Metro

P3010
Los Angeles LRV

PANTOGRAPH

Section 0800
RUNNING MAINTENANCE & SERVICING MANUAL

LIST OF EFFECTIVE PAGES

Insert latest changed pages; dispose of superseded pages in accordance with applicable regulations.

NOTE: On a changed page, the portion of the text affected by the latest change is indicated by a vertical line.

Total number of pages in this section (0800) is **64** consisting of the following:

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SAFETY SUMMARY

Some of the procedures in this section are preceded by warnings/cautions regarding potential hazards in handling this equipment. These warnings/cautions should be carefully read and understood before proceeding. Failure to observe these precautions may result in serious injury or death to personnel performing the work and/or bystanders. The key warnings for this equipment are as follows:

Electrical - The electrical equipment described in this section operates at voltages and currents that are extremely dangerous to life. Personnel should closely observe all generally prescribed cautions and warnings before performing any work on the LRV.

Chemicals – Follow safety precautions for handling hazardous chemicals as provided by the manufacturer. The manufacturer's warnings should be closely heeded to avoid personal injury.

Location – Special caution should be taken when accessing or servicing equipment located on the roof and under the car.

Weight – To prevent possible personal injury when attempting to remove or install equipment on the vehicle, adequate support of a lifting device must be used to prevent the equipment from falling. Personnel's failure to heed these warnings could result in severe injury or death and or damage to the equipment.

Stored/Potential Energy – Some components of this pantograph store a large amount of energy that can quickly be released leading to serious injury or even death. Closely follow all warnings and recommended procedures for handling the pantograph and its related components. Personnel should additionally stand clear during the raising and lowering of the pantograph.

WARNING

TO PREVENT SERIOUS INJURY OR DEATH: BEFORE PROCEEDING WITH ANY SERVICE TO THE PANTOGRAPH, ENSURE THE SAFETY PIN IS FULLY ENGAGED PER SECTION 4.2 OF THIS MANUAL.

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CHAPTER 1.0

GENERAL DESCRIPTION

1.1 Introduction

The function of the pantograph is to provide power from the Overhead Catenary System (OCS) to the car; this is achieved by conducting electricity through the carbon assemblies on the collector head, the shunts, the members of the pantograph and ultimately through the power take-off plate(s) on the base frame. The pantograph is electrically insulated from the car roof by insulators which are mounted on the roof and to which the pantograph feet are bolted. The pantograph is spring-raised and lowered by an electric ball screw linear actuator with a shear pin release. The shear pin release is part of the Auto Drop Device (A.D.D.), which minimizes the opportunity for damage to the pantograph and catenary system in the event of collision. The collector head includes a suspension that allows for optimal wire tracking of the catenary and absorption of obstructions. An adjustable dampening system is utilized to ensure proper wire tracking and smooth pantograph raising and lowering. A hand crank is provided such that in the event of a loss of power the pantograph can be raised or lowered manually.

1.2 Reference Data

Table 1-1. Reference Data

Description	Specification	
Annual mileage	120,000	
Design life	30 years	
Temperature	-7C to 46C (20F to 115F)	
Wind	30 sustained, 75mph gust	
	From top of rail	From bottom of pantograph insulator
Lockdown height	149.88 inches (3807mm)	17.15 inches (435mm)
Maximum operating height	282 inches (7163mm)	149.15 inches (3788mm)
Minimum operating height	153.81 inches(3907mm)	20.95 inches (532mm)
Lateral misalignment	+/- 1 inch (51mm)	
Carbon length	42 inches (1067mm)	
Head width	78 inches (1981mm)	
Carbon spacing	11.8 inches (299mm) maximum outside to outside	
Weight	418 lbs. (195 kg)	
OCS	750VDC (550VDC minimum)	
Low voltage DC	28.5V nominal (17-30VDC range)	
Maximum safe speed	70 mph (113 km/hr)	
Maximum current	1400A per car	
Design	Single arm, bi-directional design	
Maximum reach	287 inches (7290mm) from top of rail	
Head	One-segment carbon insert, cast aluminum end horns, 1981mm wide	
Cross-bar	Non-Insulated	
Bearings and lubrication	Sealed roller bearings and non-lubricated bushings	
Power take-off plate	Tinned copper	
Roof mount	4 non-tracking insulators at 1000x850mm	
Head	Rotation about lateral axis, spring mounted to upper arms, stable tracking at all speeds	
Carbon life	50,000 miles (approximately 80,000km)	
Head	Each carbon assembly individually adjustable to maintain planar head	
Head force	20 lbf.+/- 3.4 lbf (89 N +/- 15 N)	
Lateral stability	65.2 lbs. (290N) load at max height with max deflection of 1.5 inches (38m)	
Electrically lowered	No more than 8 seconds, rapid initial motion to minimize arcing	
Spring raised	Spring raised when restraining mechanism released, speed controlled to prevent damage when striking wire	
Electric motor	Operate at specified voltage ranges	
Manual raise/lower	Operable from inside the vehicle using the provided manual crank	
Shear pin	Replaced with common hand tools	

