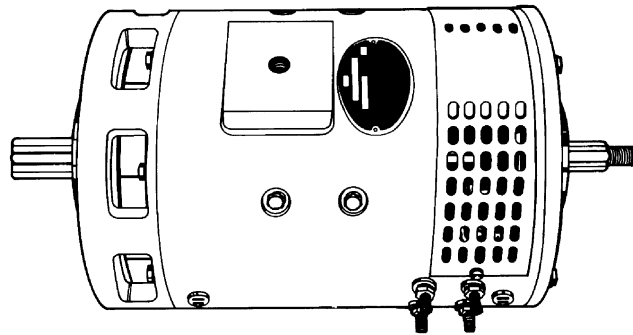


DC MOTOR MAINTENANCE

ALL ELECTRIC LIFT TRUCKS



HM100000

HYSTER

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This section is for the following models:

All Electric Lift Trucks

General

This section describes disassembly and assembly, brush installation, inspection, and checks for malfunctions of DC motors. Inspect the commutator and brushes every 350 hours of operation. The commutator is the rotating electric connection between the armature and the electric power supplied by the battery. Brushes made of carbon compounds slide on the rotating commutator and are the path for electricity from the battery to the commutator and the armature. The maintenance of the commutator and the brushes is important to the good operation of a DC motor.

Traction motors and hydraulic pump motors are similar in design. The hydraulic pump motors are smaller than the traction motors, but the disassembly and maintenance of these motors are similar.

The cooling fan in the traction motors is fastened to the armature and can be removed from the armature. The cooling fan can be removed during disassembly of the traction motor.

The cooling fan in the hydraulic pump motors can be a press fit on the armature shaft and is not easily removed during disassembly of the motor. The armature and cooling fan must be removed from the drive end of the motor during disassembly.

The assembly and disassembly of the motor used for the power steering pump is described in the **Steering System** section. This motor is a permanent magnet motor.

Brush and Commutator Inspection

HYDRAULIC PUMP MOTOR AND TRACTION MOTOR

NOTE: When inspecting brush conditions and motor commutator conditions for head damage or abnormal wear, the battery maintenance and condition should be eliminated as a cause first. See **Industrial Battery** 2240 SRM 1.

NOTE: The brushes and commutator can be inspected, the brushes can be replaced, and Stoning the Commutator can be done with the motor installed in the truck.

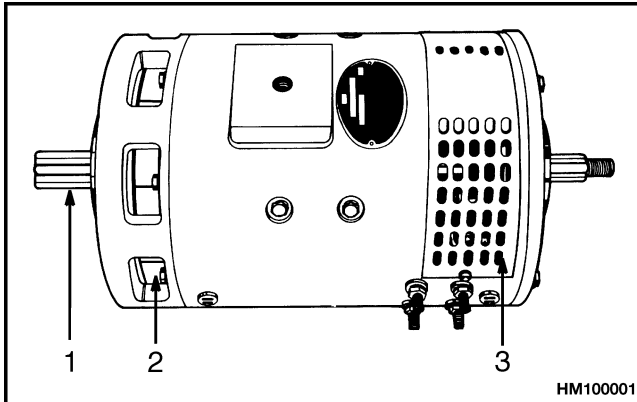
NOTE: Inspect the brushes and commutator every 350 hours for best operation and to prevent motor damage. The hydraulic pump motor normally has more start cycles than other motors, so it can have more wear and possible damage.

NOTE: The following procedure is for inspecting the brushes and commutator with the motor installed in the lift truck. The same inspections can be done with the motor removed. If the motor is removed, start at Step 3.

1. To rotate the commutator of the traction motor without moving the truck, the drive wheels must be raised. See Figure 1. Raise drive wheels so commutator of the traction motor can be rotated without moving lift truck. See **How To Raise Drive Wheels** in the **Operating Manual** or the **Periodic Maintenance** SRM section for your lift truck.

NOTE: For some models of lift trucks, the battery does not need to be removed to access the electric motors. Other models will require the removal of the battery before gaining access to the electric motors. To remove the battery, either raise the hood panels or unfasten the floor plate, depending on which motor needs to be accessed.

2. Remove battery. See **How to Remove Battery** in the **Operating Manual** or the **Periodic Maintenance** SRM section for your lift truck. Remove access plate to motors. If the battery in your lift truck does not need removal for access to the motors, go to Step 3.



- | | |
|------------------------------|----------------|
| 1. ARMATURE
(DRIVE) SHAFT | 2. COOLING FAN |
| | 3. BRUSH COVER |

Figure 1. Traction Motor

WARNING

Compressed air can move particles so that they cause injury to the user or to other personnel. Make sure that the path of the compressed air is away from all personnel. Wear protective goggles or a face shield to prevent injury to the eyes.

NOTE: Vacuum cleaning, when possible, is the recommendation of manufacturers of electric motors. The use of compressed air can send dirt particles into the bearings and other areas of the motor that can cause possible damage.

- Remove brush covers at rear of motor. See Figure 2. Wear eye protection. Use a vacuum cleaner or compressed air to remove dirt and brush dust from commutator area.

