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# **I. SMB-000/00 PROCEDURES**

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## A. General

### **NOTES:**

1. Site approved thread-locking compound may be used to secure fasteners and keys during the performance of this program. Typically Limitorque uses LOC-TITE 242.
2. Limitorque Corporation does not recommend or disapprove a contact cleaning solvent.

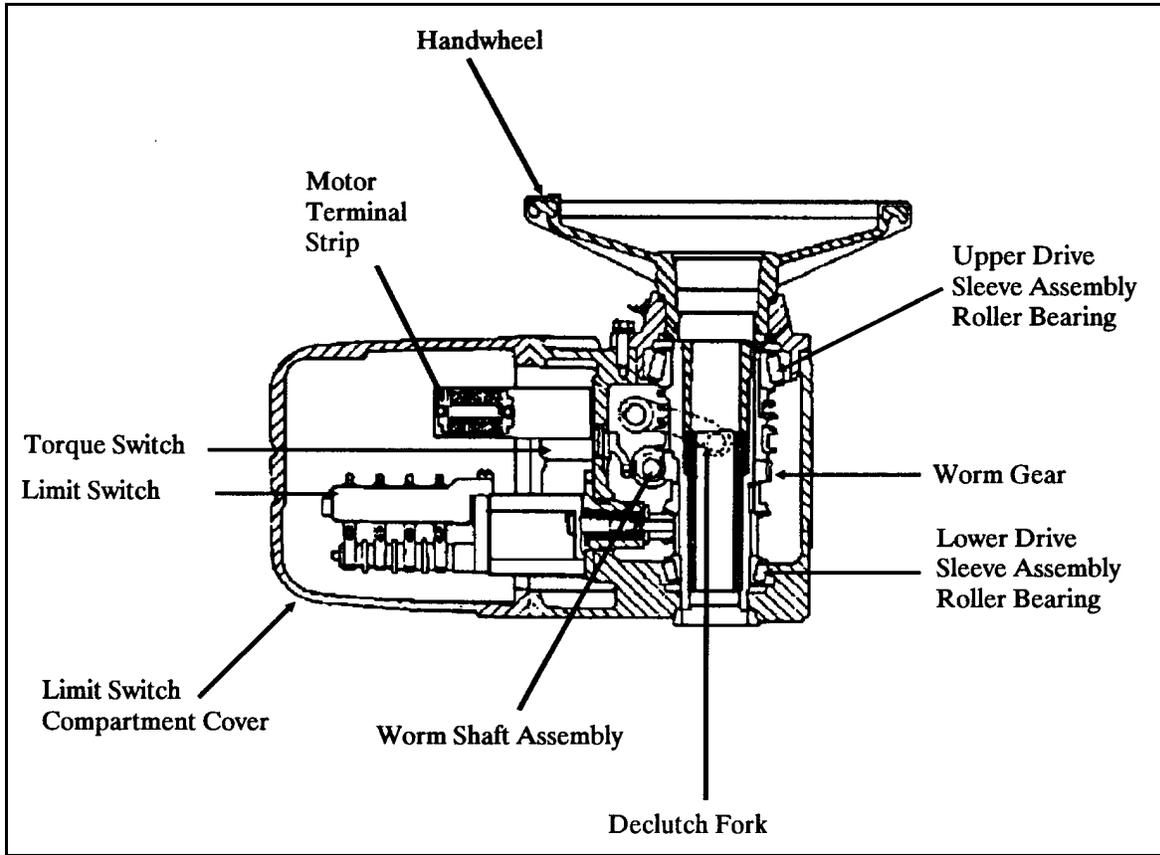
### **1. Task Grouping**

See Figures 4-1 through 4-4

Some tasks under the "Procedure for Major Tasks" section may be used for partial disassembly of the actuator. The following groupings suggest tasks for different parts or areas.

#### **Handwheel Removal**

- Handwheel assembly removal
- Handwheel components inspection/disassembly
- Handwheel components reassembly
- Handwheel housing gasket thickness determination
- Handwheel assembly installation



**Figure 4-1 Actuator (Cut Away Slide View)**

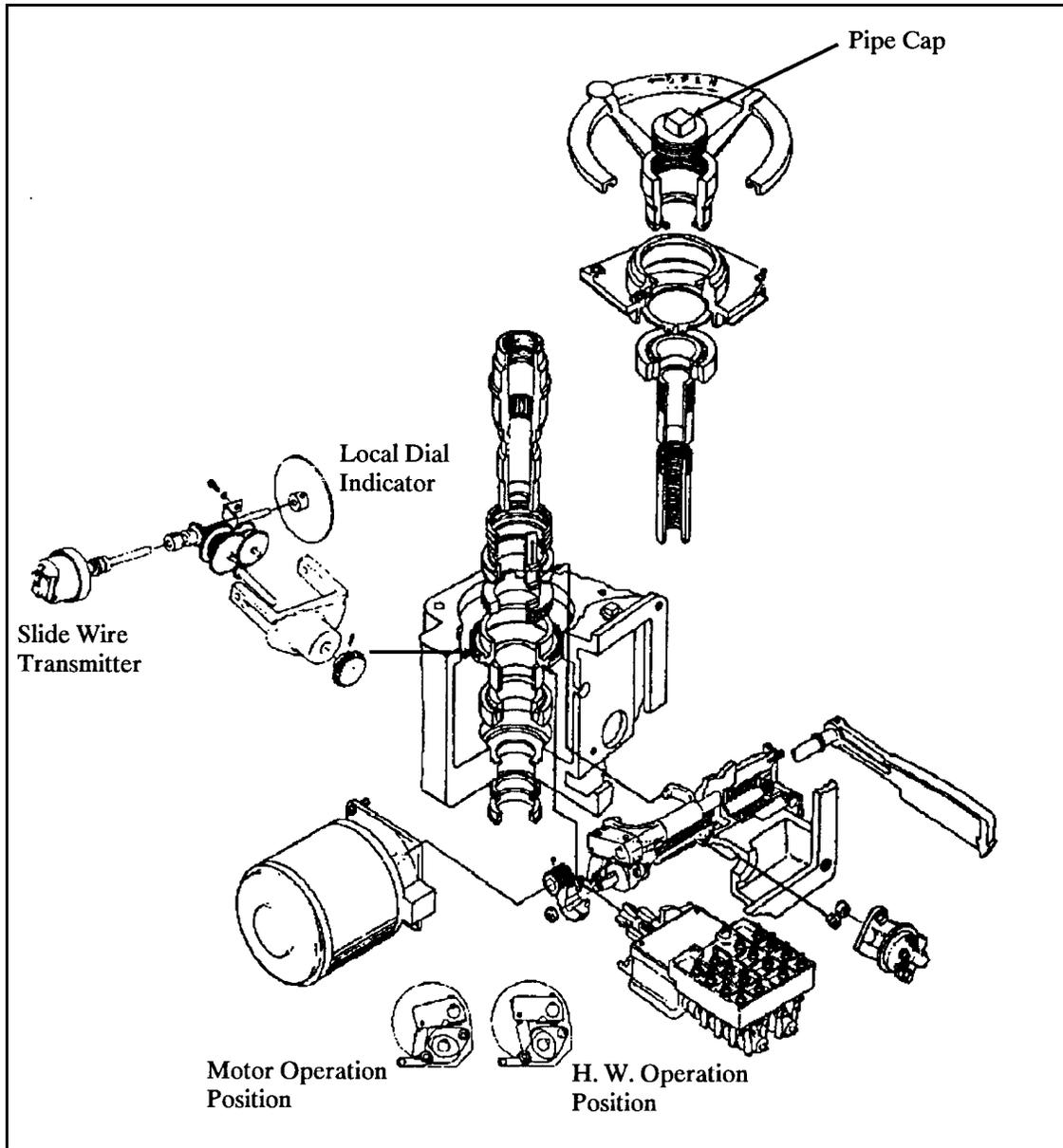


Figure 4-2 SMB-000 Actuator (Exploded View)



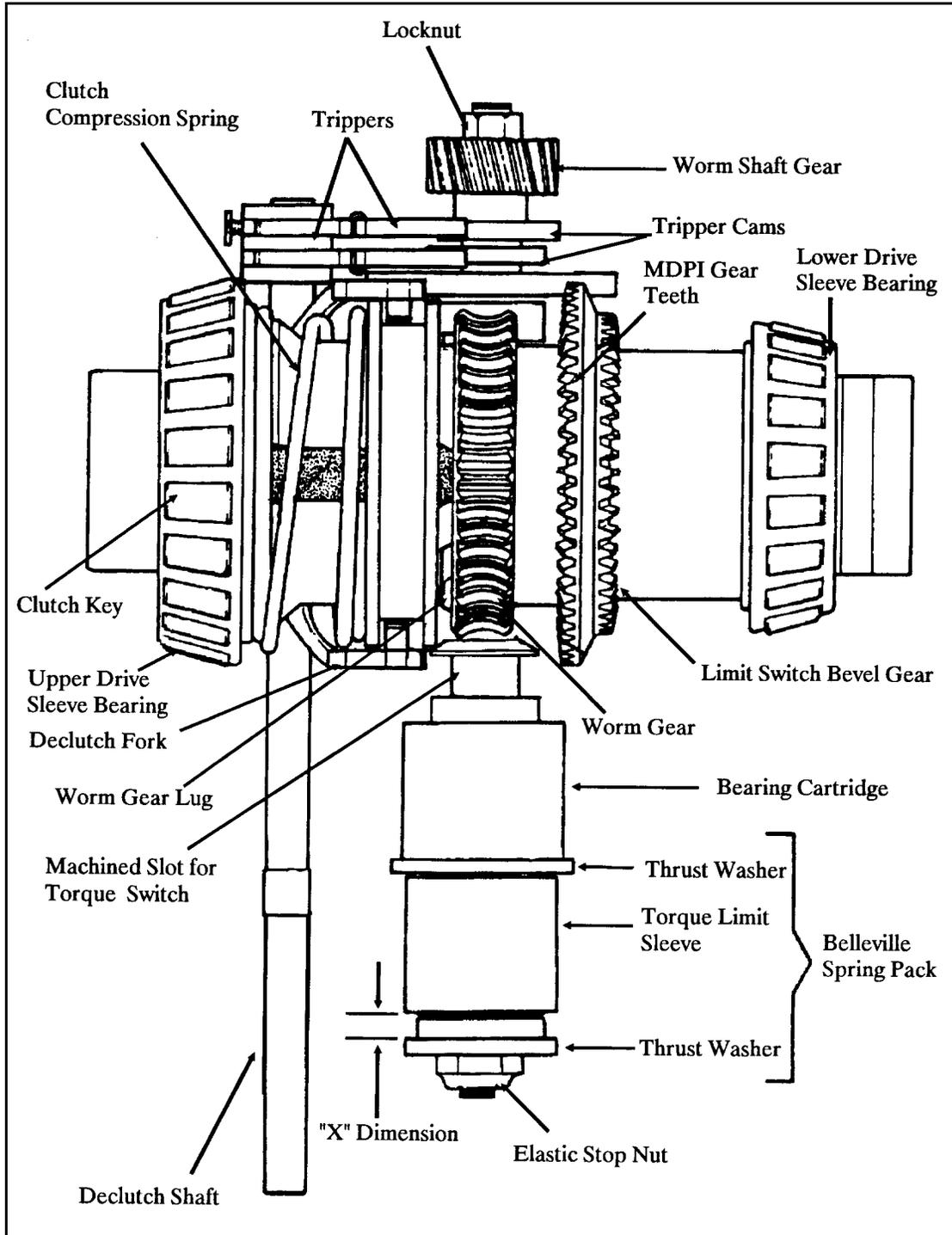


Figure 4-4 Actuator Drive Train (View Opposite Worm)

## **Worm and Belleville Spring Pack Removal**

- Limit and torque switch removal/inspection
- Declutch lever removal
- Worm and Belleville spring pack assembly removal
- Worm and Belleville spring pack inspection/disassembly
- Worm disassembly/reassembly
- Worm and Belleville spring pack reassembly
- Spring cartridge cap assembly installation
- Declutch lever installation
- Torque switch installation
- Limit switch finger base installation
- Installation of limit switch cartridge into actuator
- Installation of gear frame onto cartridge and actuator

## **Actuator Motor Removal**

- Motor removal
- Motor bearing and pinion checkout

## **Declutch Tripper Adjustment**

- Motor removal
- Clutch tripper adjustment
- Motor bearing and pinion checkout

## **Limit and Torque Switch Removal and Installation**

- Limit and torque switch removal
- Torque switch installation
- Limit switch finger base installation
- Installation of limit switch cartridge into actuator
- Installation of gear frame onto cartridge and actuator

## **Drive Sleeve Disassembly**

- Removal of actuator
- Limit and torque switch removal and inspection
- Handwheel assembly removal
- Declutch lever removal
- Worm and Belleville spring pack assembly removal
- Drive sleeve assembly removal
- Drive sleeve inspection and disassembly
- Drive sleeve reassembly
- Drive sleeve installation
- Worm and Belleville spring pack assembly installation
- Spring cartridge cap assembly installation
- Handwheel housing gasket thickness determination
- Handwheel assembly installation
- Declutch lever installation (partial)
- Actuator lubrication
- Torque switch installation
- Limit switch finger base installation
- Installation of limit switch cartridge into actuator
- Installation of gear frame onto cartridge and actuator
- Actuator installation

## **2. Complete Actuator Disassembly General Guidelines (Bench)**

Disassembly of major subassemblies is not recommended unless inspection results show a need.

1. De-energize power and isolate system fluid flow to valve.
2. Disconnect connections to the actuator (supports, conduit, etc.).
3. Isolate the work area.
4. Install equipment required to support work (scaffolding, temporary lighting, etc.).
5. Determine and install suitable rigging and actuator transport equipment.
6. Remove actuator from valve.
7. Disassemble actuator using the following guidelines.
8. Clean and inspect component parts.
9. Repair or replace parts when necessary.

NOTE: Worn parts should be examined to determine any future wear or possible failure before the next scheduled maintenance period. This helps prevent unscheduled corrective maintenance.

10. Reassemble the actuator using the following guidelines.
11. Reinstall the actuator onto the valve.
12. Reinstall actuator external connections.
13. Remove all temporary actuator work-supporting items.
14. Perform post-maintenance testing and any other required work.

### 3. Precautions

#### General Precautions for the Use and Repair of Limitorque Actuators

1. DO NOT use excessive force when depressing the declutch lever, this force can either twist the declutch lever shaft and/or shear the declutch lever key.
2. DO NOT move the declutch lever in the opposite direction from the cast directional arrow on the declutch lever. To do so may cause the declutch trippers to force the tripper adjustment arm out of position or damage the tripper lever.
3. DO NOT place the actuator in manual during motor operation except in an emergency situation which requires stopping drive sleeve motion. Any attempt to do so may cause rounding of the worm gear lugs. When the declutch lever is released, the worm gear lugs and clutch keys re-engage at motor speed with a high impact force. In addition, the groove pin that connects the arm to the torque switch shaft may fail as a result of this type declutching.
4. **DO NOT** use any torque amplifying device (valve bar, wrench, etc.) on the actuator handwheel. The handwheel has been designed so that an average man is able to exert sufficient torque to operate the valve. Operation of a valve with anything other than two hands is an indication of severe mechanical problems with either the actuator or valve and is, more importantly, a potential worker safety problem. Instances have occurred resulting in valve bonnet/yoke failures due to use of these devices.
5. DO NOT attempt to disassemble any actuator which is under a thrust load.
6. DO NOT use the handwheel or declutch lever as a lift point for the actuator. The handwheel is only held in place with a spiral ring and may break loose. The declutch shaft is not strong enough to support the actuator weight and may bend or twist. Use proper rigging and lifting equipment when handling the actuator.
7. DO NOT allow the valve stem to become a fulcrum point for the actuator during removal or installation of the actuator.

8. DO NOT plug the motor (alternating starting and stopping the actuator). This type of operation quickly exceeds the motor duty cycle, and may cause severe overheating which can damage or destroy the motor insulation.
9. DO NOT use abrasive cloth or paper to clean silver contacts of the limit switch or torque switch. The contacts should be burnished.
10. DO NOT attempt to set the limit switch without first removing control power for the actuator, or use an insulated screwdriver.
11. DO NOT remove the limit switch compartment cover if the surrounding environment contains excessive moisture, dust, grit, metal grindings, etc.
12. Ensure electrical power to the actuator has been de-energized prior to performing any hands-on maintenance. Electrical potentials from other sources may be present at the limit switch contacts.
13. Any adjustment of the torque switch set point requires the actuator to be in the manual position, which ensures the Belleville spring is in a relaxed condition placing no load on the torque switch.
14. Ensure adequate ventilation is available when opening the actuator gear case compartment and when using cleaning solvent to prevent inhalation of vapors.
15. No hard steel tools, such as screwdrivers or punches, should be used to assist in the removal of grease from the actuator. Use a plastic straw, ty-rap, clear plastic tubing, or dowel rod, rather than a steel tool, for insertion through the grease inspection ports when sampling or inspecting grease during periodic maintenance.
16. Be alert to De-energize the actuator motor while performing operational testing, should a limit switch or torque switch failure occur.
17. Take precautions to avoid contact with electrically energized parts of the actuator while performing operational tests or maintenance, such as insulation resistance testing.
18. Surgeon's gloves may be used to reduce the health hazard to personnel exposure from grease with a lead base additive (i.e., Sun 50 EP). Surgeon's gloves can also provide improved dexterity for holding parts rather than standard anti-C gloves.

19. Control of temporary jumper cables should be maintained to prevent inadvertent bypassing of any electrical or protective control functions.
20. Exercise caution when the motor is energized as this causes the declutch lever to snap back out of the manual depressed position.
21. All loose parts should be controlled to prevent loss and damage.
22. When removing the limit switch compartment cover, carefully lift it straight away from the actuator.
23. Take necessary precautions to prevent test instruments from becoming contaminated.
24. Ensure that any disconnected leads are properly marked prior to disconnecting them. Tape the ends of leads that have been disconnected.
25. Prior to working inside motor-operated valve actuators, verify by electrical measurements, that all control and power circuits have been de-energize.
26. Match marking (see page 1-10) of the actuator components, such as limit switch cartridge assembly, housing cap to actuator, and cartridge assembly to gear frame, before separation reduces human error in the reassembly of these components.
27. The actuator to valve position must be match marked before actuator removal. If an actuator is installed in a different position it may be impossible for an operator to operate the declutch lever or the handwheel, or the cabling may not be long enough with the actuator in the new position.

#### 4. **Material Requirements**

- Bags and containers for control of loose parts
- Bolts with nuts, 3/8" diameter x 2-1/2" long
- Site approved penetrating oil
- Disassembly table or platform
- Container for solvent
- Site approved lubricant for limit switch gear box
- Site approved lubricant for main gear box
- Site approved anti-seize compound
- Site approved cleaning solvent
- Elastic stop nut(s)
- Rags, clean, lint free
- Gear frame intermittent shafts clamping device
- Emery cloth.
- Limit switch compartment cover guide pins
- Brush (soft bristle, stainless steel or bronze)
- Gasket, Anchor 443 or Klinger SIL-C-4401 bulk material in 1/32", 1/64", and 1/16"
- Site approved thread locking compound

## 5. Equipment Requirements

- Bronze drift pin or soft metal punches
- Hammer, dead blow (lead, wood, or phenolic)
- Long and short hex key wrench set (including 1/16") A ball driver set is preferred.
- Honing stone
- File set
- Gauge, feeler
- Tool, locknut removal
- Chisel, cold, diamond point (alternate: prick punch)
- Drill bits (set)
- Electrical hand drill
- Scribe or pin punch
- Pliers, retaining ring, small (internal and external)
- Puller, bearing, mechanical (alternate: arbor press, for bearing removal and installation)
- Micrometers, inside (0 to 3 inch)
- Micrometers, outside (0 to 1 inch and 0 to 3 inch)
- Magnet, small
- Vernier caliper (0 to 3 inch)
- 5/16" open end wrench
- Brass rod, 1/2" x 12"
- Thin, 8-inch slot screwdriver
- Set of combination wrenches
- Large, slot screwdriver
- Limitorque available, limit switch adjusting tool
- Strap wrench and padded vise
- Rigging equipment, as needed

## B. Procedures for Major Tasks

### 1. Removal of Actuator

NOTE: Refer to provided training aid (i.e. actuator) for components not identified in noted drawings.

1. Establish a work boundary area.
2. Set up scaffolding and temporary lighting as required.
3. Determine the rigging and transport equipment to be used.
4. Remove any interference with lifting and transporting the actuator to the desired disassembly area.
5. Fabricate, as necessary, any valve stem-locking devices. (Figure 4-5)

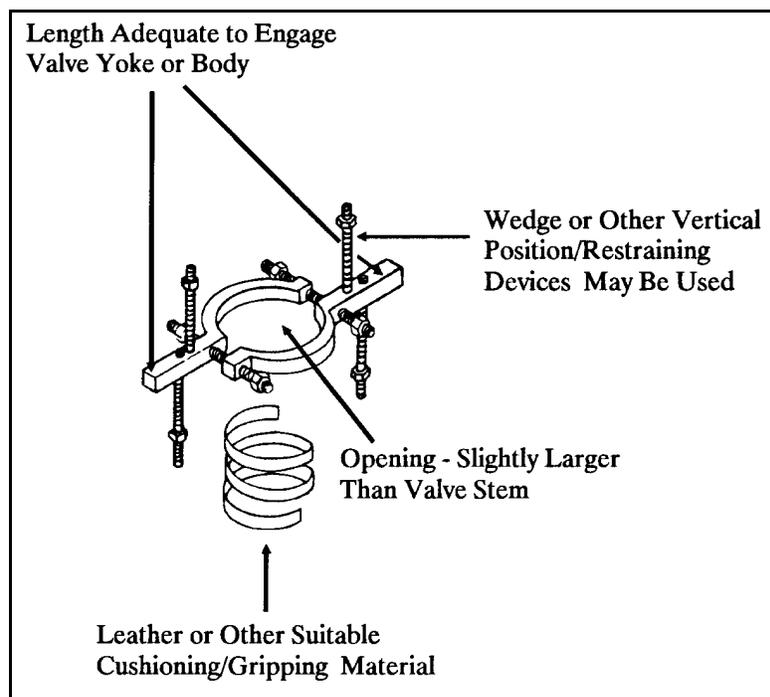


Figure 4-5 Typical Stem Clamping Device

6. Verify the availability of special tools necessary to disassemble the actuator.
7. Remove any line pressure on the valve (vent the line if possible).

**CAUTION:** Some actuators may have more than one power source and multiple voltage circuits.

8. De-energize the actuator and place on tag out program.
9. Remove the limit switch compartment cover's fasteners and washers. (Figure 4-1)

**NOTE:** The limit switch compartment cover is easier to remove when using guide pins inserted into the two upper screw holes.

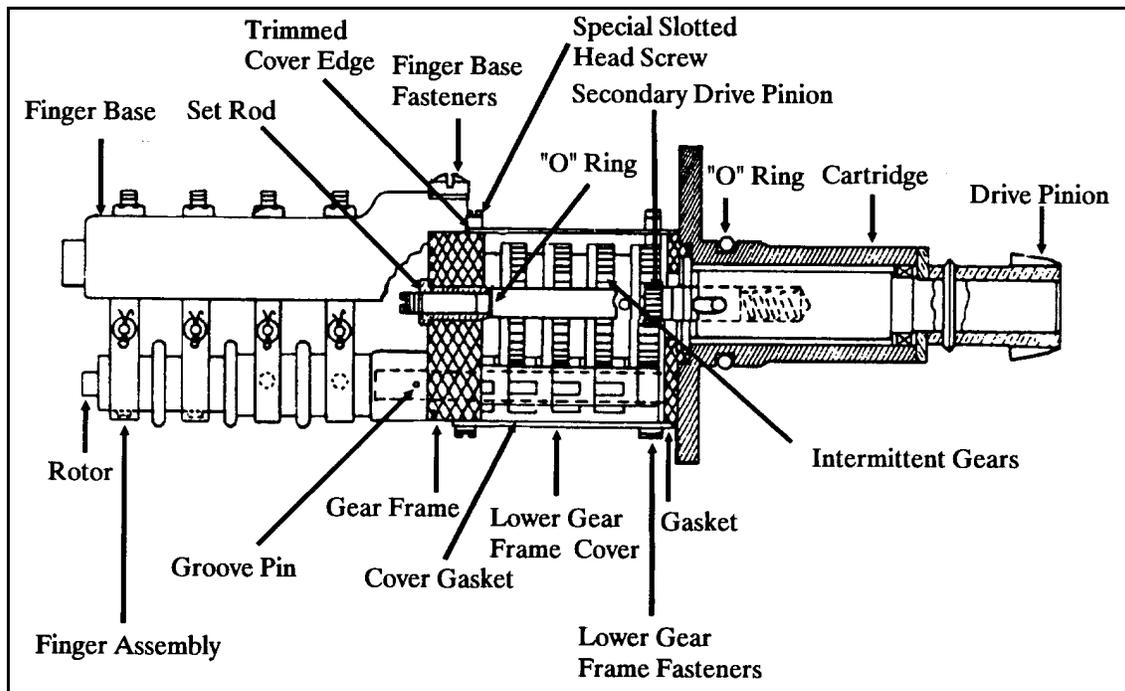
10. Remove the limit switch compartment cover and gasket by pulling the cover straight away from the actuator (to clear the limit switch and wiring).
11. With appropriate electrical test equipment such as a volt ohm meter, verify the actuator is de-energize.
12. Verify the power supply leads to the motor terminal block, and any other leads entering or exiting the limit switch compartment from attached electrical conduits, are adequately identified for future installation.
13. Disconnect all electrical leads routed to the limit switch compartment components from attached electrical conduit. Protect lead and connectors by securing with protective tape and covering the ends.

