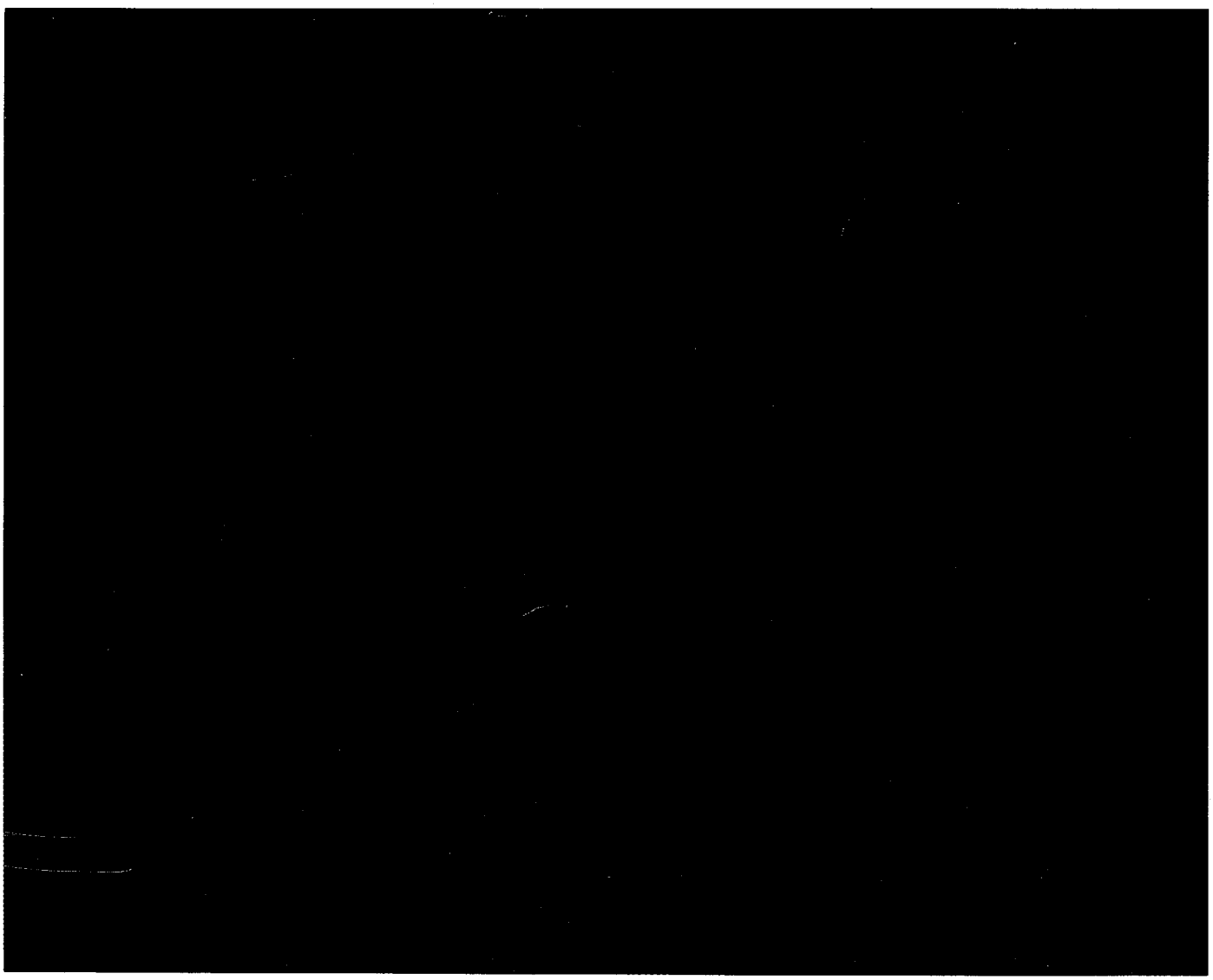
COLUMBIA

# Service Manual

## 1985 to 1987 • Electric Golf Car



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# SERVICE MANUAL

## 1983 to 1986

Electric Golf Car

# WARNINGS AND CAUTIONS

Statements in this manual preceded by the words WARNING or CAUTION and printed in bold face are very important.

**WARNING**

**Means there is the possibility of personal injury to your self or others.**

**CAUTION**

**Means there is the possibility of damage to the vehicle.**

We recommend you take special notice of these items.

# CONTENTS

All photographs and illustrations may not necessarily depict the most current model or component, but are based on the latest production information available at the time of publication.

Columbia ParCar, Corp., reserves the right to change specifications, equipment, or designs at any time without notice and without incurring obligation.

To ensure a satisfactory and lasting repair job, follow the manual instructions carefully and use only genuine Columbia replacement parts. This is your insurance that the parts you are using will fit right, operate properly and last longer. When you use genuine Columbia parts, you use the best.

# PRODUCT REFERENCES

When reference is made in this manual to a specific brand name product, tool or instrument, an equivalent product, tool or instrument may be used in place of the one mentioned.

# SERVICE BULLETINS

In addition to the information given in this Service Manual, Service Bulletins are issued to Columbia Dealers from time to time, which cover interim engineering changes and supplementary information. Service Bulletins should be consulted for complete information on the models covered by this manual.

# USE GENUINE REPLACEMENT PARTS

**WARNING**

**When replacement parts are required, use only genuine Columbia parts or parts with equivalent characteristics including type, strength and material. Failure to do so may result in product malfunction and possible injury to the operator and/or passenger.**

**WARNING**

**Proper service and repair is important for the safe, reliable operation of all mechanical products. The service procedures recommended and described in this service manual are effective methods for performing service operations. Some of these service operations require the use of tools specially designed for the purpose. These special tools should be used when and as recommended.**

**It is important to note that some warnings against the use of specific service methods which could damage the golf car or render it unsafe are stated in this service manual. However, please remember that these warnings are not all inclusive. Since Columbia could not possibly know, evaluate and advise the service trade of all possible ways in which service might be done or of the possible hazardous consequences of each way, we have not undertaken any such broad evaluation. Accordingly, anyone who uses a service procedure or tool which is not recommended by Columbia must first thoroughly satisfy himself that neither his nor the operator's safety will be jeopardized by the service methods selected.**

**WARNING**

**Working on heavy golf cars without following proper procedures and using proper lifting equipment may result in car damage or personal injury.**

**WARNING**

**Safety procedures are essential. A running golf car must be worked on with great care. Avoid spinning wheels. Use caution and common sense.**

# ELECTRICAL SYSTEM 1

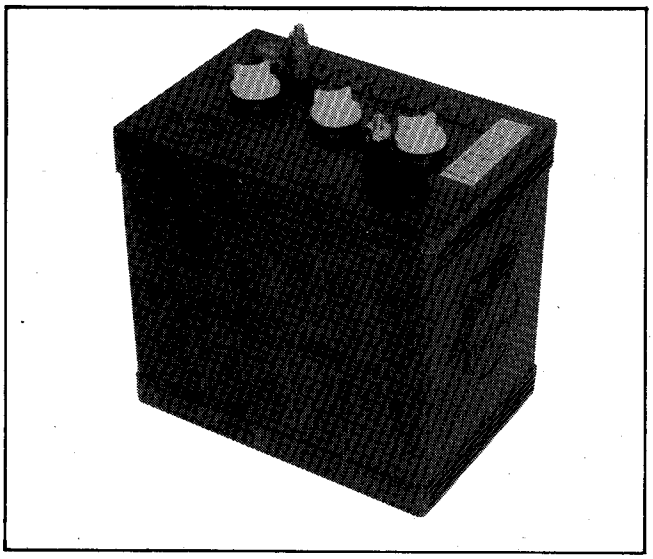
# BATTERY

## Battery Cycle

The electric golf car storage battery receives, stores and delivers electrical power. The battery does not manufacture electricity, it merely stores it in chemical form for later use. This receiving, storing and delivering of electrical power is called a cycle.

| | | |
|---|---|---|
| Receive | — | Charging car batteries |
| Store | — | Car standing idle |
| Deliver | — | Driving car |

Batteries furnished for electric golf car operation are specially constructed for this type of service.



**Golf Car Battery**

Automotive batteries are designed to furnish high current draws for short durations, and are kept in a near fully charged state by the charging system. Electric car batteries must be able to furnish currents up to 50 amperes for long durations, and also be able to supply that current while in a partially discharge condition. This type of service requires a deep cycle battery — a battery that is durable enough to withstand repeated complete cycling. For this reason golf car batteries are constructed with heavier plates, and cells with a greater capacity for electrolyte.

**CAUTION**

**Only batteries designed for electric golf car service should be used.**

**WARNING**

**Batteries contain sulphuric acid, which is highly corrosive and can cause chemical burns. Avoid contact with skin, eyes or clothing. Always wear approved eye protection when working around batteries.**

**ANTIDOTE**

**External — Flush with water.**

**Internal — Drink large quantities of milk or water, followed by Milk of Magnesia, vegetable oil or beaten eggs. CALL DOCTOR IMMEDIATELY.**

**Eyes — Flush with water, get immediate medical attention.**

## BATTERY INSTALLATION AND CONNECTION

Batteries are installed and connected in the golf car

Follow procedure outlined in BATTERY CARE after installing batteries.

## BATTERY CARE

### Visual Inspection and Maintenance

Batteries should be carefully inspected every week, 6 hours operating time, or every 10 rounds of play. This procedure should also be followed before any tests are performed on the batteries.

1. Battery must be clean and dry. Dirt and electrolyte on top of battery causes battery to self-discharge. Clean battery top with baking soda (sodium bicarbonate) and water solution (5 teaspoons baking soda per quart water). Do not allow solution to enter cap vent holes.

2. Inspect battery posts, clamps, and cables for breakage, loose connections and corrosion. Clean posts and clamps.

3. Be sure battery hold downs are properly tightened. A loose hold down may allow the battery to become damaged from vibration or jarring. A hold down that is too tight may buckle or crack the battery case.

4. Check to see that battery cap vent holes are clear. Plugged vent holes will not permit gas to escape from the cell and could result in battery damage.

5. Check electrolyte level. Sufficient water should be added to cover plates before charging, then after charging, remaining water can be added to bring electrolyte to correct level.

6. Inspect battery case for cracks or leaks.

# CHARGING BATTERY

The lead-acid storage battery supplies electrical power through chemical action. This action is reversible, which means the battery must be connected to a charger and have an electrical current passed through it in the direction opposite to the direction of discharge in order to restore the battery s active chemicals.

**CAUTION**

**Overcharging is harmful. Batteries should be charged just long enough to bring them up to full charge and no more. The state of charge can be tested accurately with a Hydrometer. SEE TESTING BATTERY.**

**WARNING**

**The gasses produced by a storage battery on charge are highly explosive. To prevent possible personal injury, charge batteries in a well ventilated area, keep fire and flame away from battery charging area and do not work around charging batteries with tools that could cause a short circuit resulting in a spark. Always shield eyes when working near charging batteries.**

## Charging Procedure

1. Check electrolyte level in all cells and add water as necessary to cover tops of plates.

2. Be sure charger is turned OFF, and plug charger receptacle into car.

3. Determine state of charge and charging time using the following tables.

*NOTE*

*The specific gravity check is a more accurate method of determining required charging time than is the number of holes played.*

| STATE OF CHARGE | SPECIFIC GRAVITY (80 °F) |
|---|---|
| 100% | 1.250-1.270 |
| 75% | 1.220-1.240 |
| 50% | 1.190-1.210 |
| 25% | 1.160-1.180 |

**Specific Gravity Taken From At Least 2 Cells of Each Battery**

| State of Charge (80 °F) | Charging Time |
|---|---|
| 1.260 to 1.280 sp. gr. | none needed |
| 1.240 to 1.260 sp. gr. | 4 hours |
| 1.220 to 1.240 sp. gr. | 8 hours |
| below 1.220 sp. gr. | 12 hours |

| GOLF CAR USE | CHARGING TIME |
|---|---|
| 9 Holes or Less | 7 Hours |
| 18 Holes or More | 12 Hours |

5. Set timer on charger to appropriate time as determined in previous step. Charger turns off automatically at end of set period. Note "finished charge rate" as indicated by ammeter on charger. Batteries are fully charged when finish charge rate is approximately 3 amps immediately before charger turns off. A higher finish rate indicates aging or defective battery or batteries. If finish rate is above 8 amps, batteries should be tested SEE TESTING BATTERIES.

6. After charging, check electrolyte level and add water as necessary to triangle or split ring of each cell.

**CAUTION**

**Avoid further charging after the batteries are fully charged and equalized. Practical charging time maximum limit is 12 hours.**

## Conditions Which Affect Charging

1. If car is used only occasionally, a refresher charge should be given prior to using the car. Use specific gravity reading to determine length of refresher charge.

2. Fleet cars should be rotated so that all cars are used the same amount of time.

3. Battery efficiency is affected by temperature.

| Comparison of Power Available From Fully Charged Batteries At Various Ambient Temperatures |
|---|
| 80°F — 100% |
| 32°F — 65% |
| 0°F — 40% |

If the temperature of the outside air and/or batteries is below 60°F, battery capacity is reduced. Batteries will require more frequent and longer charge periods in early spring, fall and winter. It will help to put batteries on charge while they are still warm from use.

4. As batteries age, they finish charge at progressively higher charge rates and tend to use more water. At this point in battery age, the battery's life can be extended by reducing the hours on charge. For example, a 12 hour charge, as determined by the specific gravity readings, can be reduced to 10 hours after approximately one year, or 100 rounds or 60 hours of use.

5. If batteries are unusually hot at the end of normal charge with heavy deposits of moisture around the filler caps and/or water use is high, this may indicate one or more defective cells or that the batteries are nearing the end of their useful life. See TESTING BATTERY.

6. If batteries do not respond to normal charging, one or more cells may be defective and all should be checked. See TESTING BATTERY. Batteries found defective must be replaced. All batteries in a car should be matched according to age, capacity and brand.

## Overall Battery Bank Condition After Charging

The charger can be used to determine the overall condition of the battery bank after charging. Compare the finish charge rate with the specific gravity readings of the batteries. See table below.

**USING THE HYDROMETER**

# TESTING BATTERY

## Testing With 36V Charger

The charger can be used to give an overall test of the battery bank after it has received a full charge. The finish charge rate of a good set of batteries is 1-3 amp as read on the charger ammeter.

Test: Connect charger to car and turn on. Charger ammeter needle should jump to 15 amps or more and then taper into the 1-3 amp area within 15 minutes, indicating good fully charged batteries. Battery banks failing this test should be tested with hydrometer and/or load tester. See SPECIFIC GRAVITY TEST.

## Specific Gravity Test

It is possible to determine a battery's ability to perform by measuring the specific gravity of each cell with a hydrometer. The hydrometer readings indicate two things:

1. State of Charge - The amount of electrical power stored in the battery.

2. Condition - The ability of battery to store and deliver power.

*NOTE*

*Batteries should be fully charged before performing specific gravity tests to determine battery condition.*

**USING THE HYDROMETER**

1. Squeeze rubber bulb and insert nozzle in cell, release bulb, slowly drawing electrolyte up into barrel.

2. Adjust electrolyte level in barrel so float rides free of bottom but is not striking top of barrel.

3. Hold hydrometer vertically, making sure float moves freely and is not contacting sides of barrel. Read scale at the level of electrolyte in the barrel.

4. Record the reading.

| Finish Charge Rate | Specific Gravity at 80°F | Possible Condition |
|---|---|---|
| 1-3 amps | All cells above 1.250 and even | Good |
| 8-10 amps | All cells above 1.250 and even | Batteries nearing end of useful life |
| Above 4 amps | All cells below 1.250 and even | Batteries need additional charge |
| Above 10 amps | All cells above 1.250 and even | Batteries bad - (see TESTING BATTERIES) |
| Above 4 amps | Cell readings vary more than .050 | See SPECIFIC GRAVITY TEST |

5. Return electrolyte to cell from which it was removed.

6. Repeat these steps on all battery cells.

Hydrometer readings are affected by the temperature of the electrolyte being tested. Measure the temperature of the electrolyte and correct your readings as follows:

Above 80°F — Add.004 to the specific gravity readings for each 10° above 80°F.

