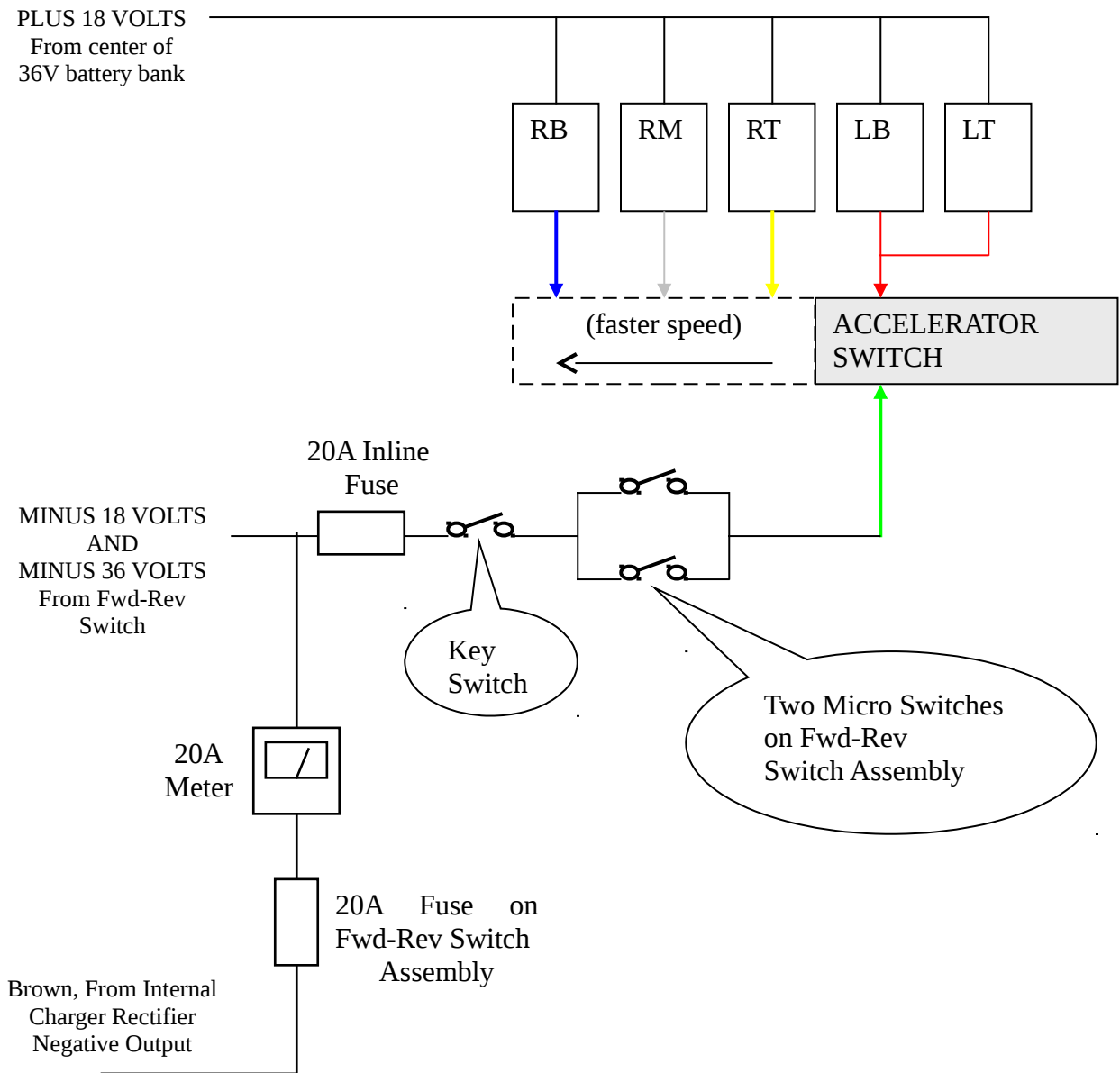


COPPER SHORTING BARS SHOWN BELOW IN 'REVERSE' POSITION.