**NOTE:** Record valve position.

14. Disengage the limit switch by rotating the set rod (Figure 4-6) in the clockwise direction. Loosely replace the compartment cover. This disconnects the intermittent gears in the limit switch gear frame from the secondary drive pinion of the limit switch cartridge.

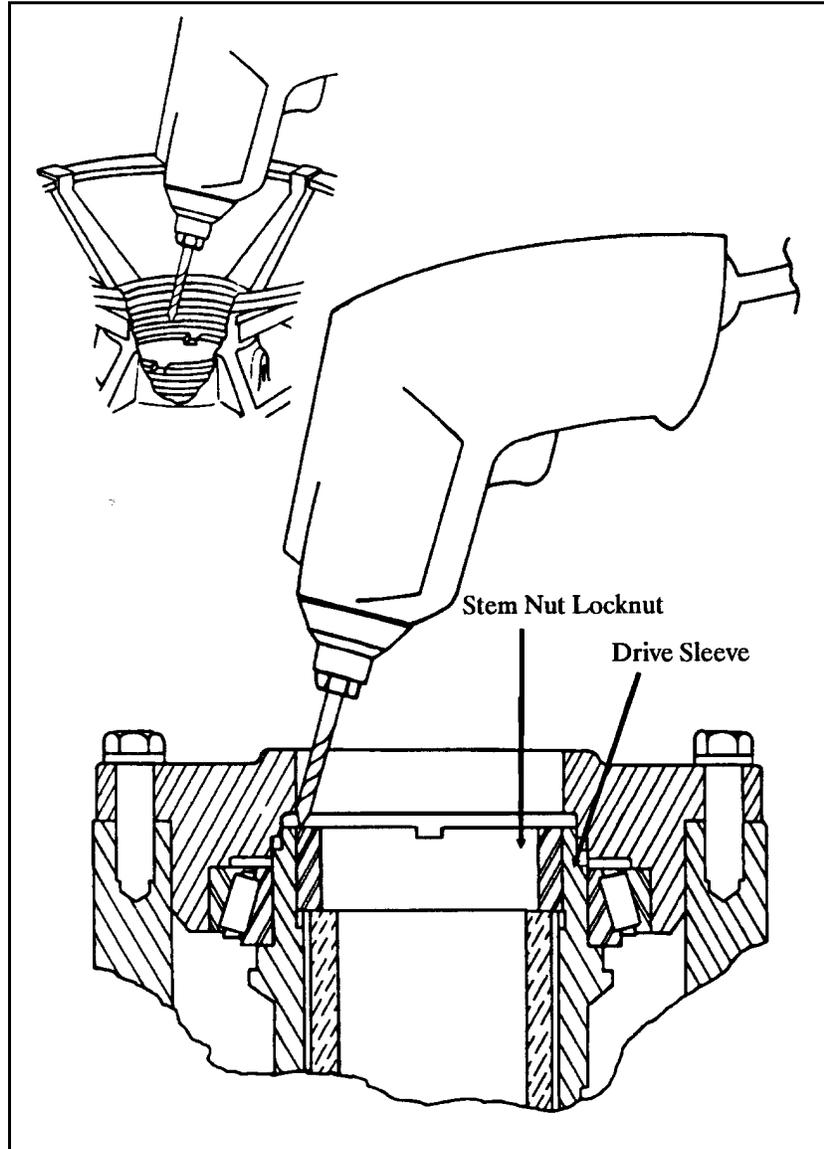
Valve Position: \_\_\_\_\_

15. Install a valve stem clamp (Figure 4-5), if required, to lock the valve in the desired position.
16. Identify and disconnect any external grounding leads from the actuator.
17. Loosen and remove the actuator's attached conduit.
18. Reinstall the limit switch compartment cover and gasket, including its fasteners and washers.
19. Loosen and remove any actuator physical restraints or supports.



**Figure 4-6 Limit Switch Section View**

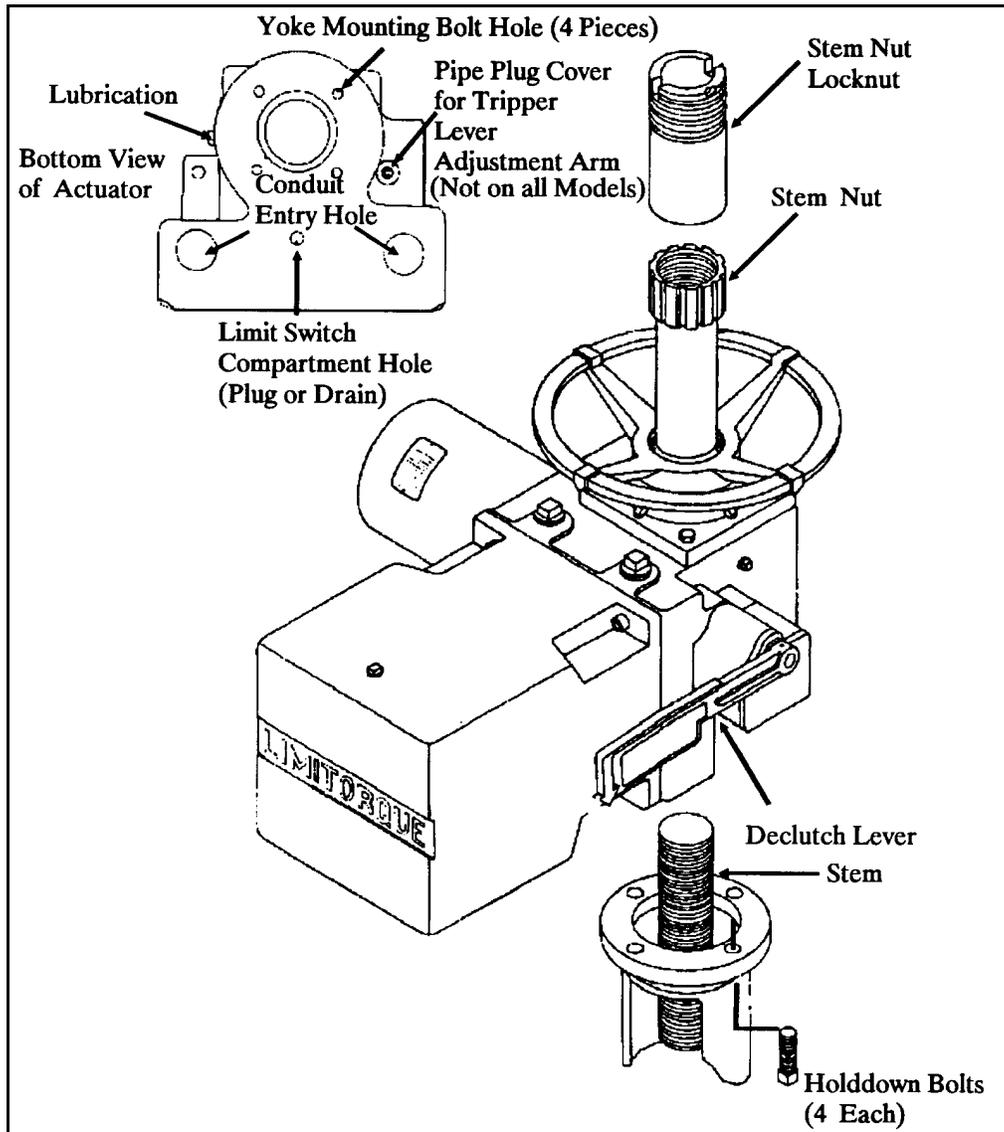
20. Remove pipe cap or stem protector from the actuator housing, and remove the extension (indicator) rod, if so equipped. (Figure 4-2)
21. Match mark actuator flanges and mating valve yoke flange.
22. Place a rag on top of the stem to minimize foreign particle contamination of the stem threads. Drill out the staked threads at both places between the stem nut locknut and drive sleeve (Figure 4-7).



**Figure 4-7 Removing Staked Threads**

23. Remove all metal particles using a small magnet. Remove the stem nut locknut (Figure 4-8). A special T-wrench is normally required for this, although a drift pin can sometimes be used.
24. Depress the declutch lever and rotate the actuator handwheel in the close direction,

while observing the upward movement of the stem nut (Figure 4-8). Continue to turn handwheel until the stem nut stops rising, indicating it has disengaged from the drive sleeve splines.



**Figure 4-8 Actuator Removal (Stem Nut Removal)**

25. Manually unscrew remaining length of stem nut from valve stem.
26. Remove the stem nut from the drive sleeve assembly.

NOTE: Weight of SMB-000 actuator is approximately 175 pounds.

27. Attach approved rigging to the actuator. The rigging must be capable of lifting the actuator off the valve.
28. Remove the four actuator to valve yoke fasteners and washers.

**CAUTION:** Do **not** lift the actuator by the handwheel or the declutch lever.

29. Using the attached rigging, remove the actuator from the valve and transport to the predetermined work area.

### **1a. Removal of Actuator (Expedited Method)**

This method is useful when speed is critical.

1. Establish a work boundary area.
2. Set up scaffolding and temporary lighting as required.
3. Determine the rigging and transport equipment to be used.
4. Remove any interference with lifting and transporting the actuator to the desired disassembly area.
5. Fabricate, as necessary, any valve stem-locking devices.
6. Verify the availability of special tools necessary to disassemble the actuator.

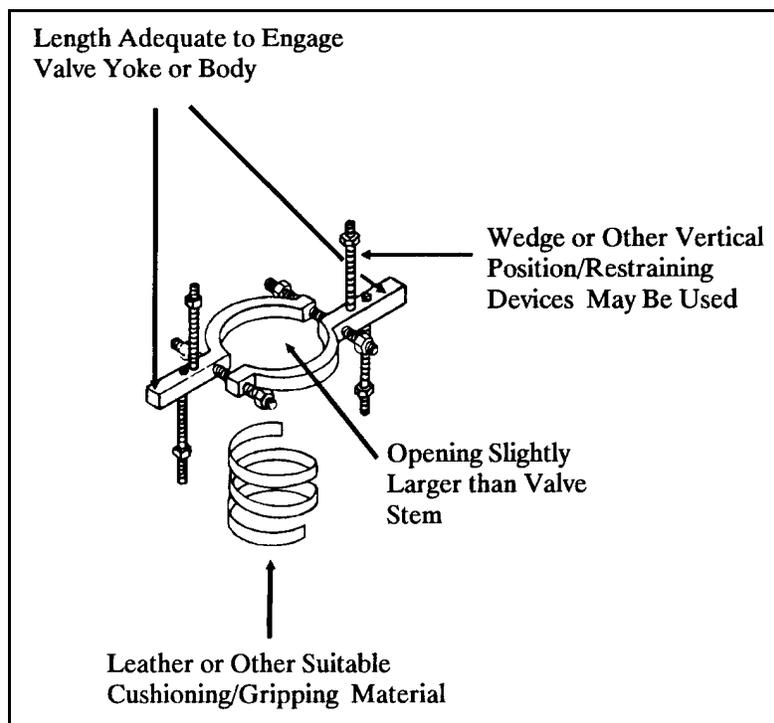
**WARNING:** Some actuators may have more than one power supply and multiple voltage circuits.

7. Remove any line pressure at the valve.
8. De-energize the actuator and place in the tag out program.
9. Remove the limit switch compartment cover's fasteners and washers. (Figure 4-1)

**NOTE:** The compartment cover is easier to remove when using guide pins inserted into the two upper screw holes.

10. Remove the limit switch compartment cover and gasket by pulling the cover straight away from the actuator (to clear the limit switch and wiring).
11. With proper electrical test equipment, verify the actuator is de-energize.
12. Verify the power supply leads to the motor terminal block and any other leads entering or exiting the limit switch compartment from the attached electrical conduits are adequately identified for future installation. (Figure 4-1)
13. Disconnect all electrical leads routed to the limit switch compartment components from attached electrical conduit. Protect leads and connectors by securing with protective tape and covering the ends.
14. Manually position the valve to the full open or full closed position, or as system conditions require. Install a valve stem clamp (Figure 4-9), if required, to lock the valve in the desired position. Record position.

Final Position: \_\_\_\_\_



**Figure 4-9 Typical Stem Clamping Device**

15. Disengage the limit switch by rotating the set rod (Figure 4-10) in the clockwise direction. This disconnects the intermittent gears in the limit switch gear frame from the secondary drive pinion of the limit switch cartridge.
16. Identify and disconnect any external grounding leads from the actuator.
17. Loosen and remove the actuator's attached conduit.
18. Reinstall the limit switch compartment cover and gasket, including its four hold down cap screws and washers.
19. Loosen and remove any actuator physical restraints or supports.
20. Remove pipe cap or stem protector from the actuator housing, remove the stem nut locknut, and remove the stem extension (indicator rod) if so equipped. (Figure 4-2)

NOTE: Weight of model SMB-000 actuator is approximately 175 pounds. Do **not** lift by the handwheel or the declutch lever.

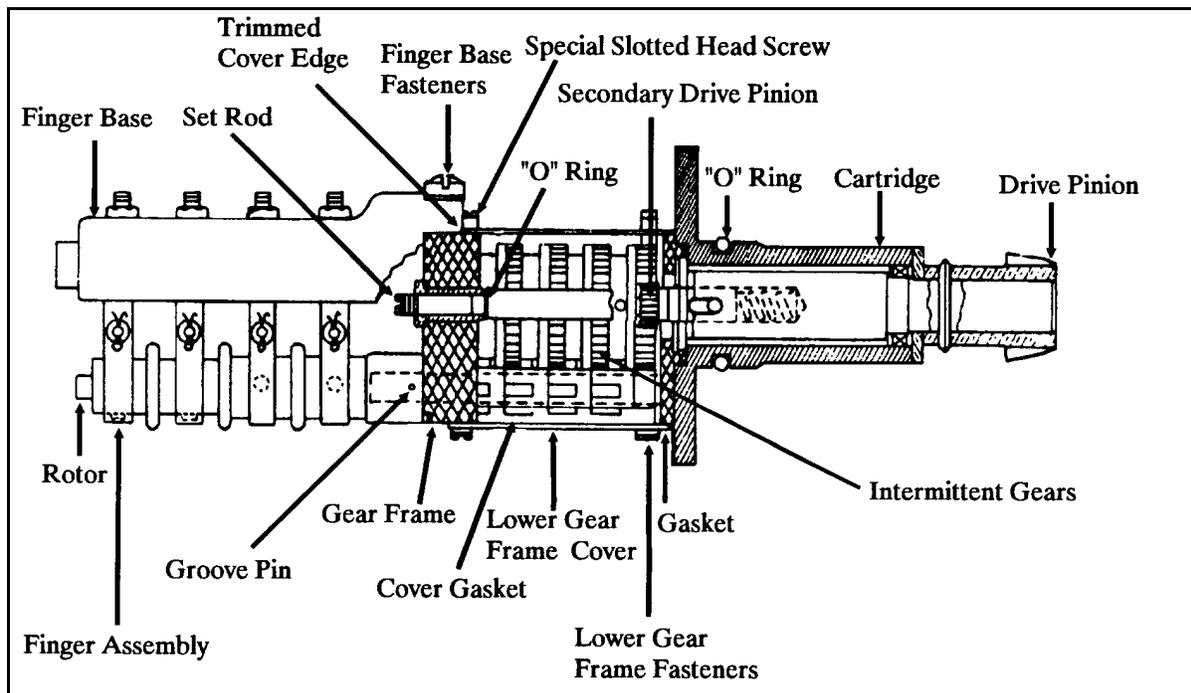
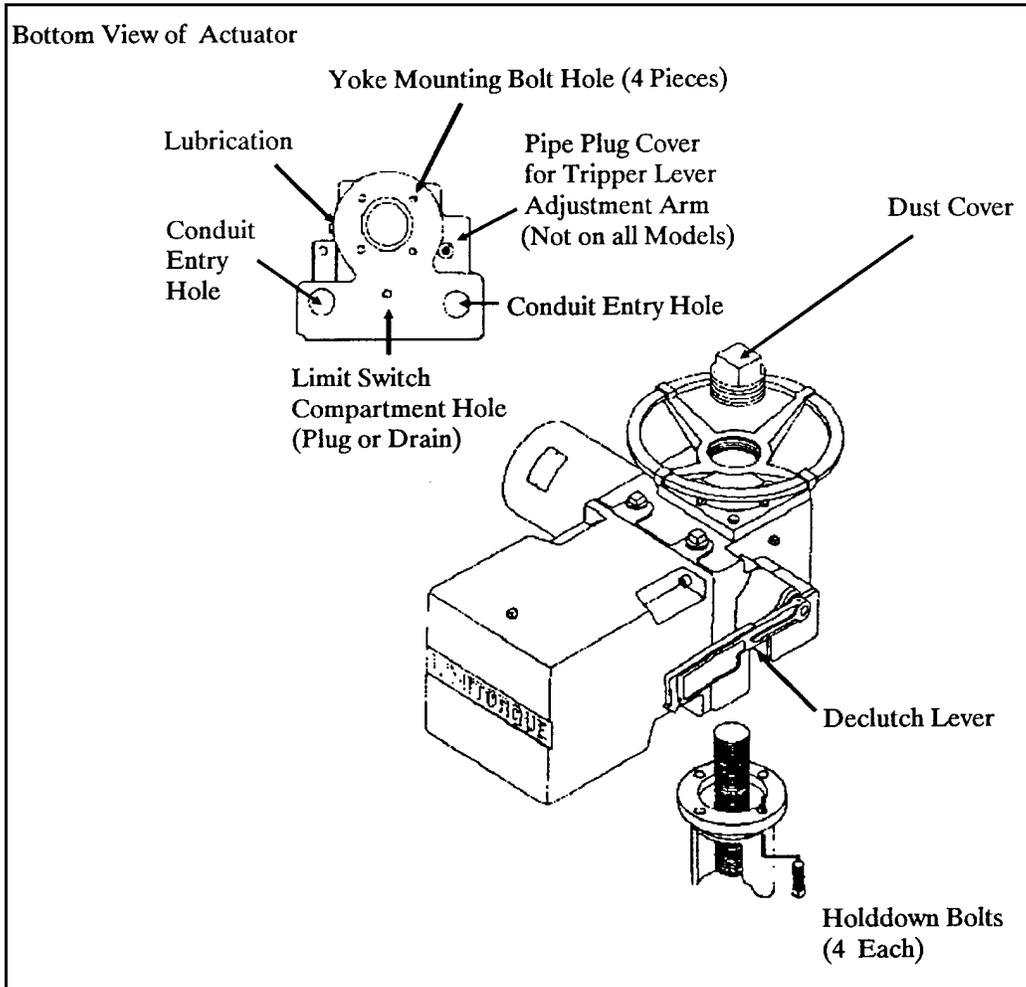


Figure 4-10 Limit Switch Section View

21. Attach approved rigging to the actuator. The rigging must be capable of lifting the actuator off the valve.
22. Match mark the actuator and valve yoke flanges.
23. Remove the four actuator to valve yoke fasteners. (Figure 4-11)
24. Depress the declutch lever. (Figure 4-11)



**Figure 4-11 Actuators Fasteners and Dust Cover Removal**

25. Rotate the handwheel in the close direction, while supporting total actuator weight by the attached rigging.
26. While supporting the actuator with the rigging equipment, rotate the handwheel until the stem nut disengages from the valve stem.
27. Remove actuator from valve and transport to the designated work area.

### 1b. Post Actuator Removal Instructions

After the actuator is removed from the valve, do the following.

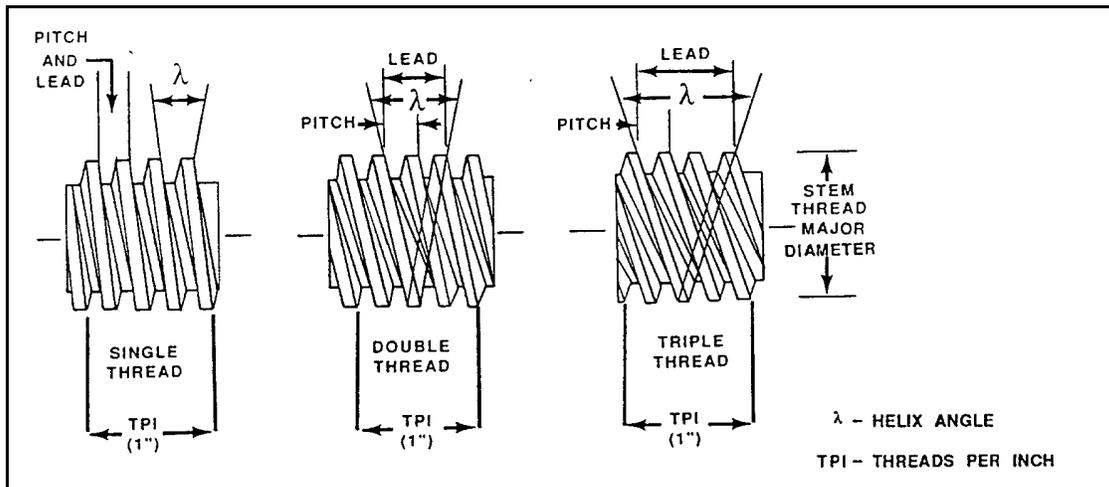
1. Inspect valve stem for lubrication condition, contamination, galling, deformation, or excessive wear.

Results. \_\_\_\_\_

2. If required, verify the valve stem thread, pitch, lead, and diameter. (Figure 4-12)

Results. \_\_\_\_\_

3. Install stem (thread) protector on the exposed valve stem as required.



**Figure 4-12 Valve Stem Thread Determination**

**NOTE:** The following several tasks will be performed in class as you will be expected to disassemble, inspect and reassemble a Limitorque SMB actuator referencing the appropriate procedures. Disassembling, inspection and reassembling of the sub-components (i.e. worm shaft, limit switch, drive sleeve, etc.) will be performed only at the request of the instructor.

## Limit and Torque Switch Removal and Inspection

This section gives instructions for removal and disassembly of the limit switch (Figure 4-13) and torque switch.

### 2. Limit Switch Removal

Removal of the Limit Switch Compartment Cover

1. Loosen and remove the cap screws and lockwashers that secure the limit switch compartment cover.
2. Remove the limit switch compartment cover and gasket.