Below 80°F — Subtract .004 from the specific gravity readings for each 10° below 80°F.

**INTERPRETATION OF HYDROMETER READINGS**

State of Charge: Check specific gravity of each cell. Refer to tables below.

| Specific Gravity Reading at 80°F | State of Charge |
|---|---|
| 1.250 - 1.270 | 100% |
| 1.220 - 1.240 | 75% |
| 1.190 - 1.210 | 50% |
| 1.160 - 1.180 | 25% |

Condition: If the difference between the highest and lowest cell is .050 (50 points) or more, the battery is nearing the end of its useful life and should be replaced.

*NOTE*

*If the highest cell reads less than 1.200, the test for condition is questionable. Recharge battery and perform test again.*

## Discharge (Load) Test

The Discharge, or Load Test, is the recommended method of determining battery condition because it simulates golf car operation under controlled conditions. A 75 amp draw is applied to the battery bank with a Load Tester. The time it takes the battery bank to drop to 31.5 volts, along with individual battery voltages, is used to determine battery condition.

**PREPARATION FOR DISCHARGE TEST**

1. Batteries must receive a full charge before conducting Discharge Test.
2. Discharge Test must be performed within 18 hours of charging.
3. Car must not be used, even for short runs, prior to Discharge Test.
4. Electrolyte level must be correct in all cells.

**DISCHARGE (LOAD) TEST PROCEDURE**

1. Connect tester leads to battery bank.

2. Check and record electrolyte temperature of center cell of each battery.

3. Turn tester on.

4. After 20-30 minutes, with tester on, check and record individual battery voltages to the nearest .10 (1/10) volt.

*NOTE*

*All six individual battery voltage readings must be made as rapidly as possible to be accurate.*

6. Allow tester to shut off automatically and record time elapsed from start of discharge.

*NOTE*

*Tester shutoff should occur at a battery voltage of 31.5v ± .2v. Check tester shutoff voltage periodically. This setting must be accurate for a valid test.*

**INTERPRETATION OF DISCHARGE TEST RESULTS**

1. Compare individual battery voltages recorded in step 5 of Test Procedure and discard any battery that is .20 (2/10) volt lower than the highest battery in bank. If a defective battery is found, recharge the entire bank for 12 hours. Then replace the defective battery with a good fully charged battery of the same brand and date code, if possible.

| Specific Gravity Reading Each Cell at 80°F | | | | |
|---|---|---|---|---|
| Battery | 1 | 2 | 3 | Required Action |
| 1 | 1.100 | 1.100 | 1.100 | Charge and recheck |
| 2 | 1.260 | 1.180 | 1.250 | Bad cell (2) replace battery |
| 3 | 1.250 | 1.260 | 1.250 | Good |
| 4 | 1.190 | 1.170 | 1.120 | Charge and recheck (suspect cell #3) |

Equalize the bank by placing it on charge for an additional three hours, then retest.

2. If all battery voltages are within .20 volts of each other, compare discharge time from step 6 of Test Procedure with minimum times in table below.

| Electrolyte Temperature (Step 3) | Minimum Discharge Time To 31.5v (Step 6) |
|---|---|
| 40 to 49°F | 40 Minutes |
| 50 to 59 | 45 |
| 60 to 64 | 50 |
| 65 to 69 | 54 |
| 70 to 74 | 57 |
| 75 to 79 | 60 |
| 80 to 84 | 62 |
| 85 to 89 | 64 |
| 90 to 99 | 66 |
| 100 to 109 | 68 |
| 110 to 119 | 70 |
| 120 to 129 | 72 |
| 130 to 150 | 74 |

*NOTE*

*Even if individual battery voltages are satisfactory, but the discharge time fails to meet minimums in table, the entire battery bank should be replaced.*

# STORING BATTERIES

1. Batteries can remain in car.
2. Fully charge batteries.
3. Clean tops and connections.
4. Fully charged batteries should be stored in as cold an environment as possible. Batteries "self discharge" when not in use. The colder the temperature, the slower batteries self discharge.

**CAUTION**

**Batteries in low state of charge (low specific gravity readings) will freeze at low temperatures.**

Check specific gravity every 8 to 10 weeks and recharge as necessary to bring batteries to 1.250 - 1.270 specific gravity to prevent batteries from freezing.

As ice forms in a freezing battery, the electrolyte expands and can crack the case, ruining the battery.

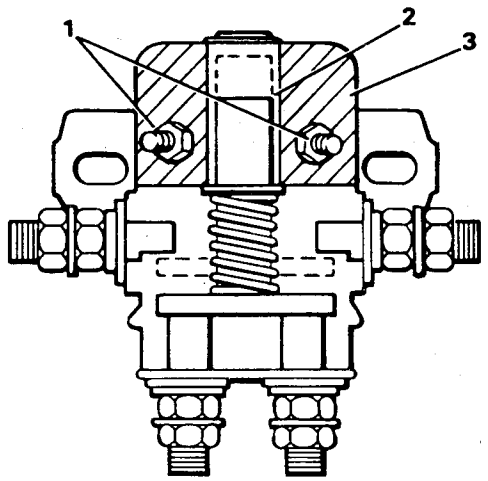
If a battery is allowed to stand or is operated in a discharged condition for a long period of time, lead sulphate may develop on the plates, which is dense, hard and crystalline, and which cannot be electrochemically converted to normal active material again.

Lead sulphate formed on the plates during discharge is relatively insoluble as long as the specific gravity of electrolyte is kept above 1.125 specific gravity, but if allowed to drop below this value, the lead sulphate becomes increasingly soluble and may migrate into the pores of the separators and deposit as a white crystalline mass. Subsequent charging may convert these deposits into stringy metallic lead which may SHORT the positive and negative plates through the areas affected. These small shorts may cause a condition of low cell voltage when battery is allowed to stand idle in less than 25% charged condition.

| State of Charge | Specific Gravity | F° — Freezing Point — C° | | Risk of Sulfation |
|---|---|---|---|---|
| 100% | 1.260 | -70° | -57° | Low |
| 75% | 1.230 | -39° | -38° | Low |
| 50% | 1.200 | -16° | -26° | Low |
| 25% | 1.170 | - 2° | -19° | Moderate |
| Discharged | 1.110 | +17° | - 8° | High |

# COMPONENT OPERATION

In order to successfully troubleshoot, test and repair the electronic speed control system used on 1985 and later electric cars, it is important to first understand the operation and function of the various components.




1. Control terminals
2. Core
3. Coil

**Solenoid**

## Solenoid

The solenoid is an electro-magnetic switch which energizes when current is applied to the small control circuit terminals. When energized, the solenoid core moves up due to magnetism created by the coil and connects two large terminals, allowing current to pass through the solenoid. When current is removed from the small terminals, the magnetic field collapses and a spring returns the core to its at rest position. A single contact solenoid in the at rest position prevents current from passing through it. A double contact solenoid in the at rest position allows current to flow through its lower contacts.

*NOTE*

*Solenoids are mounted with canister up to utilize gravitational pull on disc to aid spring in returning disc to at rest position.*

## Motor Resistor

Impedes current flow which reduces voltage to traction motor causing motor to run slower.

The circuitry uses solenoids and resistors to control current flow to the traction motor.

There are two basic circuits involved:

1. Solenoid control circuit includes key switch, speed control, solenoid coils and light gage control circuit wiring.

2. Motor circuit includes solenoid contacts, resistor coils, traction motor, heavy gage motor and battery cables, and batteries.

In the system, two 36 volt, 6 terminal solenoids control forward and reverse direction and two 36 volt, 4 terminal solenoids control speed by switching resistance in and out of the circuit.

# ELECTRONIC SPEED CONTROL

## Adjustment Model E3 and E4C

When properly adjusted, the speed control will provide all four speeds, and allow the parking brake to be fully applied without activating first speed. The parking brake should release before activating first speed. Adjustment is accomplished by moving the complete speed switch forward or backward as required.

**TO CHECK SPEED CONTROL FOR PROPER ADJUSTMENT:**

1. Raise rear of car so rear wheels are clear of ground. Support car with suitable blocks or stands.

2. Set parking brake.

3. Slowly depress accelerator pedal until brake releases. At this point, motor should not be running. Slowly continue to depress pedal. First, second, third, and fourth speeds should be selected in order. If the brake does not release before first speed engages, or if fourth speed is not engaged before the pedal bottoms on the floorboard, the speed control requires adjustment.

The speed control mounting bracket on the frame has slotted mounting holes to allow front to back adjustment of the switch.

**TO ADJUST SPEED CONTROL:**

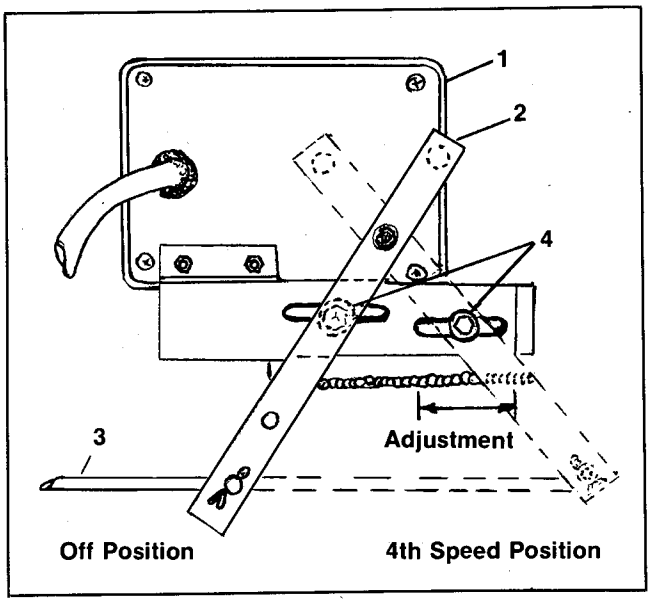
1. Raise rear of car so rear wheels are clear of ground. Support car with suitable blocks or stands.

2. Speed control is located between the right and left battery banks on E4C, and on the left side of the front battery tray on E3.

3. Loosen the two speed control mounting bolts just enough to allow movement of control.

4. Move control forward if car is not going into fourth speed, and move control backward if car is not shutting off.

5. Tighten mounting bolts and recheck function.




1. **Speed Control**
2. **Magnet Arm**
3. **Accelerator Arm**
4. **Mounting Bolts**

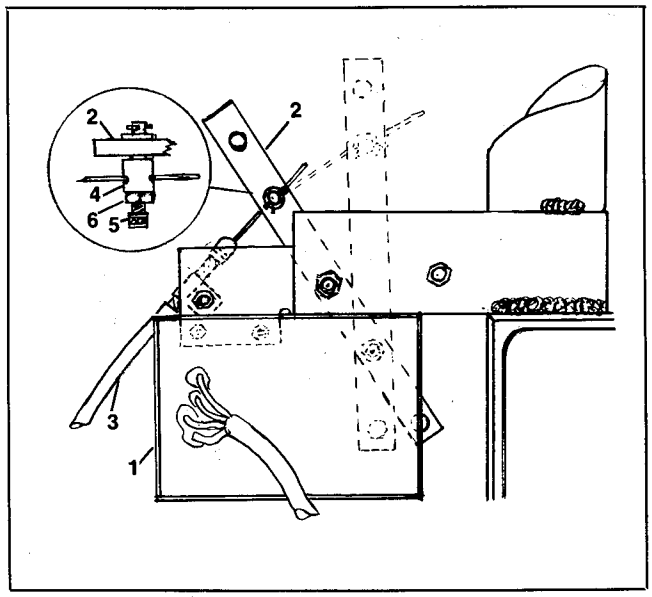
# ELECTRONIC SPEED CONTROL

## Adjustment Model E4S

When properly adjusted, the speed control will provide all four speeds, and allow the parking brake to be fully applied without activating first speed. The parking brake should release before activating first speed. Adjustment is accomplished by moving the cable block on the cable as required.

**TO CHECK SPEED CONTROL FOR PROPER ADJUSTMENT:**

1. Raise rear of car so rear wheels are clear of ground. Support car with suitable blocks or stands.
2. Set parking brake.
3. Slowly depress accelerator pedal until brake releases. At this point, motor should not be running. Slowly continue to depress pedal. First, second, third, and fourth speeds should be selected in order. If the brake does not release before first speed engages, or if fourth speed is not engaged before the pedal bottoms on the floorboard, the speed control requires adjustment.




**TO ADJUST SPEED CONTROL:**

1. Raise rear of car so rear wheels are clear of ground. Support car with suitable blocks or stands.
2. Speed control is located behind the battery tray on the left side of the car. The control is cable operated and therefore, adjustment involves repositioning the cable block on the cable.
3. Loosen the cable block set screw lock nut and back off screw just enough to allow cable to slide in block.
4. Pull cable outward as far as possible. This should position front cable block all the way back in the slot in the accelerator rod under floorboard.
5. While holding cable out, slide cable end of speed switch magnet arm toward rubber dust boot so cable clamp rests firmly against dust boot.
6. Tighten set screw and lock nut securely.
7. Follow procedure (TO CHECK SPEED CONTROL FOR PROPER ADJUSTMENT) to check operation.
8. Final adjustment, if necessary, can be made by making slight changes in the position of the cable block on the cable.

1. **Speed Control**
2. **Magnet Arm**
3. **Accelerator Cable**
4. **Cable Block**
5. **Set Screw**
6. **Lock Nut**

# ELECTRICAL OPERATION AND CIRCUITS

## Charging

| | |
|---|---|
| Key Switch position | Off |
| Speed Switch Arm position | At rest |
| Solenoid C1 | Not energized — open |
| Solenoid C2 | Not energized — open |
| Solenoid F | Not energized; continuity between lower terminal; side terminals open. |
| Solenoid R | Not energized; continuity between lower terminal; side terminals open. |
| Voltage to Motor A1-A2 | None |
| Resistor R1 | No current flow |
| Resistor R2 | No current flow |

## First Speed

| | |
|---|---|
| Key Switch position | Forward |
| Speed Switch position | First speed |
| Solenoid C1 | Not energized |
| Solenoid C2 | Not energized |
| Solenoid F | Energized; continuity between side teminals; side terminals open. |
| Solenoid R | Not energized; continuity between bottom terminals; side terminals open. |
| Voltage to Motor A1-A2 | Approximately 26.5 Volts |
| Resistor R1 | In circuit (hot) |
| Resistor R2 | In circuit (hot) |

## Second Speed

| | |
|---|---|
| Key Switch position | Forward |
| Speed Switch Arm position | Second speed |
| Solenoid C1 | Energized; continuity between large side terminals. |
| Solenoid C2 | Not energized |
| Solenoid F | Energized; continuity between side terminals; bottom terminals open. |
| Solenoid R | Not energized; continuity between bottom terminals; side terminals open. |
| Voltage at Motor A1-A2 | Approximately 29 Volts |
| Resistor R1 | Out of circuit (cold) |
| Resistor R2 | In circuit (hot) |

## Third Speed

| | |
|---|---|
| Key Switch position | Forward |
| Speed Switch Arm position | Third speed |
| Solenoid C1 | Not energized |
| Solenoid C2 | Energized; continuity between large side terminals. |
| Solenoid F | Energized; continuity between side terminals; bottom terminals open. |
| Voltage at Motor A1-A2 | Approximately 31.5 Volts |
| Resistor R1 | In circuit (hot) |
| Resistor R2 | In circuit (cold) |

## Fourth Speed

| | |
|---|---|
| Key Switch position | Forward |
| Speed Switch position | Fourth Speed |
| Solenoid C1 | Energized |
| Solenoid C2 | Continuity between side terminals. |
| Solenoid F | Energized; continuity between side terminals; bottom terminals open. |
| Voltage at Motor A1-A2 | Approximately 34 Volts |
| Resistor R1 | Out of circuit (cold) |
| Resistor R2 | Out of circuit (cold) |

## Reverse

| | |
|---|---|
| Key Switch position | Reverse |
| Speed Switch Arm position | Same as forward speeds. |
| Solenoid C1 | Same as forward speeds. |
| Solenoid C2 | Same as forward speeds. |
| Solenoid F | Not energized; continuity between bottom terminals; side terminals open. |
| Solenoid R | Energized; continuity between side terminals; bottom terminals open. |
| Voltage at Motor A1-A2 | Same as forward speeds. |
| Resistor R1 | Same as forward speeds. |
| Resistor R2 | Same as forward speeds. |

## Procedure for Troubleshooting Solid State Speed Control System

1. The speed control system cannot function properly if the batteries are not fully charged and in good condition. Always test the batteries as a first step in diagnosing any electrical problem.