LOW CURRENT SCHEMATIC

This schematic is for the low-current wiring, showing the solenoid coils, switches, and fuses. The accelerator switch progressively connects more solenoids as the pedal is pressed down. With the accelerator resting, none of the solenoids is energized. The drawing shows the switch having energized LB and LT, for the slowest of the four speeds. The colored lines below indicate the wire color code in my S-71.



OTIS S-71 BATTERIES

BATTERY SPECIFICATIONS

My S-71 uses six 6-volt Trojan batteries, model T-105, rated at 185 ampere-hours for 5 hours. Each measures 7 1/8" wide by 10 3/8" long by 10 7/8" high. The two 5/16 -18 threaded post connections are at diagonal corners. Other high-quality deep-cycle Golf Cart batteries may be used. Each T-105 weighs 62 pounds. Use a battery-lifting strap rated for this weight when removing or installing batteries.

TROJAN BATTERY DATE CODES

The Trojan date code is a letter-number combination stamped on the negative post. The code is MY, with the Month being A = January, B = February, etc. The Year is a single digit such that 3 = 2003, 4 = 2004, etc. Thus A3 indicates January 2003.

WARNING: WHILE 6 OR 36 VOLTS WILL NOT PRESENT A SHOCK HAZARD, THE HIGH AMPERAGE AVAILABLE FROM THESE BATTERIES CAN MELT OR WELD JEWELRY AND TOOLS THAT MAY ACCIDENTALLY SHORT ONE OR MORE OF THESE BATTERIES. TO ENSURE YOUR SAFETY WHEN WORKING ON OR NEAR THE BATTERIES, REMOVE RINGS, WATCHES, AND OTHER METAL OBJECTS FROM YOUR HANDS AND ARMS, AND WRAP ALL TOOL HANDLES WITH TAPE.

WARNING: THESE BATTERIES CONTAIN SULFURIC ACID. IF THIS ACID CONTACTS SKIN, EYES, OR OTHER BODY PARTS IMMEDIATELY FLUSH WITH LOTS OF WATER.