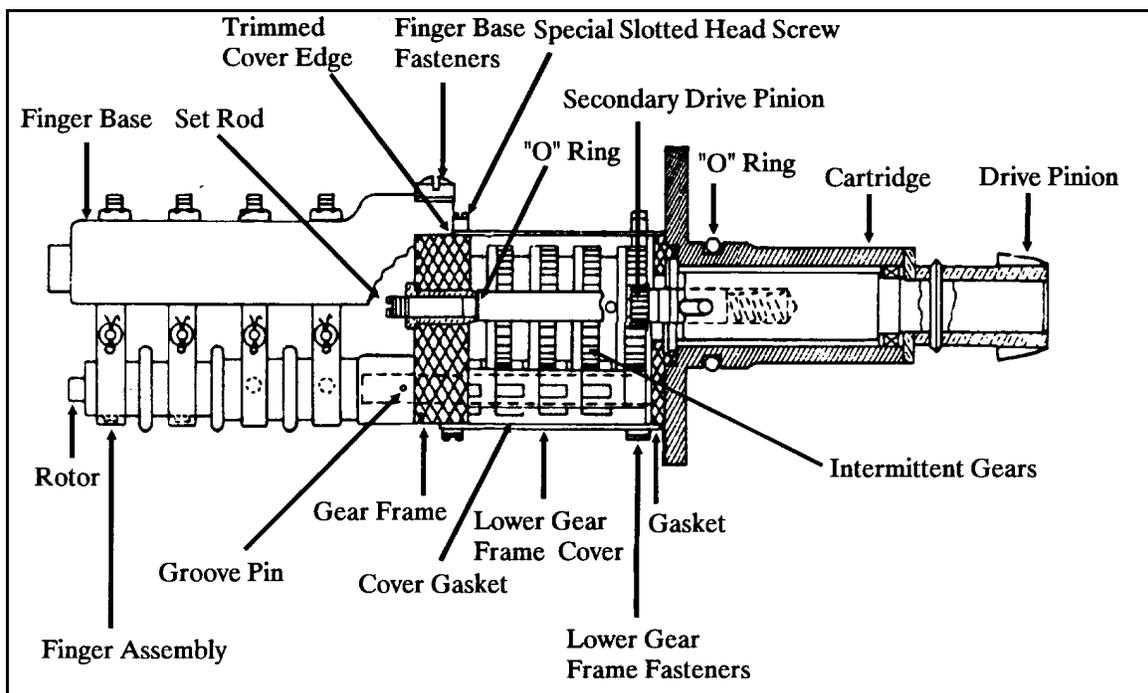


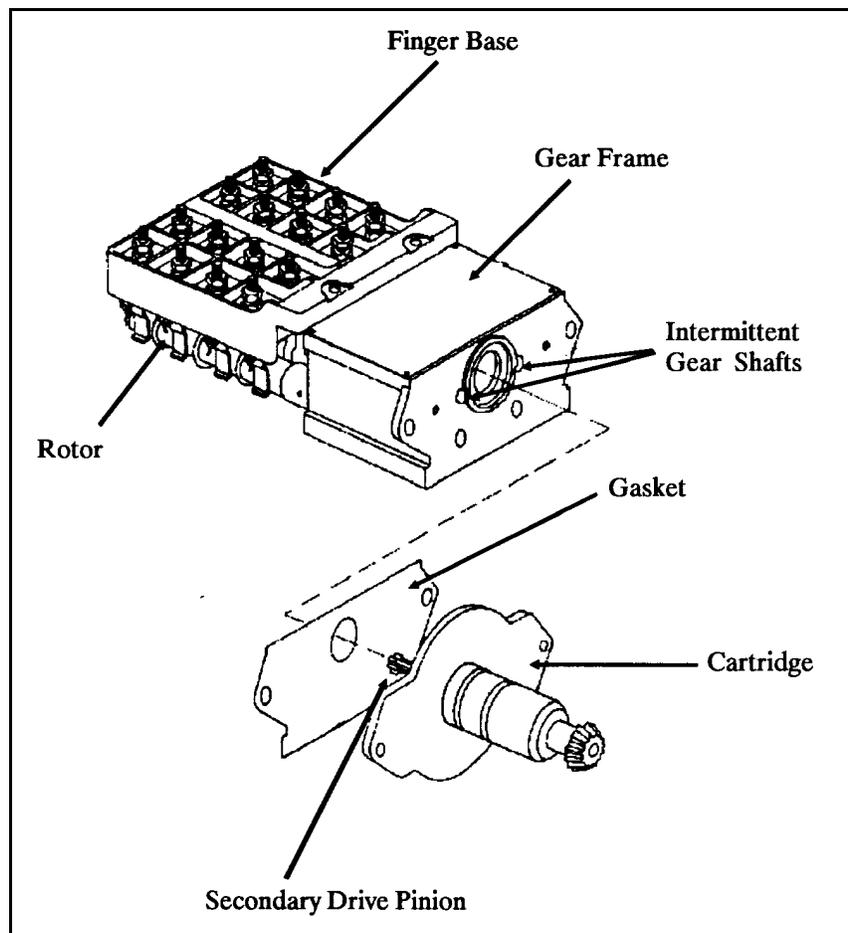
Figure 4-13 Limit Switch Section View

NOTE: Before removal of any component wiring connectors, ensure that the mounting terminals and connectors are identified.

Refer to Figure 4-14

**CAUTION:** Do not disconnect leads at the torque switch. Disconnection of the leads at the torque switch may affect the torque switch balance.

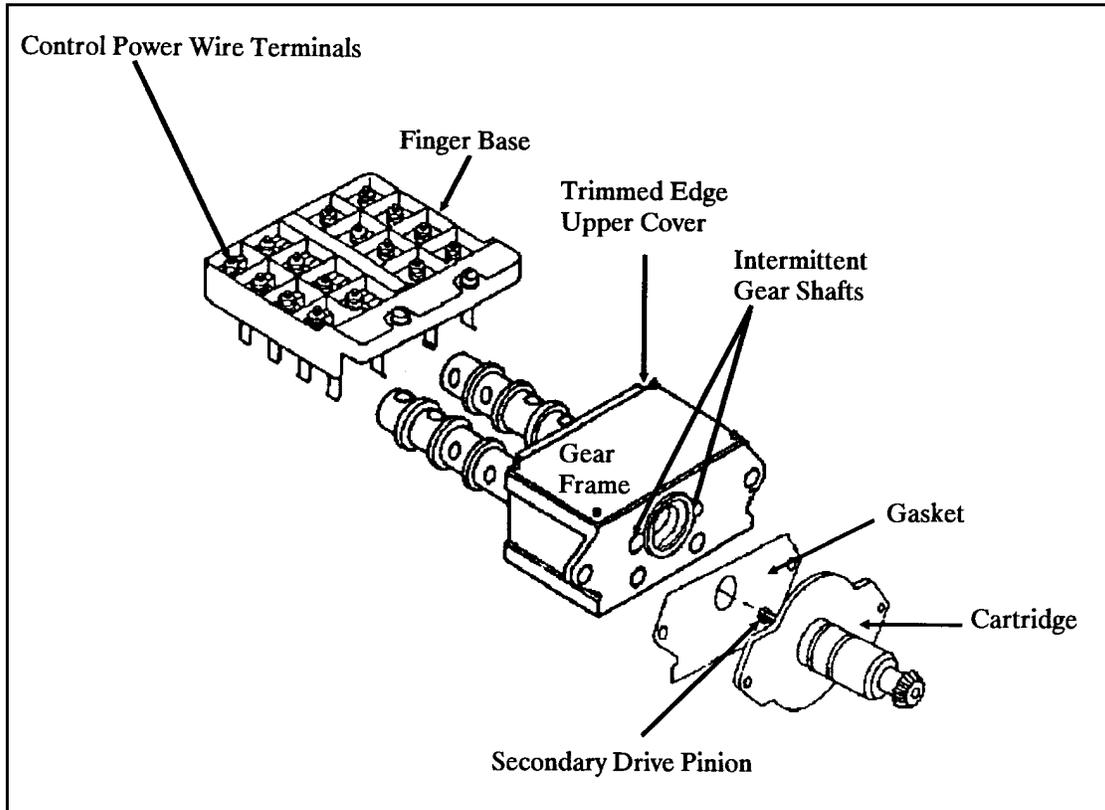
3. Mark and remove all leads from finger base as required.



**Figure 4-12 Limit Switch Removal and Disassembly**

**2a. Two-Train Limit Switch** Refer to Figure 4-15

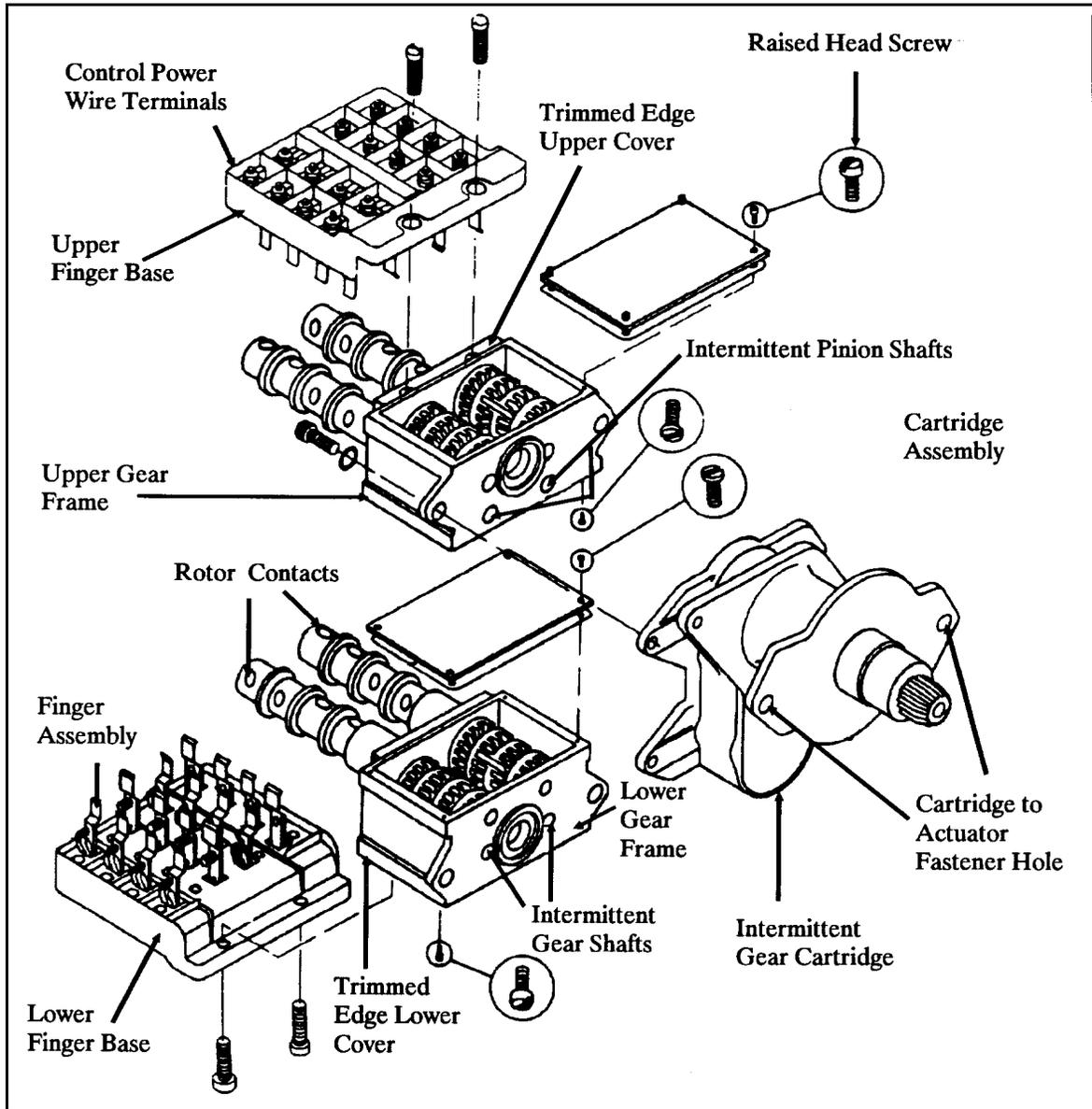
1. Loosen and remove the limit switch cartridge to actuator fasteners.
2. Remove the limit switch (upper) gear frame assembly from the cartridge
3. Remove the cartridge and limit switches from the actuator and retain any shims found for reinstallation.



**Figure 4-15 Two Train Limit Switch Exploded View**

**2b. Four-Train Limit Switch** Refer to Figure 4-16

1. Remove cartridge and gear frame from the actuator
2. Match mark one gear frame to the cartridge
3. Remove gear frame from the cartridge



**Figure 4-16 Four-Train Limit Switch Exploded View**

**3. Limit Switch Lubrication Inspection**

1. Place a reference mark on the (upper) gear frame cover.
2. Remove the four raised head upper gear frame cover fasteners.

NOTE: These fasteners' heads have smaller diameters than the lower gear frame cover fasteners to prevent interference with the finger base attachment edge.

3. Remove the upper gear frame cover and gasket. Note and record the number of counter gears. Three, four, and five counter gear sets and cartridges are not interchangeable.

Number of gears: \_\_\_\_\_

NOTE: The gear frame cover gasket is thin (1/32") and may tear upon removal. It is recommended that a replacement cover gasket for each gear frame cover be removed from stores and included into an expendables or spares list for the task.

4. The grease consistency should be soft or slightly fluid. Replace hardened or degraded grease as follows:
  - a. Loosen and remove the two finger base to gear frame holddown fasteners and their respective washers.
  - b. Lift the finger base from the rotors and gear frame.
  - c. Remove bottom gear frame cover holddown screws, cover plate, and gasket. Inspect gaskets for damage. Replace as required.

NOTE: The bottom holddown screws have thinner, wider diameter heads. The thinner heads prevent interference between the upper and lower gear frames on four-train limit switches.

**CAUTION:** Tilting the gear frame with the cartridge opening downward may permit the intermittent pinion shafts to slide partially out of the gear frame and allow the gears to fall out of alignment.

**RECOMMENDATION:** A convenient method to prevent inadvertent slippage of the intermittent pinion shafts from the gear frame is to secure them with an old cartridge bolted to the gear frame. Elastic bands or metal clamps can also be used.

- d. Mechanically remove grease from the gear frame.
- e. Using a small soft-bristled brush and a site-approved solvent, clean the remaining grease from the gears, gear frame, and covers.

**CAUTION:** Limit exposure of the rotors to the solvents.

- f. Install the bottom gear frame cover bowed outward with a lubricated gasket and the four wider diameter fasteners. (Figure 4-17)
- g. Add approved grease to the gear frame, leaving a small air space.

**CAUTION:** Do **not** mix lubricants with dissimilar bases; use of the same lubricant is preferred.

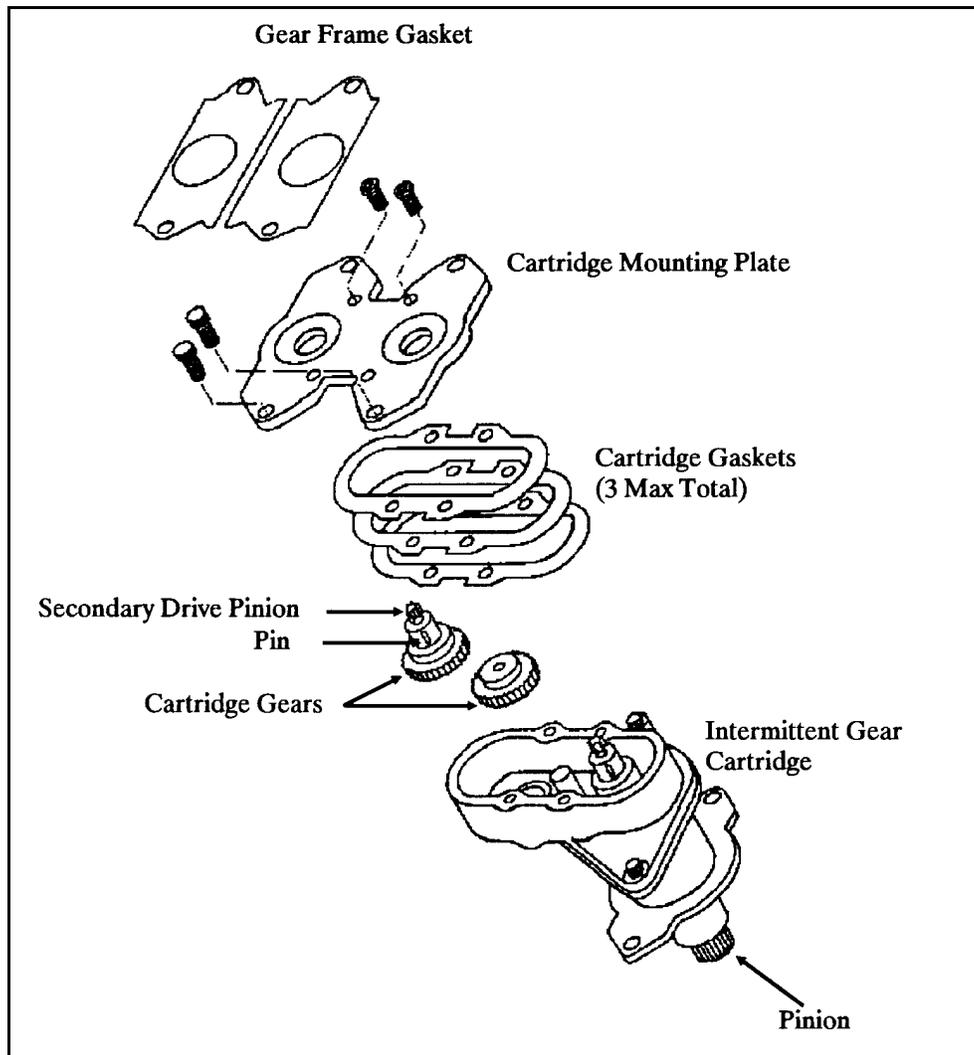
- h. Verify the grease level is above the top of the smaller gears and that the gear frame is not completely filled. Add or remove grease as necessary.
- I. Coat the mating surfaces of the gasket with a thin film of gear frame grease, if not previously lubricated.
- j. Install the gasket onto the gear frame. The use of a new gasket will require trimming due to the close proximity of the finger base edge to the upper gear frame cover. The gasket must not protrude under the finger base mounting surface. This could result in cracking of the finger base upon installation and tightening of its hold down screws.
- k. Install the upper gear frame cover bowed away from the gear frame with the short edge towards the finger base. (Figure 4-17)
- l. Install and tighten the four raised head upper gear frame fasteners.
- m. If a four-train (four-rotors) limit switch is installed, repeat the above steps for the other gear frame.

### **3a. Four-Train Limit Switch Cartridge Lubrication Inspection**

- 1. Remove the cartridge mounting plate fasteners. Refer to Figure 4-18
- 2. Remove the cartridge mounting plate and gasket.



**Figure 4-17 Installation Orientation- Gear Frame Covers**



**Figure 4-18 Four-Train Cartridge Lubrication Inspection**

3. Inspect the grease. Grease consistency should be soft or slightly fluid. Replace hardened or degraded grease as follows:

**CAUTION:** The secondary drive pinion is held in place by a spring loaded pin. Depressing the drive pinion spur will relieve spring tension and allow the pin to fall. Handle by the spur.

4. Remove cartridge gears.

5. Mechanically remove grease.
6. Using a soft-bristled brush and an approved solvent, clean all gears, mating surfaces, and covers.
7. Install cartridge gears.
8. Add site-approved lubricant to the cartridge leaving a small air space.
9. Verify the grease level is above the top of the gears.
10. Utilizing a new gasket, install the cartridge mounting plate with fasteners.
11. Evenly tighten the fasteners, while turning the cartridge pinion gear to ensure freedom of rotation. If the cartridge pinion does not rotate freely, add additional gaskets up to a total of 3 gaskets to increase clearance.

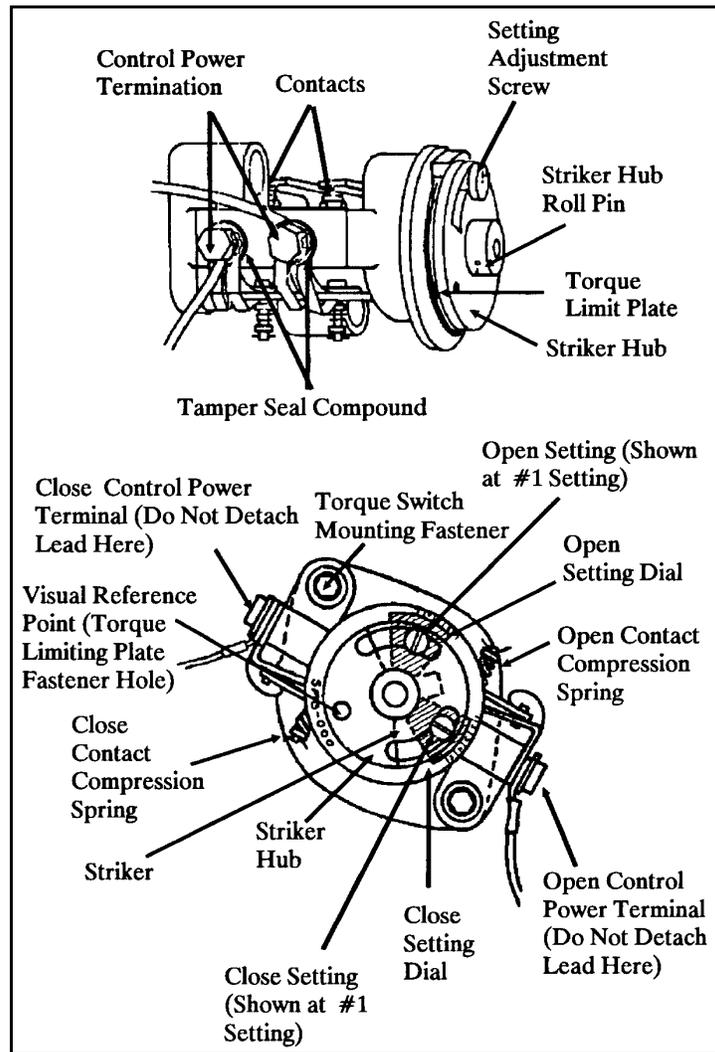
#### **4. Torque Switch Removal**

**CAUTION:** Do **not** disconnect the leads at the torque switch. This alters the torque switch actuation point.

1. Disconnect the torque switch electrical leads from the limit switch finger base, if required.
2. With the spring pack relaxed, record the as-found open and close switch settings. (Figure 4-19)

Open Setting: \_\_\_\_\_

Close Setting: \_\_\_\_\_



**Figure 4-19 Torque Switch Contact Setting**

3. Set the torque switch to a setting of 1 and 1.
4. Loosen and remove the two torque switch mounting screws.
5. Remove the torque switch from the housing.
6. Inspect the torque switch plastic parts for cracks.

Results: \_\_\_\_\_

7. Check for fiber shims under the torque switch contacts and record results (number and thickness) if any found.

Results: \_\_\_\_\_

8. Check that the arc barrier is intact and located between the open control power terminations and the actuator housing. (Figure 4-20)
9. Inspect the contact tension for a gap between the shunt and the corresponding finger. (Figure 4-20)
10. Inspect the torque switch contact for wear, fouling, corrosion, and damage. Clean as required by burnishing and spraying with approved solvent.

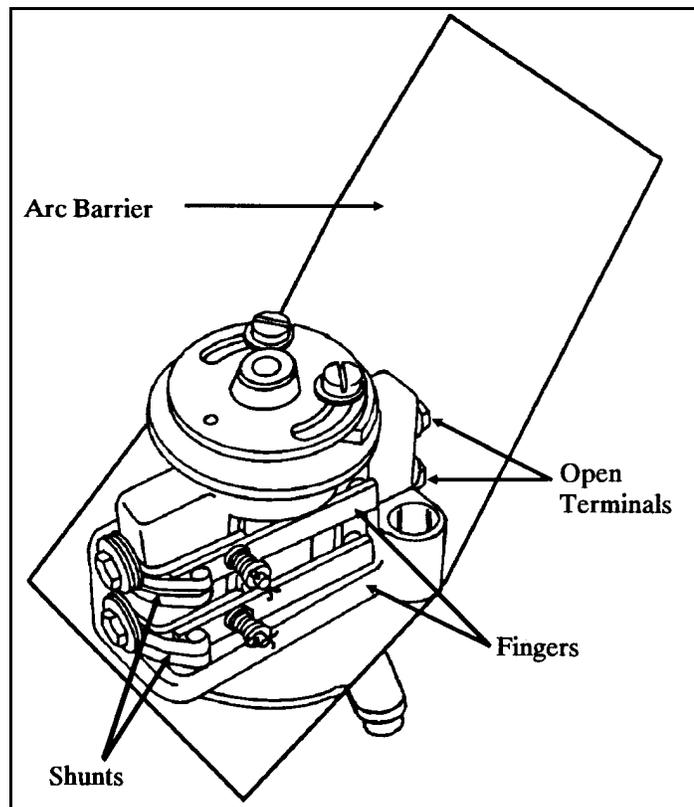
NOTE: Balancing of scissor or leaf type torque switches cannot be performed while it is installed in the actuator.

11. Rotate the setting dial and check for excessive free play. Total movement of the setting dial with respect to the striker hub should not exceed  $\frac{1}{2}$  increment total.