2. Check connections of cables at each battery, at the solenoids and at the traction motor. Check plug at speed switch.

3. Test ride vehicle, if possible, or support vehicle with rear wheel off ground. Operate to identify exactly what the problem is and which of the four speeds are involved. Operate vehicle in both forward and reverse direction.

4. Suspect components can be identified by referring to the electrical operation and circuits in this section. The circuit description along with the wiring diagram will enable you to identify which components may be involved.

5. Refer to the following troubleshooting guide to help identify specific electrical problems.

If the speed control solenoid C1 or C2 is not functioning properly, one of the following conditions will exist:

## Solenoid

C1 (Above 3 coil resistor) — Stuck closed (welded)

| SPEED CONTROL POSITION | CAR ACTUALLY RUNS IN ( ) SPEED |
|---|---|
| 1st | 2nd |
| 2nd | 2nd |
| 3rd | 4th |
| 4th | 4th |

## Solenoid

C1 — Stuck open (not energizing)

| SPEED CONTROL POSITION | CAR ACTUALLY RUNS IN ( ) SPEED |
|---|---|
| 1st | 1st |
| 2nd | 1st |
| 3rd | 3rd |
| 4th | 3rd |

## Solenoid

C2 (Above 5 coil resistor) — Stuck closed (welded)

| SPEED CONTROL POSITION | CAR ACTUALLY RUNS IN ( ) SPEED |
|---|---|
| 1st | 3rd |
| 2nd | 4th |
| 3rd | 3rd |
| 4th | 4th |

## Solenoid

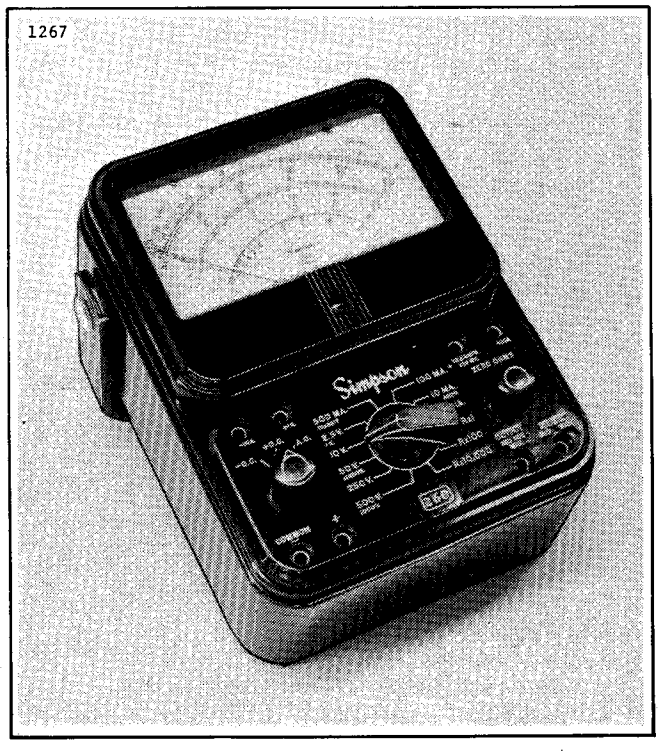
C2 — Stuck open (not energizing)

| SPEED CONTROL POSITION | CAR ACTUALLY RUNS IN ( ) SPEED |
|---|---|
| 1st | 1st |
| 2nd | 2nd |
| 3rd | 1st |
| 4th | 2nd |

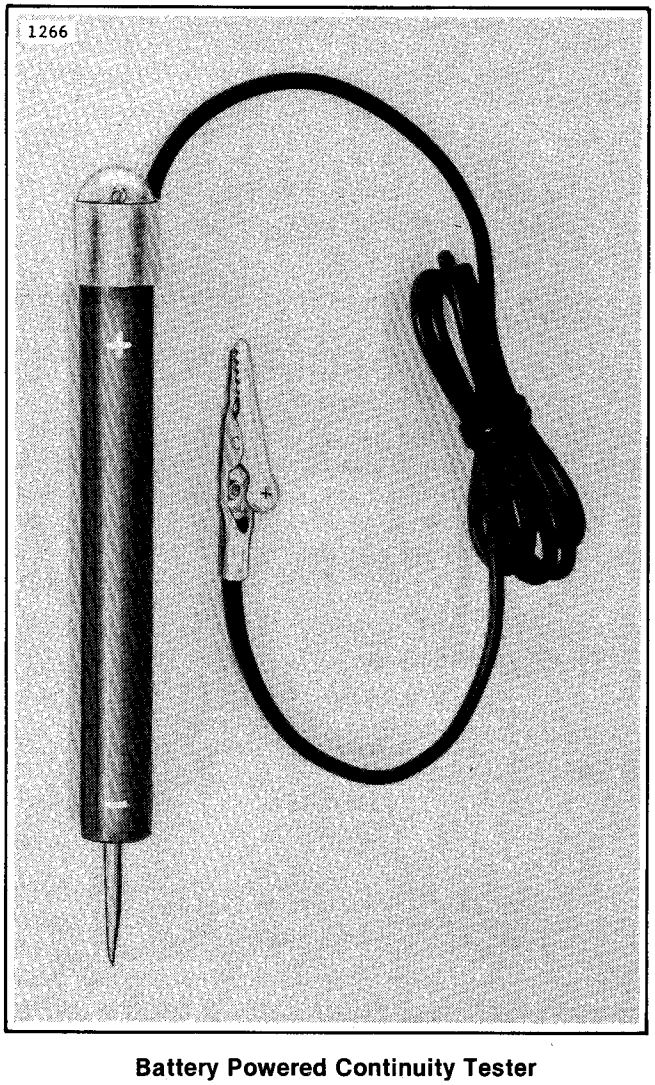
# SOLID STATE SPEED CONTROL TROUBLESHOOTING GUIDE

| PROBLEM | POSSIBLE CAUSE |
|---|---|
| Car will not charge | Poor battery condition.<br>Faulty charger.<br>Faulty charger plug.<br>Faulty receptacle. |
| No forward or reverse. | Faulty batteries or connections.<br>Faulty key switch.<br>Faulty speed switch.<br>Faulty motor.<br>Both "F" and "R" solenoid not functioning. |
| Forward OK,<br>no reverse | Faulty key switch.<br>Solenoid "F" open between large bottom terminals.<br>Solenoid "R" not energizing. |
| Reverse OK,<br>no forward | Faulty key switch.<br>Solenoid "R" open between large bottom terminals.<br>Solenoid "F" not energizing. |
| No 1st and 2nd,<br>3rd and 4th OK | Resistor coil R2 broken |
| No 1st and 3rd,<br>2nd and 4th OK | Resistor coil R2 broken. |
| No 2nd and 4th,<br>1st and 3rd OK | Solenoid C1 not energizing.<br>No continuity between large side terminals of solenoid C1. |
| No 3rd and 4th,<br>1st and 2nd OK | Solenoid C2 not energizing.<br>No continuity between large side terminals. |
| No 4th,<br>1st 2nd and 3rd OK | Speed switch linkage out of adjustment preventing<br>full travel of magnet arm. |
| Car continues to run<br>in 1st with key in<br>forward or reverse. | Speed switch linkage out of adjustment preventing<br>magnet arm from returning to off position. |
| Car continues to run<br>with key in off position. | "F" or "R" solenoid stuck in energized position. |

# BENCH TESTING COMPONENTS




Volt-Ohm Meter




Battery Powered Continuity Tester

*Bench tests must be made with component out of car or with all wires and connection removed from component being tested.*

## Key Switch Bench Test

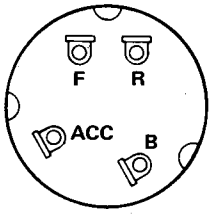
Equipment needed for test

- Battery powered continuity tester or ohmmeter set at X1.

1. Switch in OFF position. Check continuity between all terminals, and between all terminals and case. There should be no continuity.
2. Switch in FORWARD position. Check continuity between F and B terminals.
3. Switch in REVERSE position. Check continuity between R, ACC and B terminals.

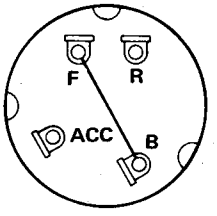
### Key Switch Bench Test

**Key in "OFF" Position**



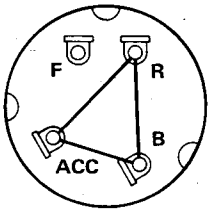

**No continuity between any terminals and/or case.**
**Continuity tester light out or ∞ ohms.**

**Key in "FORWARD" Position**




**Continuity between B and F only.**
**Continuity tester light "on" or 0 ohms.**

**Key in "REVERSE" Position**



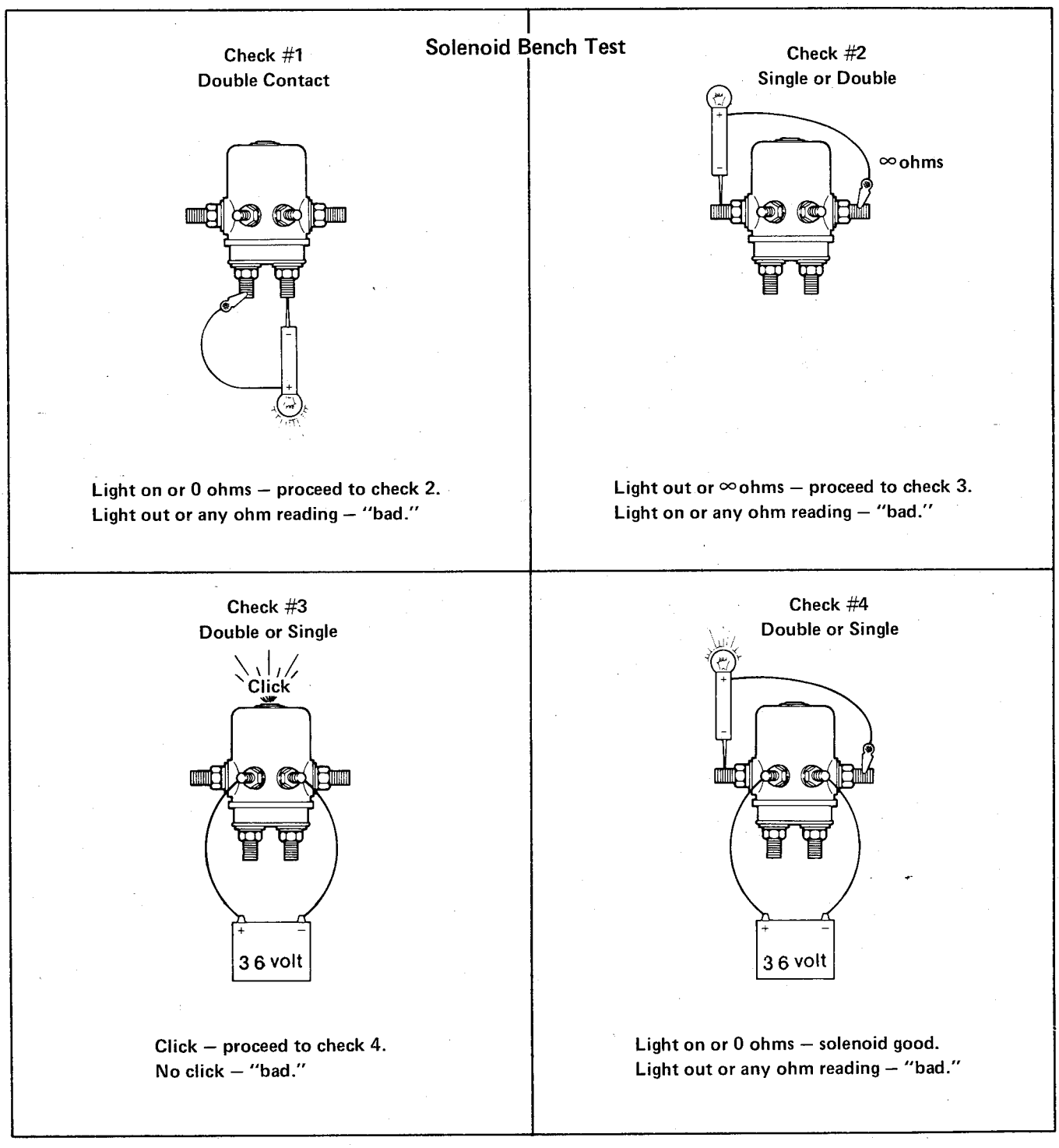

**Continuity between B, ACC, and R.**
**Continuity tester light "on" or 0 ohms.**

## Solenoid Bench Test

Equipment needed for test

- 3 6 volt battery
- Battery powered continuity tester or ohmmeter set at X1 scale.

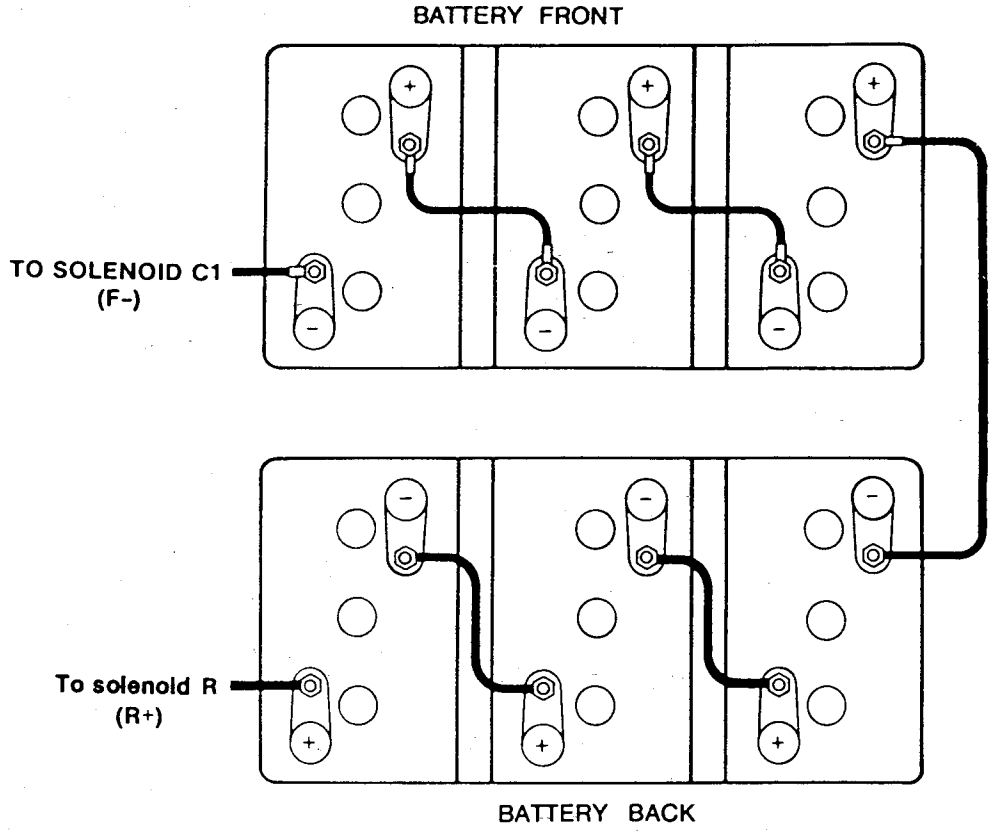
1. Double contact solenoids: Check continuity of bottom terminals.
2. Single or double contact solenoids: Check continuity across side terminals.
3. Single or double contact solenoids: Apply 3 6 volts to small terminals, check for solenoid energizing (click).
4. Single or double contact solenoids: Apply 3 6 volts to small terminals, check continuity across side terminals.