BATTERY MAINTENANCE

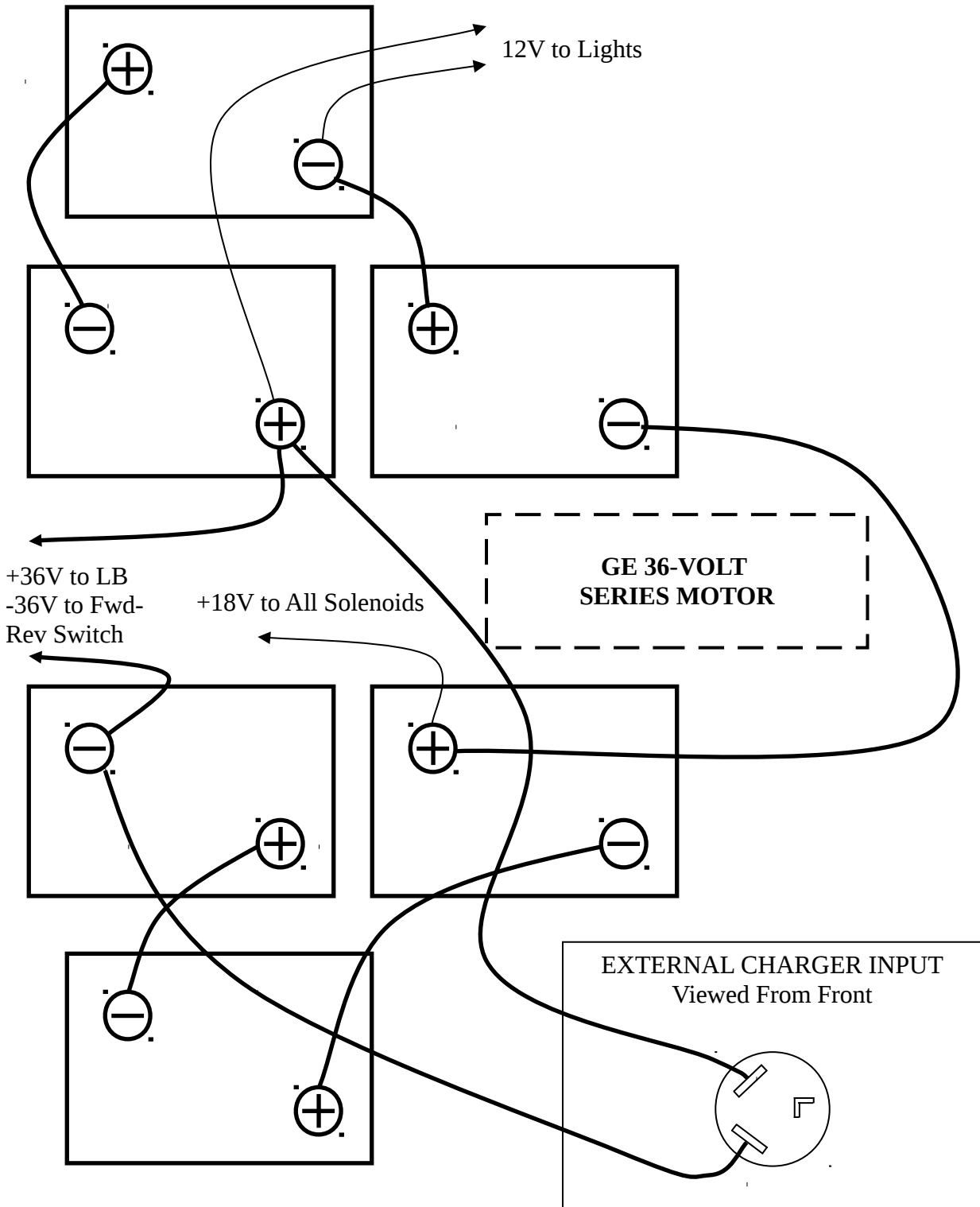
Periodically check the fluid level in the batteries- in all 18 cells. Hot weather and the battery charging process will normally cause the batteries to lose water. Remove the caps and verify that the fluid level is above the lead plates. If it is not, slowly add DISTILLED WATER until it is over the plates. DO NOT USE TAP WATER, as the dissolved minerals in it will shorten the life of the batteries.

Periodically check the battery terminals and, if any corrosion is observed, clean the battery terminals. Corrosion may be removed by using a solution of baking soda mixed with just enough tap water to make a wet paste. Using an old toothbrush, brush this paste over the corrosion, let it stand a few minutes while the paste bubbles, and then rinse the terminals with tap water. Repeat as needed until the terminals are clean.

Once the terminals are clean and the connections are tight, smear automotive grease over them to inhibit future corrosion.

BATTERY LAYOUT AND WIRING

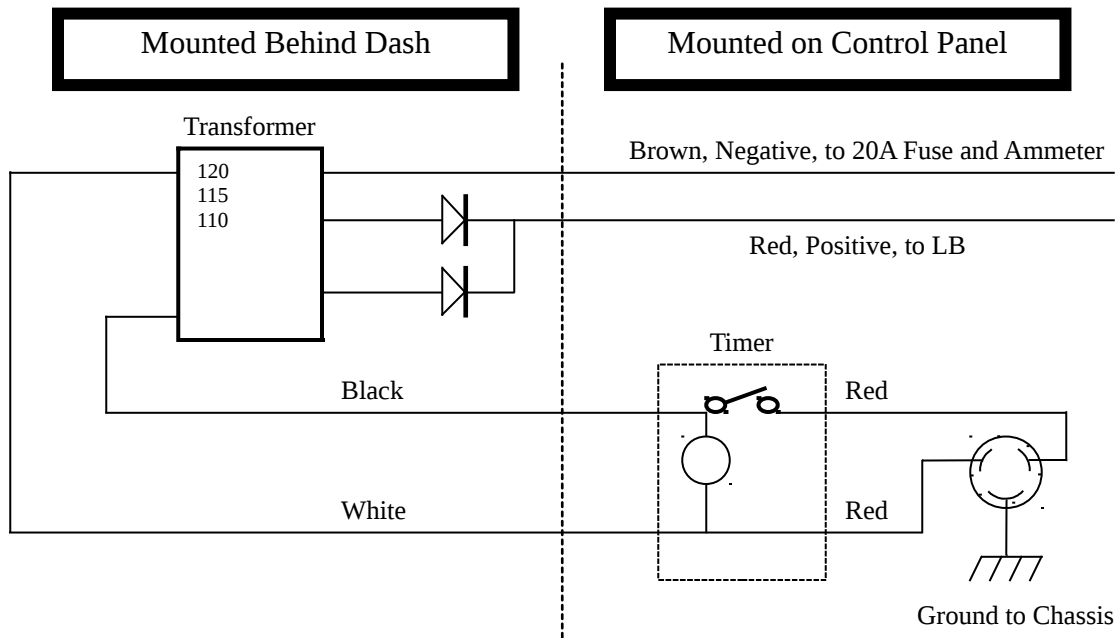
Driver's side view looking down on the batteries with the seat raised. Top of the page is the passenger side of the S-71. Left side of the page is toward the front of the S-71.