NOTE: Only brown (Fibrite) or grey (Melamine) materials are approved for use on environmentally qualified actuators inside nuclear constraints.

12. Record torque switch plastic base material color.

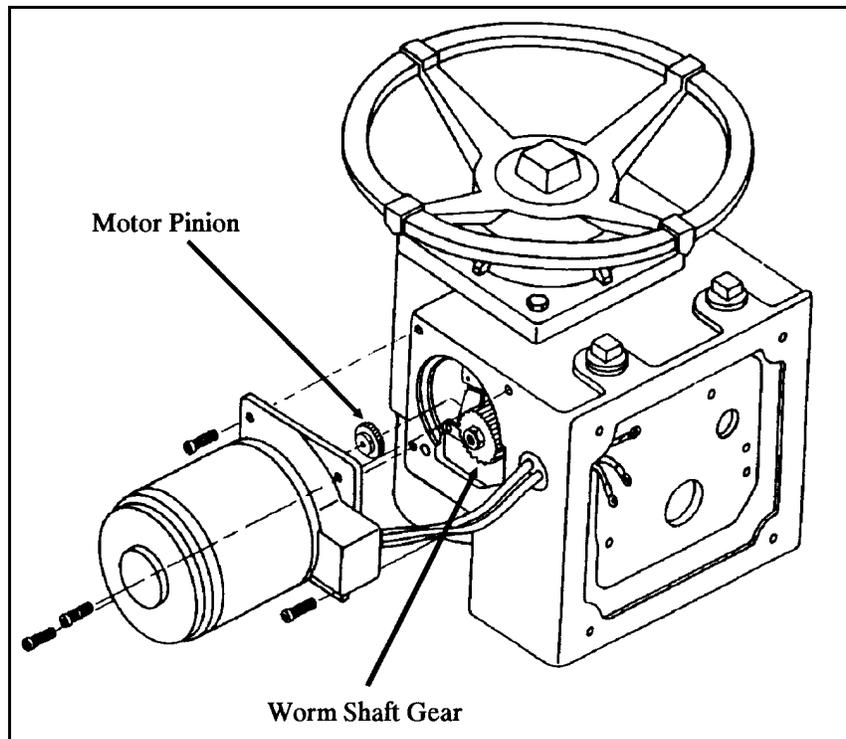
Color: \_\_\_\_\_



**Figure 4-20 Torque Switch Inspection Points**

**5. Motor Removal** Refer to Figure 4-21

1. Verify the motor leads and field leads in the limit switch compartment are identified for future installation.
2. Disconnect the motor leads.
3. Loosen and remove the four motor mounting fasteners and washers while supporting the motor.
4. Separate the motor and gasket from the actuator.
5. Carefully guide the motor lead wires through the limit switch compartment port.
6. Remove the motor and place in a protected storage area.



**Figure 4-21 Motor Removal**

## 6. Handwheel Assembly Removal Refer to Figure 4-22

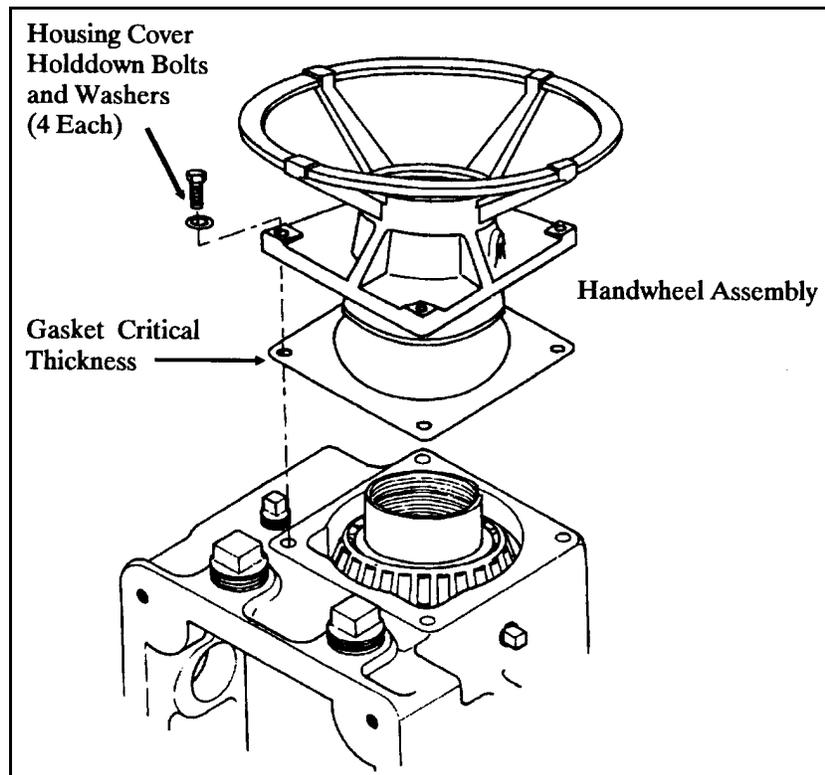
1. Match mark handwheel assembly housing cover and main gear case to ensure correct assembly arrangement.

**CAUTION:** The drive assembly upper bearing cone fitted into the handwheel assembly may be loose and fall during removal.

2. Place or verify the actuator is in the motor mode.
3. Loosen and remove the four handwheel assembly fasteners and washers. Remove handwheel assembly from the actuator.

Carefully remove and retain gasket(s).

4. Store the handwheel assembly for later inspection.



**Figure 4-22 Handwheel Assembly Removal**

## 7. Tripper Removal Refer to Figure 4-23

1. With the motor removed, wipe away excess grease. Work through the opening at the motor pinion cavity end of the actuator, loosen the tripper lever set screw bolt with a 5/16" wrench. Pull the tripper lever off the declutch shaft and tripper lever key.

NOTE: If the tripper lever is difficult to remove, apply penetrating oil around the joining area, and gently pull or wiggle the tripper lever off the declutch shaft.

2. Remove tripper lever key from the shaft keyway.
3. Verify that the trippers are approximately 1/32" different in length.
4. Inspect the keyway and remove any nicks, burrs, and deformations using a fine file or emery paper.
5. Check trippers for straightness, free movement and spring tension.
6. Store the tripper lever and key for later installation.

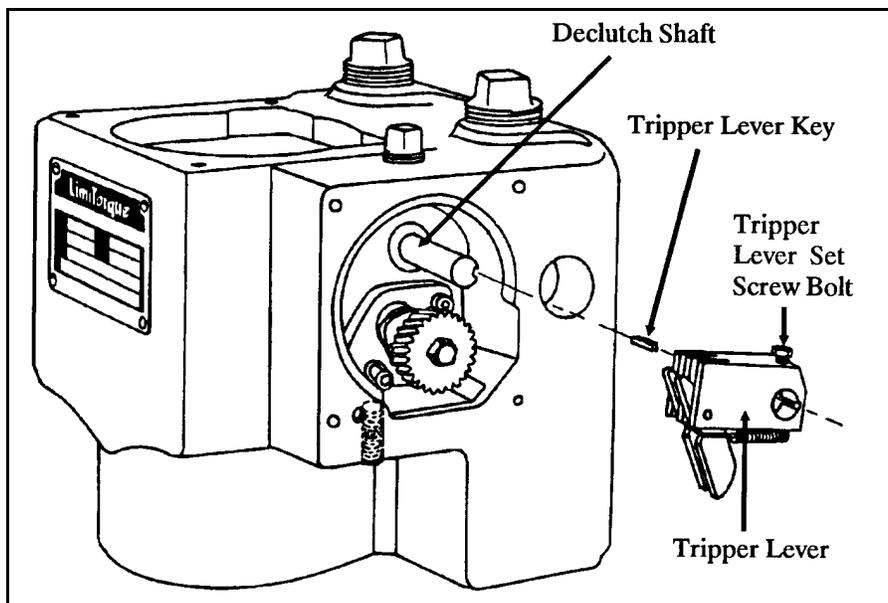


Figure 4-23 Tripper Removal

## 8. Declutch Lever Removal Refer to Figure 4-24

1. Loosen declutch lever set screw and slide declutch lever off declutch shaft and key.

NOTE: If declutch lever is difficult to remove, apply penetrating oil or equivalent around joining area and gently tap lever off the declutch shaft with a hammer.

2. Remove declutch lever key from the shaft keyway, and the spacer, if equipped.
3. Examine the declutch lever key and keyway for deformation.
4. Store all declutch lever parts for later installation.

NOTE: Any noticeable bends (not twists) seen on the handle end before disassembly will prevent removal of the shaft. Remove the spring cartridge cap as far as possible and cut the shaft off behind the cap with a hacksaw. Before trying to remove the shaft, deburr and smooth the handle end.

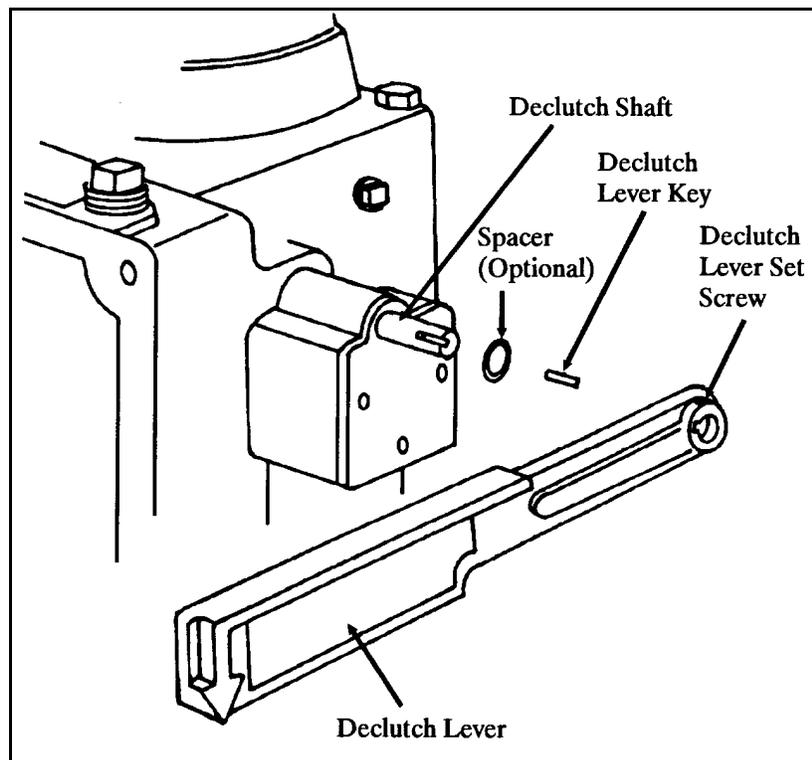


Figure 4-24 Declutch Lever Removal

## 9a. Worm and Belleville Spring Pack Assembly Removal (Old Style Spring Cartridge Cap)

Refer to Figure 4-25

**CAUTION:** A seal or gasket thickness change can vary the clearance between the spring cartridge cap lands and the Belleville spring pack outer thrust washer.

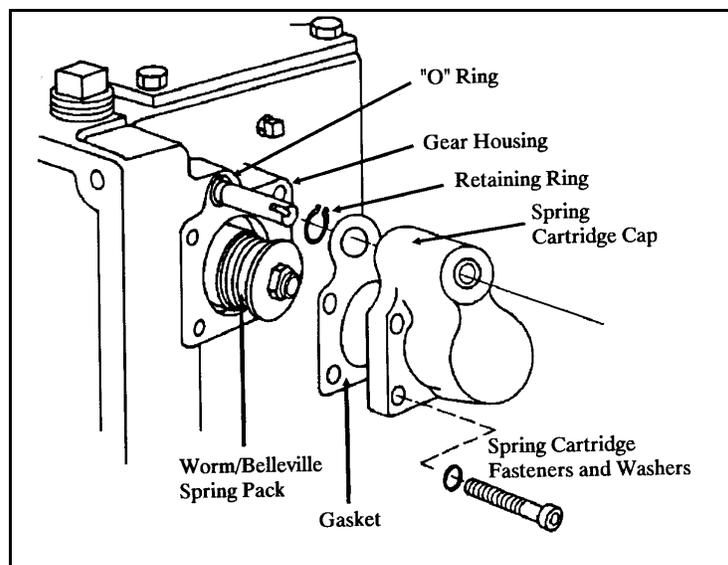
1. Unscrew and remove the four spring cartridge cover hold down cap screws and washers. Remove spring cartridge cap and gasket.
2. Measure the uncompressed gasket thickness, or determine the gasket thickness in the same manner as the housing cover gasket.

Thickness: \_\_\_\_\_

3. Remove the worm and Belleville spring pack assembly from actuator (by either rotating the worm shaft or pulling the assembly from the actuator).
4. The worm and Belleville spring pack assembly may be immersed in solvent to remove the majority of the grease.

**CAUTION:** The retaining ring can easily be damaged during its removal if sprung too far.

5. Remove retaining ring from the declutch shaft with snap ring pliers.

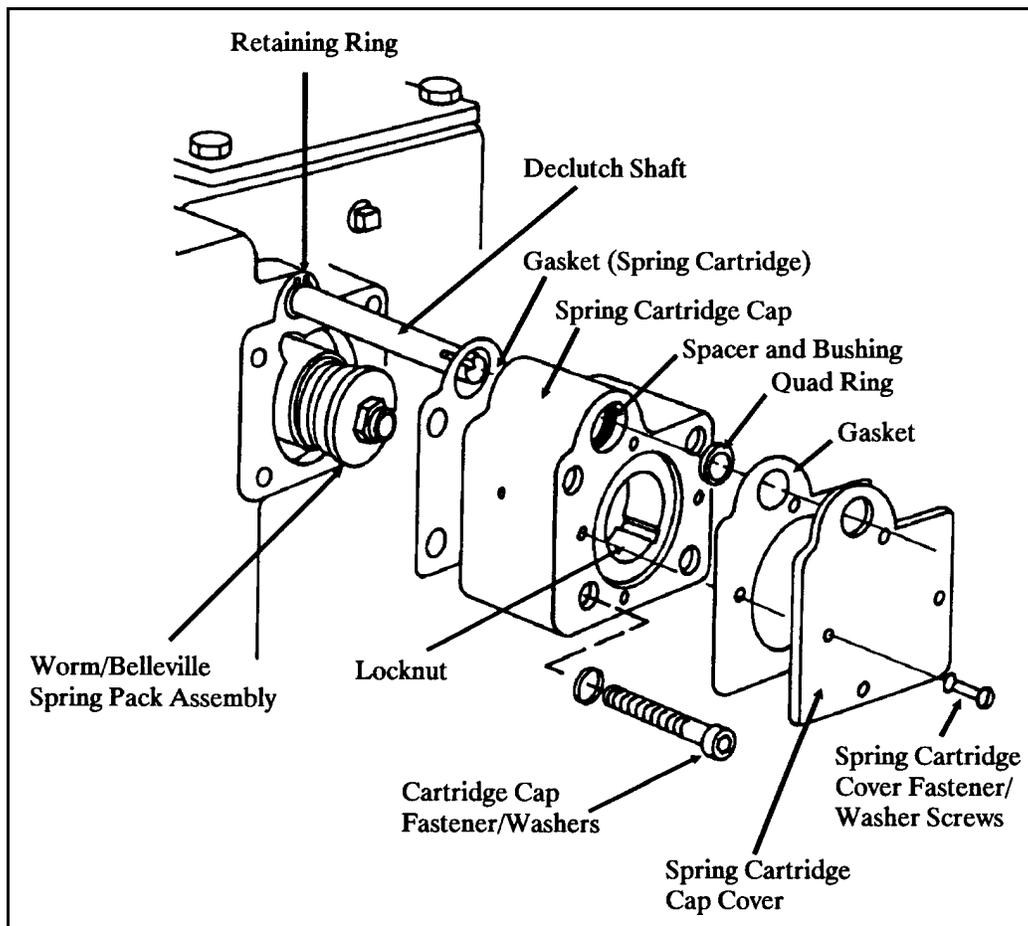


**Figure 4-25 Worm/Belleville Assembly Removal-Old Style**

## 9b. Worm and Belleville Spring Pack Assembly Removal (New Style Spring Cartridge Cap)

Refer to Figure 4-26

1. Remove the four cartridge cap cover fasteners and washers.
2. Remove spring cartridge cap cover and gasket.
3. Unscrew and remove four cartridge fasteners and washers with a 1/4" hex key.
4. Remove spring cartridge cap and gasket.
5. Remove quad ring seal from spring cartridge cap. Removal of bushing and spacer is generally not required.



**Figure 4-26 Worm/Belleville Assembly –New Style**

NOTE: Spacer is now an "O" ring on newer models; an "O" ring is supplied as a substitute.

**CAUTION:** The retaining ring can easily be damaged during its removal if sprung too far.

6. Remove retaining ring from the declutch shaft with snap ring pliers.
7. Remove or withdraw the worm and Belleville spring pack assembly from the actuator by either rotating the worm shaft or pulling the assembly from the actuator.

NOTE: It may also be helpful to rotate the worm shaft gear to assist with the removal of the bearing cartridge.

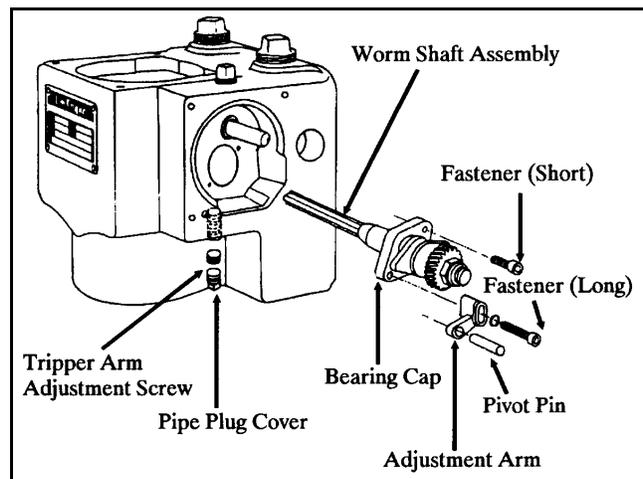
8. The worm and Belleville spring pack assembly may be immersed in solvent to remove the majority of the grease.

NOTE: Store all spring cartridge parts together for ease of reassembly.

## 10. Worm Shaft Assembly Removal

Refer to Figure 4-27

1. Unscrew and remove worm shaft bearing cap fasteners.
2. Remove pivot pin and adjustment arm.
3. Remove the worm shaft assembly from case.



**Figure 4-27 Worm Shaft Assembly Removal**

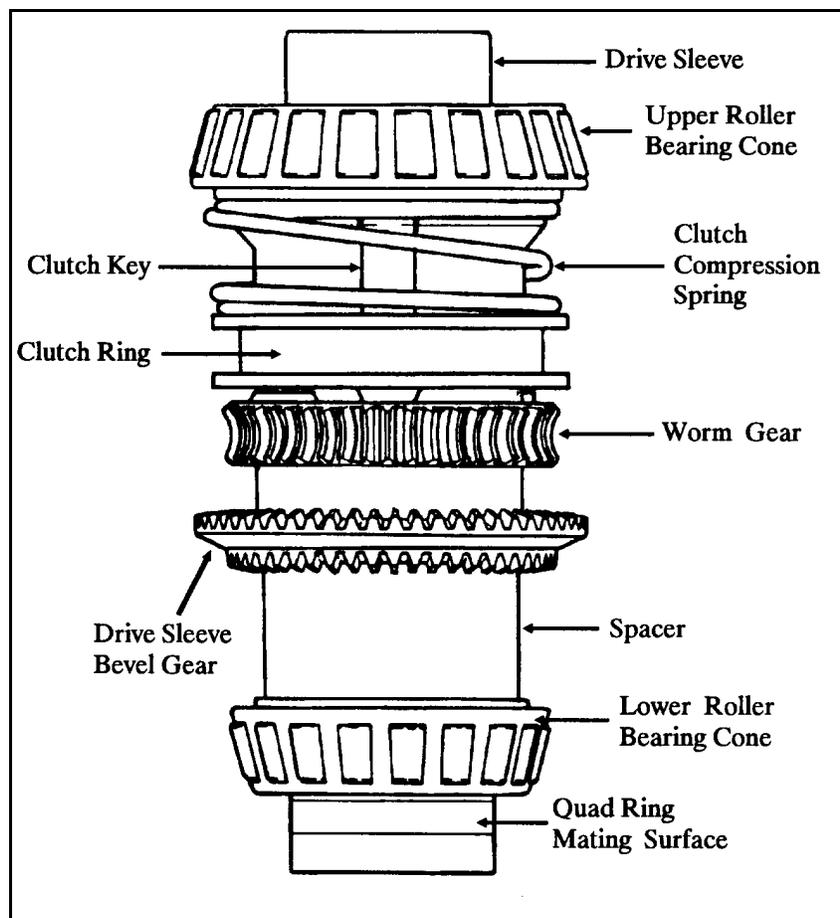
NOTE: Keep worm shaft assembly parts together for ease of installation.

4. Remove the tripper arm adjustment screw pipe plug, if so equipped.

5. Unscrew or back out the tripper arm adjustment screw one or two turns, if so equipped.
6. Reinstall the pipe plug into the actuator, if so equipped.
7. Store all loose parts. The worm shaft (with attached parts) may be submersed in solvent and cleaned with a soft brush.

**11. Drive Sleeve Assembly Removal** Refer to Figure 4-28

1. Lift drive sleeve assembly from housing and store; secure from damage.
2. The drive assembly may be immersed in solvent and cleaned with a soft bristled brush.
3. Store for later use.



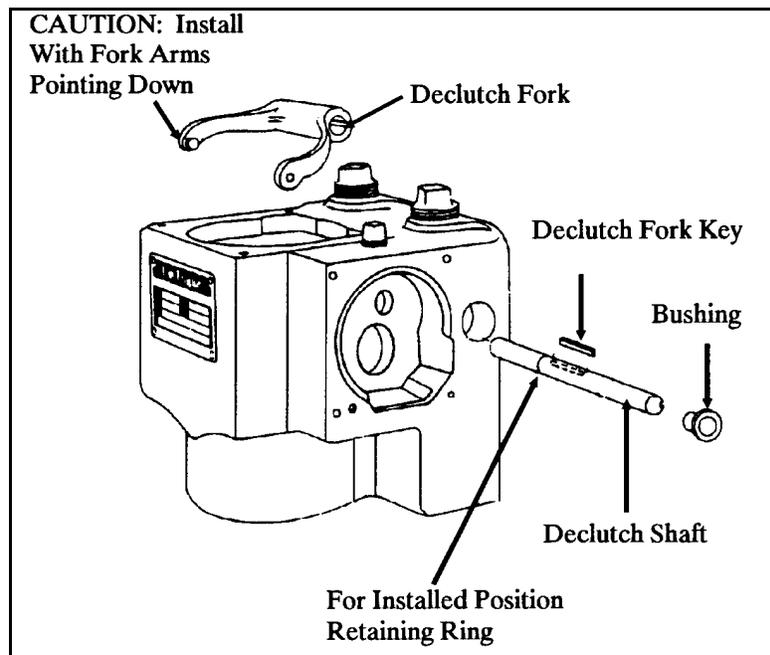
**Figure 4-28 Drive Sleeve Assembly Removal**

## 12. Declutch Shaft and Fork Removal Refer to Figure 4-29

**CAUTION:** The declutch shaft must be removed through the motor end of the gear case.

1. If installed, loosen the declutch fork set screw.
2. The declutch shaft has a relatively small diameter and if used in an abusive way, such as forcing, or using as a step, the shaft will be bent. If the shaft is bent, saw it off flush at the housing and then remove it.
3. If the declutch shaft is not bent, clean the declutch shaft portion protruding from the actuator spring pack end sufficiently to allow removal through the actuator. The metal may be pushed out in the keyway area, if so, remove pushed out metal with a file.

**CAUTION:** Ensure that the fork tips are not bent against the side of the housing while forcing the declutch shaft out of the actuator.