**4-Step Solenoid Bench Test**

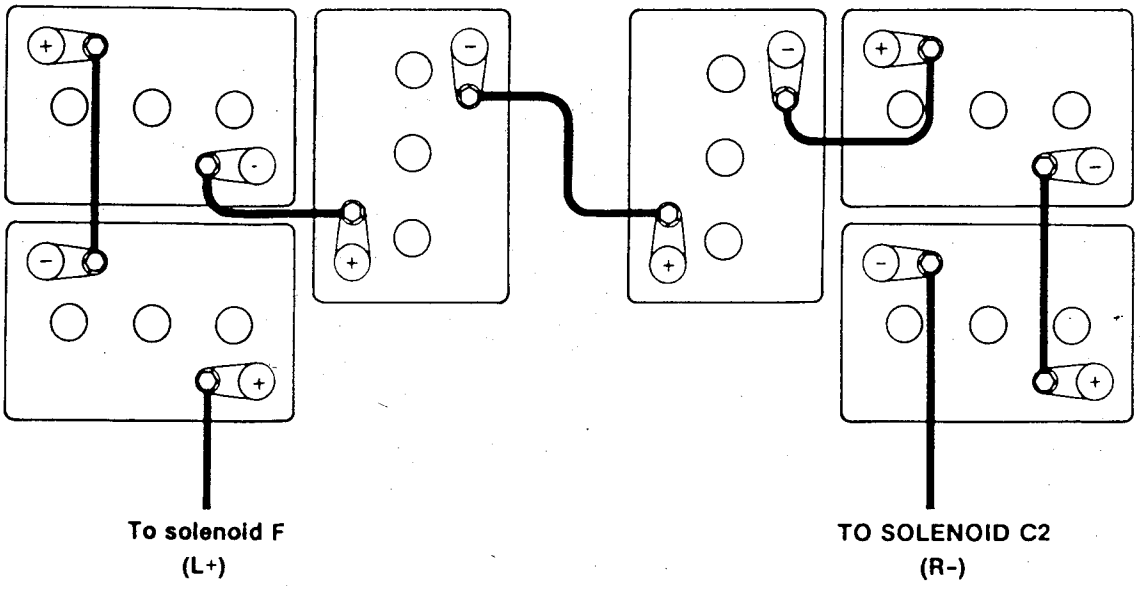
## E3 BATTERY INSTALLATION DIAGRAM

**Front of car**



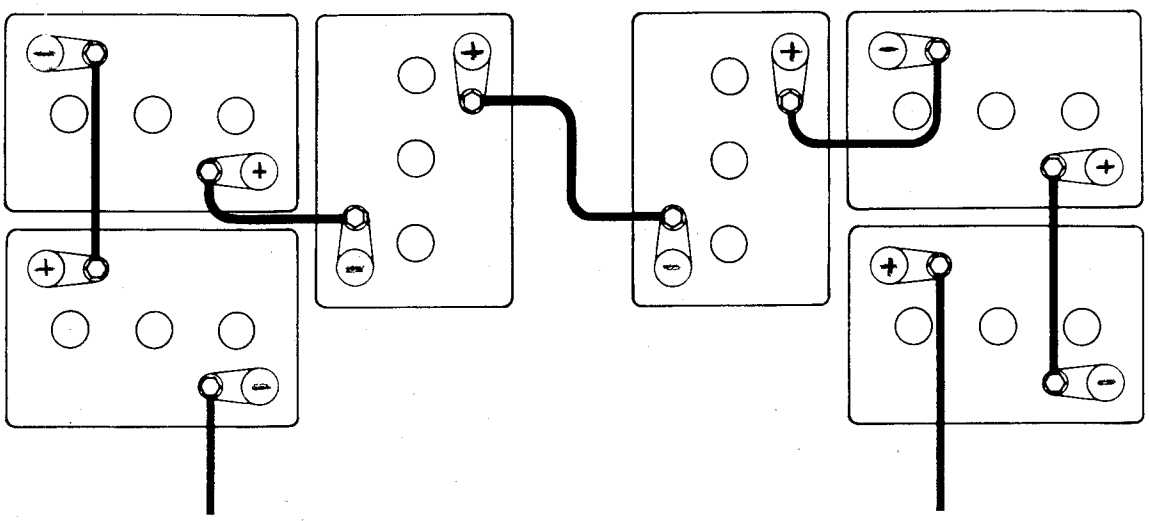

## E4C BATTERY INSTALLATION DIAGRAM

**Front of car**



## E4S BATTERY INSTALLATION DIAGRAM

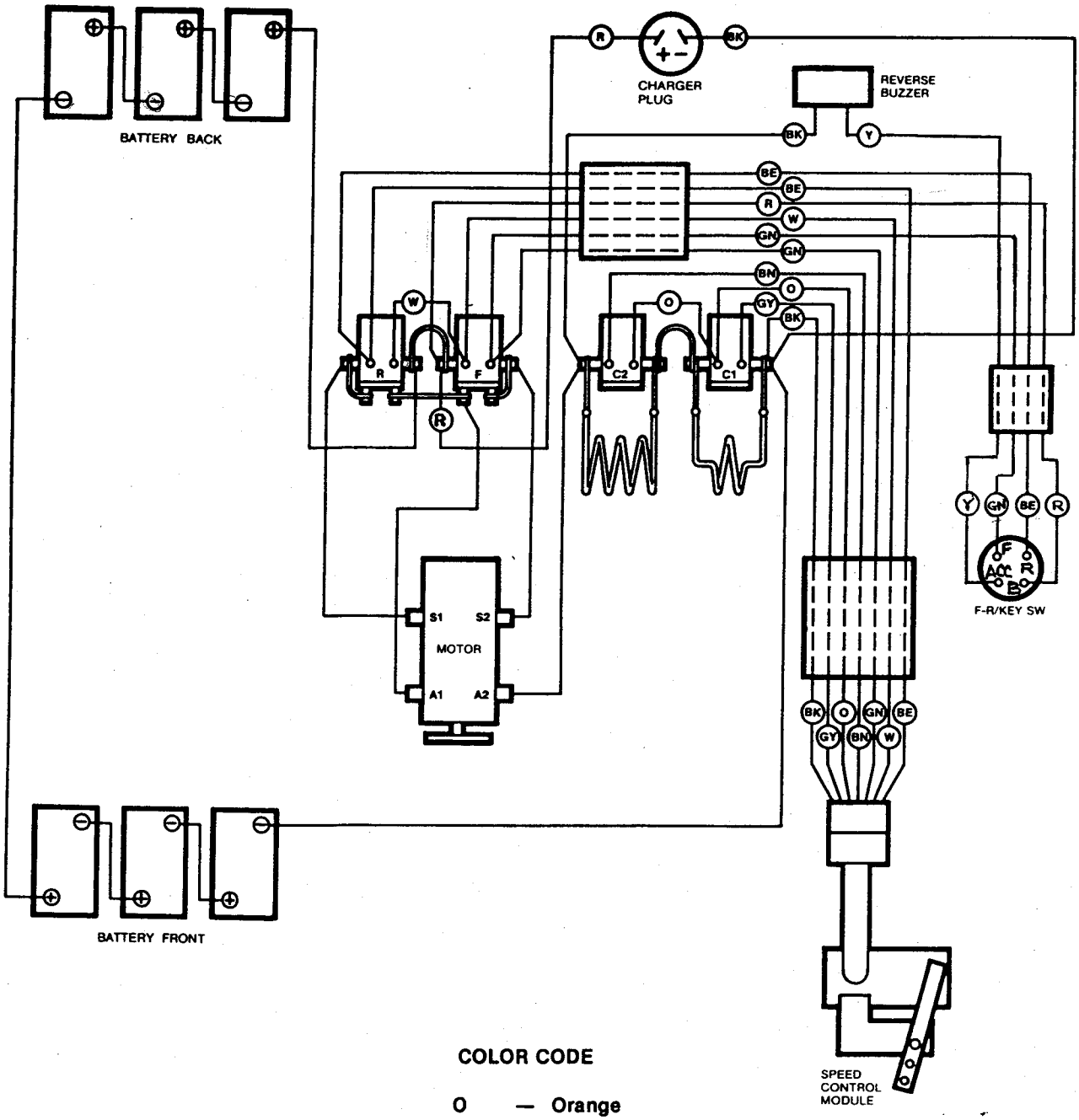
Front of car



TO SOLENOID C2

To solenoid F

# WIRING DIAGRAM E3

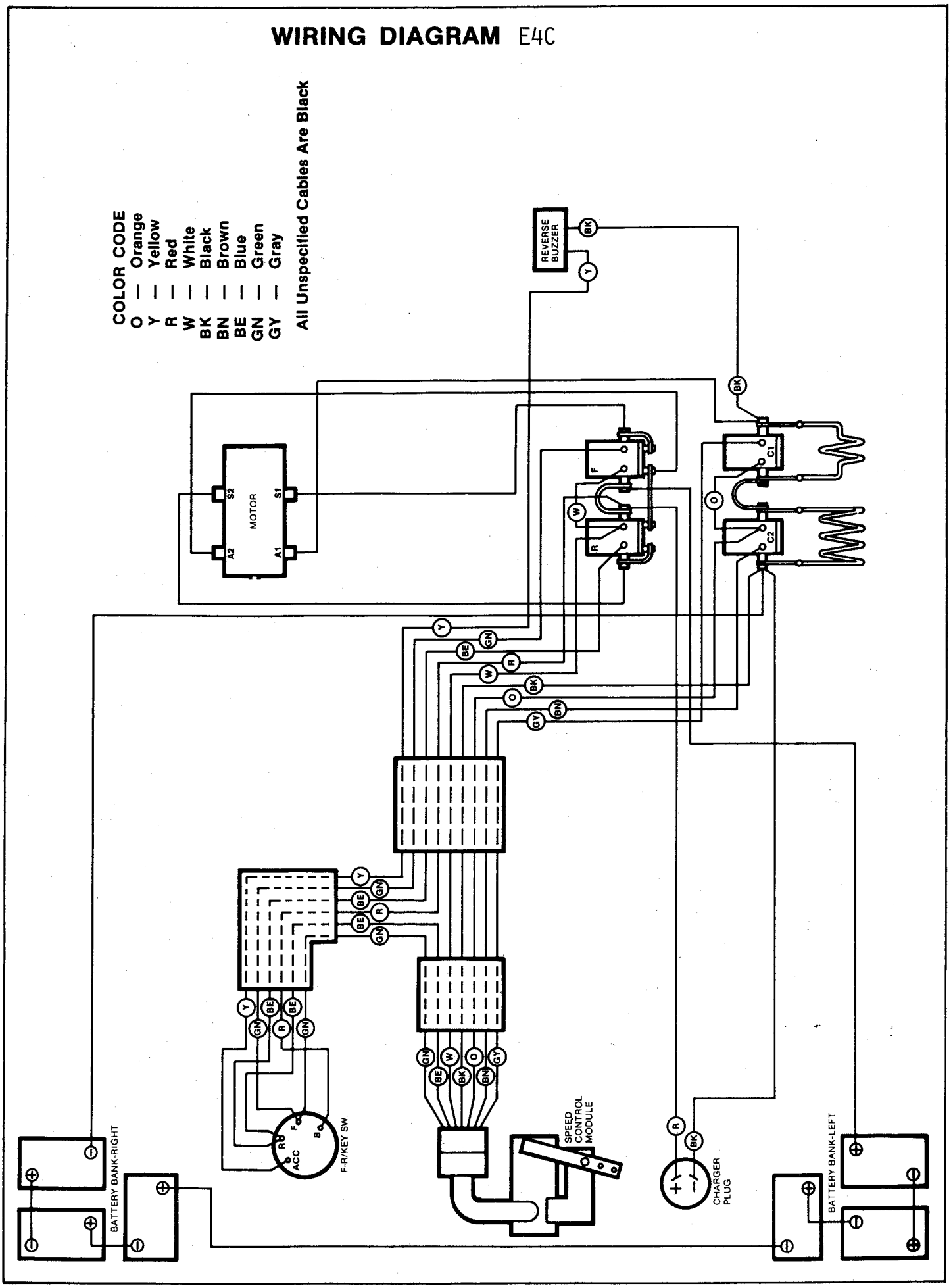



**COLOR CODE**

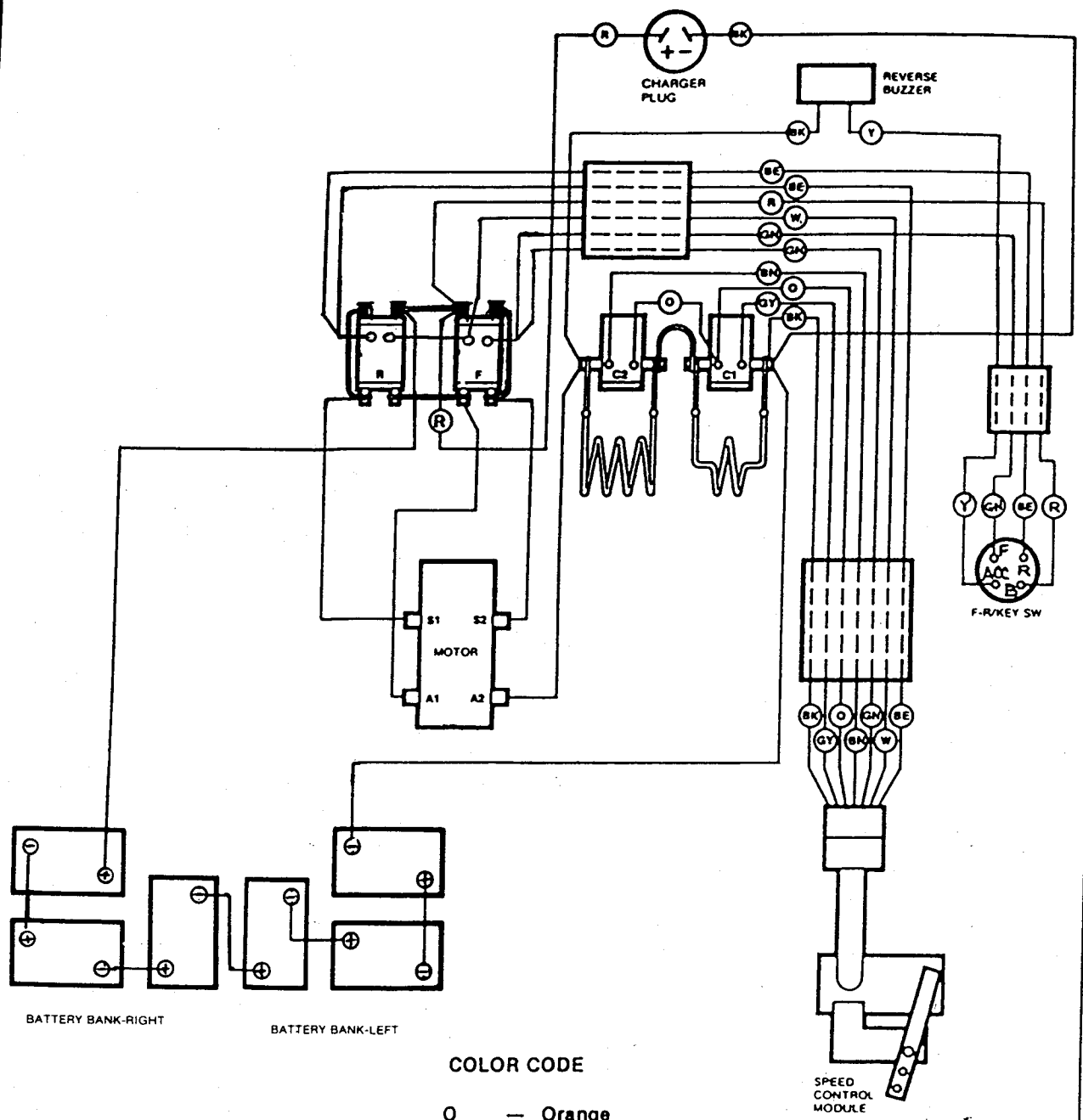
| | | |
|---|---|---|
| O | — | Orange |
| Y | — | Yellow |
| R | — | Red |
| W | — | White |
| BK | — | Black |
| BN | — | Brown |
| BE | — | Blue |
| GN | — | Green |

**All Unspecified Cables Are Black**

# WIRING DIAGRAM E4C



# WIRING DIAGRAM E4S




## COLOR CODE

| | | |
|---|---|---|
| O | — | Orange |
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| BK | — | Black |
| BN | — | Brown |
| BE | — | Blue |
| GN | — | Green |

All Unspecified Cables Are Black

# HITACHI TRACTION MOTOR 2

# TRACTION MOTOR

## GENERAL

The golf car traction motor does not require lubrication, and under normal use the only motor components that will require attention are the brushes and commutator. Inspect and clean brushes and commutator once a year. See later sections for detailed procedures.