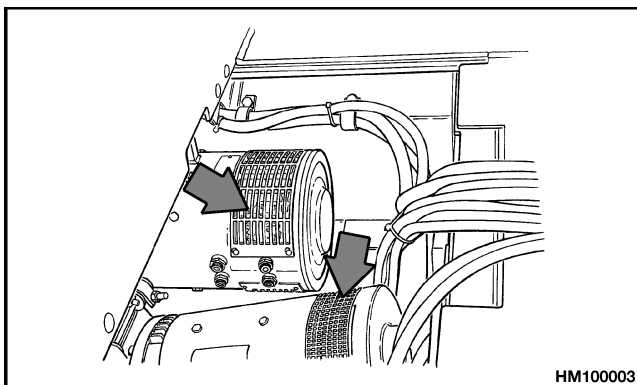


Figure 2. Brush Cover Removal From Motor

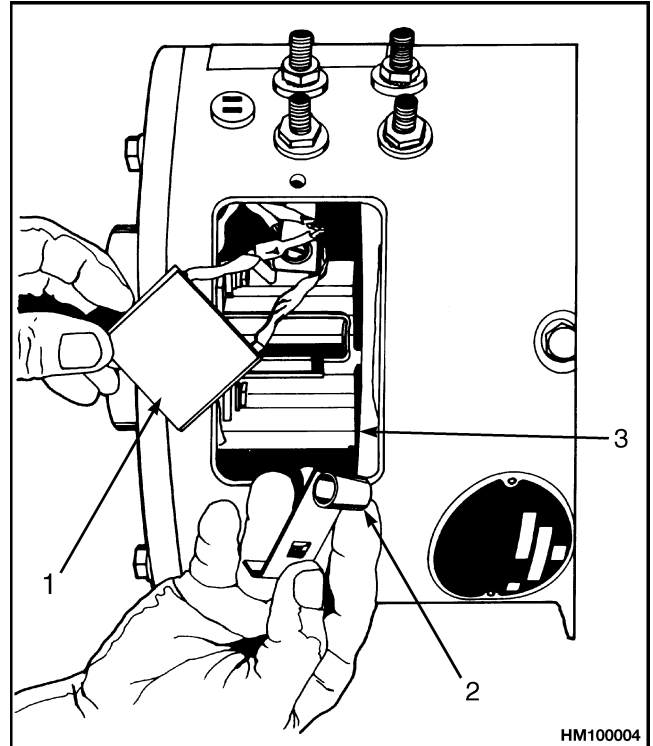
- Remove and inspect brushes for damage or uneven wear. Replace all brushes if any brush is worn or damaged. The brushes must be at least half their original length. Move brush springs away from top of each brush and pull brushes from their holders to inspect surface that rides on commutator. See Figure 3. That surface must have the same shape as the commutator and must not have cracks or defects. Some brushes have wear sensor wires attached, even if they are not connected to an indicator. Replace these brushes if brushes are worn enough to see sensor at commutator end of brush.
- Inspect commutator surface. See Table 1 and Table 2. Carefully rotate armature. **DO NOT** damage commutator if you use a tool to rotate armature.

The commutator wears slowly in normal service. The mica must be cut below the surface of the commutator bars after a long service period or after a commutator has been turned in a lathe.

A commutator that has been in service will have a smooth and polished surface with a darker brown color where it rotates under the brushes. A variation of color on the commutator surface between light brown and darker brown is normal. The surface condition is the lubrication between the commutator and the brushes. The brushes will wear rapidly if this surface condition does not develop during the first 6 to 10 hours of operation after a commutator with a new surface is installed. If the commutator has deep grooves, rough edges of the bars, or a few bars that are black or raised above the others, the motor must be removed for service.

- Inspect white or gray insulation (mica) between commutator bars. The mica must not touch the brushes or the brushes will wear very rapidly.
- To replace a brush set, remove screw that holds brush wires to bus. Pull brush end of springs from brushes, and pull brushes from holders. Lift brush springs away from holders, and install new brushes so brush commutator surface fully touches commutator. Make sure the springs are pushing on each brush. Install and tighten screws for brush wires and bus connectors.

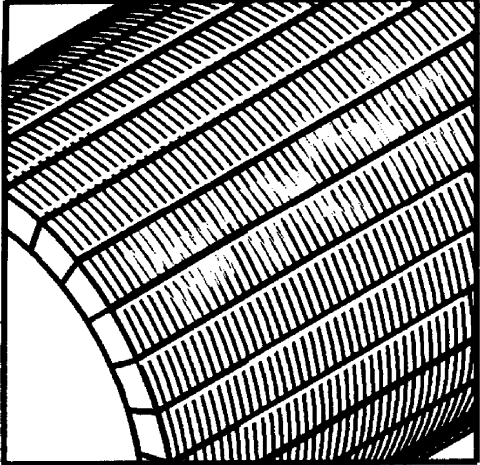
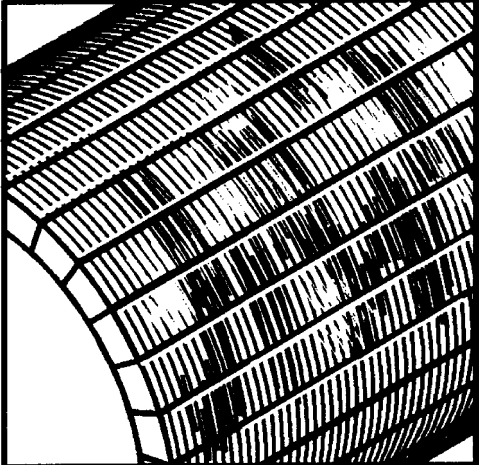
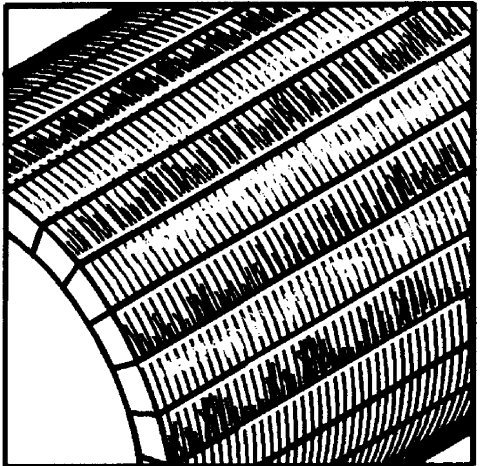
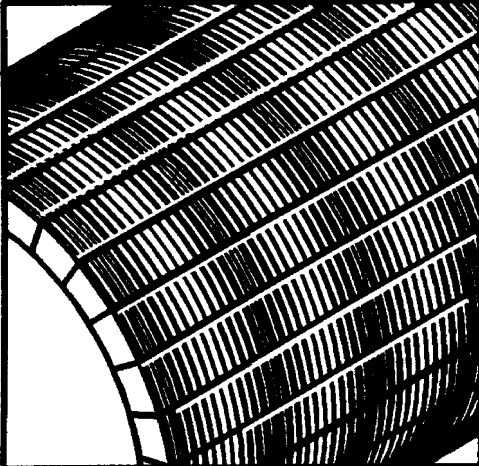
8. Carefully install brush covers so sparks are kept inside motor housing. Install battery as described in **Operating Manual** or the **Periodic Maintenance** SRM section for your lift truck.



1. BRUSH
2. BRUSH SPRING
3. MICA

Figure 3. Brush Removal and Inspection

Table 1. Normal Commutator Surfaces

<p>A light brown surface of the commutator where it rotates on the brushes is a normal condition. The surface of the commutator must be smooth.</p>  <p style="text-align: right;">HM100005</p>	<p>Variations between light brown and dark brown colors are also normal. The surface of the commutator must be smooth.</p>  <p style="text-align: right;">HM100007</p>
<p>A condition called slot bar marking is also normal if the commutator surface is smooth. The variable color occurs in a pattern according to the number of conductors per slot.</p>  <p style="text-align: right;">HM100006</p>	<p>A very dark surface is also a normal and an acceptable condition if the commutator surface is smooth.</p>  <p style="text-align: right;">HM100008</p>

STEERING PUMP MOTOR

NOTE: Some electrical trucks use a steering pump motor. Refer to your truck model's service manual for instructions on removal and installation of steering pump motors.

1. Disconnect battery connector. Remove floor plate from lift truck for access to steering pump motor. Open hood for access to motor. Remove screws

that hold two brush cover plates to motor housing.

2. Inspect brushes and commutator as described in previous paragraphs for traction and hydraulic pump motors. The brush replacement procedure is also the same, although there are only two brushes for the steering pump motor. See Table 3.

3. Install brush covers and screws. Install floor plate or close hood and connect battery connector.

NORMAL COMMUTATOR SURFACE

A commutator that has been in service will have a smooth and polished surface with a darker brown color where it rotates under the brushes. See Table 1. A variation of color on the commutator surface between light brown and darker brown is normal.