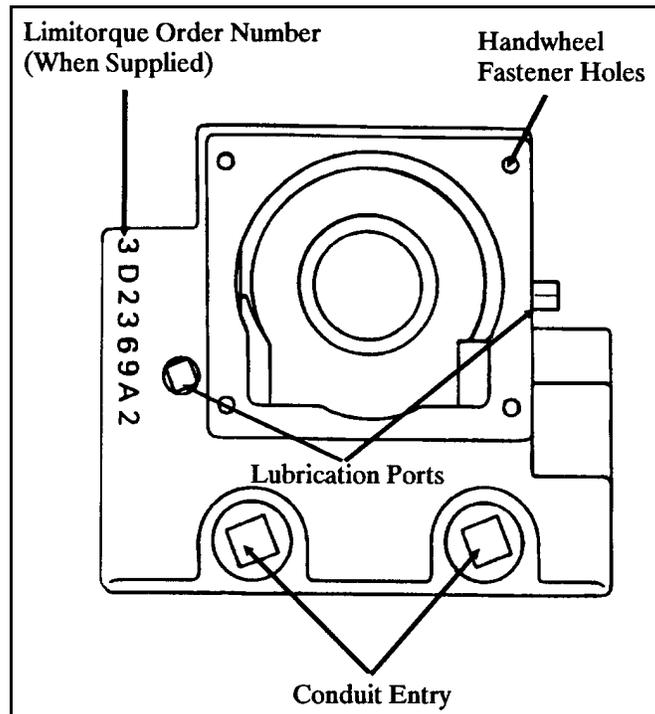


**Figure 4-28 Declutch Shaft and Fork Removal**

4. While holding the declutch fork through the handwheel assembly opening, remove the declutch shaft and declutch bushing through the opening at the motor end of the gear case by lightly tapping the declutch shaft from the spring pack end.
5. The declutch shaft may be checked for straightness by placing a straight edge along the keyways. Each key is installed on a straight line. Any misalignment of the keyways causes faulty operation. This is a common occurrence due to over torquing the declutch shaft by either using the declutch lever as a step, or when attempting to either pull up or push down on the lever to change the actuator operating mode.

### 13. Gearbox Grease Removal Refer to Figure 4-30

1. Mechanically remove as much grease as practical from the housing.
2. Remove grease from inside the housing using a site-approved solvent. Ensure all grease is completely removed from the inside surfaces of the housing when changing grease types.



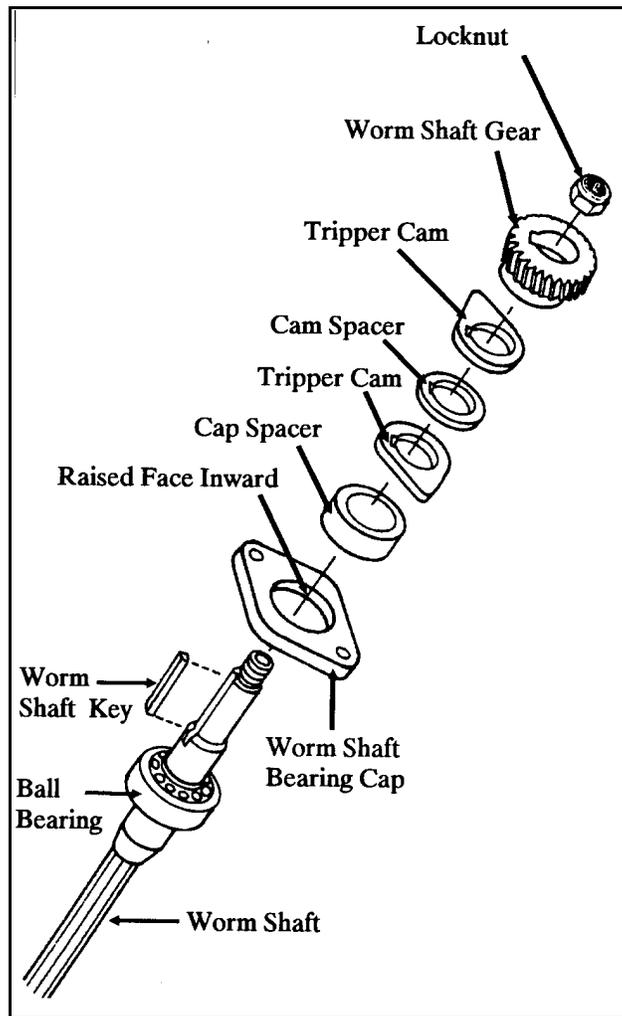
**Figure 4-30 Gear Box Grease Removal**

3. Remove any accumulated sand or debris (particularly at internal corner areas).
4. Remove all grease plugs and zerk fittings, clean and replace as necessary.
5. Inspect lower bearing cup for nicks, corrosion, burrs or gouges. Replace as necessary, reusing shims if installed.

**14a. Worm Shaft Inspection and Disassembly** Refer to Figure 4-31

1. Inspect the worm shaft assembly for excessive wear, damaged parts, galling, or nicks. Inspect the bearing and ensure it rotates smoothly.

Results: \_\_\_\_\_



**Figure 4-31 Worm Shaft Assembly Exploded View**

If inspection results were unsatisfactory, perform the following steps for worm shaft disassembly.

2. Use a strap wrench or padded vise to hold the worm shaft. Unscrew and remove locknut. Remove the following parts from the worm shaft.

- a. Worm shaft gear.
  - b. Tripper cam (two pieces).
  - c. Cam spacer.
  - d. Worm shaft key
  - e. Cap spacer.
  - f. Worm shaft bearing cap.
3. Using a bearing puller, remove the worm shaft ball bearing, if required.
  4. Clean all parts as necessary.
  5. Check worm shaft parts for indications of wear, deformity, scoring, cracking, and pitting. Replace as necessary.

#### **14b. Worm Shaft Reassembly**

1. Install ball bearing on worm shaft, if removed.
2. Pack the worm shaft ball bearing with grease.
3. Apply a light film of grease on the fluted portion of the worm shaft.
4. Install bearing cap with its inner surface raised edge facing, and firmly seated, against the ball bearing.
5. Install cap spacer, worm shaft key, tripper cams and cam spacer onto the worm shaft. Install the tripper cams in opposing positions 180 degrees apart.
6. Install worm shaft gear.

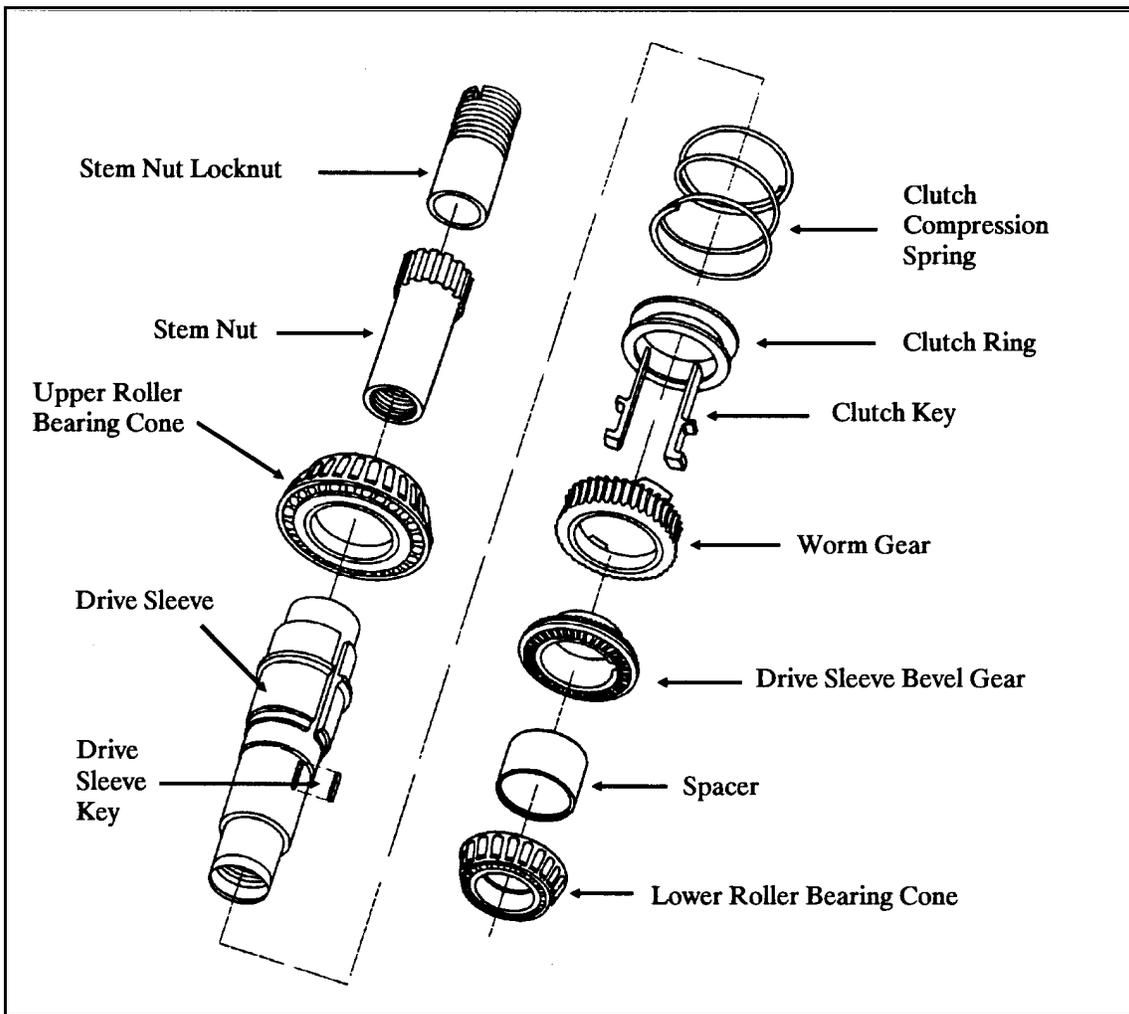
NOTE: The locknut deteriorates with each installation/removal cycle. Replacement is recommended each time the locknut is removed.

7. Place the worm shaft into a padded vise, or use a strap wrench to hold the worm shaft. Install locknut and tighten against worm shaft gear until snug.

**15a. Drive Sleeve Inspection/Disassembly** Refer to Figure 4-32

1. Inspect the drive sleeve for excessive wear, damaged parts, galling or nicks, paying particular attention to the stem nut threads. Inspect the bearings and assure they rotate smoothly.

Results \_\_\_\_\_



**Figure 4-32 Drive Sleeve Assembly Exploded View**

**CAUTION:** Do not apply any puller tool force on the bearing cage when pressing upper and lower cone bearings off the drive shaft. The cage deforms easily. The clutch spring must be held clear of the press jaws during removal.

If inspection results were unsatisfactory, perform the following.

2. If required, and not previously done, remove the stem nut locknut by spot drilling to remove the thread stakes. Turn the locknut out of the drive sleeve. Clean any loose metal chips from the threads. Invert the drive assembly and tap the stem nut with a soft metal drift pin, driving the nut from the drive sleeve splines. Clean any loose metal chips from the drive sleeve.
3. Set up an applicable size bearing puller or arbor. Attach puller jaws onto the inner race of the lower drive sleeve bearing cone or onto the inside of the bevel gear.
4. Pull the drive sleeve lower bearing off the drive sleeve.
5. Remove spacer and bevel gear from the drive sleeve.
6. Remove the drive sleeve key from the drive sleeve.
7. Remove worm gear, clutch ring, two clutch keys, and clutch compression spring from drive sleeve. Clean and store the loose parts to prevent damage.
8. Install the bearing puller or arbor by placing the jaw on the inner race of the upper roller bearing cone, and pull bearing off the drive sleeve.
9. Clean all parts by entirely immersing in solvent, including the upper and lower drive sleeve bearings. Brush clean, as necessary, with a soft bristled brush.

**NOTE:** If the components are to be stored for an extended period of time steel parts should be coated with a light coating of corrosion inhibitor.

10. Be sure inner bearing races are free of nicks, burrs, and gouges. Replace if necessary. (Dirt or chips on the shaft can prevent accurate bearing alignment, resulting in poor operation.) Smooth any machine marks from the clutch key edges and any indications on the sides of the drive sleeve keyway with fine emery paper. Clean the inner bearing races and their mating surfaces on the drive sleeve with solvent and dry with lint free towels.
11. Inspect all parts, especially the worm gear and clutch keys, for wear, scoring, cracks, and corrosion. Replace parts as necessary.

## **15. Drive Sleeve Reassembly** Refer to Figure 4-33

**CAUTION:** When pressing bearings onto the drive sleeve, apply a steady pressure to the inner race of the bearing. Do not apply force to the bearing cage.

**NOTE:** All machined surfaces that are subject to sliding contact should be lubricated to minimize surface wear.

1. Coat the upper drive sleeve bearing journal with a light film of grease, then press the upper bearing cone onto the drive sleeve.

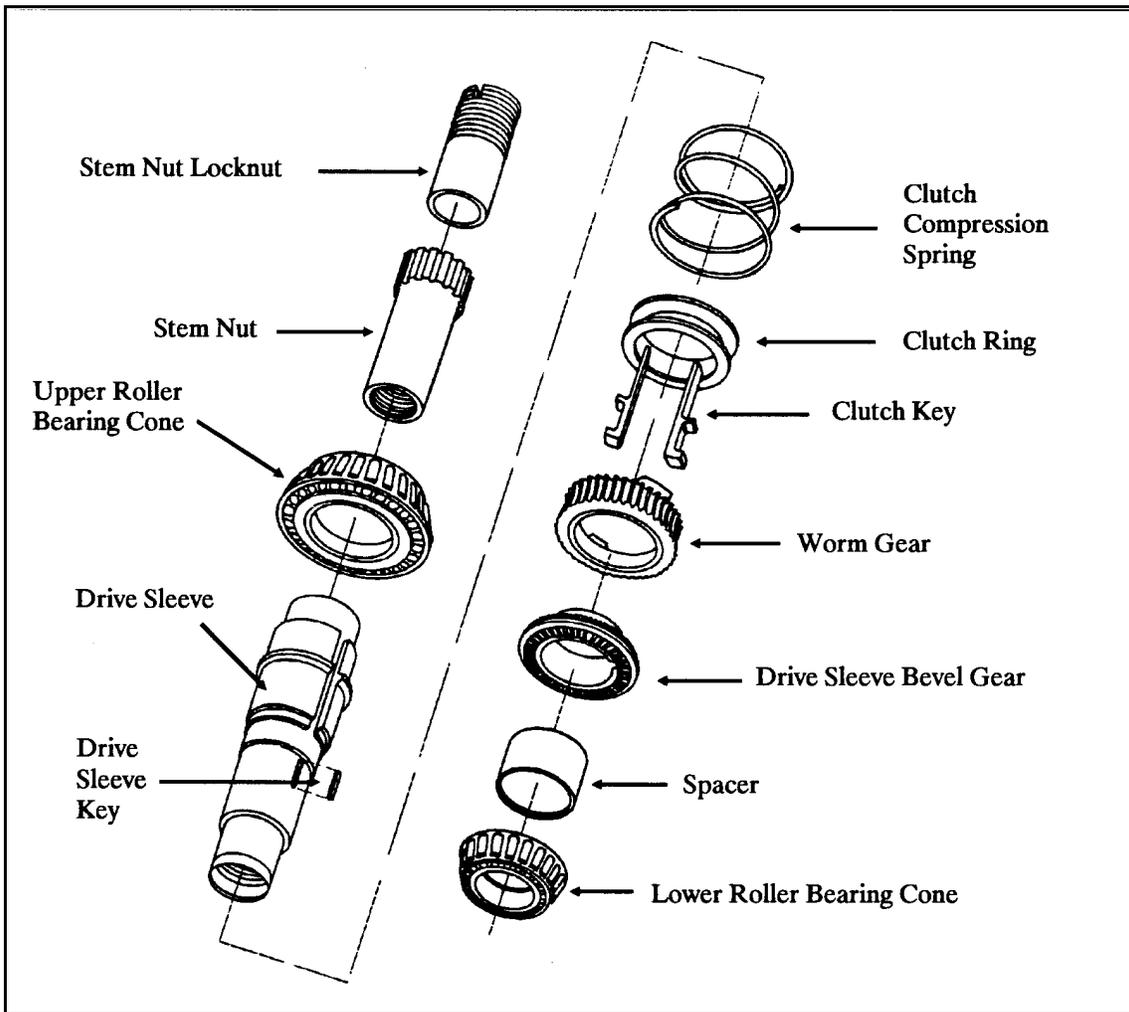


Figure 4-33 Drive Sleeve Assembly Exploded View

2. Fit clutch keys into clutch ring. Slide clutch compression spring and clutch ring with keys into place on the drive sleeve. Align keys with keyways on the drive sleeve
3. Slide the worm gear into place on the drive sleeve with the lugs against the end of clutch keys.
4. Install the lower drive sleeve key into its keyway.
5. Slide the drive sleeve bevel gear and spacer onto the drive sleeve and key.
6. Coat the lower drive sleeve bearing inner race or journal with a light film of grease and press the lower bearing cone onto the lower portion of the drive sleeve. The clutch key and worm gear lugs should be end-on-end for proper spacing.
7. Pack bearings with clean, fresh grease.
8. Dress threads on the locknut if required.
9. Check the clutch compression spring for unwinding, indicated by an enlarged diameter, that will result in the spring contacting the upper bearing cone's cage or rollers. Replace if required.
10. If the stem nut is to be installed at this time, place the stem nut and the locknut into the drive sleeve assembly. Stake locknut to prevent loosening of stem nut in the drive sleeve. Cover and store for later installation into the actuator.

## 16a. Worm and Belleville Spring Pack Inspection/Disassembly

Refer to Figure 4-34 and Table 4-1

1. Inspect the worm and Belleville spring pack assembly for excessive wear, damaged parts, galling, and nicks. Inspect the bearings for looseness and ensure smooth rotation, paying particular attention to the worm for cracking, metal transfer, or signs of overheating. Polish the worm if required.

Results: \_\_\_\_\_

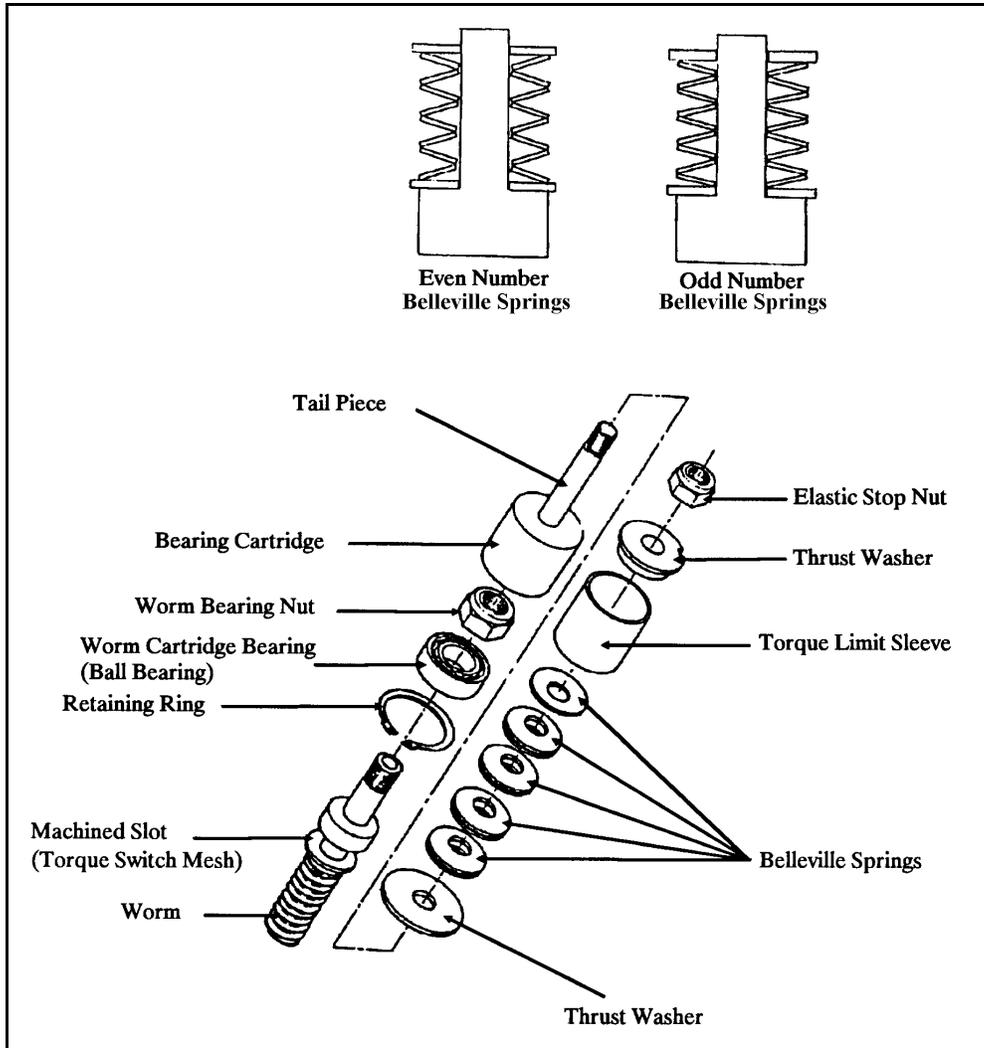


Figure 4-34 Worm and Belleville Spring Pack

NOTE: Replace the spring pack as a unit if any spring pack subassembly parts replacement is required.

2. Check the springs for looseness or other signs of degradation. Notify the instructor if any problems are found.

Results: \_\_\_\_\_

3. If the inspections above were unsatisfactory, or the spring pack operation is suspect, disassemble as follows:
  - a. With the torque limit sleeve tight against a thrust washer measure and record the distance between the torque limit sleeve and the remaining thrust washer at two or more points. This is referred to as the "X" dimension, see Figure 4-4.

Distance: \_\_\_\_\_

4. Clamp the bearing cartridge in a padded soft-jaw vise or use a strap wrench to hold the assembly. Remove elastic stop nut. Count and record the exact number of turns to remove nut.

Turns: \_\_\_\_\_

Refer to Table 4-1 for spring pack information.

OLD SPRING PACK PART NO.	NO. OF SPRINGS	NOMINAL PRELOAD	NEW SPRING** PACK PART NO.
60-600-0060-1	26	Solid Against Shoulder++	0101-090
60-600-0023-1	18*	1-3/4 Turns+	0101-091***
60-600-0023-1	18	1-3/4 Turns+	0101-091
60-600-0024-1	19	1-3/4 Turns+	0101-092***
60-600-0024-1	17*	1-5/8 Turns+	0101-092***
60-600-0024-1	17	1-5/8 Turns+	0101-092
60-600-0063-1	15	Solid Against Shoulder++	0101-093
60-600-0027-1	Helical Spring	3/4 Turns+	Discontinued
* Denotes Spacer Within ** New Spring Packs Have Different Belleville Spring Dimensions *** Discontinued + Referenced From Initial Contact of Plastic Stopnut With Thrust Washer (Figure 4-34) ++ Thrust Washer Making Contact With Shoulder of Tail Piece			

**Table 4-1 Torque Spring Configuration & Preload Table**

NOTE: A 3/8 inch diameter bolt, 2-1/2 to 3 inches long can serve as a handy holding tool for maintaining the arrangement of the springs. Hold the end of the bolt against the end of the cartridge shaft and slide the springs, in order, onto the bolt, then secure with a nut.

**CAUTION:** The spring pack arrangement is critical.

5. Carefully slide off the outer thrust washer and torque limit sleeve. Do not allow springs including any spacers, to become separated during this action.
6. To maintain Belleville spring pack arrangement, slide the Belleville springs onto a bolt, string, or wire. Remove the inner thrust washer from cartridge stem. A measurement of the Belleville springs can be performed at this time. The thickness that each Belleville spring should be in noted on the torque switch calibration plate.
7. Clean all parts with an approved solvent. The internal face surfaces may require cleaning with a soft bristled brush to remove hardened grease.
8. Check the bearing cartridge components (including the springs), for cracks, wear, deformity, and corrosion.

**16b. Worm Disassembly/Reassembly** Refer to Figure 4-34 or 4-35

**CAUTION:** Do not place the bearing cartridge between the jaws of a vise unless a bearing is installed within to prevent deformation of the bearing cartridge.

1. If further disassembly is necessary, perform the following steps, as required.
2. Place the worm into a padded soft-jaw vise with the bearing cartridge exposed. Remove retaining ring. Disengage the worm assembly which consists of worm, bearing, and worm bearing nut from the cartridge by inserting a brass or soft metal drift pin into the worm's center void and tapping the bearing cartridge from the worm assembly. Store the bearing cartridge for later assembly.
3. Inspect the worm bearing for looseness, wear, and damage. Replace if required using the following step.
4. Unscrew worm bearing nut and press bearing off the worm using an arbor or bearing puller. Degrease with solvent.

NOTE: The worm bearing nut deteriorates with each installation/removal cycle. Replacement is recommended each time it is removed.