## TESTING ASSEMBLED MOTOR

**Before disassembling motor, test for the following to determine problem areas which will require further testing and/or repair. The following tests can be made with the motor in the car, using a continuity tester.**

*NOTE*

*Motor wires (A1, A2, S1 and S2) must be disconnected before testing to ensure accurate test results.*

### Motor Internally Grounded

Connect continuity tester lead to ground on motor frame and touch each motor terminal in turn (A1, A2, S1 and S2). **Tester should not light.** Lighted tester indicates internal ground in motor circuit tested.

Tester Lamp "on" — terminal A1 or A2 indicates possible:

- Grounded A1 or A2 terminal
- Grounded wire end in brush area
- Grounded armature/commutator

Tester Lamp "on" — terminal S1 or S2 indicates possible:

- Grounded S1 or S2 terminal
- Grounded field or field wire

### Open In Armature Circuit

Check continuity between terminals A1 and A2. **Tester should light,** indicating continuity between terminals A1 and A2.

Tester Lamp "out" indicates possible:

- Open in brush assembly
- Open in armature

### Open In Field Circuit

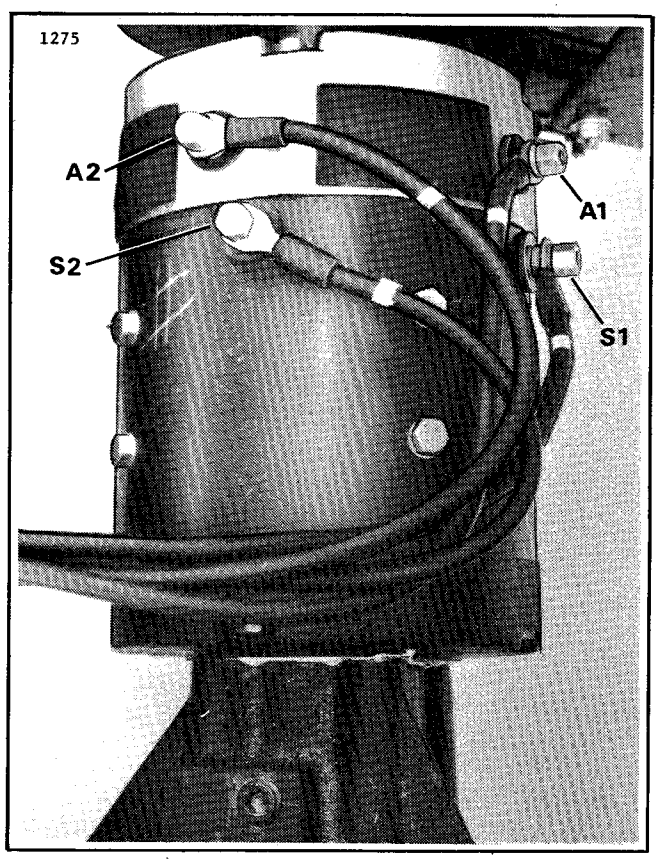
Check continuity between terminals S1 and S2. **Tester should light,** indicating continuity between terminals S1 and S2.

Tester Lamp "out" indicates possible open in field or field wires.

*NOTE*

*If Assembled Motor Tests reveal no problem, but motor is still suspected faulty, disassemble motor and inspect and test components individually. See INSPECTING, TESTING AND REPAIRING MOTOR COMPONENTS.*

**When tightening terminal stud nuts, *snug* the inner nut first and hold it with a wrench while tightening the outer nut. This procedure will prevent the terminal mounting stud from turning and causing possible damage to the motor.**

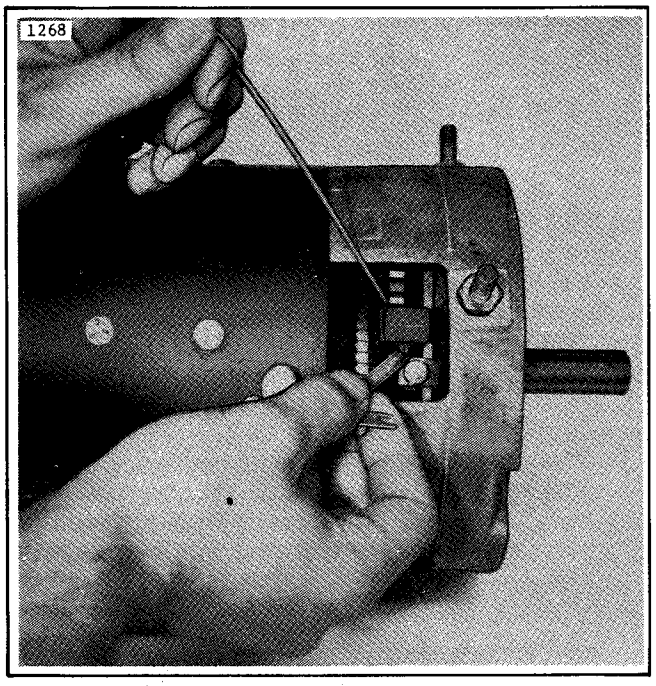



**Hitachi Motor Wire Connections**

# INSPECTING/REPLACING BRUSHES
## HITACHI

The brushes can be inspected or replaced with the traction motor in the car.

1. Remove four rubber brush covers.




**Releasing Brush-Hitachi**

2. Using a wire hook, pull brush spring up to release brush and pull brush out of holder
   Measure brush length at its shortest point.

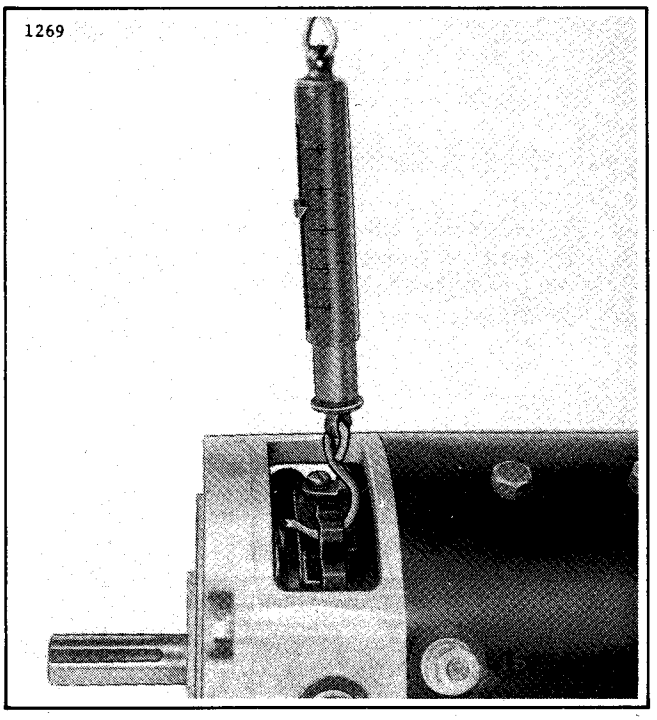
   Hitachi brush minimum length — .512 (1/2) in. (13mm)

   Brushes should be replaced in sets of four only, don't replace one brush without replacing the others.

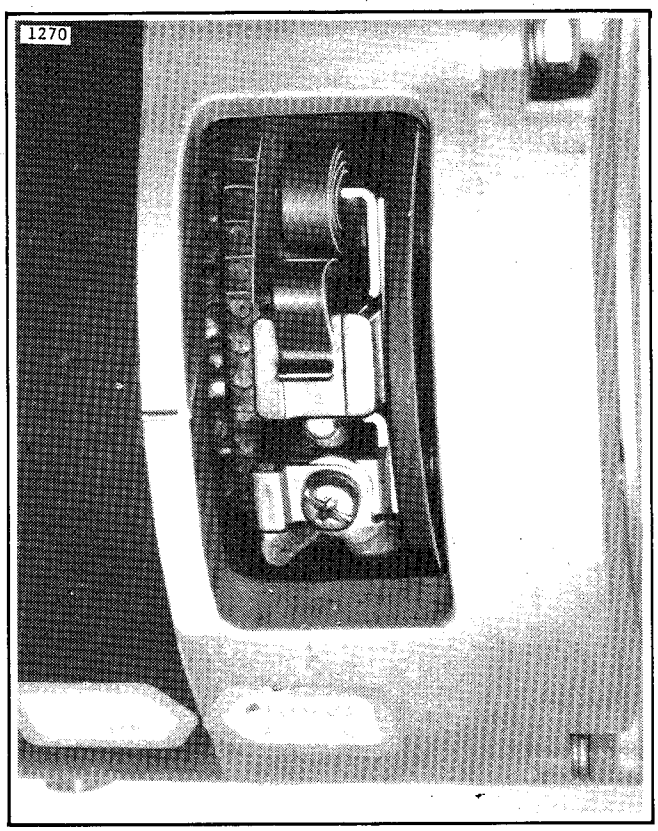
3. Use a spring scale to measure brush spring tension. Reject springs which apply a force of less than 1 lb. (.5 kg). See INSPECTING, TESTING AND REPAIRING MOTOR COMPONENTS.

4. To remove brush from motor, remove brush mounting screws.

5. Always check condition of commutator before reinstalling or replacing brushes. If commutator is oily, the oil seal located in the end cover should be inspected and replaced if necessary. See REMOVING TRACTION MOTOR OR REAR OIL SEAL. If commutator is worn or pitted it will require refinishing. See INSPECTING, TESTING AND REPAIRING TRACTION MOTOR COMPONENTS.




**Brush Spring Tension Hitachi**




**Brush Pig Tail Routing-Hitachi**

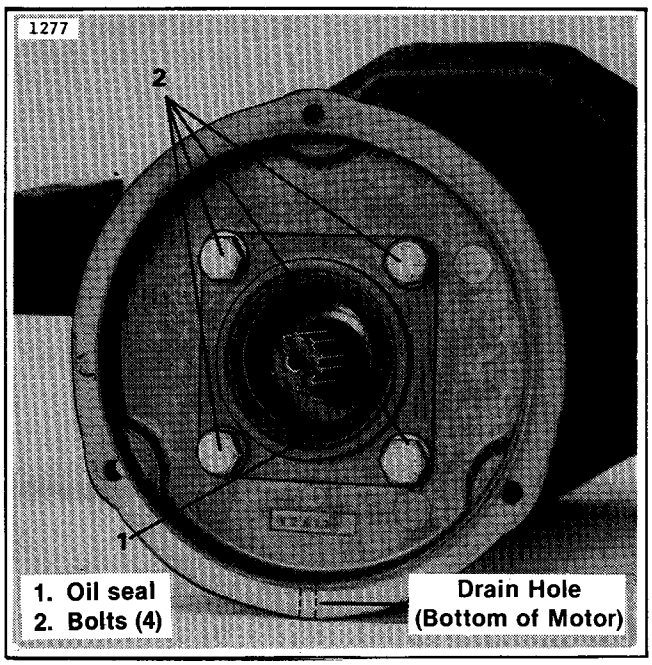
6. Use compressed air to blow carbon and copper dust from brush area before reassembly.

7. Install brush and secure pigtail with mounting screw. Route pigtail under mouinting screw.

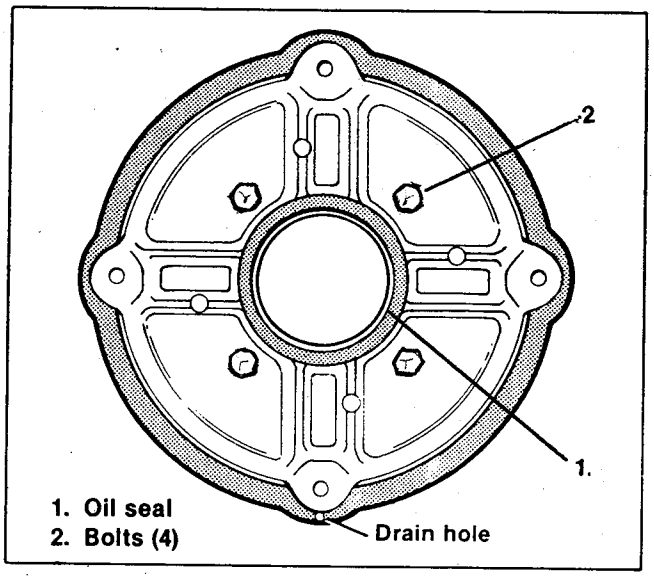
8. Install four rubber brush covers.

# REMOVING TRACTION MOTOR OR MOTOR REAR OIL SEAL

1. Remove wires from motor
2. Remove brake bracket bolts.
3. Remove brake bracket with brake caliper attached.
4. Remove traction motor mounting bolts
5. Remove the end cover bolts.
6. Move motor forward off of differential pinion shaft and out of car.
7. To remove oil seal, pry out of end frame.
8. To remove end cover from differential remove four bolts.



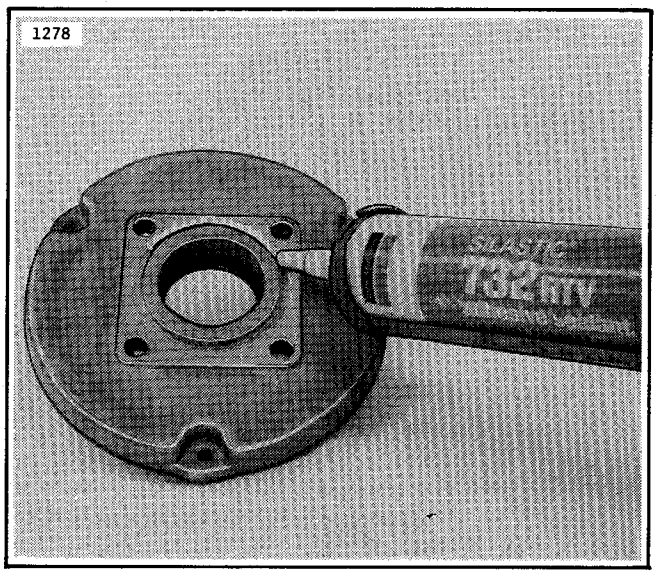

**End Cover to Differential Bolts And Rear Motor Seal• GE**




**End Cover To Differential Bolts And Rear Motor Seal•Hitachi**

# INSTALLING TRACTION MOTOR

1. Install rear oil seal flush with end cover. Lip side of seal should face differential.




**Applying Silicone Sealant to End Cover**

2. If end cover has been removed from differential, apply a 1/16 in. bead of silicone rubber (RTV) to the flange on the differential housing. Install end cover, and tighten end cover bolts to 30 ft-lbs (4.2 kgm) torque.

**CAUTION**

**On Hitachi motors, install end cover onto the differential with the drain hole position down. On GE motors, install traction motor onto end cover with drain hole in field coil frame down.**

3. Apply grease to differential pinion shaft spines and oil seal lip.

4. Install traction motor onto pinion shaft.

5. Align holes and install end cover bolts (Figure 6-30). Tighten bolts to 9 ft-lbs (1.2 kgm) torque.

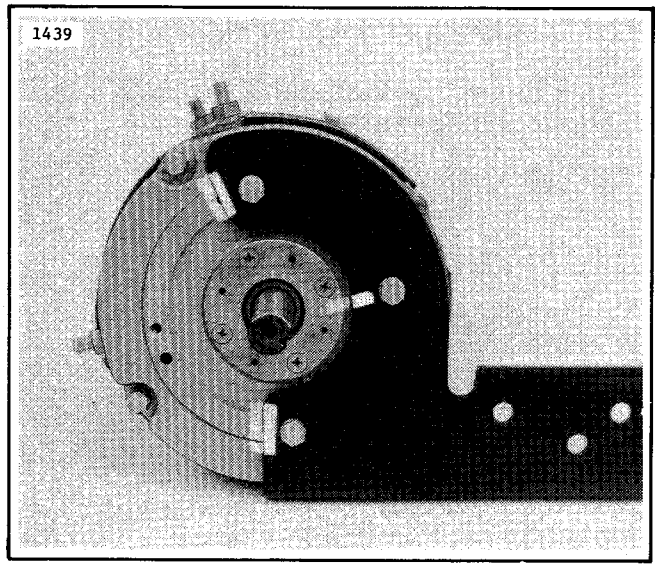
6. Install wires to motor.