BUILT-IN CHARGER

The Otis S-71 originally came with a built-in battery charger. Many of these are no longer functioning and an external charger must be used. The transformer and rectifiers are under the front “hood” behind the dash. The 20-ampere ammeter, timer, and AC power cord connector are on the operator control panel between the seats. Behind this panel, located on the Fwd-Rev Switch Assembly, is a 20-ampere fuse between the charger output and the batteries.

The built-in charger uses a transformer and two silicon diodes in a standard full-wave rectifier circuit. The transformer has a tapped primary to accommodate varying AC line voltages. The timer operates off the AC input and allows charging for the desired number of hours to prevent overcharging. The ammeter confirms that charging is taking place. The transformer and diodes may be accessed by removing the glove box in the dash. The glove box mounts with two bolts and tapped L-brackets that grip behind the dash. To remove, unscrew the two bolts about 8-turns each. It should then be possible to wiggle the glove box free of the dash. The transformer and diodes are just inside and to the left.



The recessed male AC power connector on the S-71 is a type no longer made. I made a mating female connector from an L5-15R female connector by sawing the plastic connector body to lengthen the arc of the opening for the ground terminal.

ADDED ACCESSORIES

The Otis S-71 did not originally come with the following accessories. Various owners have added them to my S-71.

EXTERNAL CHARGER INPUT

The external-charger input is wired directly to the 36-volt connections of the battery bank. The charger connector is a standard 30-ampere female connector used for 240VAC electric clothes dryers. The ground terminal is not used. Any commercial 36-volt, 20 ampere charger may be used for charging the batteries. **NOTE: Modern automatic chargers may require at least 30-volts in the 6-battery-string or they may not turn on and charge!**

LIGHTS

The front headlights and rear red taillights are all wired in parallel and use 12-volts from two of the 6-volt batteries as shown on the battery-wiring diagram. This wiring has a 5-ampere fuse for safety. An SPST toggle switch on the dash controls the lights.

BATTERY STATE OF CHARGE METER

This expanded voltmeter is widely available at golf cart shops for about \$30. This “fuel gauge” is connected to the positive 36-volt battery post. The negative lead goes to the key switch so the meter only works when the key is ON. A 5-ampere fuse in the negative lead protects the wiring.