1.3 Abbreviations/Acronyms

Table 1-2. Abbreviations/Acronyms

Abbreviation/Acronym	Description
OCS	Overhead Catenary System
ADD	Auto Drop Device
RMM	Running Maintenance Manual

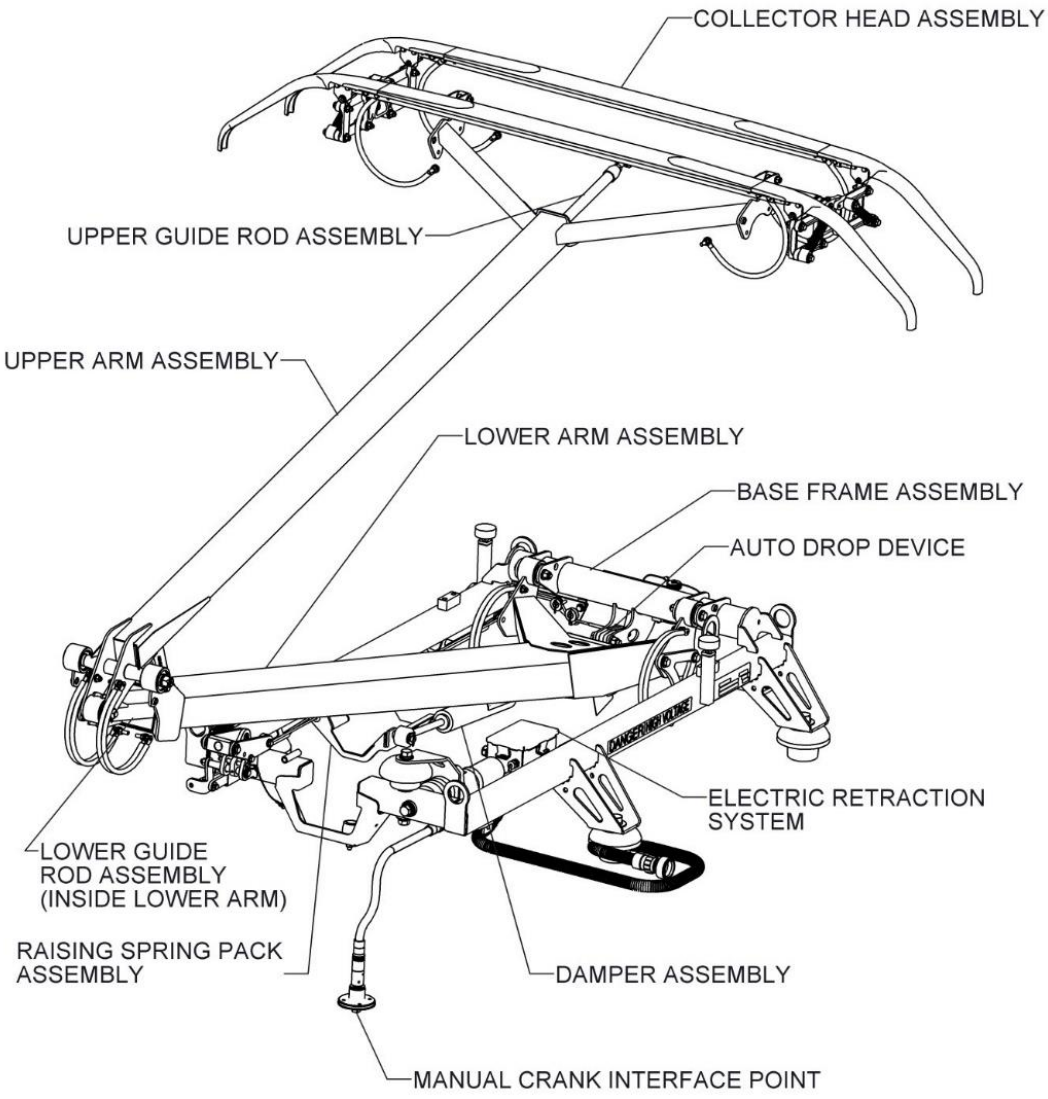

Figure 1-2: Pantograph Assembly

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CHAPTER 2.0

FUNCTIONAL EQUIPMENT DESCRIPTION

2.1 Base Frame Assembly

The fabricated base frame has four attachment points for roof mounted insulators and is provided with mounting and attachment points for the lower arm, lower guide rod, a spring pack, a damper, electric ball screw actuator, down-stop bumpers, manual latch assembly, and power terminals. See Figure 2-1.