7. Install brake bracket and caliper. Adjust brake.

# DISASSEMBLING HITACHI TRACTION MOTOR

1. Remove brake disc.

2. Remove key (1).




**Mark Brake Bracket Before Disassembly**

3. Mark brake bracket and brush plate frame with chalk so it can be reinstalled in the same position as removed Remove brake bracket bolts and brake bracket.

4. Slide front seal (2) and nylon washer (3) from shaft.

5. Remove brush covers (4).

6. Release brush springs (5) with a wire hook and pull brushes (6) from brush holder. Brush pigtails can be removed from holder by removing mounting screws (7).

*NOTE*

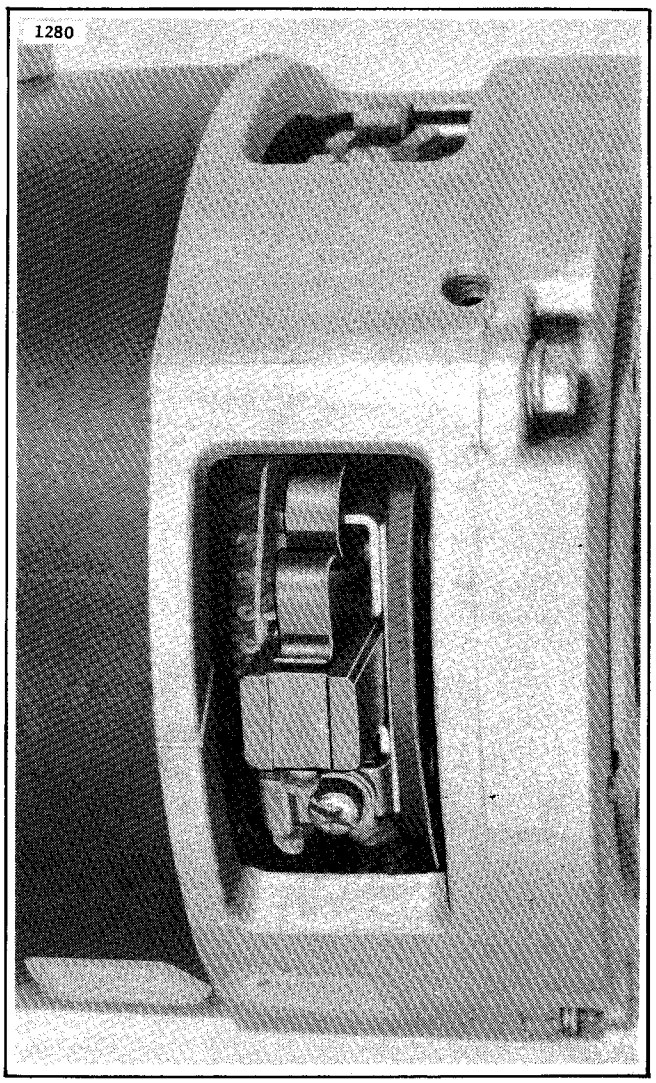
*If it is not necessary to remove brushes, they can be held off of commutator with brush spring.*

7. Mark field coil frame (9) and brush plate frame (10) with chalk for reassembly.

8. Remove thru bolts (8). Separate field coil frame (9) from brush plate frame (10). It may be necessary to tap field coil frame with a rubber or leather hammer to loosen it from the brush plate frame.

9. To separate armature (12) from brush plate frame (10), remove bearing retainer plate screws (11). Press armature (12) with bearing (14) and retainer plate (13) attached, from brush plate frame (10).

10. Use press to remove bearing (14) from armature shaft.




**Brush Held Off Commutator For Disassembly**

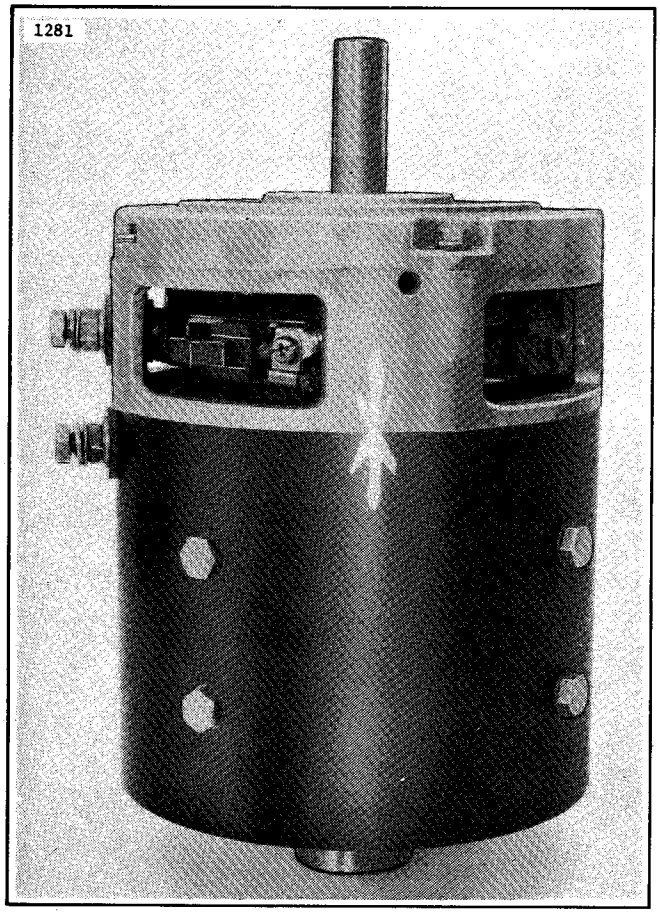
**CAUTION**

**Use caution while pressing bearing from shaft so as not to damage retainer plate.**

11. Loosen nuts on brush terminals (18).

12. Remove brush holder mounting screws (17), and remove brush holder (15), brush terminals (18) and on Hitachi motor brush terminal wires (16).

13. To remove field coil assembly (22) remove pole shoe bolts and lockwashers (19), remove pole shoes (20) and disconnect field coil mounting hardware (21).




**Mark Motor Before Disassembly**

# ASSEMBLING HITACHI TRACTION MOTOR

1. Install field coil assembly (22) and pole shoes (20) with pole shoe bolts and lockwashers (19). Tighten bolts (19) to 9 ft-lbs (1.2 kgm) torque.

2. Attach field coil mounting hardware (21).

3. Attach Hitachi brush terminal wires (16) to brush plate (15). Install brush plate (15) in brush plate frame (10) with screws (17). Attach brush terminals (18) stacking Hitachi hardware.

*NOTE*

*Hitachi brush terminal wires (16) connect opposite brushes to a common brush terminal.*

**CAUTION**

**Route Hitachi brush terminal wires behind brush plate so they will not contact armature.**

4. To install bearing (14), place bearing retainer ring (13) over armature shaft and press bearing (14) onto shaft.

5. Press armature (12) into brush plate frame (10).

6. To install bearing retainer plate (13) rotate brush plate frame or use a stiff wire to line up holes in retainer plate (13) with holes in brush plate frame (10). Install bearing retainer plate screws (11).

7. Install field coil frame (9) lining up chalk marks.

8. Install thru bolts, lockwashers and washers (8). Tighten thru bolts to 57-66 in-lbs (65-75 kgc) torque.

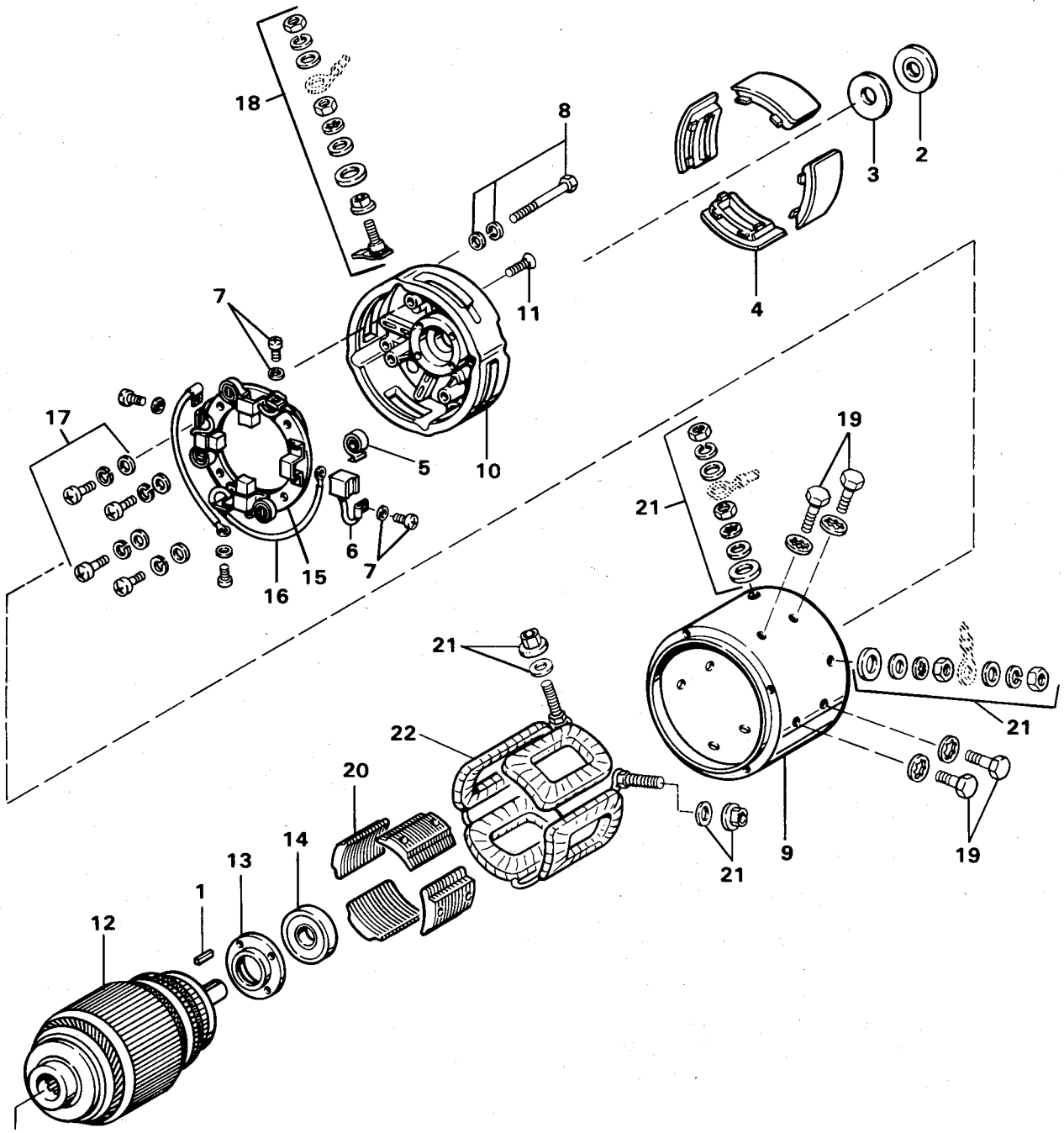
9. Install brushes (6), secure brush pigtail to brush holder with screw (7).

**CAUTION**

**Do not allow brush pigtail end or brush terminal wire to contact brush plate frame. Wires grounded to frame will cause motor damage.**

10. Install brush covers (4).

11. Lubricate armature shaft with grease and install nylon washer (3), seal (2) and key (1).




1. Key
2. Front seal
3. Nylon washer
4. Brush cover (4)
5. Brush springs (4)
6. Brush (4)
7. Brush mounting hardware (4)
8. Frame mounting hardware (4)
9. Field coil frame
10. Brush plate frame
11. Screw (4)
12. Armature
13. Bearing retainer plate
14. Bearing
16. Brush terminal wire
17. Screws (4)
18. Brush terminals
19. Pole shoe bolts (8)
20. Pole shoe (4)
21. Field coil mounting hardware
22. Field coil assembly

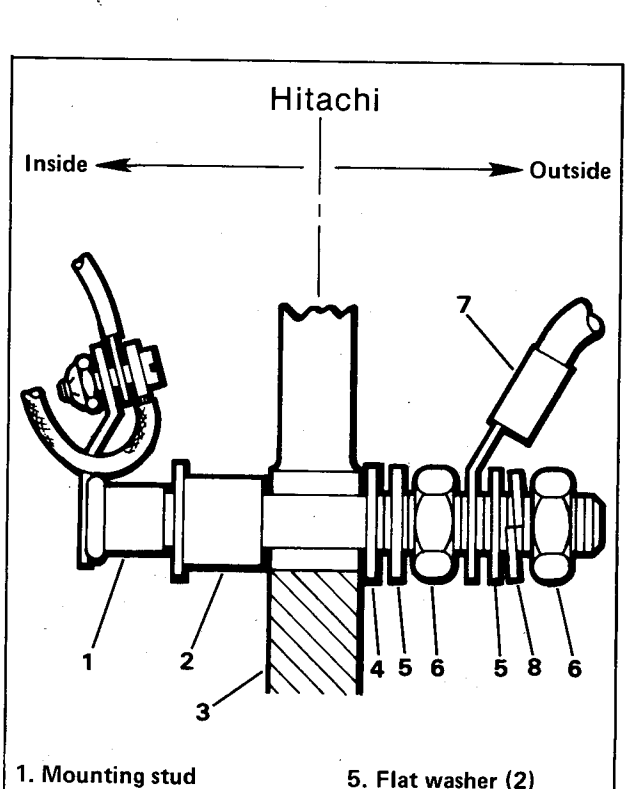
Hitachi Traction Motor

# INSPECTING, TESTING AND REPAIRING MOTOR COMPONENTS

## Terminals and Connections

1. Check all terminals and connections for corrosion and correct stacking of terminal mounting hardware (Figure 6-43 and 6-44).

2. Check condition of all insulators.




1. Mounting stud
2. Insulating bushing
3. Frame
4. Insulating washer
5. Flat washer (2)
6. Nut (2)
7. Cable to master drive
8. Lockwasher

**Figure 6-43. Motor Terminals (Hitachi)**

## Brushes

1. Visually inspect brushes. Replace brushes which are cracked or severely chipped.

2. Check brush length (Figure 6-44). If any brush is worn to its minimum length when measured at its shortest point, new brushes are needed. Replace brushes in sets of four only.