5. Replace bearing and worm bearing nut if required.
6. Press the bearing onto the bearing journal of the worm. Install worm bearing nut. Pack the bearing with grease.
7. Install worm assembly into bearing cartridge.
8. Install retaining ring into the bearing cartridge.
9. Pump grease into the center of the worm until it extrudes through the bearing.
10. If a new Belleville spring pack unit is installed, measure and record the distance between a thrust washer and torque limit sleeve.

Distance: \_\_\_\_\_

#### **16c. Worm and Belleville Spring Pack Reassembly** Refer to Figure 4-35

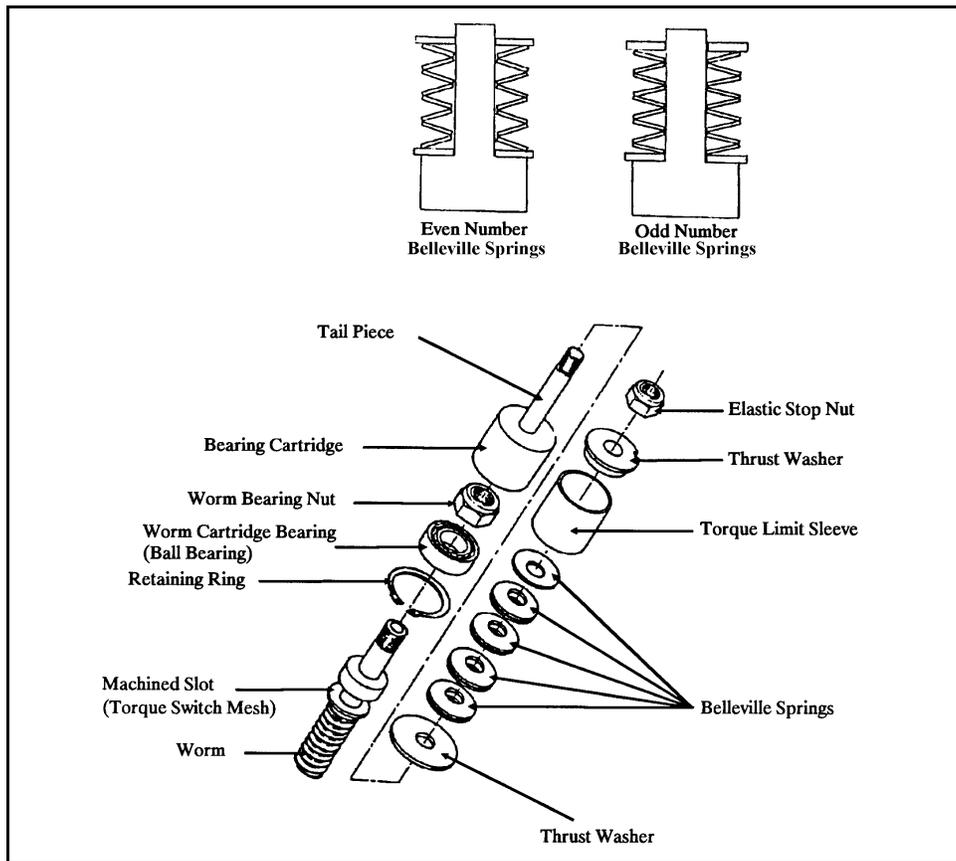
**CAUTION:** Do not clamp the bearing cartridge (bearing housing portion) in a vise without a bearing installed.

**CAUTION:** Do not lubricate the Belleville spring pack.

1. Clamp the bearing cartridge into a padded soft-jaw vise or equivalent.
2. Install the inner thrust washer onto the bearing cartridge stem.
3. Install the Belleville springs in the sequence as found in the orientation as shown in Figure 4-34.
4. Install torque limit sleeve.
5. Install the outer thrust washer onto the bearing cartridge stem.

NOTE: The elastic stop nut deteriorates with each installation/removal cycle. Replacement is recommended each time it is removed.

6. Install an elastic stop nut, using the exact number of turns recorded earlier during disassembly, and/or reestablishing the distance between the thrust washer and the torque limit sleeve recorded prior to disassembly.



**Figure 4-35 Worm/Spring Pack Reassembly**

7. Measure the final distance between the thrust washer and the torque limit sleeve.

Distance \_\_\_\_\_

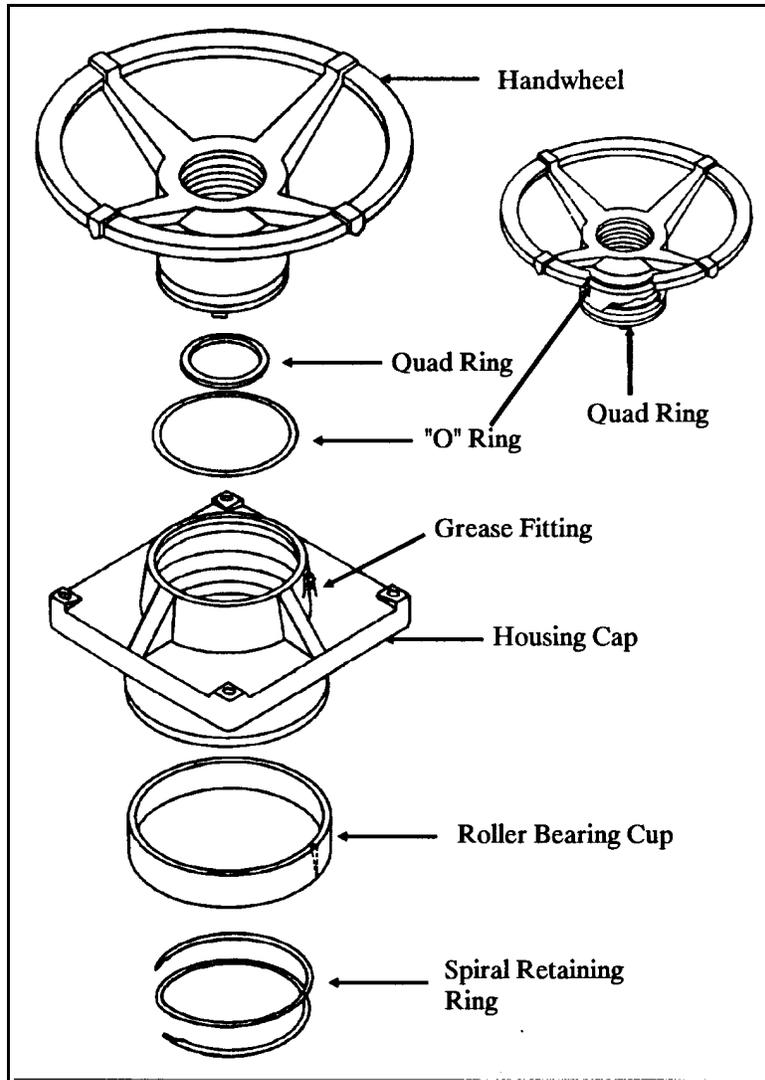
Turns: \_\_\_\_\_

NOTE: If there is no compression on the spring pack after performing the above procedure, notify the instructor.

8. Cover and protect from damage until later installation.

**17a. Handwheel Components Inspection/Disassembly** Refer to Figure 4-36

1. Remove excess grease from the assembly. Check to ensure the handwheel is tight within the housing. Remove the spiral retaining ring from housing cap.
2. Remove handwheel from housing cap.
3. Remove quad ring from inside of handwheel.
4. Remove "O" ring from the outside of handwheel.



**Figure 4-36 Handwheel Assembly Exploded View**

5. If required, use a bearing puller to remove upper drive assembly roller bearing cup from housing cap.
6. Hand clean/degrease the handwheel and housing cap.
7. Clean the roller bearing cup face with approved solvent. Examine the roller bearing cup face for scoring, pitting wear, or Brinell markings. Replace as required.
8. If roller bearing cup replacement is required, perform the following using suitable bearing puller.
  - a. Remove roller bearing cup.
  - b. Clean roller bearing cup cavity.

NOTE: The roller bearing cup may be cooled to provide easier installation.

- c. Install the bearing cup by applying an even, steady pressure across the edges of the cup. Verify the cup is seated by observing even alignment with the housing cap edge.
9. Thoroughly clean all component parts in approved solvent to remove all traces of grease.
10. Dry each component. Inspect for damage and verify correct materials.

#### **17b. Handwheel Components Reassembly**

1. Replace "O" ring and quad ring, if needed, with approved parts. Use a thin coating of grease on the "O" ring and quad ring to prevent damage during installation.
2. Reinstall the grease fitting, if removed. Ensure the fitting is operational by applying a grease gun and forcing grease through.
3. Install the lubricated "O" ring onto the outside of the handwheel. Install the lubricated quad ring into the inside handwheel groove.
4. Mate the housing cap to the handwheel assembly using a firm, even hand pressure. Take care not to damage the "O" ring.
5. Secure by installing retaining ring into its handwheel assembly outside groove.

6. Attach a grease gun containing approved grease to the grease fitting and turn the handwheel until grease is observed coming around the retaining ring.
7. Store the handwheel assembly for later installation.

### 18. Declutch Shaft and Fork Assembly Installation Refer to Figure 4-37

1. Inspect the declutch fork to ensure it is not bent or damaged and ensure the rollers are free of flat spots and can move freely.

NOTE: The easiest method of installation involves orienting the actuator to permit gravity to hold the key in the keyway before sliding the declutch shaft and key through the declutch fork. The key may be held in place by a thread locking compound.

2. Apply a liberal coat of grease to declutch shaft. Place the declutch fork key into its slot.

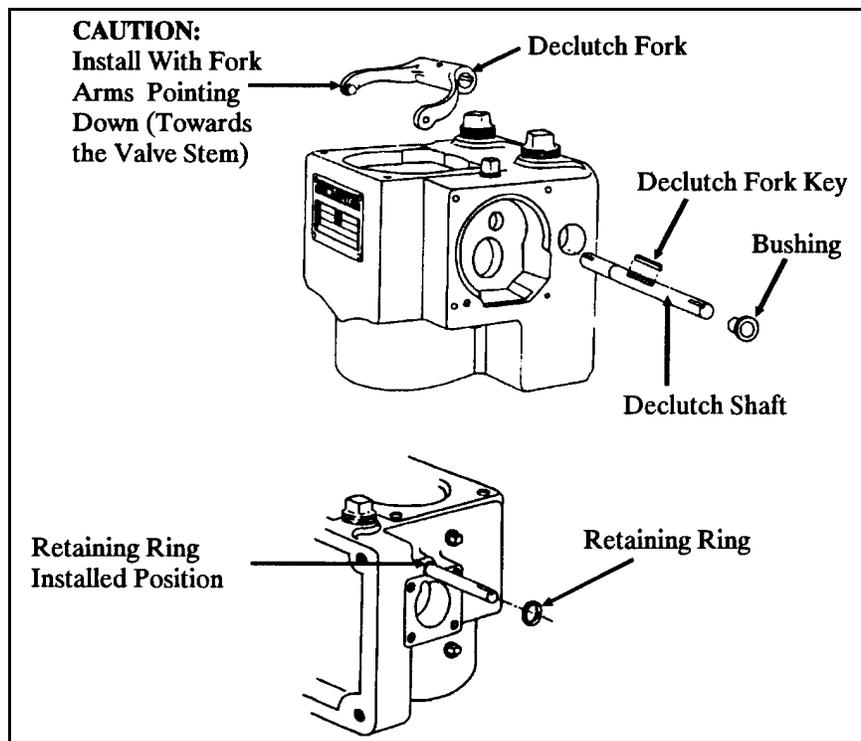


Figure 4-37 Declutch Shaft/Fork Assembly Installation

**CAUTION:** When installing the declutch fork, be sure to orient it on the declutch shaft with the fork ends and rollers pointing downward. If the declutch fork is not installed as described, the actuator does not fully engage the worm gear lugs to the clutch keys. Eventually, the actuator lugs and actuator fail. The actuator will not normally stay in manual due to the top of the clutch keys engaging the bottom of the handwheel before lifting the trippers high enough to engage the top of the adjustment arm.

3. Place the declutch fork into the actuator with its fork ends and rollers pointing down and toward the drive assembly cavity.
4. Insert the declutch shaft retaining ring groove end through the actuator port in the motor pinion cavity. Pass the declutch shaft through the declutch fork and through the spring cartridge port. Make sure the declutch fork is positioned on the declutch shaft over the declutch fork key.

**CAUTION:** The retaining ring will be damaged during its installation if sprung too far.

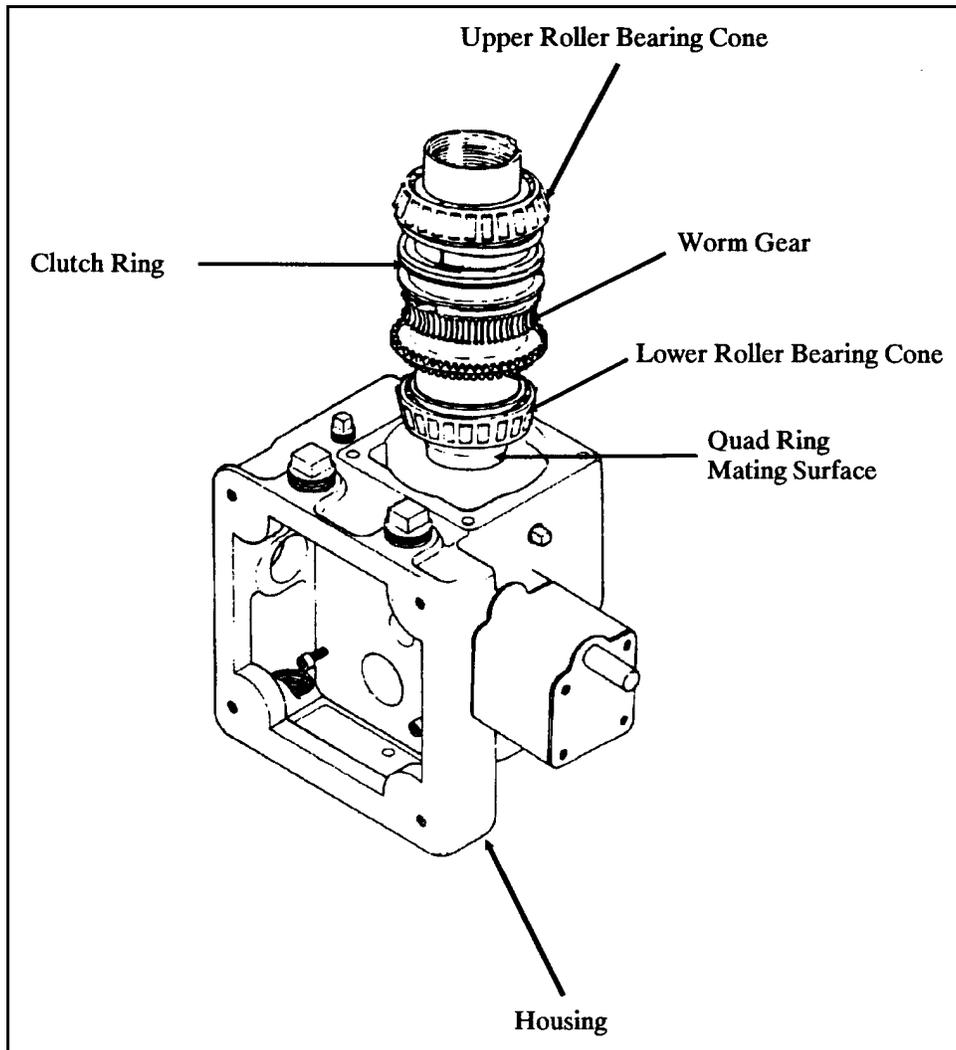
5. Install retaining ring into its groove on the declutch shaft on the spring cartridge cap end.
6. Install bushing onto the declutch shaft on the motor end. Seat the bushing into its actuator cavity port.

### **19. Drive Sleeve Installation** Refer to Figure 4-38

**NOTE:** A blue check should be performed to ensure proper gear mesh, if required.

1. Cover quad ring with a thin lubricant film and install into the lower housing groove.
2. Install bearing shim(s) and lower drive assembly bearing cup, if removed. The lower drive assembly cup placement has a direct influence on the worm to worm gear vertical mesh point.
3. Insure both the upper and lower bearings are hand-packed with approved grease.
4. Apply a liberal coating of grease onto the entire drive sleeve assembly.

5. When installing the drive sleeve, ensure the ends of the declutch fork are inserted into the clutch ring as the drive sleeve is inserted into the cavity. Apply a firm downward pressure to ensure that the drive sleeve is fully inserted into the gear case. This is evidenced by a seating jerk and the drive sleeve becoming more stable in the actuator.



**Figure 4-38 Drive Sleeve Installation**

## 20. Worm Shaft Assembly Installation Refer to Figure 4-39

1. Insure the worm shaft bearing is packed with approved grease. Coat the worm shaft fluted end with a thin film of grease, and install the worm shaft assembly into the gear case.
2. Install pivot pin through the adjustment arm, then into its actuator port as shown in the figure.
3. Install the long fastener and washer through the adjustment arm and bearing cap, and thread into the actuator.
4. Secure the bearing cap by installing the short fastener and washer. Tighten the short fastener, allow the long fastener to remain snug.

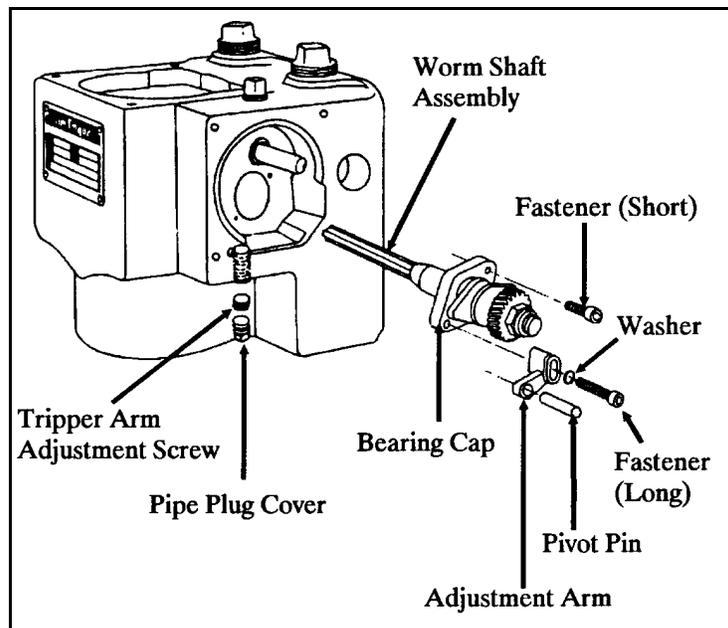
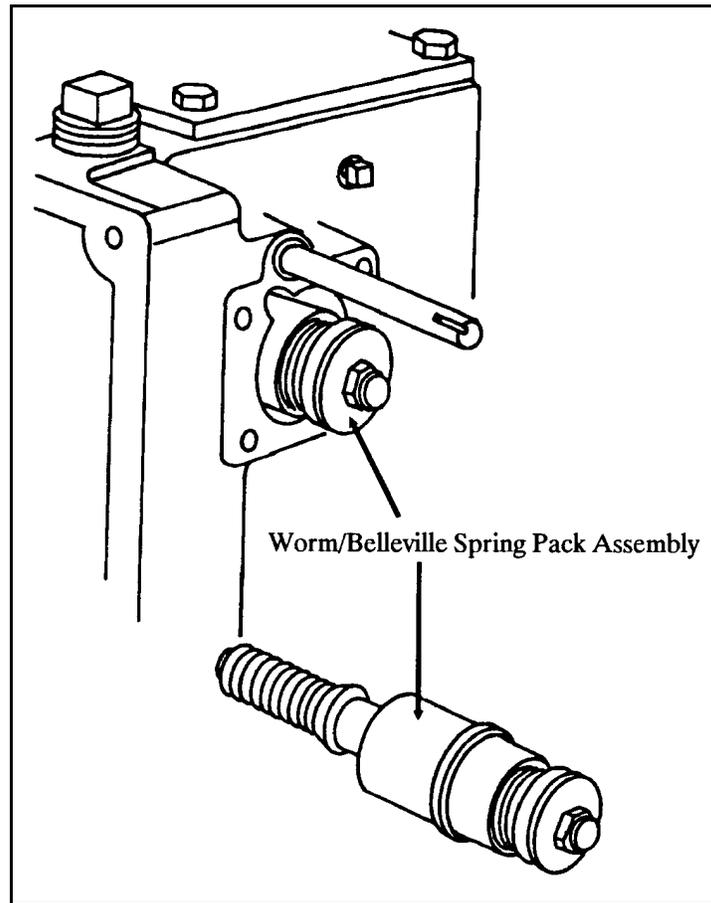


Figure 4-39 Worm Shaft Assembly Installation

## 21. Worm and Belleville Spring Pack Assembly Installation Refer to Figure 4-40

NOTE: A blue check should be performed to ensure proper gear mesh, if required.

1. Coat worm with grease and install worm/Belleville spring pack assembly onto the worm shaft inside the gear case by rotating the worm shaft assembly. This aligns (meshes) the worm splines with the worm shaft splines and draws the worm over the worm gear teeth.
2. Be sure the worm/Belleville spring pack assembly is seated in the gear case and meshed with the worm gear. Rotate the worm shaft gear to ensure a tight fit. This is evidenced by the inner thrust washer being seated against its gear case housing shoulder.



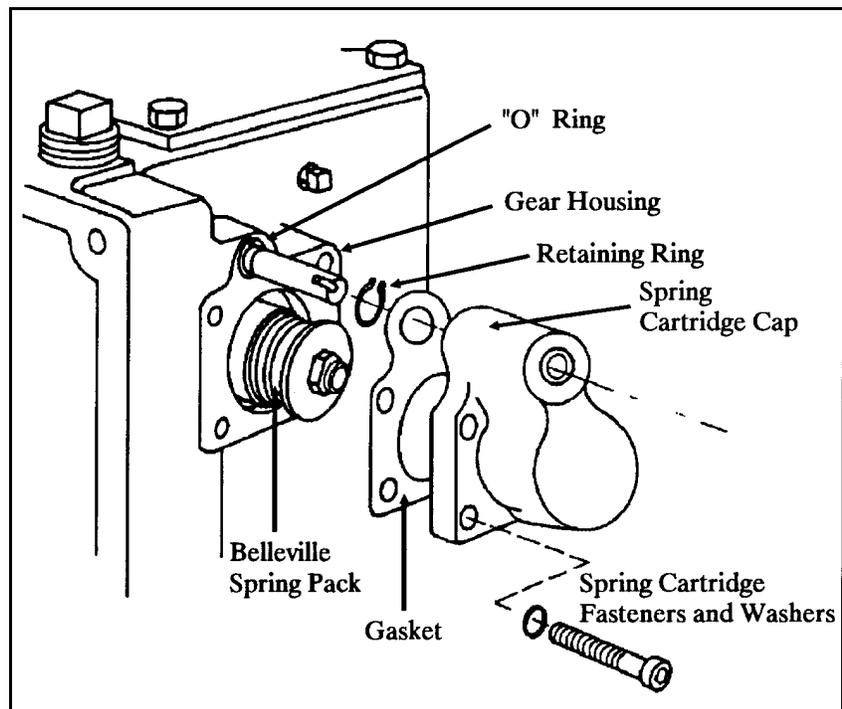
**Figure 4-40 Worm/Belleville Spring Pack Installation**

**22a. Spring Cartridge Cap Assembly Installation (Old Style)** Refer to Figure 4-41

**RECOMMENDATION:** If available, replace the old style spring cartridge cap with a new multi-piece cartridge cap.

**CAUTION:** A seal or gasket thickness change can vary the clearance between the spring cartridge cap lands and spring pack outer thrust washer.

1. Apply a slight film of grease on all seal and gasket mating surfaces of the spring cartridge cap.
2. Install the "O" ring, retaining ring and gasket.
3. Install old style spring cartridge cap onto the actuator.
4. Install the spring cartridge cap fasteners and washer snug tight.
5. Tighten the spring cartridge cap fasteners.