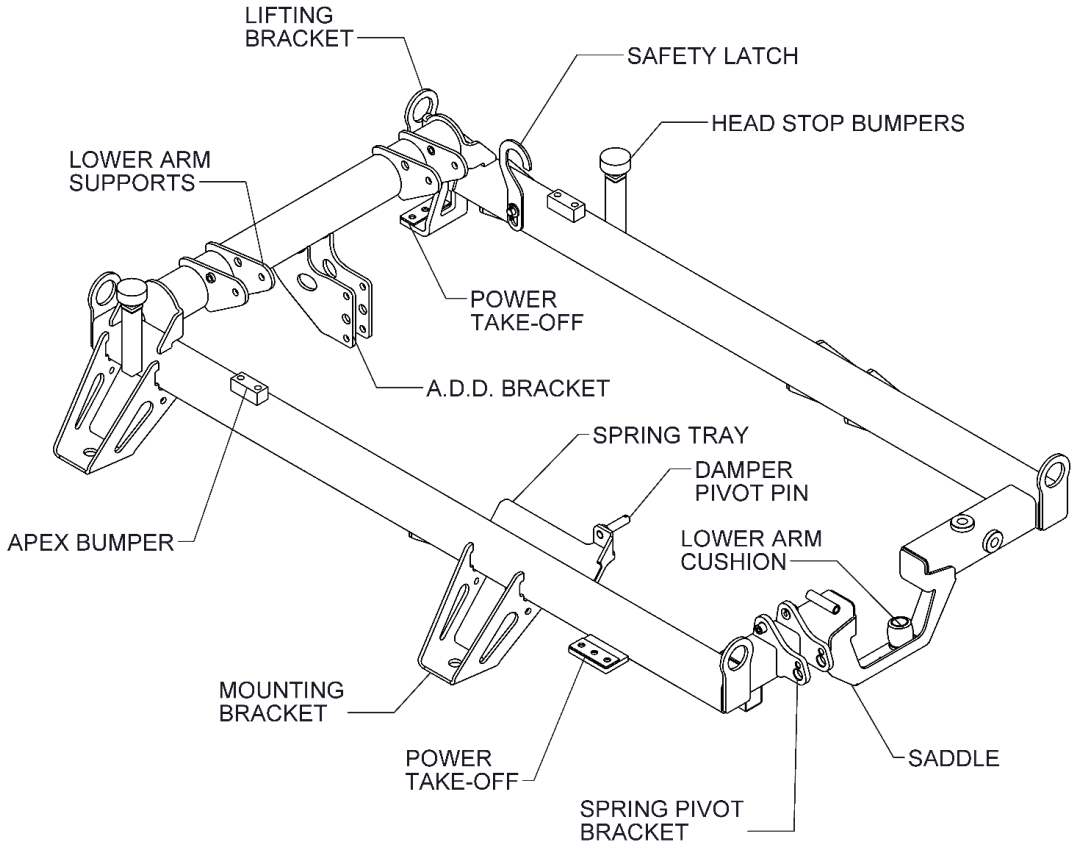

Figure 2-1: Base Frame Assembly

2.2 Lower Arm and Lower Guide Rod Assembly

A tube-in-tube design, where the fourth bar of the four-bar linkage that governs the pantograph motion is located inside the main lower arm, provides improved aerodynamic performance and reduced area for ice buildup. The lower arm and fourth bar are steel and fully welded and provisions for sealed bearings for the lower and upper axles; all bearings are insulated from the electrical circuit to prevent arc damage to the bearings. See Figure 2-2.