This surface condition is the lubrication between the commutator and the brushes. The brushes will wear rapidly if this surface condition does not develop during the first 6 to 10 hours of operation after a commutator with a new surface is installed.

COMMUTATOR PROBLEMS

Commutator and motor problems and are shown in Table 2.

Table 2. Commutator Problems

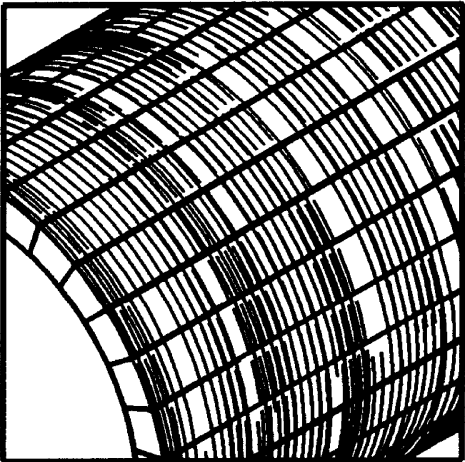
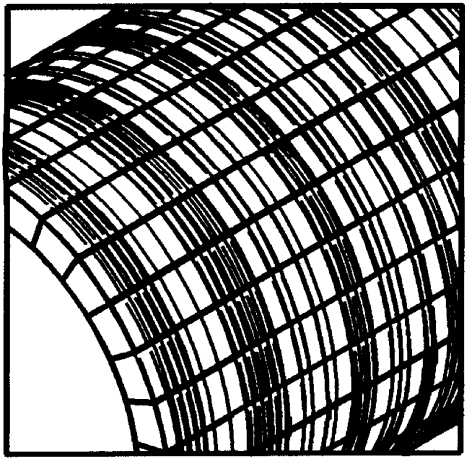
Problem	Possible Cause	Illustration
<p>Heavy streaks and fine grooves indicate the beginning of damage to the commutator.</p>	<ul style="list-style-type: none"> • Operation of the motor in dirty and abrasive conditions. • Continuous operation of a motor with a light load. • Brush pressure is too low. • Worn brushes. 	 <p style="text-align: right; font-size: small;">HM100009</p>
<p>Grooves and lines that have followed the heavy streaks and fine grooves shown above. The armature must be removed from the motor so the commutator can be repaired. A commutator with this condition will cause the brushes to wear rapidly.</p>	<ul style="list-style-type: none"> • Operation of the motor in dirty and abrasive conditions. • Continuous operation of a motor with a light load. • Brush pressure is too low. • Worn brushes. 	 <p style="text-align: right; font-size: small;">HM100010</p>

Table 2. Commutator Problems (Continued)

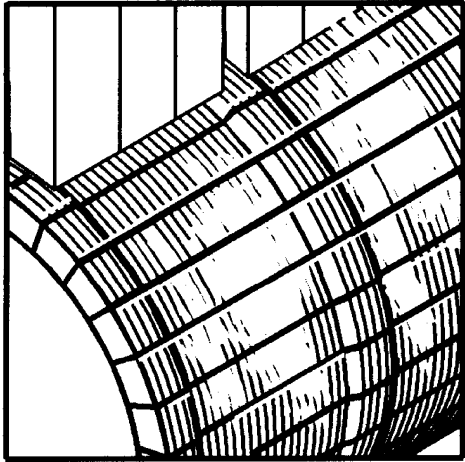
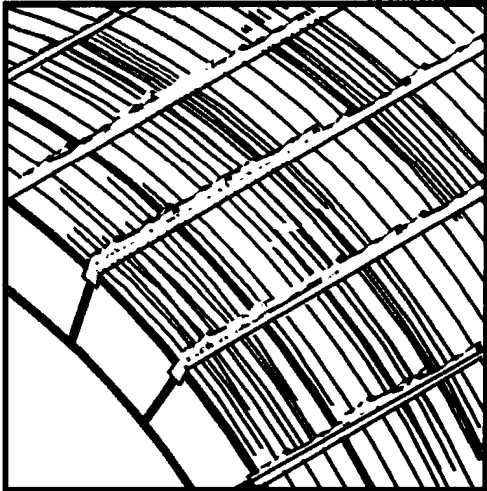
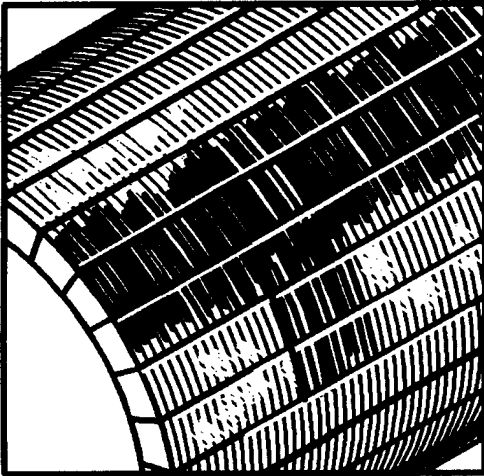
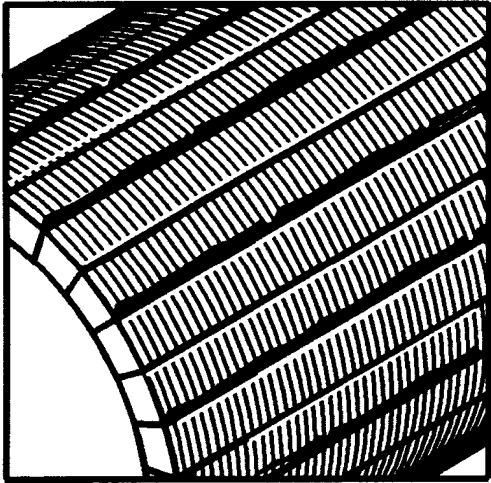
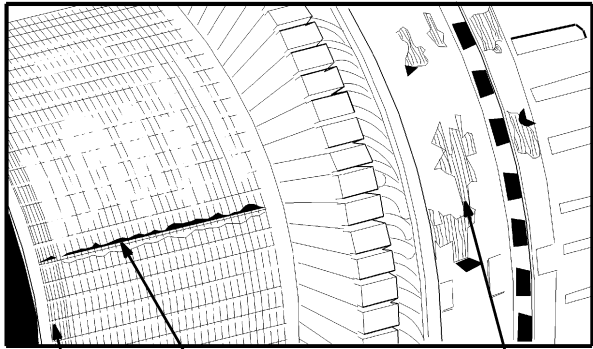
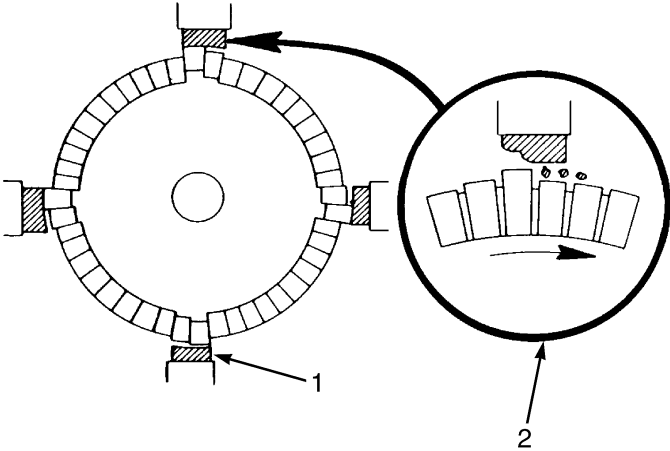
Problem	Possible Cause	Illustration
<p>Grooves that are the width of the brushes.</p>	<ul style="list-style-type: none"> • Operation of the motor in dirty and abrasive conditions. • Wrong type of brushes for this motor and operation. • Brush pressure is too high. 	 <p style="text-align: right; font-size: small;">HM100011</p>
<p>A condition called copper drag occurs when copper from the commutator bar is pulled into the slot between the commutator bars. This condition will cause a short circuit between the commutator bars if it is not corrected. The brushes will wear rapidly.</p>	<ul style="list-style-type: none"> • Operation of the motor in dirty and abrasive conditions. • Brush holder is not adjusted electrically correct for the motor. • Wrong type of brushes for this motor and operation. • Brush pressure is wrong (too high or too low). 	 <p style="text-align: right; font-size: small;">HM100012</p>
<p>Electrical burns on commutator bars on opposite sides of the commutator.</p>	<ul style="list-style-type: none"> • Open armature winding. • Motor has been stalled. 	 <p style="text-align: right; font-size: small;">HM100013</p>