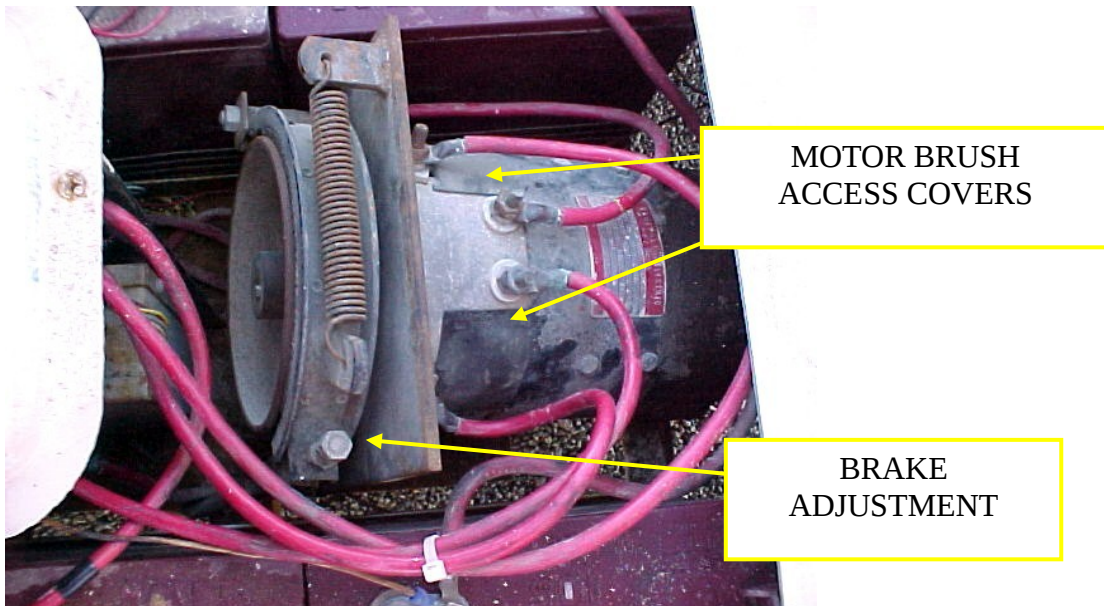
OTIS S-71 MECHANICAL

WHEELS AND TIRES

The S-71 has four wheels, which use 18 x 8.50 – 8 standard golf cart tires widely available in many tread designs. Normal tire pressure is 20 PSI. I am using 10-PSI tire pressure for a smoother ride on gravel roads. The S-71 is unique in using a five-lug rim. The current standard golf cart rim mounts with only four lugs.

BRAKING

The brake pedal operates a single brake shoe that is pulled against a drum attached (using a key and an Allen screw) to the forward-end of the motor shaft. The brake pedal is attached to a flexible cable, the other end of which pulls on the shoe through a spring. Pushing the brake pedal further engages a pawl that holds the brake ON as a parking brake. The brake pedal is also interlocked with the accelerator pedal. Simply pushing on the accelerator pedal will release the parking brake. An adjusting nut and locking nut are provided where the brake cable attaches to the shoe. The shoe should be adjusted so that the parking brake functions reliably. The photo below is taken from the driver's side with the seats raised, looking down on the motor.



REAR SUSPENSION

Rear suspension on each side consists of a coil spring, with a shock absorber inside each spring (like a two-piece strut), and a swing-arm that bolts to the rear axle and pivots at the frame attachment.

The two rear swing-arms are of different construction. The right (passenger) side is made of hollow steel pipe. The left arm is of flat steel. The reason for this is unknown to me at this writing.

The rear shock absorbers are stamped “Monro-Matic” with the part number “1034”. The date code is “C10C71”. The rear coil springs are pre-loaded. The spring must be compressed about an inch in order to safely bolt or unbolt the shock. We jacked up the frame and set it on blocks located at the rear of the battery framework, just at the forward edge of the rear trailing arms, and then used a floor-jack under the rear axle to raise the axle until the shocks could be fastened without tension. The rubber bushings for the shocks may be replaced with HELP! part number 31018 or Napa part number 650-1113.