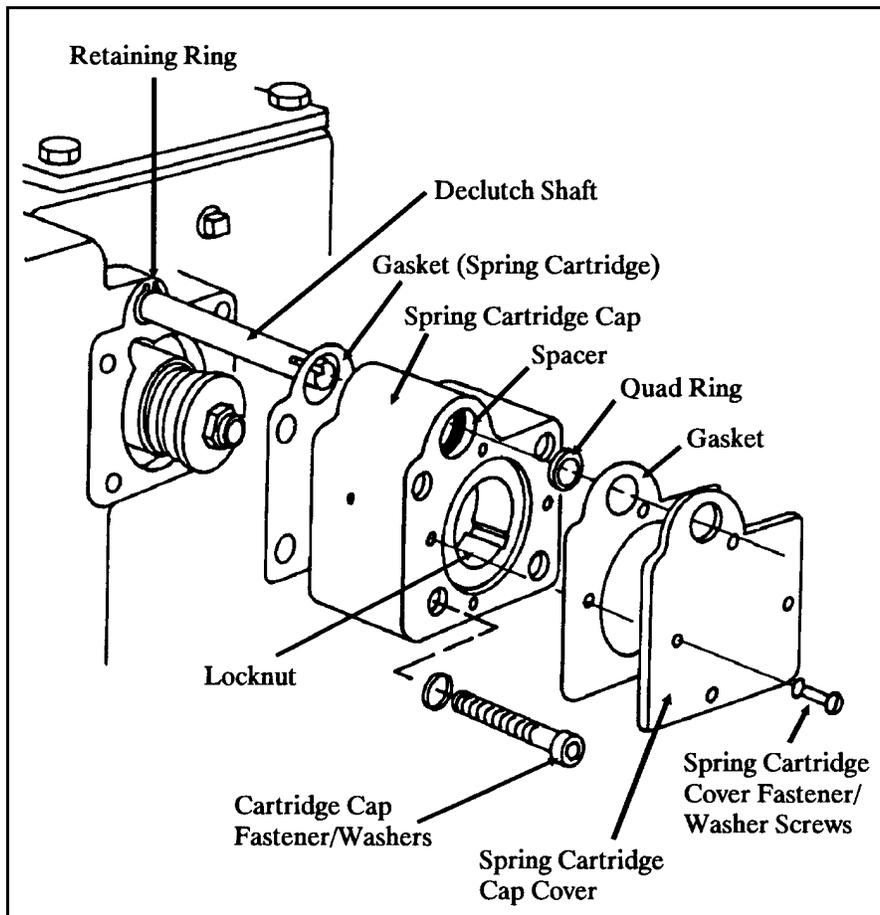
**Figure 4-41 Spring Cartridge Cap Assembly Installation (Old Style)**

**22b. Spring Cartridge Cap Assembly Installation (New Style)** Refer to Figure 4-42

1. Apply a slight film of grease on all seal and gasket mating surfaces of the spring cartridge cap.
2. Remove pipe plug or outer set screw cover. Loosen adjusting nut lock screw and remove locknut. Clean and dress threads as required.

NOTE: Coat both gaskets with a light film of grease.

3. Install gasket. Install spring cartridge cap with spacer or substitute "O" ring.
4. Install and tighten fasteners and lockwashers.



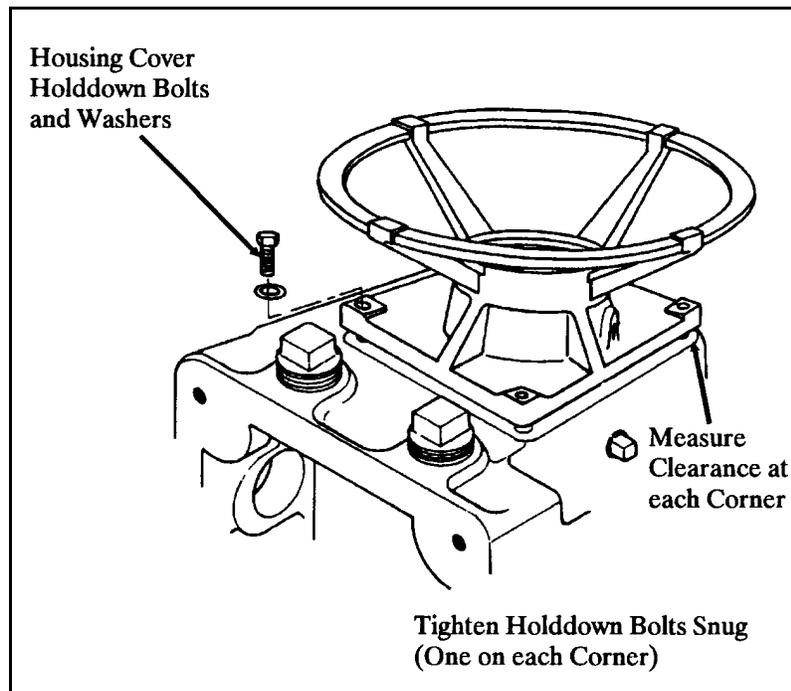
**Figure 4-42 Spring Cartridge Cap Assembly Installation (New Style)**

5. Install and tighten the locknut until it just contacts the Belleville spring pack's outer thrust washer (but not compressing the spring pack).
6. Tighten the locknut's locking screw. Install pipe plug; do not over tighten.
7. Check that the quad ring is properly seated in the spring cartridge cap. Install cover with gasket and secure with fasteners.

**23. Housing Cover Gasket Thickness Determination** Refer to Figure 4-43

**CAUTION:** To provide correct upper drive assembly clearance, the replacement handwheel assembly gaskets must be the correct thickness to obtain bearing preload.

1. Inspect the housing cover for flatness by use of a straight edge against its housing mating surfaces. The old gasket may be installed if inspected and found satisfactory. If not satisfactory, use the following steps to determine correct gasket thickness.



**Figure 4-43 Determination of Handwheel Gasket Thickness**

2. Install the handwheel assembly onto the housing without the gasket(s). Screw in the assembly mounting bolts hand tight.
3. Rotate the worm shaft pinion gear by hand until the drive sleeve is rotating, this gives excellent bearing loading feel.
4. While rotating the worm shaft pinion/drive sleeve, tighten the mounting bolts in a crisscross pattern one flat at a time until bearing loading is felt at the worm shaft pinion gear.
5. Loosen each mounting bolt one flat.
6. Using a thickness (feeler) gauge, measure and record the gap between the housing cap and housing at four places 90 degrees apart.
7. Add the four readings and divide the sum by 4.

Reading 1: \_\_\_\_\_

Reading 2: \_\_\_\_\_

Reading 3: \_\_\_\_\_

Reading 4: \_\_\_\_\_

Sum: \_\_\_\_\_

Divide

By 4: \_\_\_\_\_ (Average Value)

8. Multiply the average value by 1.1 which allows 10 percent for gasket crush.

Average Value X 1.1: \_\_\_\_\_

9. Remove the bolts, washers, and handwheel assembly.

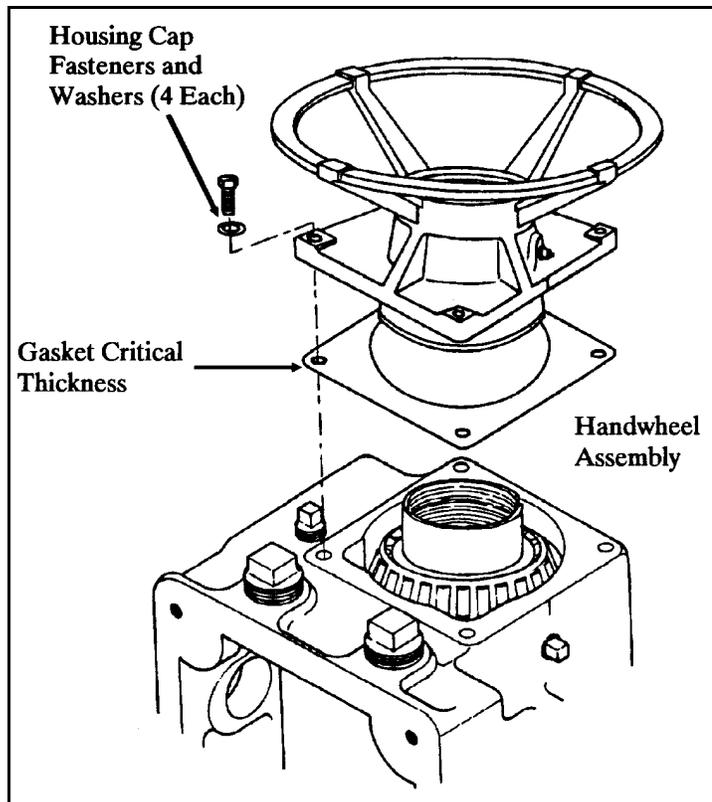
**24. Handwheel Assembly Installation** Refer to Figure 4-44

1. Select a gasket set of the closest nominal thickness on the high side of the calculated value, using combinations of 1/64", 1/32", or 1/16" Anchor 443A or Klinger SIL-C-4401 gasket material.

Selected gasket thickness:\_\_\_\_\_

2. Install handwheel assembly onto the gear case with gasket(s).
3. Install and tighten the four housing cap fasteners with washers alternately in a crisscross pattern until snug.
4. Ensure the drive assembly is not bound by rotating the worm shaft gear/drive sleeve.
5. Place, and hold, the actuator in the manual mode and verify no vertical drive sleeve movement and no excessive handwheel effort is required.
6. If too loose, or too tight, add or remove thickness by use of gaskets or shims in approximate.002" increments until thickness gives proper results.
7. Record final thickness.

Final Thickness:\_\_\_\_\_



**Figure 4-44 Handwheel Assembly Installation**

## 25. Declutch Lever and Tripper Lever Installation Refer to Figure 4-45

1. Lubricate end of declutch shaft projecting from the spring cartridge cap cover (Figure 4-42).
2. Install spacer, if available, and declutch lever onto the declutch shaft with declutch lever key, and secure by tightening declutch lever set screw.

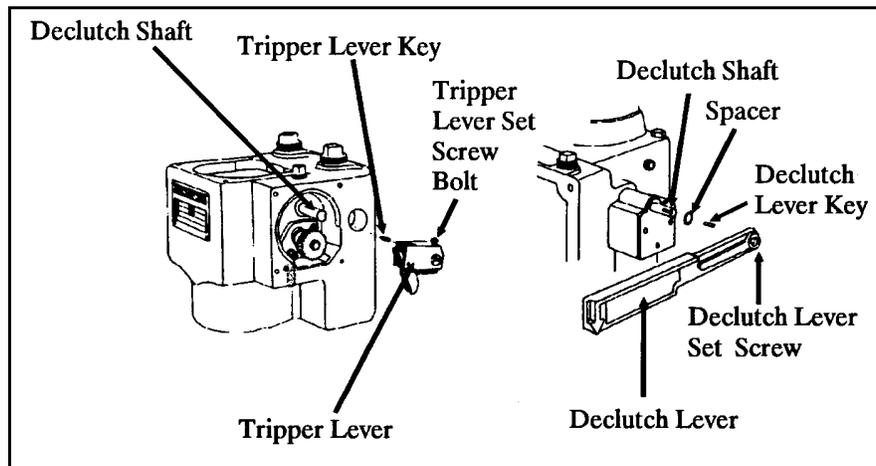
### Tripper Lever Installation

NOTE: Declutch tripper lever installation is easier if the declutch lever is held in the manual position.

1. Install the tripper lever key into its slot. Place a thin film of lubricant on the inner diameter of the tripper lever. Install the tripper lever onto the declutch shaft and its respective key. Align the tripper lever to be as even as possible with the end of the declutch shaft. This aligns the tripper fingers with their respective cams on the worm shaft.

**CAUTION:** do not over torque the tripper lever set screw bolt, because it shears easily.

2. Insure the trippers are lined up with their respective cams. Carefully tighten the tripper lever set screw bolt.



**Figure 4-45 Declutch Lever / Tripper Lever Installation**

## 26. Tripper Adjustment Refer to Figure 4-46

1. Depress declutch lever. If the lever does not remain in the declutched position, rotate the handwheel approximately 30 degrees and try again. The lever should remain in the declutched position.
2. If required, remove the pipe plug covering the tripper lever external adjustment cap screw and loosen the external tripper adjustment arm cap screw.
3. If required, loosen the long worm shaft assembly cap screw which secures the adjustment arm.
4. Depress and hold down declutch lever. Assure it is fully depressed by rotating handwheel.
5. Position cams so neither tripper will be held off the adjustment arm.

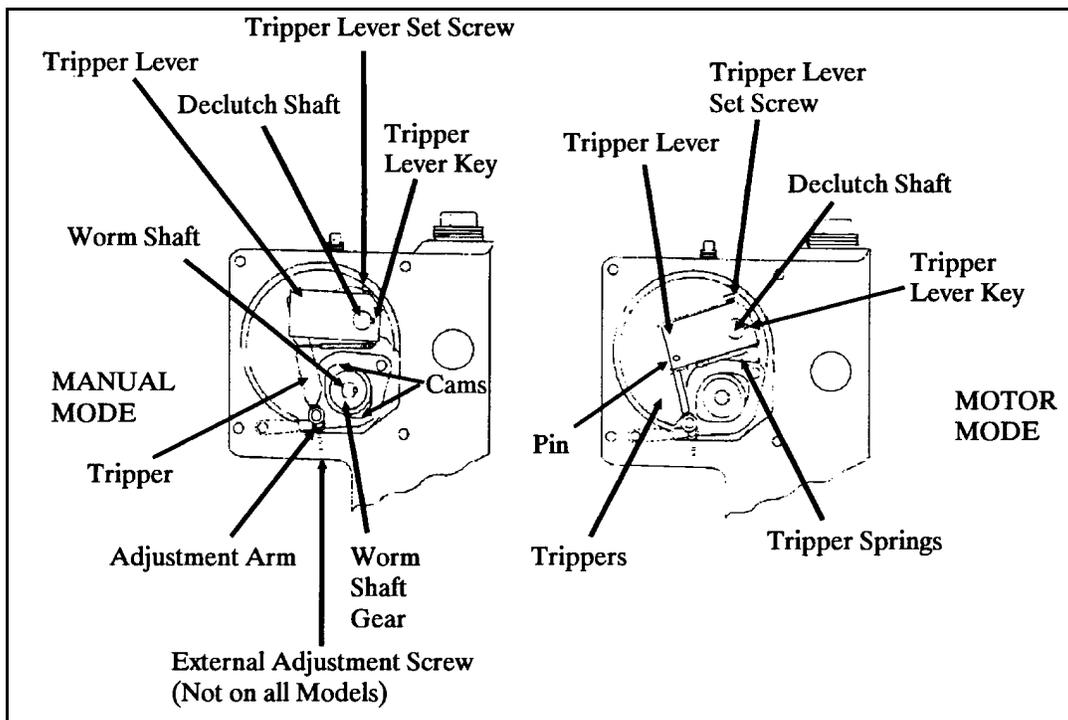


Figure 4-46 Tripper Adjustment

6. Move the end of the declutch lever approximately 1/8" away from the fully depressed condition. This allows component growth on hot systems while still permitting the longest tripper to move onto the adjustment arm.
7. Move adjustment arm up or down until the toes of the longest tripper just touch the adjustment arm. Tighten worm shaft assembly cap screw (long). Adjust external adjustment arm set screw to contact the adjustment arm, if so equipped.

**CAUTION:** Excessively worn or short trippers may ride over the center of the adjustment arm, causing difficulty in rotating the worm shaft. Excessively worn trippers may also slip between the cams and hang up. If either of these conditions exist, replace the tripper lever assembly.

8. Using approved grease, lubricate the trippers and cams.
9. Rotate the worm shaft so the shortest tripper is held off the adjustment arm. Place the actuator in manual.
10. Rotate the worm shaft and check for proper tripping.
11. Rotate the worm shaft so the longest tripper is held off the adjustment arm. Place the actuator in manual.
12. Rotate the worm shaft and check for proper tripping.

**NOTE:** The trippers require a flat "toe" to set on the adjustment arm. After long usage, the toe can be worn away to the point where the trippers will not stay on the adjustment arm. If this condition has occurred, file a flat toe on the end of the trippers as required. Care must be taken to assure one tripper is longer than the other.

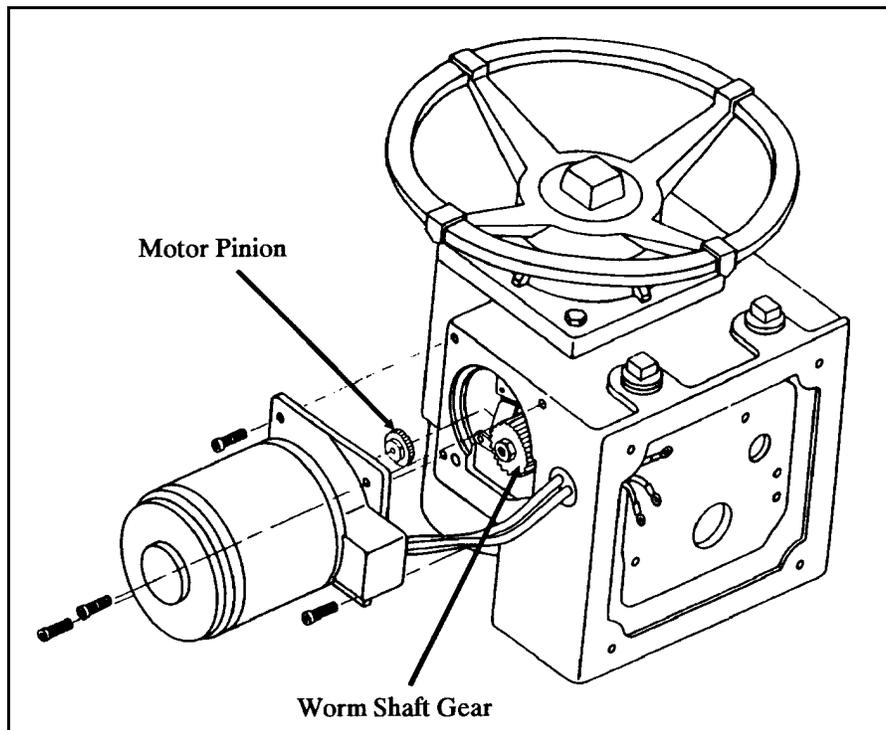
13. Depress the declutch lever and verify correct manual operation with the handwheel.
14. Install cap screw cover if required.

**27. Motor Bearing and Pinion Checkout** Refer to Figure 4-47

1. Remove any lubricant from motor shaft and pinion. While holding the motor shaft, check the pinion for looseness and ensure a snug fit against the shoulder.

NOTE: Any looseness is unacceptable. The pinion is keyed and set screw fastened to the motor shaft.

2. On environmentally qualified actuators, if required, verify that the motor has a T-drain installed at the lowest point for moisture draining purposes. Verify that the T-drain is not fouled, clogged, or painted over. Unclog as necessary.
3. Check the motor housing for cracks.



**Figure 4-47 Motor Bearing and Pinion Checkout**

4. Observe the motor housing for discoloration, or any signs of overheating.
5. Check the motor shaft bearings for roughness and looseness. Looseness can be detected by applying an up-down, side to side motion to the end of the motor shaft (pinion). Any indication of bearing looseness requires bearing replacement.

NOTE: Total number of teeth on pinion and worm shaft gear sets for SMB-000 actuators must be 45.

NOTE: The motor pinion and worm shaft gear should both be replaced if either shows signs of wear. Either gear may be replaced individually for reasons other than tooth wear. Slight deformations, such as nicks and scratches, may be removed with a fine file and emery paper.

6. Check the motor pinion teeth for indications of excessive or abnormal tooth wear.

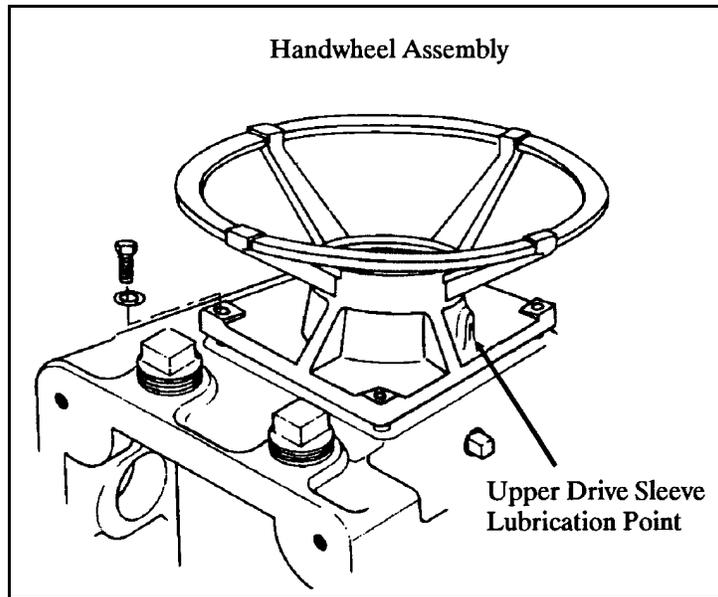
**CAUTION:** If the motor pinion is to be replaced, ensure the set screw for the motor pinion is positioned so that it is closest to the motor. If a pinion is found to have the set screw located in the middle of the gear, make sure the pinion is replaced in the same configuration as it was on the old motor.

7. If the motor is to be replaced, transfer the motor pinion and its set screw to the new motor shaft snug against the shoulder. Reestablish the exact distance from the tooth edge to the motor flange. Ensure the set screw is placed on the motor shaft closest to the motor. Spot drill the motor shaft to accept the set screw.
8. Pack the motor pinion cavity with grease to one inch above the worm shaft gear if possible.
9. The motor gasket should be checked for compression set or damage; replace as necessary. Install the gasket.
10. While supporting the motor, feed the motor power leads through the motor gasket and limit switch compartment port.
11. Install the motor onto the actuator.
12. Install fasteners with washers and tighten.

**28. Actuator Lubrication** Refer to Figures 4-48 and 4-49

NOTE: Actuator should be cycled in the manual position using the handwheel. This allows voids or air pockets in the grease to be released from the gear case.

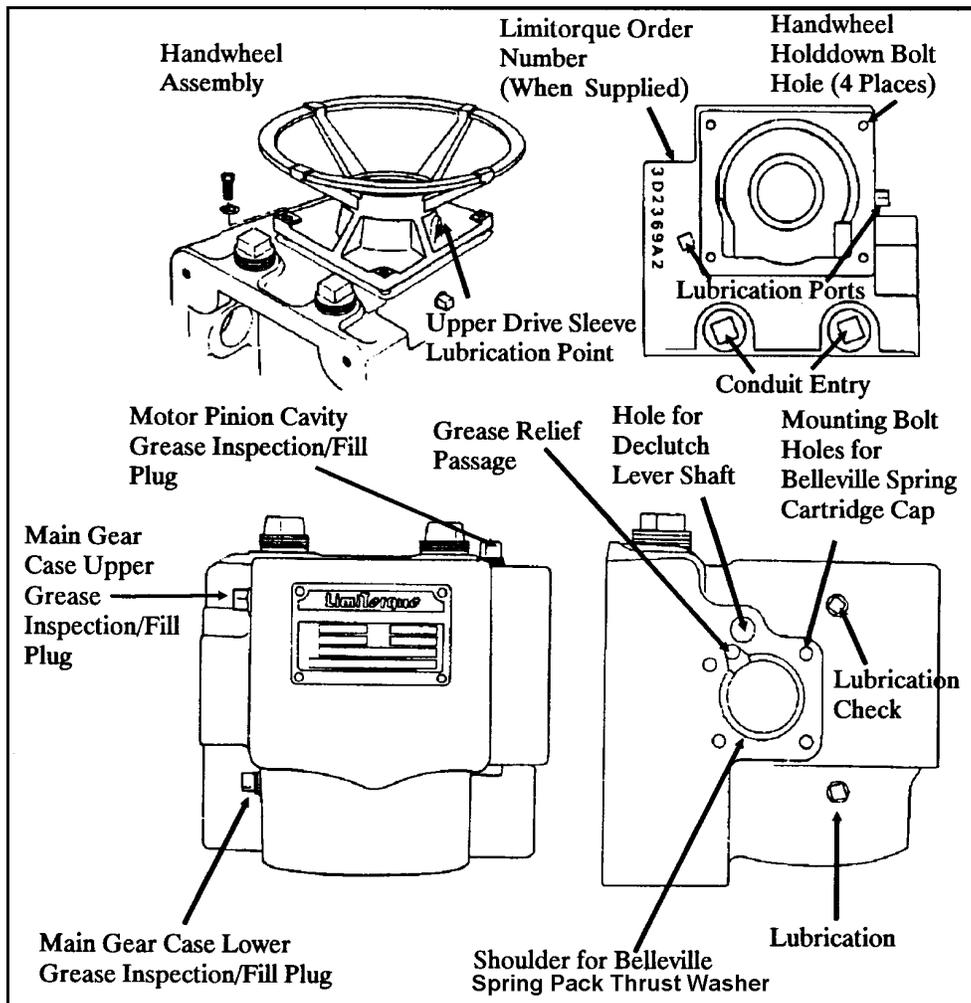
**CAUTION:** Do not mix lubricants with dissimilar bases; use of the same lubricant is preferred.