Table 2. Commutator Problems (Continued)

Problem	Possible Cause	Illustration
<p>Copper wears rapidly at the edge of the commutator bars.</p>	<ul style="list-style-type: none"> • Operation of the motor in dirty and abrasive conditions. • Wrong type of brushes for this motor and operation. 	 <p style="text-align: right;">HM100014</p>
<ol style="list-style-type: none"> 1. Flashover causes burning of the ends of the commutator bar. 2. Open circuit in winding causes deep burning of adjacent commutator bars. 3. Overheating causes damage to varnish insulation. 	<ul style="list-style-type: none"> • Motor has been too hot. Wrong lift truck for the application. • Motor has been stalled. • Open armature winding. • Open field coil. 	 <p style="text-align: right;">HM100015</p>
<p>Brush and commutator damage occurs when the high commutator hits and forces the brush up. Arcing and burns occur as the brush moves back down to the normal surface. Check for loose or high commutator bars.</p>	<ul style="list-style-type: none"> • Motor has been stalled. (High commutator bars at each brush position can occur if the motor is stalled.) • Motor has been too hot. 	 <p style="text-align: right;">HM100016</p> <ol style="list-style-type: none"> 1. High commutator bars at each brush position can occur if the motor is stalled. 2. Rapid brush wear from high commutator bars.

Brush Replacement

1. Motor brushes must be replaced before they are worn enough to damage the surface of the commutator. Move the brush spring and remove a brush from its brush holder. Install new brushes as a set if length of any brush is worn to a minimum length. See Table 3. If the brush lead is fastened to the brush with a rivet, install a new set of brushes if it is worn to within 3 mm (0.118 in.) of the rivet. If a brush does not move easily in its holder, a new set of brushes must be installed.

The lead wire for some brushes is installed directly into the carbon compound of the brush. New brushes must be installed before the lead wire cuts a groove in the commutator. Install a new brush set when a brush is worn to a short length.

Brushes are made to different specifications for motors used in different applications. Use only new brushes approved by Hyster Company for that motor.

NOTE: For some models of lift trucks, the battery does not need to be removed to access the electric motors. Other models will require the removal of the battery before gaining access to the electric motors.

2. Remove battery as necessary for your lift truck. See **How To Remove Battery** in the **Operating Manual** or the SRM section **Periodic Maintenance** for your lift truck.



WARNING

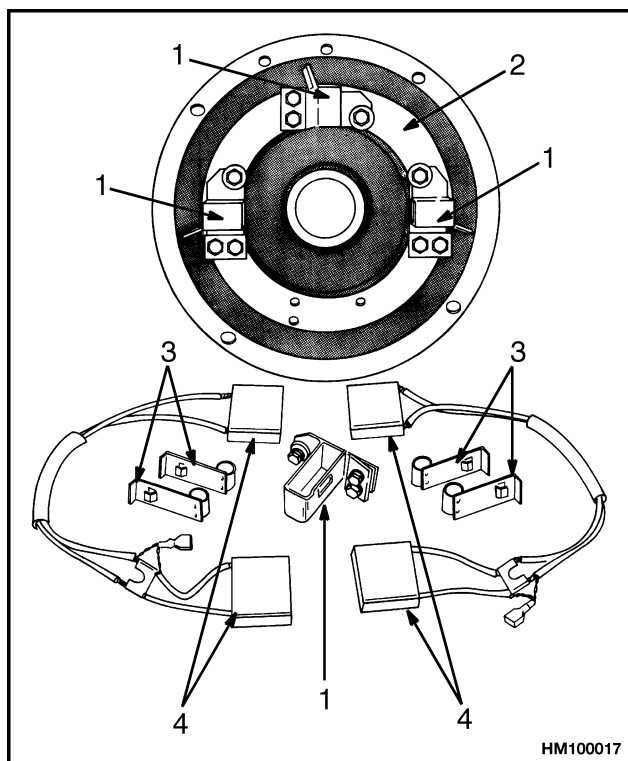
Compressed air can move particles so they cause injury to the user or to other personnel. Verify the path of the compressed air is away from all personnel. Wear protective goggles of a face shield to prevent injury to the eyes.

3. Remove access plate to motors. Remove brush covers to motor. See Figure 2. Wear eye protection. Use a vacuum cleaner or compressed air to remove dirt and brush dust from commutator area.
4. Make a note of the arrangement and connections of the brush assembly. See Figure 4. The new brushes must be installed in the same positions from which the worn brushes were removed.
5. Loosen screw that fastens brush wire to its terminal. Remove brush springs and brushes.
6. Inspect brush holders for burns and damage. Make sure brush holders are fastened tightly to brush mounting plate at end of motor. Make sure new brushes will move freely and smoothly in brush holders. Check that brush mounting plate is holding brush holder so it does not move.
7. Connect new brush wire to its terminal mount.

NOTE: When new brushes must be installed, a recommendation is to also install new brush springs. Damage from heat can cause the brush springs to have the wrong spring pressure.

Table 3. Brush Wear Replacement Guide

Brush Height	17 mm (0.67 in.)	22 mm (0.87 in.)	28 mm (1.10 in.)	30 mm (1.18 in.)	31 mm (1.22 in.)	32 mm (1.26 in.)	40 mm (1.57 in.)
Wear	8 mm (0.31 in.)	12 mm (0.47 in.)	14 mm (0.55 in.)	15 mm (0.59 in.)	16 mm (0.63 in.)	16 mm (0.63 in.)	16 mm (0.63 in.)
Worn Brush Height	9 mm (0.35 in.)	10 mm (0.39 in.)	14 mm (0.55 in.)	15 mm (0.59 in.)	15 mm (0.59 in.)	16 mm (0.63 in.)	20 mm (0.79 in.)