Minimum brush length

Hitachi ..... .512 (1/2) in. (13 mm)

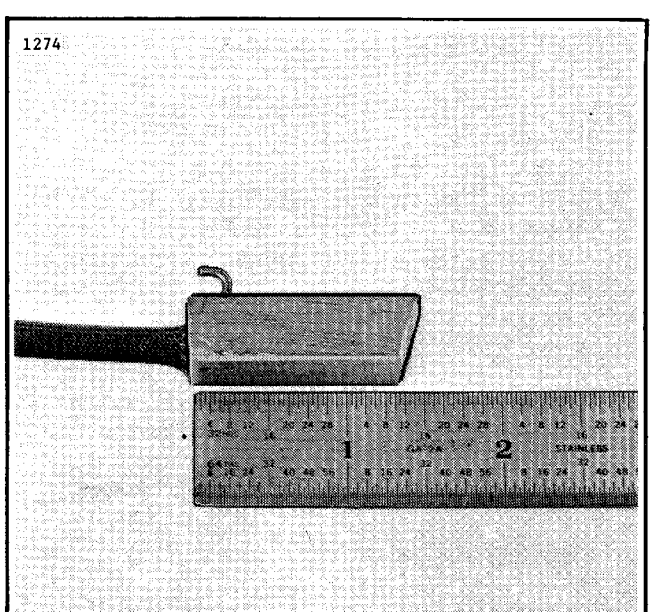



**Figure 6-44. Measuring Brush Length**

## Brush Springs

1. Inspect springs. Reject springs which are discolored from heat (straw or blue in color),

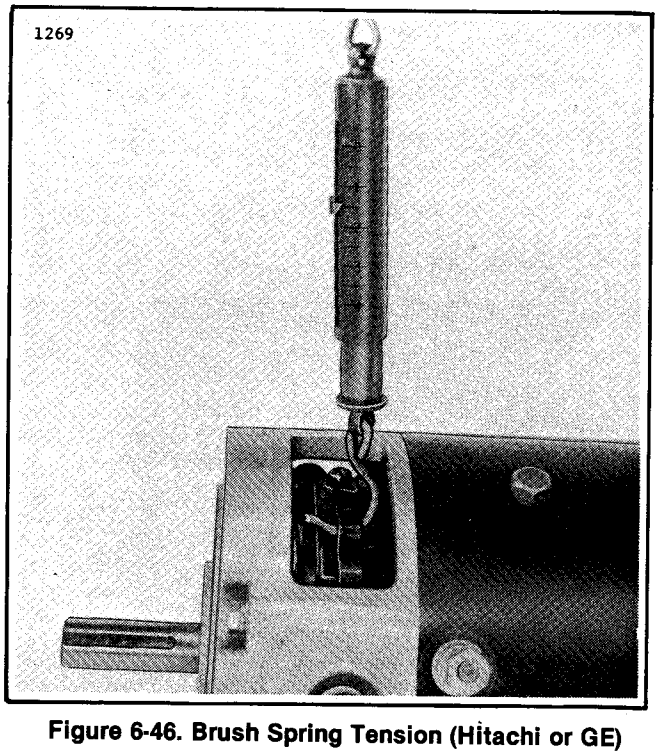



**Figure 6-46. Brush Spring Tension (Hitachi or GE)**

2. Test brush spring tension. Use a scale to test spring tension. Reject springs which apply a force less than specified.

**CAUTION**

**When checking brush spring tension, do not pull brushes beyond the point they would normally be if there were new brushes installed. Exerting excessive force, or pulling brush springs beyond normal resting point will damage springs.**

Brush spring tension

Hitachi ..... 1-2 lbs. (.5-1.0 kg) ± 10%

# ARMATURE

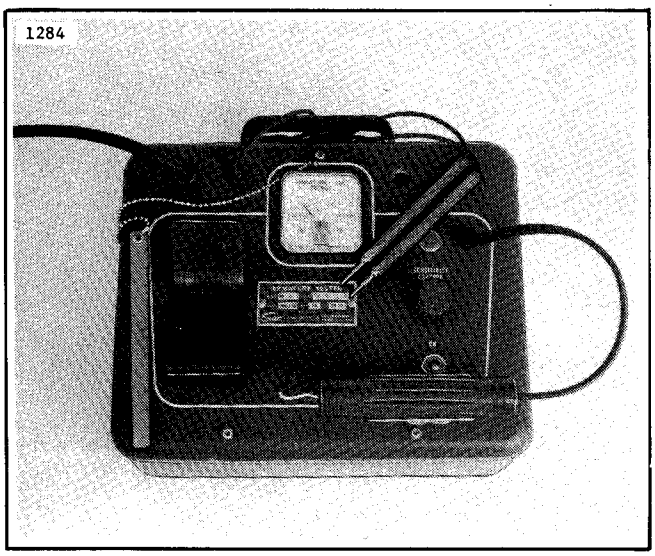
## Visual Inspection of Armature

Obvious defects can be seen by examining the armature. If an armature has frayed or charred insulation, broken wires or thrown solder, it is obvious without further testing that it should be replaced.

Faults seen during the visual inspection can aid in diagnosing the original cause of failure.

Visually check armature for:

1. Burned, charred or cracked insulation.
2. Thrown solder.
3. Worn, burned or glazed commutator.
4. Loose commutator bars.
5. Bruised armature core laminations.
6. Worn armature bearing or shaft.




**Armature Tester (Sun® Model AT-76)**

7. Dirty or oily commutator.

*NOTE*

*Oily commutator indicates worn motor seal at differential.*

## Testing Armature With Armature Tester (Growler) (Sun Model AT-76)

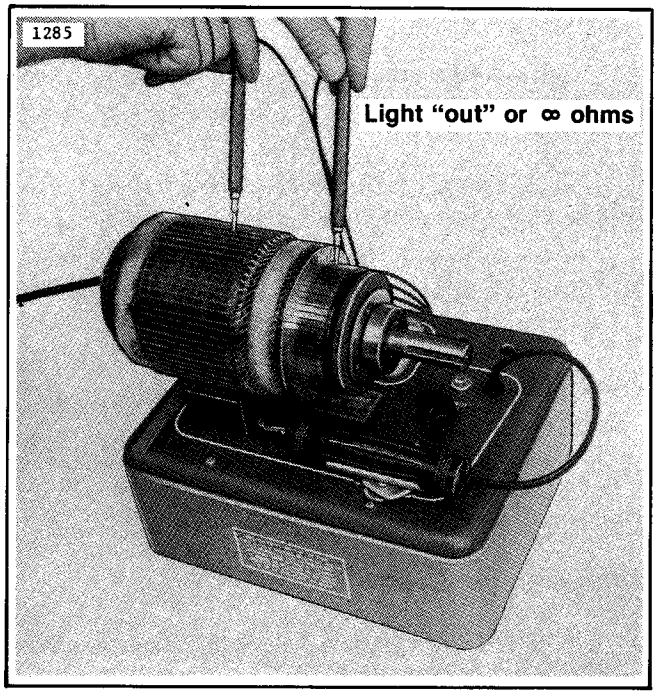
*NOTE*

*Before testing, wipe armature with clean rag and blow carbon dust and metal particles from between commutator bars.*

**CAUTION**

**Do not submerge armature in solvent.**

A completely GROUNDED or SHORTED armature will prevent a traction motor from operating. However, an armature may have an open or high resistance winding and still operate at a lower efficiency than normal.

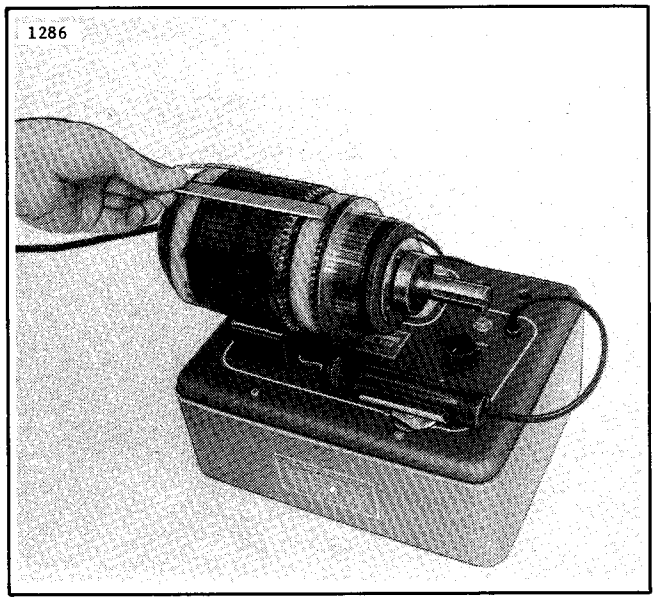



**Armature Ground Test**

## Armature Ground Test

1. Plug in tester.
2. Place armature in growler.
3. Turn on tester.
4. Touch one test probe to commutator and other to

armature core. Test lamp should be "OFF," indicating no continuity. If the test lamp is on the armature is grounded and must be replaced.



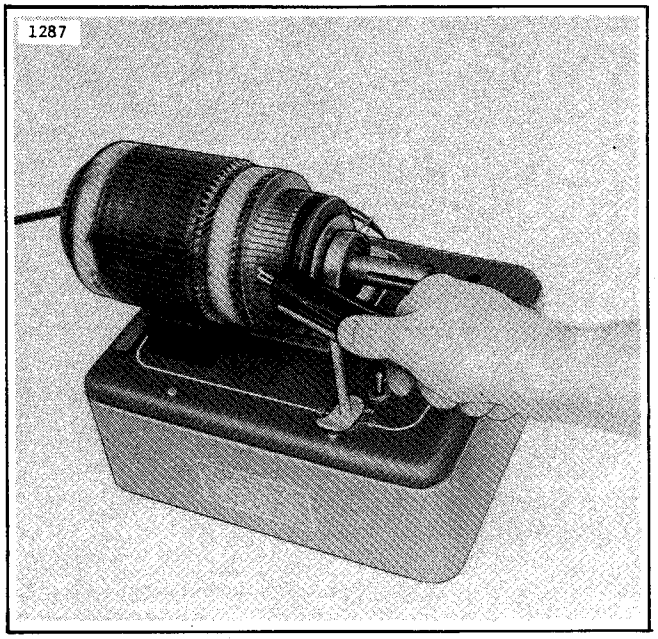

**Armature Short Test**

*NOTE*

*The armature ground test can also be performed in the same manner with a continuity tester or ohmmeter.*

## Armature Short Test

1. With armature in same position as previous test, turn tester on.
2. Using steel blade provided with tester, or hack saw blade, hold blade parallel with and touching armature core.




**Armature Coil Balance Test**

3. Slowly rotate armature one complete revolution in growler. If the armature is shorted the blade will vibrate on the armature core. Shorted armatures must be replaced.

## Armature Coil Balance Test

The **armature coil balance test** is designed to determine whether all the coils are of equal efficiency. This is essential for maximum motor performance and also to prevent rapid commutator burning. A wide variance in coil efficiency will reduce the torque of the motor and overheat the entire assembly.

1. With armature in same position as previous tests, turn tester on.
2. Turn sensitivity control clockwise to stop.
3. Place contact handle in cradle and position cradle so contacts of handle touch a pair of commutator bars.
4. Rotate armature and position contact handle to obtain highest reading on meter. Hold in this position and adjust sensitivity control to set line.
5. Slowly rotate armature one complete revolution pausing to note reading on meter of each pair of commutator bars. The highest reading of each pair of commutator bars should be even within one division of the lowest reading. If reading for a particular pair of bars is noticeably lower, a short, open or poor connection exists in the winding.

## Refinishing Commutator

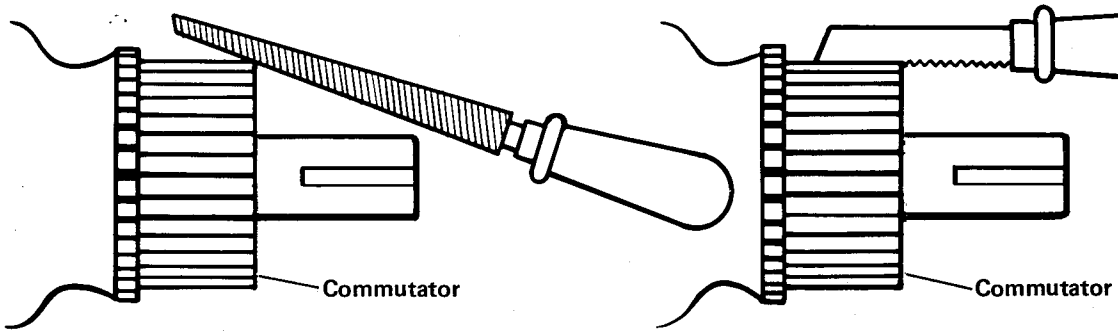
To refinish commutator, mount armature in lathe and **diamond** turn commutator. Limit depth of cut to .005 in. (.127 mm) or less and repeat cut as often as required. Do not reduce commutator diameter to less than specified.

Commutator Minimum Diameter

Hitachi ..... 3.465 in. (88 mm)

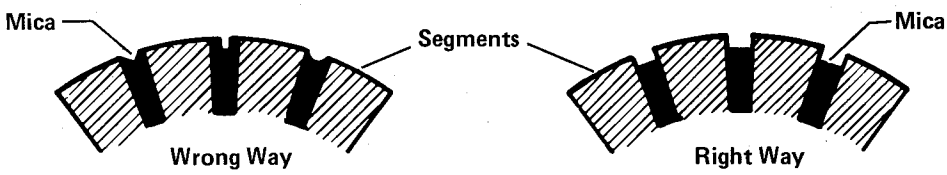
After commutator is turned, the mica insulation between segments must be under cut .031 (1/32) in. (.8 mm). Under cutting should be done with special under cutting equipment. If one is not available, satisfactory under cutting can be carefully done with a piece of hack saw blade. Carefully thin blade width, if necessary, until offset teeth are the same width as slots in commutator. Slots must be square bottomed for best results.

Finish cut commutator after under cutting, and check for excessive commutator runout. Runout should not exceed .001 in. (.025 mm).




Starting Groove in MICA
With 3 Cornered File

Undercutting MICA With Piece
Of Hacksaw Blade




Mica Must Not Be Left
With A Thin Edge Next
To Segments

Mica Must Be Cut Away
Clean Between Segments

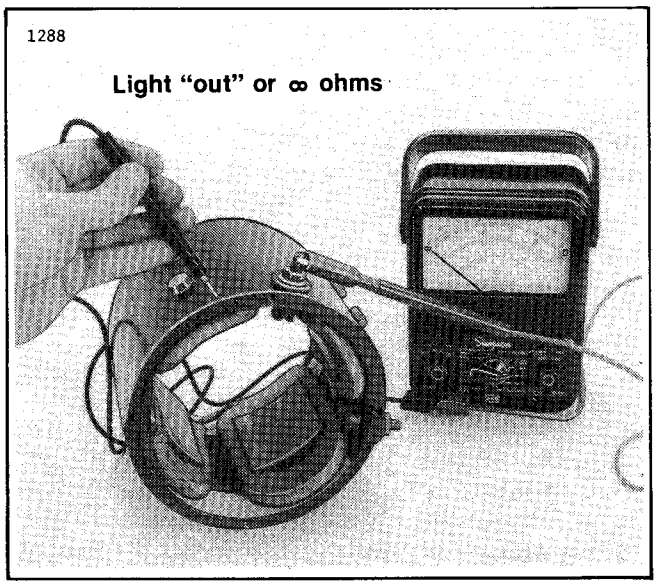
**Undercutting Mica**

# FIELD

## Visual Inspection of Field Coils

If the insulation on the field coils appears blackened or charred, the serviceability of the coils is questionable. Burned or scorched coil insulation indicates the motor has overheated due to overloads, grounded or shorted coil windings.

Check for loose pole shoes.




**Grounded Field Test**


**Open Field Test**

## Testing Field Coils With Continuity Tester or Ohmmeter

### GROUNDED FIELD TEST

1. Attach continuity tester or ohmmeter between S1 terminal and motor frame. Continuity tester should not light, ohmmeter should read ∞.

2. Repeat test on S2 terminal, results should be the same. Tester lamp on or any ohm reading indicates grounded field. Grounded fields should be replaced.

**OPEN FIELD TEST**
**(Figure 6-53)**

Attach continuity tester or ohmmeter across S1 and S2 terminals. Continuity tester should light, ohmmeter should read less than 1/4 ohm. If continuity tester does not light, or ohmmeter reads above 1/4 ohm, replace field coil.

**SHORTED FIELD TEST**

*NOTE*

*This test requires the use of a very sensitive laboratory type ohmmeter capable of reading in thousandths of an ohm.*

Field coil resistance

Hitachi ..... .017 ohms at 68 °F

On Hitachi motors, check resistance across S1 and S2 terminals.

# GENERAL ELECTRIC TRACTION MOTOR 3

# GENERAL ELECTRIC MOTOR 1986 AND LATER

## Inspecting/Replacing Brushes

The motor is totally enclosed and the amount of brush wear is determined by use of a 1/16 inch diameter drill inserted in each of two holes in the end shield. With new brushes, a 1/16 inch diameter rod can be inserted approximately .78 inch into brush measurement holes. Brushes should be replaced when rod can be inserted 1.56 inches into hole. This leaves approximately 1/8 inch allowable wear remaining.

**CAUTION**

**Continued operation of motor with worn out brushes will result in damage to the armatures.**

The motor must be disassembled to service brushes.