**Figure 4-48 Actuator Upper Bearing Lubrication Port**

**CAUTION:** The amount of grease needed by the actuator is dependent on the actuator's orientation. A final check of the lubrication level should be performed once the actuator is installed to verify that the worm and motor pinion are totally immersed in grease. Add approximately ½ gallon (or 3.5 pounds) of grease to the SMB-000 actuator. Do not completely fill the gear case with grease.

1. Fill the actuator housing with enough grease to insure the worm/worm gear will be covered in actuator operating orientation.
2. Assure the motor pinion cavity has had grease added. If not, add grease until the motor/worm shaft pinions are covered.
3. If not previously done, add four or five pumps of grease from a grease gun, if possible, to the handwheel grease fitting while turning the handwheel.

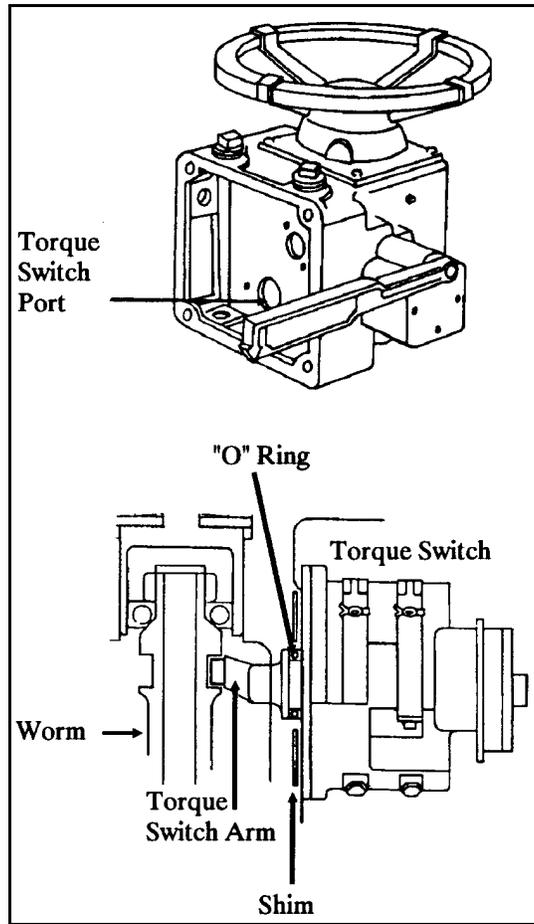


**Figure 4-49 Actuator Main Gear Case Lubrication Ports**

**29. Torque Switch Installation** Refer to Figure 4-50

NOTE: If the torque switch is replaced, remove the torque limiting plate from the torque switch and install it on the replacement switch. All electrical leads disconnected during disassembly must be reconnected.

1. Observe that the control lead termination tamper seals, if equipped, are intact, verifying that the balancing adjustment has been performed and is still valid.
2. Verify that a new, or otherwise intact, lubricated "O" ring of the approved material is installed on the torque switch prior to reinstallation.



**Figure 4-50 Torque Switch Installation**

3. Verify that the torque limiting plate (if required) is installed and that the torque switch settings are set at approximately 1 and 1.
4. Any shims found between the torque switch and housing at the time of disassembly must be reinstalled with any replacement torque switch.
5. Install the torque switch by inserting the torque switch arm with roller into the gear case housing, with the arc barrier between the open terminals and the limit switch housing. The flat side of the torque switch mounting bracket must face the limit switch, or the limit switch cannot be properly installed. If either the open or closed sets of contacts open when aligning the mounting screws, then either:
  - a. The torque switch has been improperly installed.
  - b. The actuator is under a torque loading.
  - c. The torque switch requires balancing.
6. Ensure the torque switch base is flush with the housing. Install the mounting fasteners and tighten.

**CAUTION:** The dial has a sharp edge and can cut fingers.

7. Make sure the roller is properly seated in the worm groove by applying a slight turning pressure to the striker hub. There should be slight free play in both directions.
8. With the spring pack relaxed, set the torque switch in accordance with the instructor's directions.

**NOTE:** Only brown (Fibrite) or grey (Melamine) materials are environmentally approved for use on actuators inside nuclear containments.

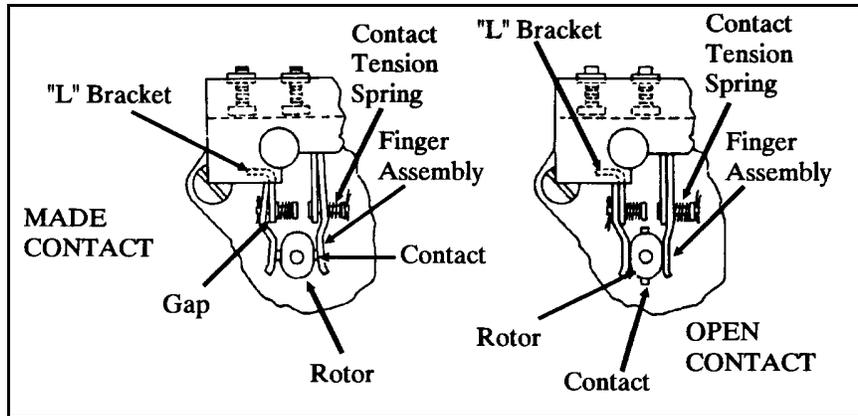
9. Record torque switch color.

Torque switch color \_\_\_\_\_

**30a. Limit Switch Finger Base Installation/Inspection** Refer to Figures 4-51 and 4-16

If a new finger base is to be installed, refer additionally to Figure 4-16 and perform the following:

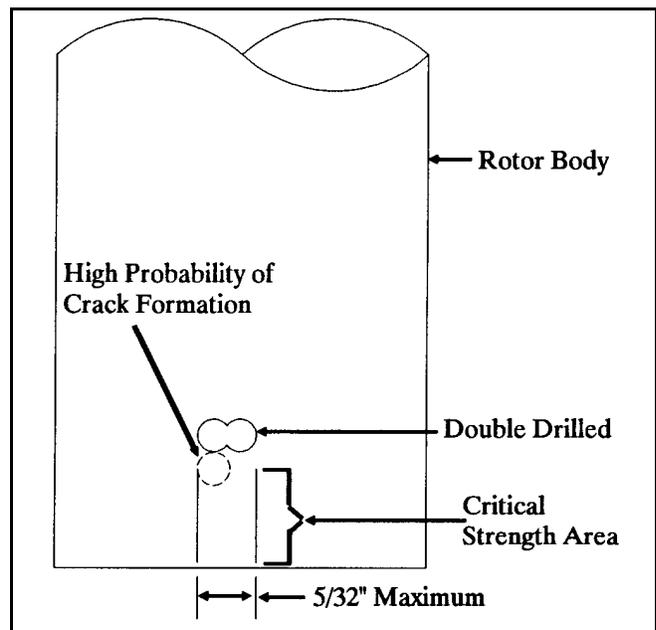
1. Ensure the terminals are identified.
2. Install the finger base onto the rotors, being careful not to damage contacts or crack rotors at the roll pin areas.
3. Secure by installing two fasteners and washers. Do not over tighten.



**Figure 4-51 Limit Switch Contact Tension**

### 30b. Limit Switch Inspection

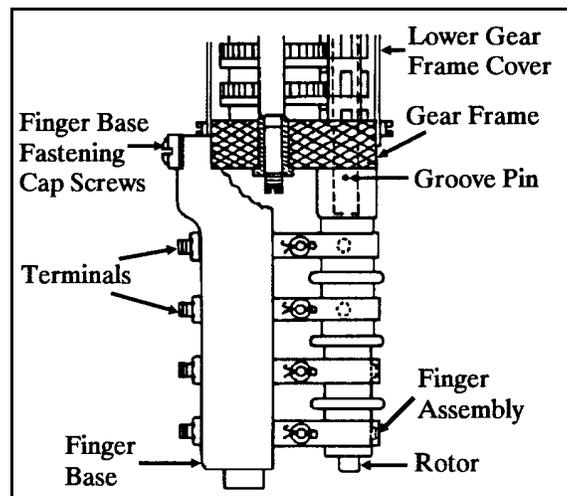
1. Visually inspect limit switch contacts to the maximum extent possible using the following steps.
  - a. Check the L-bracket tension for contacts that are made to assure there is a gap between the L-bracket and the contact finger adjacent to the finger spring at the uppermost tip of the L-bracket. The L-bracket assembly may be bent to obtain a gap.
  - b. Assure the contact finger touches the rotor for contacts that are not made. The L-bracket of the finger assembly may be bent to obtain contact.
2. Inspect the rotor contacts for wear, fouling, corrosion, and damage. Clean as required. Electrical contacts should be cleaned by burnishing and wiping or spraying with an approved solvent. Excessively worn or pitted contacts should be replaced.
3. Inspect the groove pin fastener holes (located on each rotor near the gear frame) in accordance with Figure 4-52. Replace as necessary.
4. Inspect the rotors for cracks, especially in the vicinity of the roll pin. Replace any rotors that have cracks.
5. Inspect the rotors for a small clearance between the rotor and the limit switch gear frame. Rubbing of the rotor against the gear frame may cause excessive rotor drag.
6. Inspect the rotors for straightness (contacts must be able to mate).
7. Inspect the finger base for cracks, especially in the area around the gear frame attachment fasteners. Replace a cracked finger base with a new finger base of approved material.



**Figure 4-52 Double Drilled Rotor  
(Groove Pin Area)**

### 31. Removal and Replacement of Limit Switch Rotors Refer to Figure 4-53

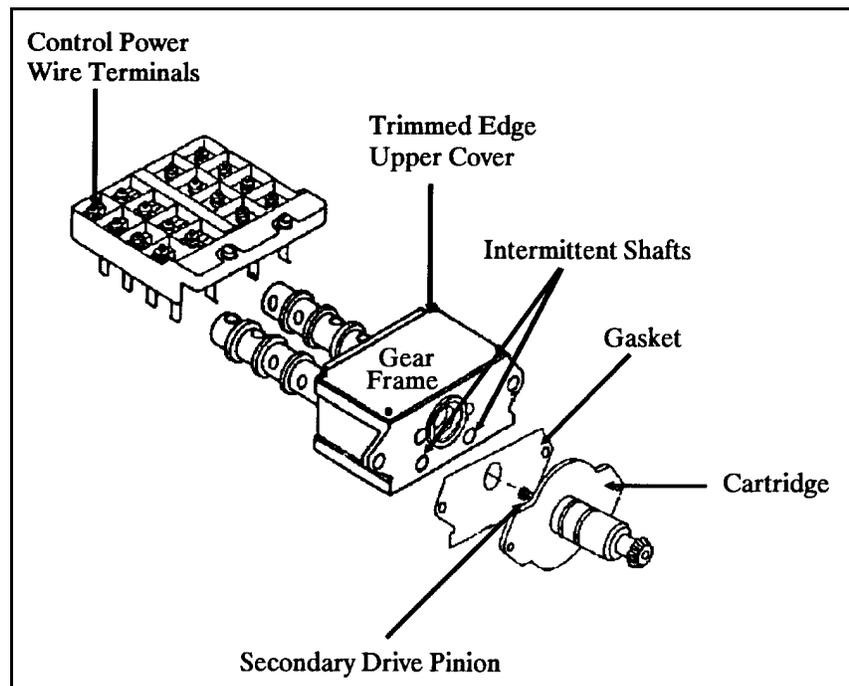
1. Rejected rotors may be replaced with Fibrite rotors.
2. Note the orientation of rotor contacts and then remove the rejected rotor using a hammer and punch to drive out the rotor groove pin.
3. The replacement rotors have the pilot hole drilled halfway through the rotor in two places.
4. Install the replacement rotor to the correct contact and pilot hole orientation as determined in step 2 above.
5. Drill through the rotor with a number 40 drill.
6. Insert the 3/32-inch roll pin with a driver.



**Figure 4-53 Limit Switch Rotor Replacement**

**32. Installation of Limit Switch Cartridge into Actuator** Refer to Figures 4-54, 4-55, 4-16.

1. Ensure that the drive pinion is not damaged or loose on the shaft. Replace cartridge if necessary.
2. Install a new, or otherwise intact, lubricated "O" ring of correct material on the cartridge shaft.
3. Install shims, as applicable, onto the cartridge.
4. Install the cartridge into the actuator housing by inserting the geared end of the cartridge shaft into the housing.
5. Place the actuator in the manual mode, turn the handwheel, and ensure that the secondary pinion(s) turn.
6. For four-train assemblies, install cartridge with fasteners and tighten.



**Figure 4-54 Two-Train Limit Switch and Cartridge Assembly**

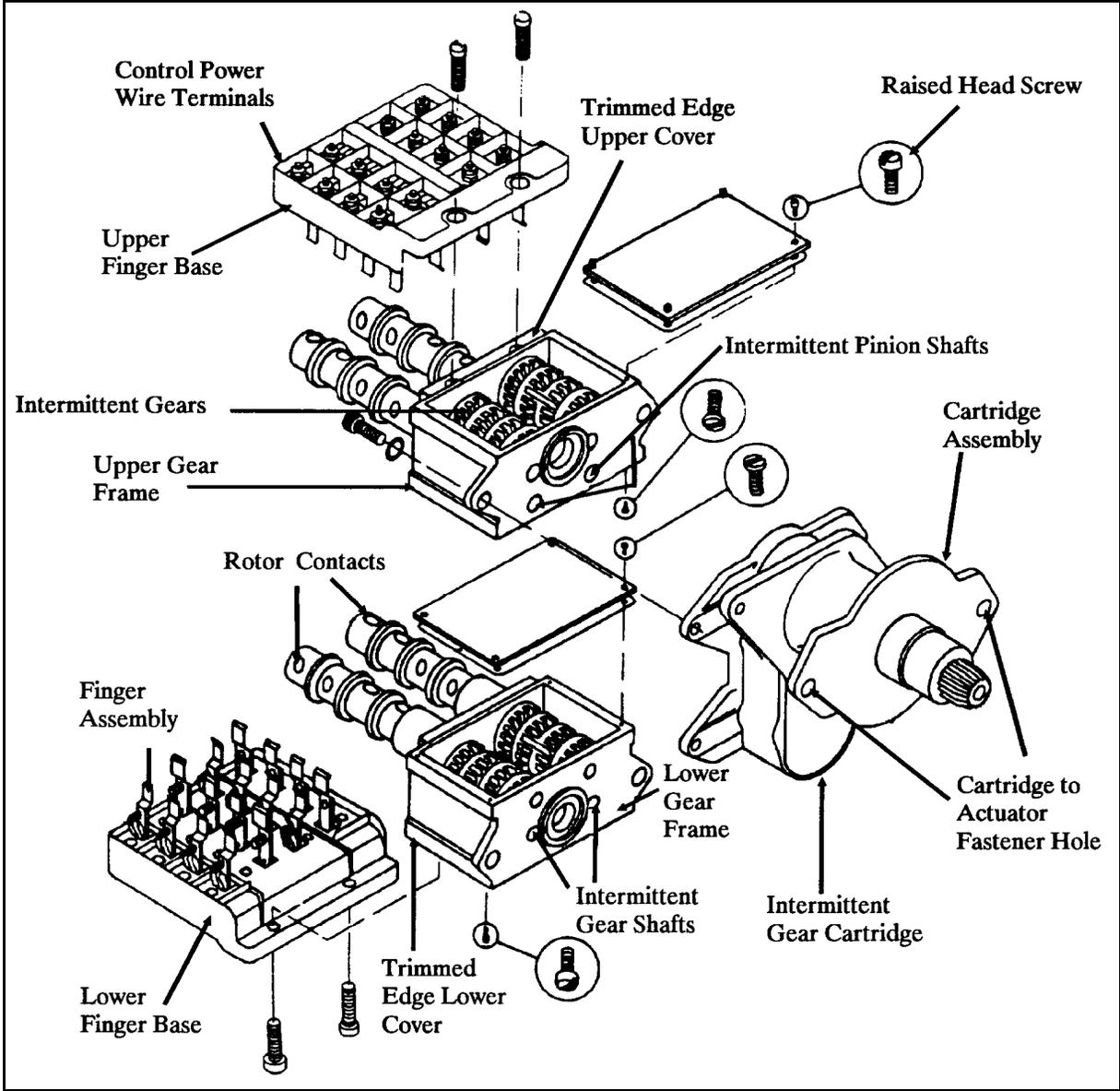


Figure 4-55 Four Train Limit Switch Exploded View

### 33. Installation of Gear Frame onto Cartridge and Actuator

1. Coat the gear frame gasket surface with a thin film of grease.
2. Install the gear frame(s) onto the cartridge assembly with the gear frame gasket(s) between the mating surfaces.

#### 33a. Two-Train Limit Switch Gear Frame Installation

1. Secure the gear frame and cartridge assembly to the actuator by installing two fasteners with washers.

#### 33b. Four-Train Limit Switch Gear Frame Installation

1. Secure the gear frames onto the cartridge assembly by installing two fasteners with washers for each gear frame.
2. Install the match marked gear frame to its appropriate location.

### 34. Limit Switch Materials

NOTE: Only brown (Fibrite) or grey (Melamine) materials are environmentally approved for use on actuators inside containment.

NOTE: A pebbly surface on the limit switch gear frame indicated a bronze casting which is approved for use on environmentally qualified actuators in containment. A smooth gear frame surface is indicative of an aluminum limit switch. Determination of housing material using gear frame color is misleading.

1. Record Limit switch plastic material color and gear frame material.

Rotor Upper: \_\_\_\_\_

Rotor Lower: \_\_\_\_\_

Finger Base Upper: \_\_\_\_\_

Finger Base Lower: \_\_\_\_\_

Gear Frame Material Upper: \_\_\_\_\_

Gear Frame Material Lower: \_\_\_\_\_

**NOTE:** This concludes the tasks to be performed in the classroom. Allow the instructor to examine your actuator for proper operation.

**35. Actuator Installation** Refer to Figures 4-8, 4-11, 4-56, and 4-57

1. Reinstall the limit switch compartment cover and gasket, if required. Transport actuator to valve location.
2. Remove the temporary valve stem thread protection if installed.
3. Clean and lubricate the valve stem threads with approved valve stem lubricant, if not previously performed.
4. Attach rigging to the actuator.

**CAUTION:** Do not lift the actuator by the handwheel or declutch lever.

**NOTE:** Align actuator to yoke match marks during installation onto the valve.

5. If the stem nut and stem nut locknut have not previously been installed, perform the following.
  - a. Lower actuator onto the valve yoke.
  - b. Align valve yoke flange and actuator match marks.

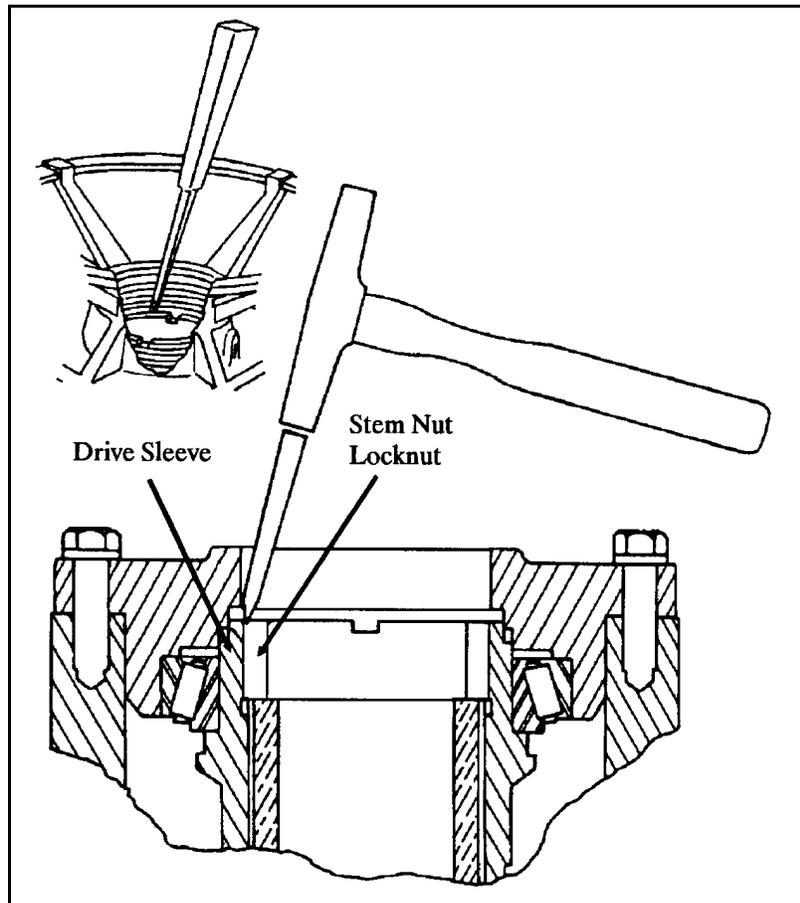
**CAUTION:** Leave actuator free to move so the stem nut can find its center when installed; otherwise it will bind.

- c. Install actuator to the valve with fasteners and washers.
- d. Thread the stem nut onto the valve stem.
- e. Place the actuator into the manual mode by depressing the declutch lever.
- f. Align the stem nut spline to the drive sleeve splines and turn the handwheel in the open direction to fully seat the stem nut.

**CAUTION:** When staking the stem nut locknut, do not mushroom (excessively damage) the drive sleeve.

- g. Install the stem nut locknut tight against the stem nut and stake in place to prevent loosening. (Figure 4-56)
  - h. Tighten the mounting bolts to the proper torque.
6. If the stem nut and stem nut locknut have been installed, perform the following:
- a. Depress the declutch lever.

**CAUTION:** Position the actuator directly above the valve so the stem nut and stem line up. **Do not** allow the actuator to teeter on the valve stem.



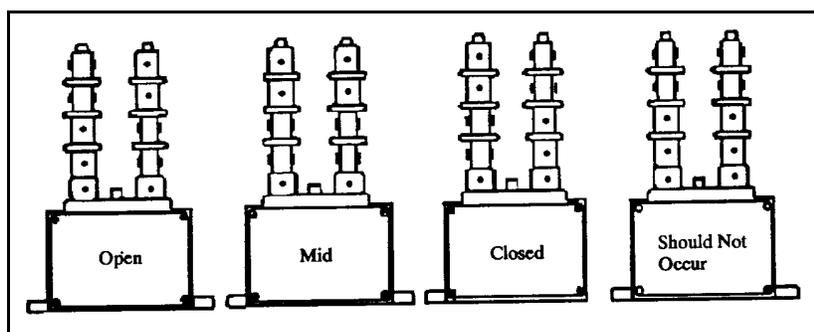
**Figure 4-56 Locknut Stacking**

- b. Carefully lower the actuator onto the valve stem until the stem nut threads are engaged with the valve stem threads. Some handwheel open direction rotation will be required.
- c. Turn the handwheel in the open direction while lowering the actuator onto the valve.
- d. Align the valve yoke flange and actuator match marks.

**WARNING:** If the actuator fasteners are torqued down without the actuator being completely pulled down onto the valve yoke, either the valve disk will be forced into the seat with possible damage, or the valve stem will be bent.

- e. Install the valve to actuator using fasteners and washers.
7. Torque the actuator fasteners to required values. The torque value on these bolts is critical for normal operation and seismic qualification, if required. The bolts may be prevented from backing out by using lock wire or thread locking compound.  
  
Torque: \_\_\_\_\_
  8. Remove the valve stem clamp (if installed).
  9. Install the indicator rod (if so equipped) and pipe cap or stem protector.
  10. Obtain permission from Operations to manually stroke the valve.
  11. Manually stroke the valve and check for binding scraping, and/or erratic operation. Leave the valve in the position noted when the actuator was removed.
  12. Remove the limit switch compartment cover and engage the limit switch by turning the set rod in the counter clockwise direction until it stops.

13. Verification of limit switch coarse adjustment may be performed at this time. (Figure 4-57)
14. Attach all disconnected actuator appendages e.g. electrical conduit, etc.
15. Reconnect the valve actuator electrically, if not previously performed, ensuring the leads are marked and installed accordingly.
16. Reinstall the limit switch compartment cover and gasket.
17. Perform post-maintenance testing.



**Figure 4-57 Limit Switch Configurations**