1. BRUSH HOLDER (4)
2. BRUSH MOUNTING PLATE
3. BRUSH SPRING (4)
4. BRUSH SET

Figure 4. Brush Assembly

8. Check brush springs for damage from heat and corrosion. If brush springs are damaged, install new brush springs. Check brush springs for approximately equal pressure.

Brush springs normally have a spring pressure of approximately:

1.0 to 2.0 Newtons per each cm^2
 (1.5 to 3.0 lbf per each in^2) when measured with a spring scale.

A brush for a traction motor has an area of approximately:

$5.33 \times 1.27 \text{ cm} = 6.8 \text{ cm}^2$
 ($2.1 \times 0.5 \text{ in.} = 1.05 \text{ in}^2$).

Brush springs for the traction motor normally have a spring force of approximately:

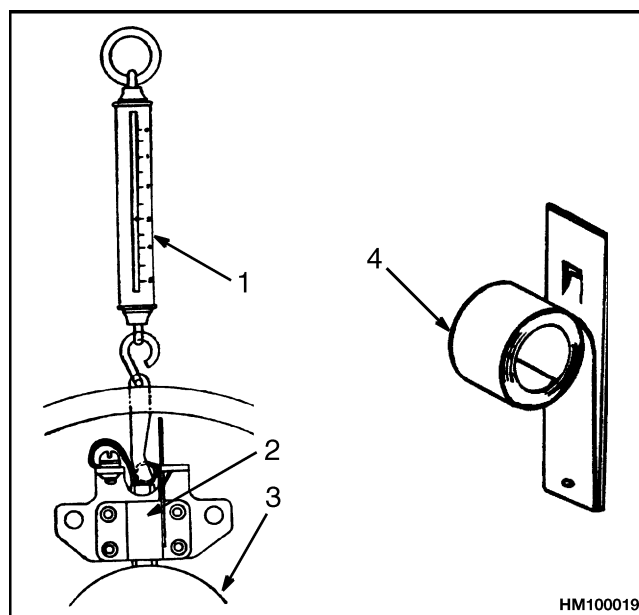
9.1 to 11.3 Newtons
 (36 to 44 ozf) when measured with a spring scale as shown in Figure 5.

A brush for a hydraulic pump motor has an area of approximately:

$4.42 \times 0.95 \text{ cm} = 4.21 \text{ cm}^2$
 ($1.74 \times 0.375 \text{ in.} = 0.653 \text{ in}^2$).

Brush springs for the hydraulic pump motor normally have a spring force of approximately:

5.2 to 7.4 Newtons
 (20 to 28 ozf) when measured with a spring scale as shown in Figure 5.



NOTE: SOME MOTORS HAVE SPRINGS AS SHOWN IN FIGURE 7 AND FIGURE 11. SOME SPRINGS ARE IN PAIRS AT EACH BRUSH HOLDER.

1. SPRING SCALE
2. BRUSH IN BRUSH
3. COMMUTATOR
4. BRUSH SPRING HOLDER

Figure 5. Brush Spring Pressure Check

 **WARNING**

Wear eye protection. Raise the drive wheels. Operate the motor at low speed. Protect your fingers. You are doing work close to moving parts of the motor. Do not use a brush seater stone less than 60 mm (2.4 in.) in length.

NOTE: The brush springs used in motors made by Hyster have a constant force design. The force of the brush spring against the brush stays almost constant as the brush wears and becomes shorter in its brush holder.

NOTE: New brushes made by the manufacturer are normally made to fit the surface of the commutator when they are installed. This contact surface must be checked when new brushes are installed. The contact surface **MUST** be approximately 85 percent of the brush surface where it touches the commutator.

A small contact surface can cause burns and a rough surface on the commutator. If the contact surface is less than approximately 86 percent, the new brushes must be made to fit the commutator better.

9. If new brushes must be made to fit the surface of the commutator, see Stoning the Commutator. Use a Brush Seater and Commutator Stone (No. 23-007M from the Ideal Company or an equivalent brush seater stone). Stoning the commutator is most easily done when the motor rotates slowly. When the motor rotates at higher speeds, the centrifugal force removes the abrasive particles from the commutator more quickly.

NOTE: To rotate the commutator of the traction motor without moving the truck, the drive wheels must be raised. See **How to Raise Drive Wheels** in the **Operating Manual** or the SRM section **Periodic Maintenance** for your lift truck.

Stoning the Commutator

1. If the commutator has grooves or other damage, the armature must be removed so the commutator can be repaired. Motors are normally repaired by service persons that have the special equipment required. Connect battery so the motor can be operated. See Figure 6. The battery must be removed for access to the motor. Use a jumper cable to connect battery to lift truck. Raise drive wheels. See **How to Raise the Drive Wheels** in the **Operating Manual** or the SRM section **Periodic Maintenance** for your lift truck.
2. Close seat switch and key switch so motor will operate.

NOTE: A brush seater stone can also be fastened to a wood stick with glue as shown in Figure 6. This arrangement makes it easier to apply a brush seater stone in small spaces.

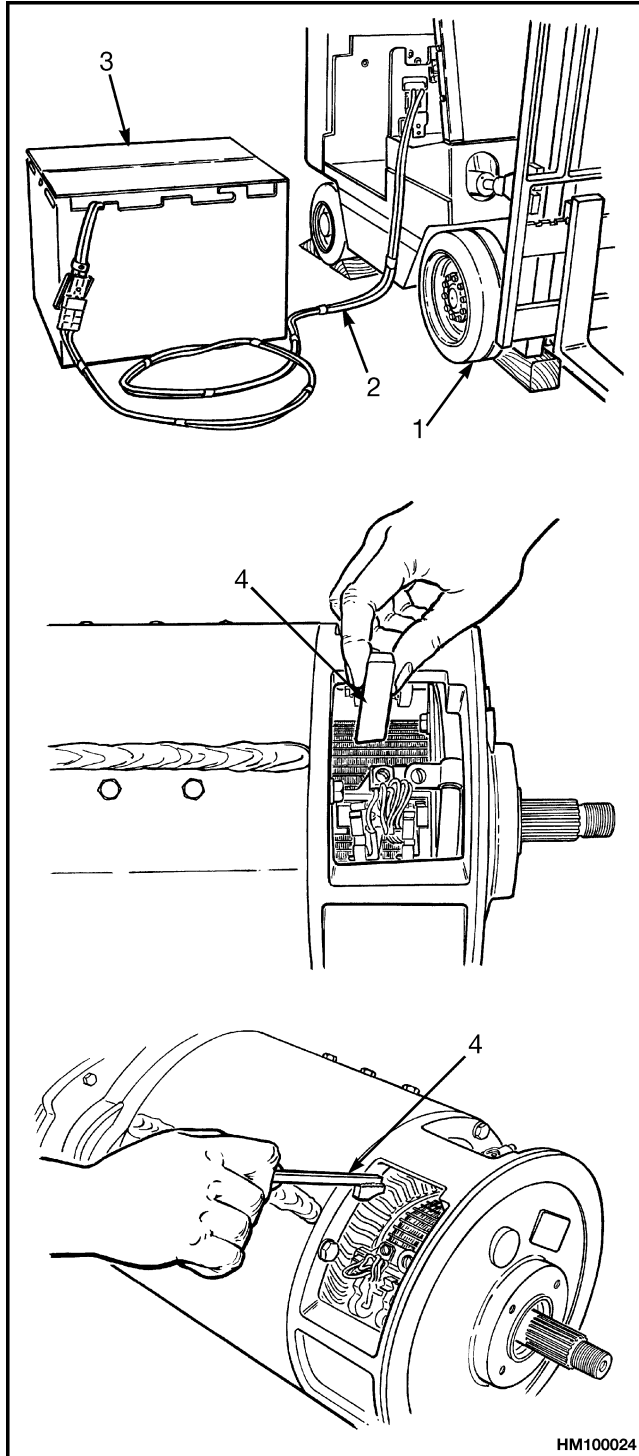
3. Operate motor so commutator rotates slowly. Apply brush seater stone to moving commutator with light pressure. Move brush seater stone backward and forward across surface of commutator until marks on commutator are removed.