FRONT SUSPENSION

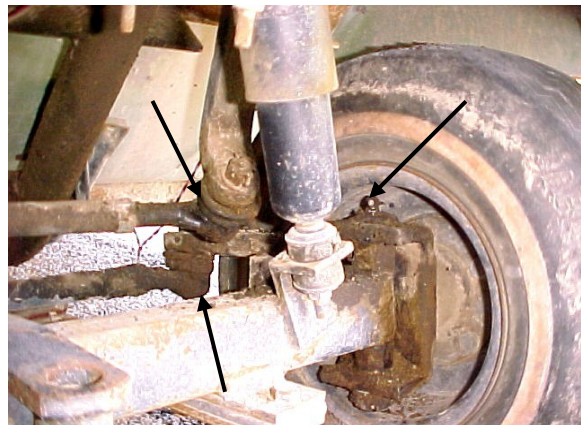
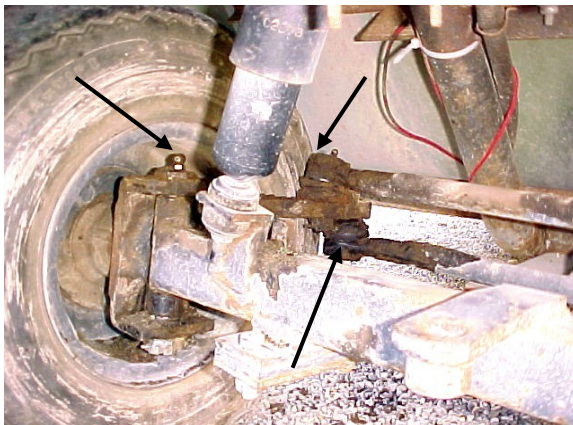
Front suspension on each side consists of a flat single-leaf spring and a flat half-leaf, and shock absorber. The rear end of the leaf spring and half leaf are solidly bolted (no pivot) to the frame. The forward end of the whole leaf spring is solidly bolted to the front axle. The shock absorbers are located between the front axle and the frame.

The front shock absorbers are stamped “MAECO” with the part number “A40099”. The date code is “C2D73”.

STEERING

Steering is a conventional automotive type, according to Otis. I strongly suspect the S-71 uses the same components as were used for Otis gasoline-powered products of higher power and speed.

The steering assembly has a total of six grease fittings, three on each side as indicated by the arrows on the photos below.



REAR AXLE AND DIFFERENTIAL

The rear axle and differential are of the automotive type, according to Otis. The differential can provide power to either rear wheel. I strongly suspect the S-71 uses the same components as were used for Otis gasoline-powered products of higher power and speed.

The differential cover, facing rear has an oil plug with a square hole for a 3/8" ratchet drive and used for inspecting and adding gear oil (see photo). Standard 90-weight gear oil is suggested.



REAR WHEEL BEARINGS

Each rear wheel uses a ball-bearing wheel bearing located in the end of the axle housing. For access, jack up the rear axle and remove the rear wheel. Remove the cotter pin and castle nut holding the hub and pull the hub straight off- it is splined to the axle shaft. The bearing will be visible at the end of the axle. This bearing should be flooded with clean grease. I have not removed one of these so cannot say further the exact procedure for bearing removal. The bearing appears to be retained by a plate that bolts to the end of the axle housing (with a large opening for the axle and through which the bearing may be viewed). To replace the hub align the splines of the hub and rear axle and push on. Replace the castle nut and tighten until it is tight, then back off the nut until the cotter pin can be inserted through the castle nut and axle and locked in place. Then replace the wheel. The recommended wheel lug nut torque is unknown to me but I use a 3/8 hand-ratchet and 3/4-inch deep well socket for this with good results.