### MOTOR DISASSEMBLY

1. Remove battery bank positive and negative cables. Remove A1, A2, S1, and S2 cables from motor.
2. Mark end cover to stator relationship on each end to allow future alignment during reassembly. This can be done with a cold chisel, or paint marker.//
3. Remove two clamp screws (22) from differential end cover (21).
4. Carefully separate motor from differential end cover (21) and withdraw from pinion shaft.
5. Position motor on bench and remove two commutator end cover retaining screws (7), three bearing retaining screws (9) and loosen the S1 and S2 terminal retaining nuts.
6. Carefully remove stator (3) and commutator end frame (8) from armature (4).

### INSPECTION

1. Check each brush for free movement in its holder and examine it for wear and general condition. If brush is broken, cracked, severely chipped, or worn to a length of less than 5/8 inch, measured on the short side of the brush, replace both brush and terminal assemblies.
2. Examine the condition of the brush springs. Make certain the spring coils are uniform and the springs do not appear discolored, which may indicate overheating that has caused loss of spring tension. If spring damage is evident, replace the spring(s), or use a small spring scale to determine if the spring requires one pound or more force to lift it at the point of contact with the worn brush.
3. To replace brushes and or springs, loosen the A1 and A2 terminal nuts (6) to release the terminals from the commutator end frame (8). Remove the two brush plate retaining screws (13) and withdraw the plate. Remove worn brushes and replace with new ones, routing long brush lead under brush plate to opposite side. Reinstall brush plate in end frame and position A1 and A2 terminals. Tighten terminal nuts (6) to 50-70 inch pounds.

## Armature Inspection

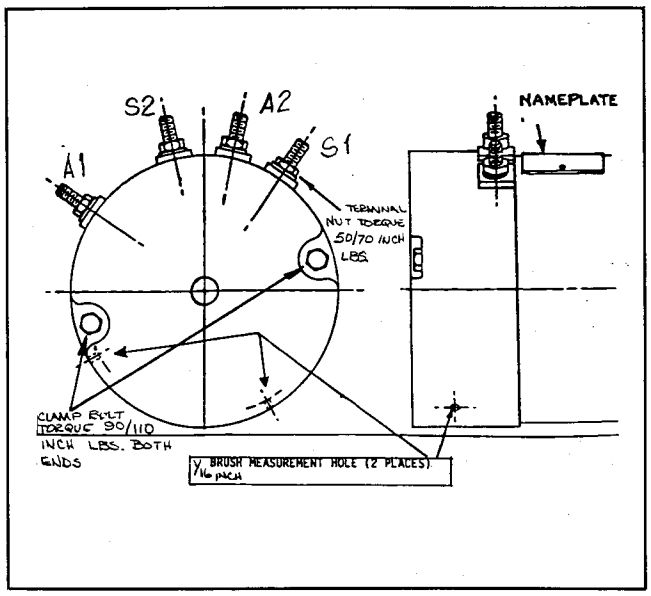
1. Visually inspect commutator bars for evidence of overheating and erosion. This is an indication of an open circuit in the armature winding. If this condition is present, measure the armature resistance by selecting any bar and then counting around to the seventeenth bar. Compare the resistance value for this set of windings with the specified resistance of .020 ohms. If it does not match this value, the armature should not be used.

2. If one or more armature conductors are abnormally black or appear burned compared with the other armature conductors, this is an indication of shorted armature winding. To check further, first blow off any accumulated dust and test on a growler. If the short circuit is not confirmed by the growler test, check resistances and apply a high potential test not exceeding 600 volts AC for one minute. If armature does not pass these tests, it should not be used.

3. If heat discoloration appears uniformly over the commutator or windings, it is usually an indication of overloading of the motor or vehicle. Even if the armature passes all tests, it will probably have a shortened service life. The cause of the overloading must be determined and corrected, or motors will be burned out frequently.

4. Bubbled insulation and individual brush burn marks on the commutator are indications that the motor has been overloaded to the point of stalling with power applied.

Armatures which have failed are rarely repairable, and should be replaced.



## Commutator Inspection and Reconditioning

Inspect condition of commutator during each brush replacement. Commutator bars should not be pitted or grooved in the brush track. If these conditions exist, the armature should be turned in a lathe, limiting the depth of cut to .005 inch or less on a side and repeat until smooth and even. Before the final cut, the mica insulation between each of the commutator bars should be removed to a depth of .032 inch below the surface of the bar. Make certain no mica slivers remain along the under cut.

Dynamic balance the armature to within .0015 inch amplitude at 3000 rpm. After balancing, the final finish cut should be made with a diamond tool to obtain a surface finish of 8 to 16 micro inches.

Do not reuse an armature with a commutator diameter less than 2.625 inches.

After refinishing, measure for eccentricity. This should not exceed .001 inch total indicator reading for the entire armature, and no more than .0002 inch bar to bar difference.

## Inspection of Field Windings

Visually inspect field coil insulation for discoloration or charring. Burned insulation is an indication of overheating due to overloads, grounded or short circuited winding.

To check field winding for grounds, connect ohmmeter to S1 terminal and frame, and to S2 terminal and frame. Continuity indicates a grounded field.

To check for open or shorted winding, connect the ohmmeter between S1 and S2 terminals. Resistance should be .016 ohms ± .0020 ohms at 77° F.

## Bearing Inspection

The commutator end bearing is prelubricated with a special high temperature grease and sealed.

Check bearing by turning with your fingers. Check for binding or gritty effects and for excessive looseness or wobble. Replace any bearing with a condition even slightly questionable.

Remove old bearing from end of armature using a suitable bearing puller. To reinstall bearing, use an appropriate size arbor that exerts pressure on inner ring, and press bearing into place on end of armature. Do not drive bearing with a hammer as this will damage bearing.

### REASSEMBLY

1. Place commutator end frame (2) on bench with brush rigging facing upward. Push each brush back into brush holder far enough to allow commutator to pass under it without hitting. Position end of each brush spring so it is against side of brush and holds brush in place.

2. Slide armature (4) with ball bearing into end frame, and install bearing plate retaining screws (9).

3. Push end of each brush into commutator, allowing brush spring to position itself so it rides on end of brush. Check that each brush lead is free to travel down slot in brush holder as brush wears.

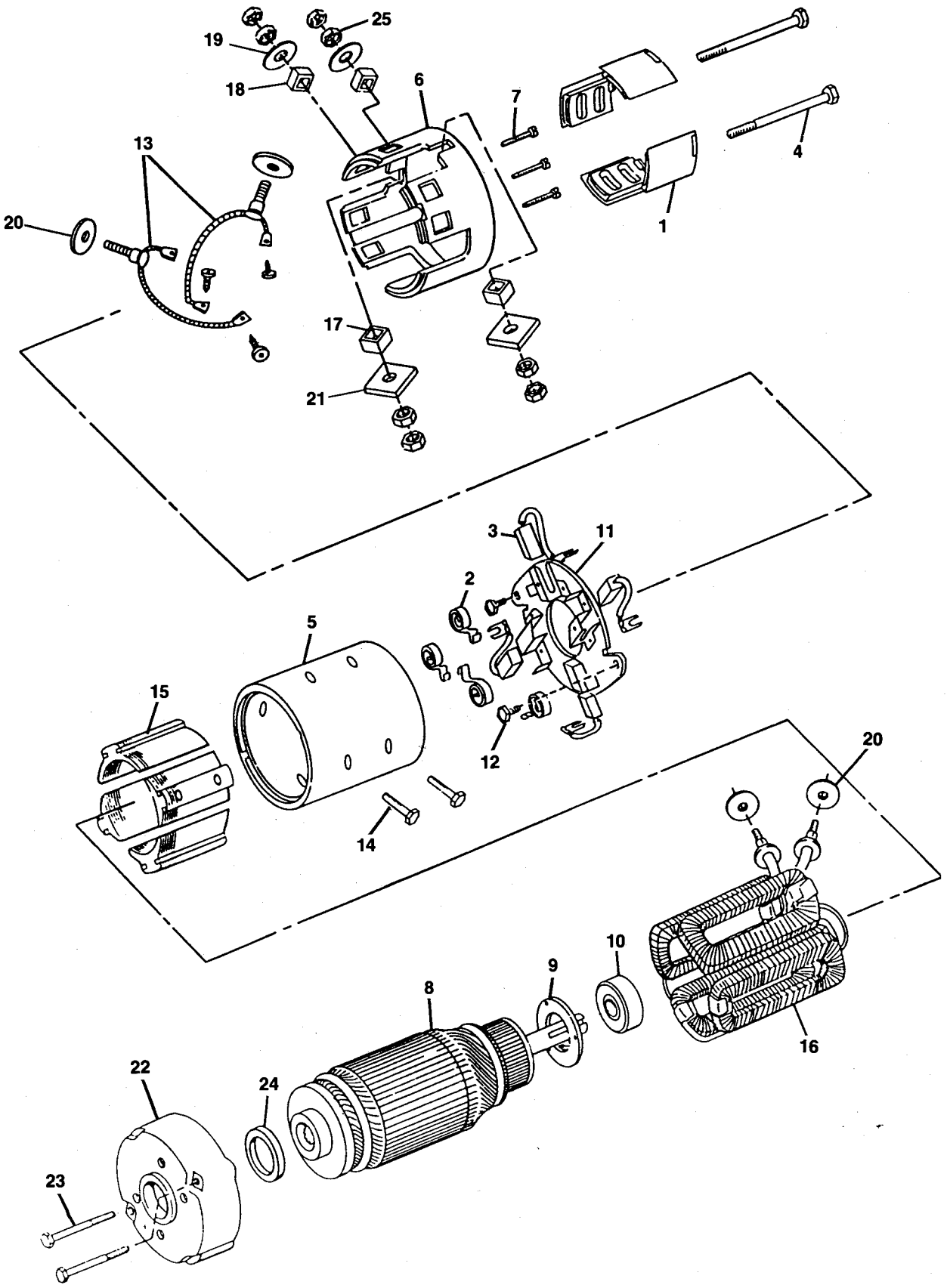
4. Install stator over armature aligning marks, and seat by tapping lightly with soft faced hammer.

5. Lay motor on side and install commutator end mounting screws (7) and tighten to 90-110 inch pounds.

6. Reinstall motor to drive end cover (21), position aligning marks, and tap lightly with soft hammer to seat frame (3) on to cover. Replace mounting screws (22) and tighten to 90-110 inch pounds.

7. Reconnect cables A1, A2, S1, and S2 to motor and then reconnect battery positive and negative cables.

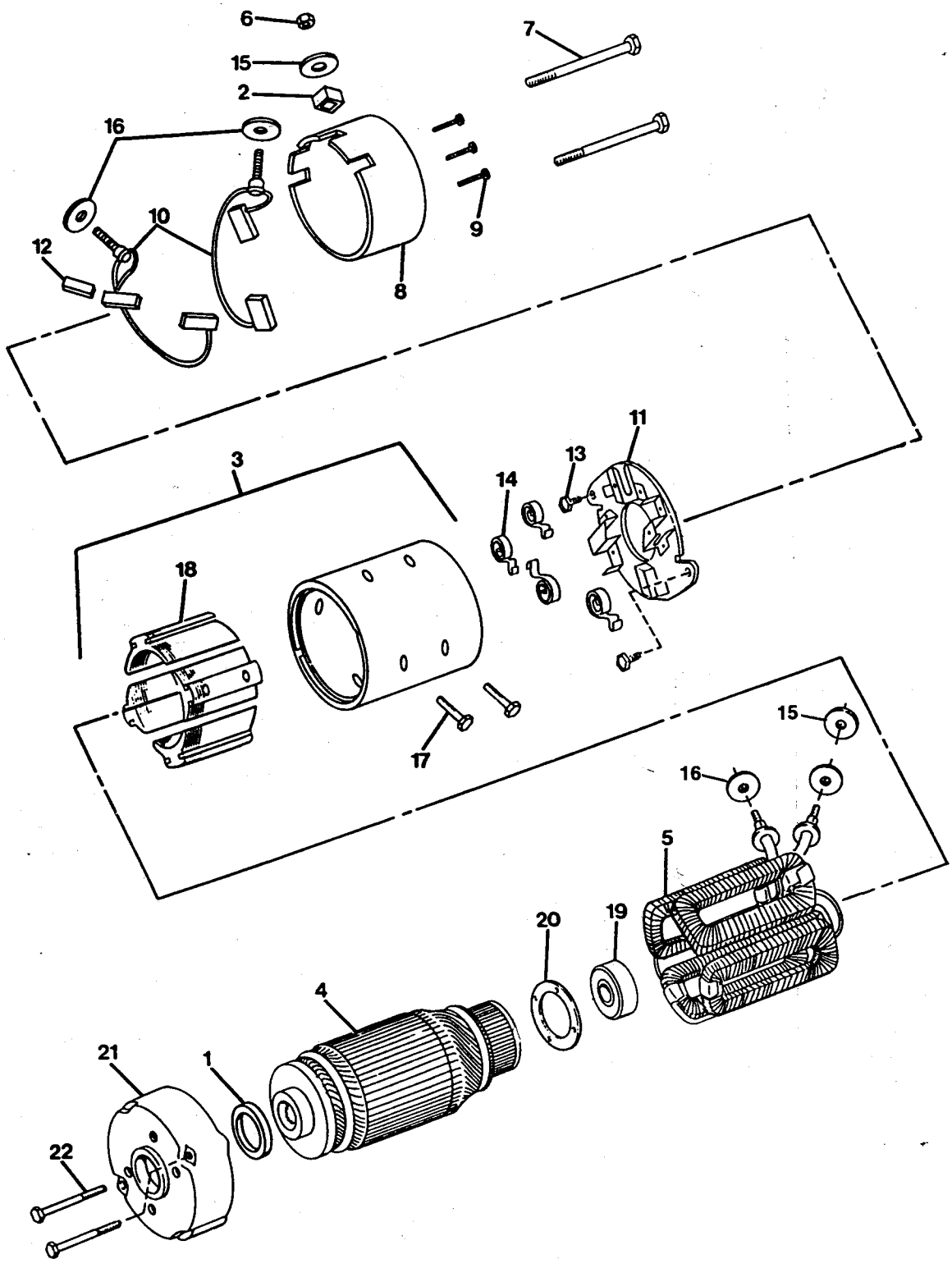
8. Test for proper function.




**TRACTION MOTOR GE — WITH DISC BRAKES E4C — 1984-85**

# TRACTION MOTOR GE — WITH DISC BRAKES E4C — 1984-85

1. Brush cover (4)
2. Brush spring (4)
3. Brush (4)
4. CE cover mounting bolt (2)
5. Field coil frame
6. CE cover
7. Bearing retainer mount screw (3)
8. Armature
9. Bearing retainer plate
10. CE bearing
11. Brush holder plate
12. Brush plate retaining screws (2)
13. Brush rigging (terminals A1, A2)
14. Pole shoe bolts (8)
15. Pole shoes (4)
16. Field coil
17. Square insulator (thin)
    A1, A2 terminals (2)
18. Square insulator (thick)
    S1, S2 terminals (2)
19. Round insulator washer
    (small hole) (2)
20. Round insulator washer
    (large hole) (4)
21. Square washer (2)
22. DE cover
23. DE cover mounting bolt (2)
24. Shaft seal
25. Terminal nut (8)




**TRACTION MOTOR GE — WITH WHEEL BRAKES E4C — 1986**

# TRACTION MOTOR GE — WITH WHEEL BRAKES E4C — 1986

1. Shaft seal
2. Square insulator (2)
3. Field coil frame
4. Armature
5. Field coil
6. Terminal nut (8)
7. CE cover mounting bolt (2)
8. CE cover
9. Bearing retainer mounting screw (3)
10. Brush with rigging and terminals A1, A2
11. Brush holder plate
12. Rubber seal
13. Brush plate retaining screws (2)
14. Brush spring (4)
15. Round insulator washer (small hole) (4)
16. Round insulator washer (large hole) (4)
17. Pole shoe bolts (8)
18. Pole shoe (4)
19. CE bearing
20. Bearing retainer plate
21. DE cover
22. DE cover retaining bolt (2)