Apply brush seater stone to commutator before each set of brushes so the brush seater particles have an even distribution.

 **CAUTION**

Do not permit the brush seater stone to stay in contact with the commutator too long and cause more wear than necessary.

4. Turn key switch to **OFF** position and disconnect battery. Check all brush contact surfaces. The brushes fit correctly when 85 percent of the brush contact surface touches the commutator. This stoning procedure normally requires approximately 15 to 45 minutes.
5. When the brushes have the correct contact surface with the commutator, use a vacuum cleaner to remove abrasive dust from commutator area and motor.
6. When the installation and checks are complete, install brush cover. Make sure wires to brushes do not touch any part of motor case and cause a short circuit.



Legend for Figure 6

- 1. RAISE DRIVE WHEELS
- 2. JUMPER
- 3. BATTERY
- 4. BRUSH SEATER STONE

Figure 6. Stoning the Commutator

Motors Repair

DISASSEMBLE

See the **Master Drive Unit** section or the **Frame** section for your lift truck for instructions on the removal and installation of the traction motor.

See the **Hydraulic System** section for instructions to remove and install the hydraulic pump and motor.

See the Brush and Commutator Inspection and Brush Replacement in this section for more information on these components of the motor.

Traction Motor and Hydraulic Pump Motor

NOTE: It is recommended that the bearings and the seal be replaced every 3,000 hours or 36 months, whichever comes first.

1. Clean outside surfaces of motor before disassembly. See Figure 8, Figure 9, and Figure 10. Put motor on its commutator (brush) end on a bench. On hydraulic motor assemblies, make index marks on pump and motor. Make index marks on end frames of motor and field frame so correct assembly is possible.
2. On hydraulic motor assemblies, remove two cap screws that fasten pump to pump motor. See Figure 11 or Figure 12. Remove pump. Put an index mark on armature shaft at the position of the coupler hub for correct assembly. Remove coupler hub from armature shaft by loosening setscrew and sliding hub off shaft and key. Do not lose key.
3. Remove brush cover. Remove brushes and spring assemblies.
4. Remove hex head screws from commutator end of motor. Carefully slide end frame from motor and armature shaft. Do not damage parts. A puller is frequently necessary to separate end frame from field frame.



CAUTION

The drive end frame and the armature are heavy components. Work carefully so the field coils, pole pieces, and armature are not damaged during disassembly and assembly.

5. Remove screws that fasten drive end frame to field frame. Remove end frame and armature.

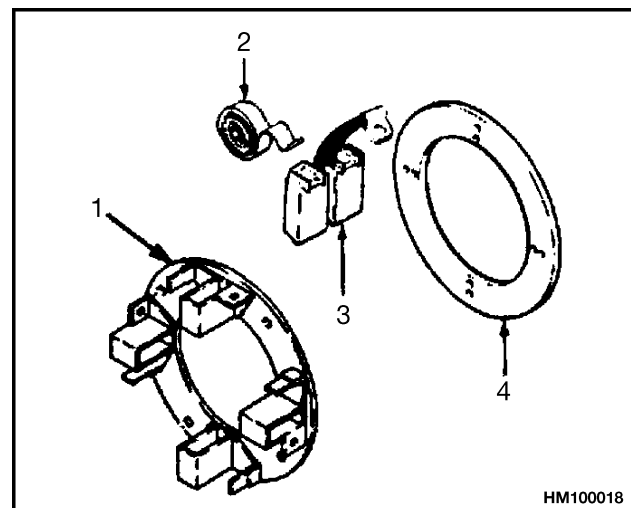
Use a plastic or rubber hammer as necessary to loosen end frame.

6. Remove drive end frame from armature.

If the brush holder (1) must be loosened or removed from the end frame for repairs, the brush holder must be installed again in the same position. See Figure 7. Make alignment marks between the brush holder and the end frame before the brush mounting plate (4) is released. The brush holder must be installed again in the same position.