FRONT WHEEL BEARINGS

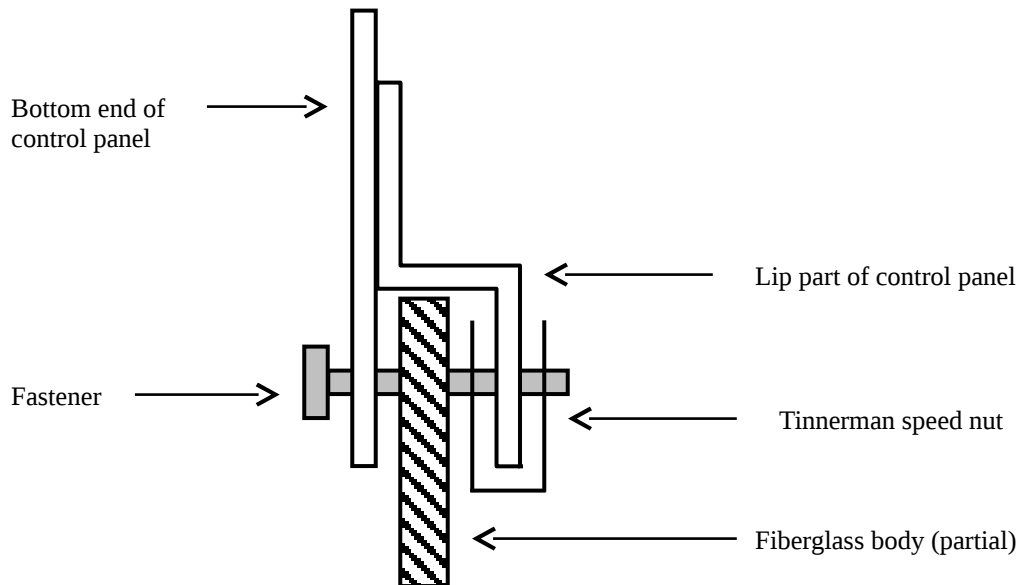
Each front wheel has an inner and an outer roller bearing that should be well greased. For access, jack up the front axle and remove the front wheel. Remove the grease cover from the hub by prying it straight out. Remove the cotter pin and castle nut holding the hub and pull the hub straight off. The roller bearings will lift out of the hub- they are only secured by grease. To replace the hub align the roller bearings with the axle and push the hub onto the axle. Replace the castle nut and tighten until it is tight, then back off the nut until the cotter pin can be inserted through the castle nut and axle and locked in place. The hub should rotate freely and have no side or end play. Then replace the wheel. The recommended wheel lug nut torque is unknown to me but I use a 3/8 hand-ratchet and 3/4-inch deep well socket for this with good results.

SEATS AND BATTERY ACCESS

The two individual seats are bolted to a piece of ½-inch plywood (covered with indoor-outdoor carpet) that is hinged at the front edge for access to the batteries. A rod and rod-holder (for propping up this cover during battery maintenance) are located on the battery side behind the driver's seat. The passenger seat mounts with four bolts from the rear of this cover into tapped nuts in the seat. The driver's seat mounts to adjustable tracks so it can be moved fore and aft to accommodate the driver. The tracks have threaded studs that extend through the cover and are attached with washers and nuts. The left-rear nut also secures the rod and the right-rear nut also secures the rod holder.

OPERATOR CONTROL PANEL

The operator control panel mounts to the fiberglass body using a bolt, nut, and washer at the top end (between the seats) and using either a bolt or sheet metal screw at the bottom edge near the floor. Remove the upper bolt first. Then remove the bottom fastener- it screws into a captive Tinnerman U-type self-retaining speed nut on the inside lip behind the fiberglass. When the bolts are removed, lift up on the panel about ½-inch so the bottom lip clears the fiberglass. The panel may then be pulled forward a few inches for access to the components mounted on it. The heavy battery cables and the studs on the reversing switch may hang up on the fiberglass but with a little patience and care the panel will come free for inspection and maintenance.



REFERENCES

[1] Westcoaster sales brochure entitled "full line". Otis Collection Item #2599. © 1971 by Otis Elevator Company. Used by permission.

[2] Circuits and Machines in Electrical Engineering, Volume II Machines
By John O. Kraehenbuehl and Max A. Fawcett
Second Edition, ©1947, John Wiley & Sons, Inc., New York
Page 251.

[3] I.C.S. Reference Library (4 volumes)
Volume: Electric Railways, Interior Wiring
©1904, International Textbook Company, Scranton
Section 24, Page 16.

INTERESTING WEBSITES

SUBJECT	WEBSITE LINK
Electric Vehicle History	www.econogics.com/ev/evhista.htm
EVA-Chloride	See listing at www.econogics.com/ev/evhiste.htm
Otis Elevator Company	www.otis.com
Otis Elevator Company	See listing at www.econogics.com/ev/evhisto.htm
Trojan Batteries	www.trojanbattery.com
Westcoaster	No listing found
Golf Cart Parts	http://www.golfcarcatalog.com/
Golf Cart Parts	http://www.teetimegolfcars.com/