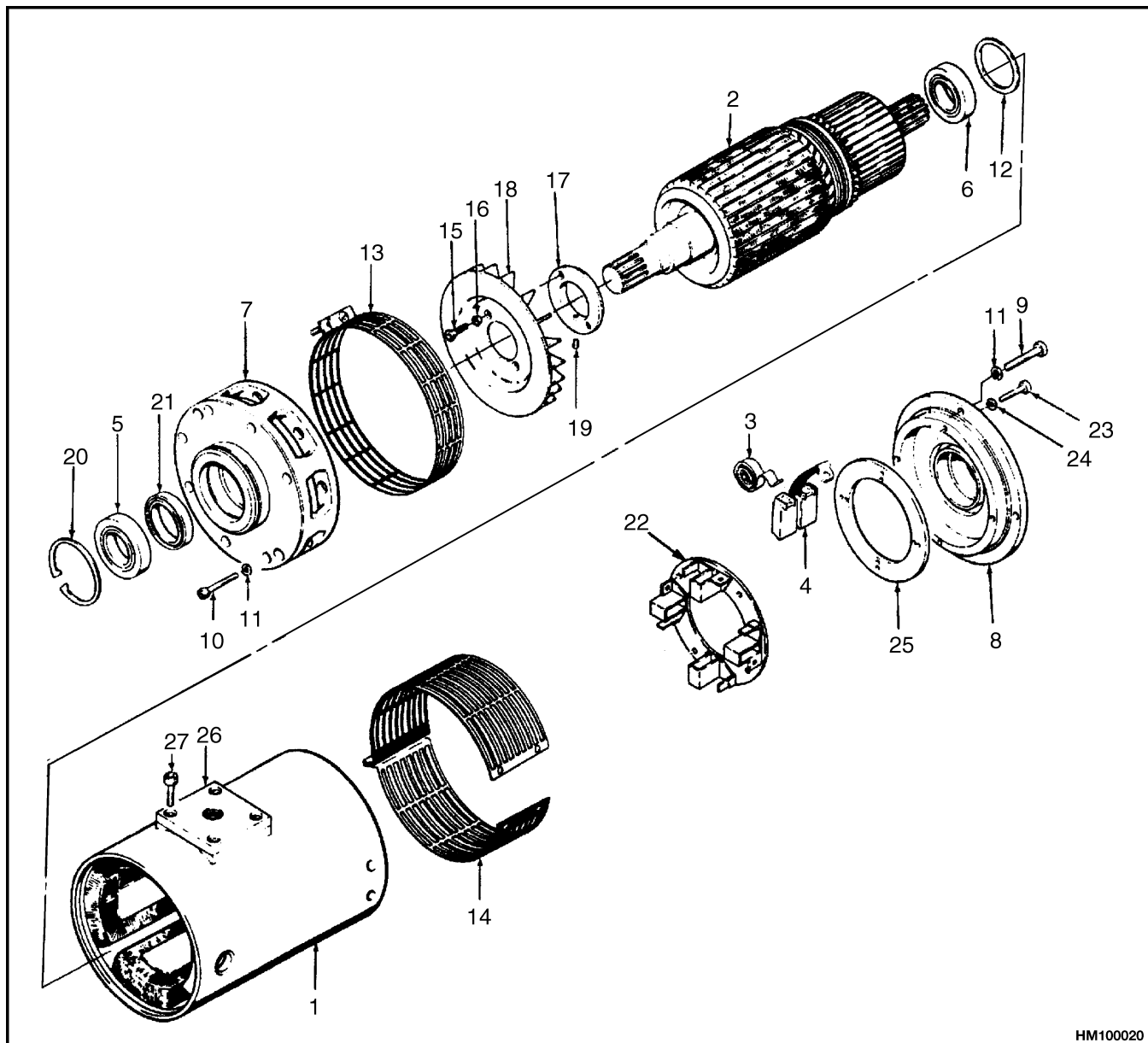
If a new brush holder must be installed, there will not be an alignment mark on the new brush holder. Make an alignment mark on end frame with a reference point on brush holder that must be removed. Install new brush holder so reference point and alignment mark are aligned. The new brush holder must be installed in the same position as the old holder so the timing will be correct.

7. Remove screws that fasten brush holder assembly to commutator end frame.
8. Disassemble components of motor as necessary to make repairs.



- | | |
|-----------------|-------------------------|
| 1. BRUSH HOLDER | 3. BRUSH |
| 2. BRUSH SPRING | 4. BRUSH MOUNTING PLATE |

Figure 7. Brush Holder and Mounting Plate



HM100020

- | | | |
|-------------------------|-----------------|--------------------------|
| 1. FIELD FRAME ASSEMBLY | 10. SCREW (4) | 19. SCREW (2) |
| 2. ARMATURE | 11. WASHER (8) | 20. SNAP RING |
| 3. BRUSH SPRING (4) | 12. WASHER | 21. OIL SEAL |
| 4. BRUSH (4) | 13. FAN COVER | 22. BRUSH HOLDER |
| 5. BEARING | 14. BRUSH COVER | 23. SCREW (4) |
| 6. BEARING | 15. SCREW (4) | 24. WASHER (4) |
| 7. DRIVE END FRAME | 16. WASHER (4) | 25. BRUSH MOUNTING PLATE |
| 8. COMMUTATOR END FRAME | 17. FAN HUB | 26. MOUNT PLATE |
| 9. SCREW (4) | 18. FAN | 27. SCREW (4) |

Figure 8. Typical Traction Motor (Example 1)

Steering Pump Motor

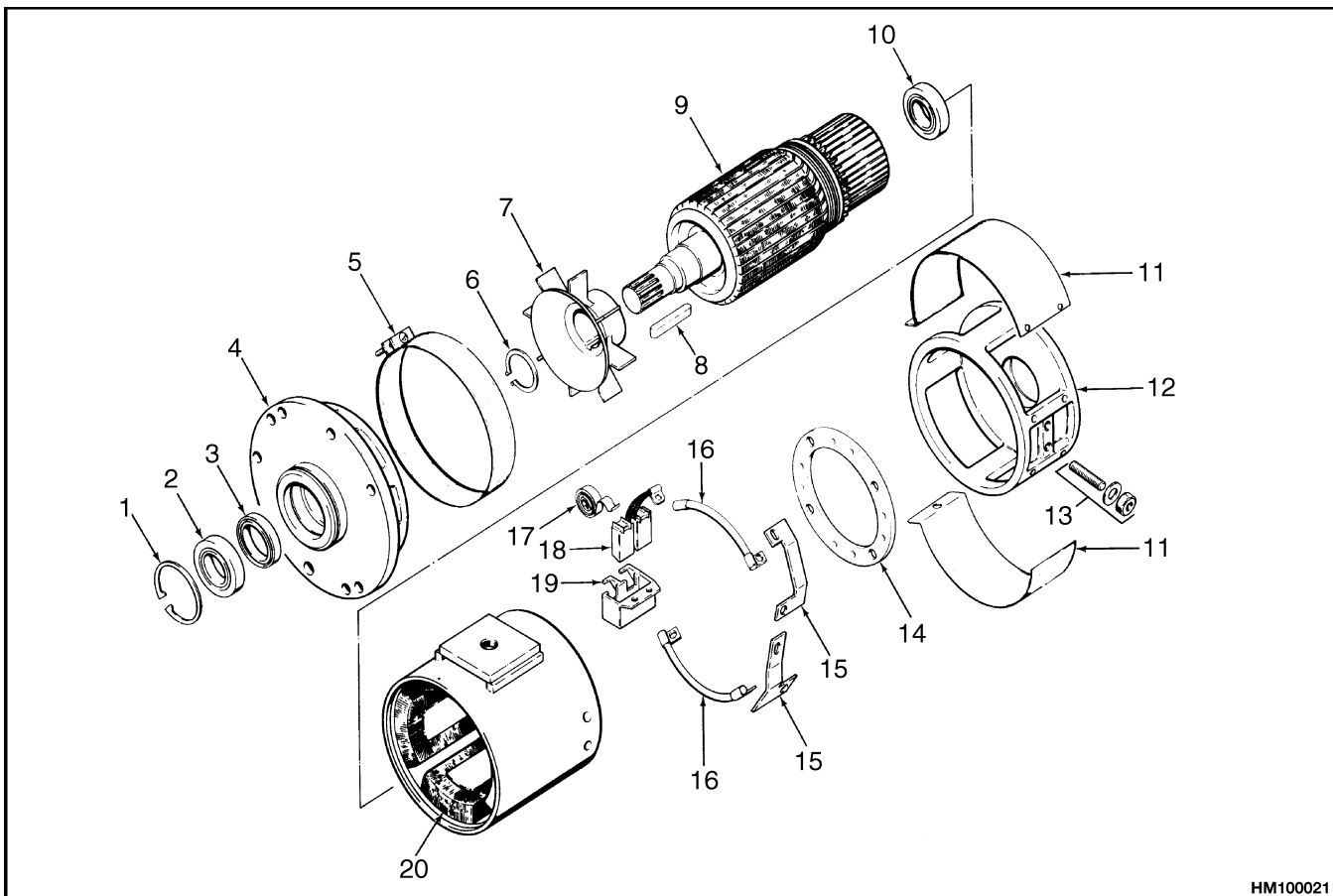
NOTE: Some lift trucks could be equipped with a Brushless DC Power Steering motor, which is non-repairable.

NOTE: Some electrical trucks use a steering pump motor. Refer to the service manual for your truck model for instructions on the removal and installation of steering pump motors.

1. See **Power Steering Motor and Pump** for the removal and installation procedures for the

steering pump motor. Make index marks on the steering pump and the drive end frame of the motor. Remove two capscrews that hold steering pump to motor. Remove pump and allow oil to drain from drive end frame.

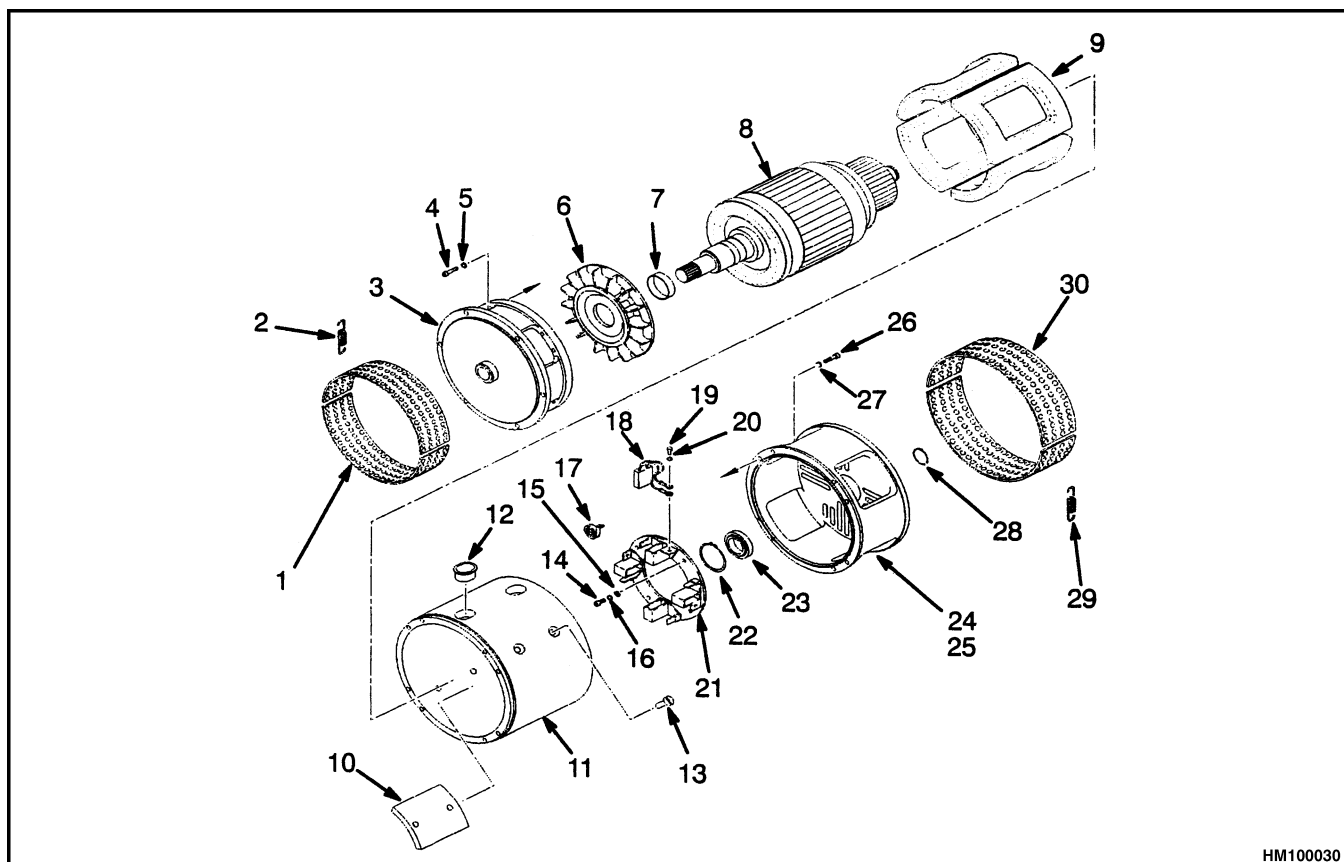
2. Remove brush covers. See Figure 2. Remove two screws that hold brushes and terminal wires to brush holders. Pull brush springs out of the way and pull two brushes from holders.



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|--------------------|--------------------------|-------------------|
| 1. SNAP RING | 8. KEY | 15. BUS CONNECTOR |
| 2. BEARING | 9. ARMATURE | 16. WIRE |
| 3. SEAL | 10. BEARING | 17. BRUSH SPRING |
| 4. DRIVE END FRAME | 11. BRUSH COVER | 18. BRUSH |
| 5. FAN COVER | 12. COMMUTATOR END FRAME | 19. BRUSH HOLDER |
| 6. SNAP RING | 13. TERMINAL | 20. FIELD FRAME |
| 7. FAN | 14. BRUSH MOUNTING PLATE | |

Figure 9. Typical Traction Motor (Example 2)



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| 1. BAND | 16. DISC |
| 2. SPRING | 17. BRUSH SPRING |
| 3. DRIVE END PLATE | 18. BRUSH |
| 4. SCREW | 19. SCREW |
| 5. WASHER | 20. DISC (SPRING) |
| 6. FAN | 21. BRUSH HOLDER |
| 7. RING | 22. CIRCLIP |
| 8. ARMATURE | 23. BALL BEARING |
| 9. FIELD COIL (FRAME) | 24. END PLATE (CPL) |
| 10. POLE SHOE | 25. END FRAME (COMMUTATOR) |
| 11. HOUSING | 26. HEX HEAD BOLT |
| 12. TUBE | 27. LOCKWASHER |
| 13. HEX HEAD BOLT | 28. RING |
| 14. SCREW | 29. SPRING |
| 15. LOCKWASHER | 30. BRUSH COVER |

Figure 10. Typical Traction Motor (Example 3)

3. Make alignment marks on commutator end frame and field frame. Remove four long screws that hold commutator end frame to drive end frame. Pry commutator end frame from field frame. The bearing will stay with the armature. Make sure the special spring stays in the end frame.
4. Make alignment marks on drive end frame and on field frame. Use a soft hammer to tap drive end frame from field frame. The bearing will stay with the armature.
5. Pull armature assembly from field frame. The force of the permanent magnets in the frame makes it difficult to remove the armature. Use a pry bar to help move armature assembly.
6. Make alignment marks on brush holder plate and on commutator end frame. Remove two

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