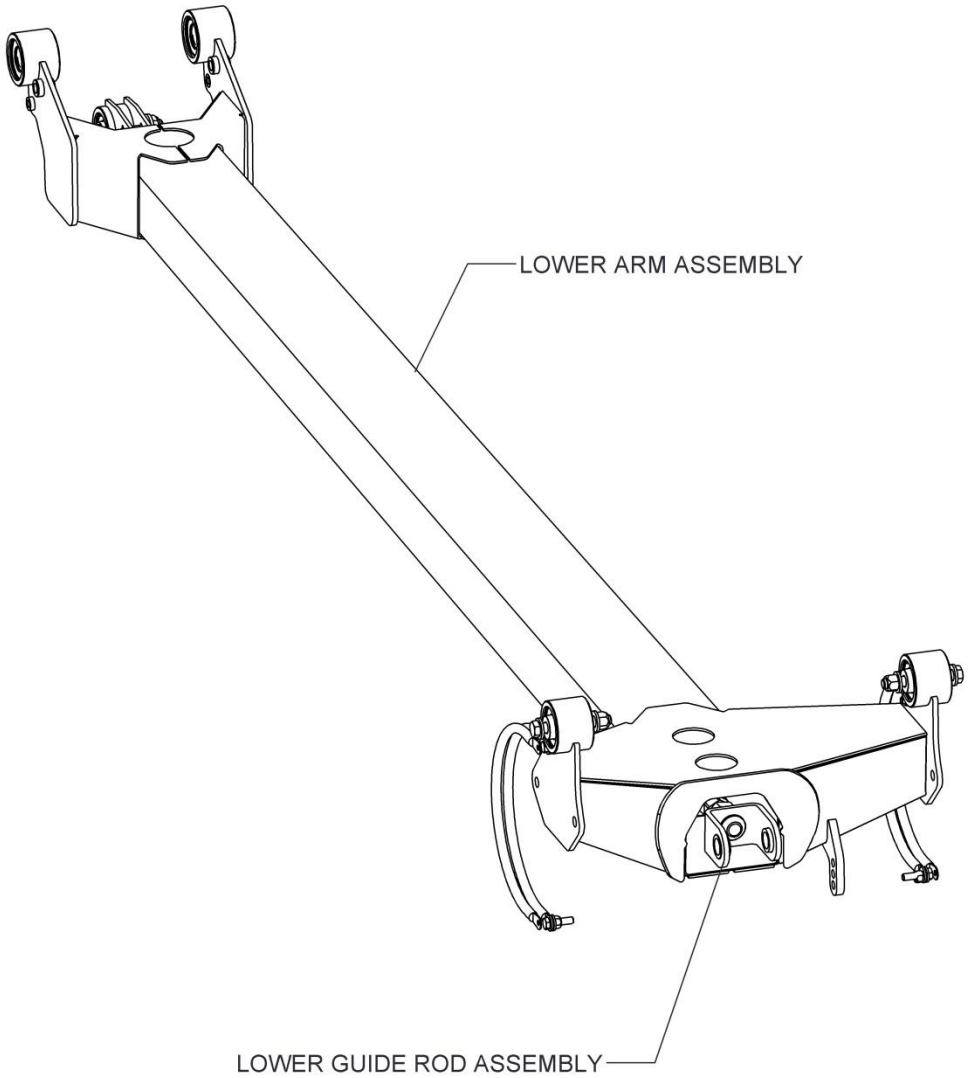

Figure 2-2: Lower Arm Lower Guide Rod Assembly

2.3 Upper Arm and Upper Guide Rod Assembly

As with the lower arm assembly, the upper arm also uses a tube-in-tube design with an internal upper guide rod that provides the head-leveling functionality. The upper arm is fabricated in steel and fully welded for exceptional strength while maintaining low weight. The upper arm is essentially the same length as the lower arm, providing superior kinematics with very small lateral variation throughout the full range of motion. See Figure 2-3.

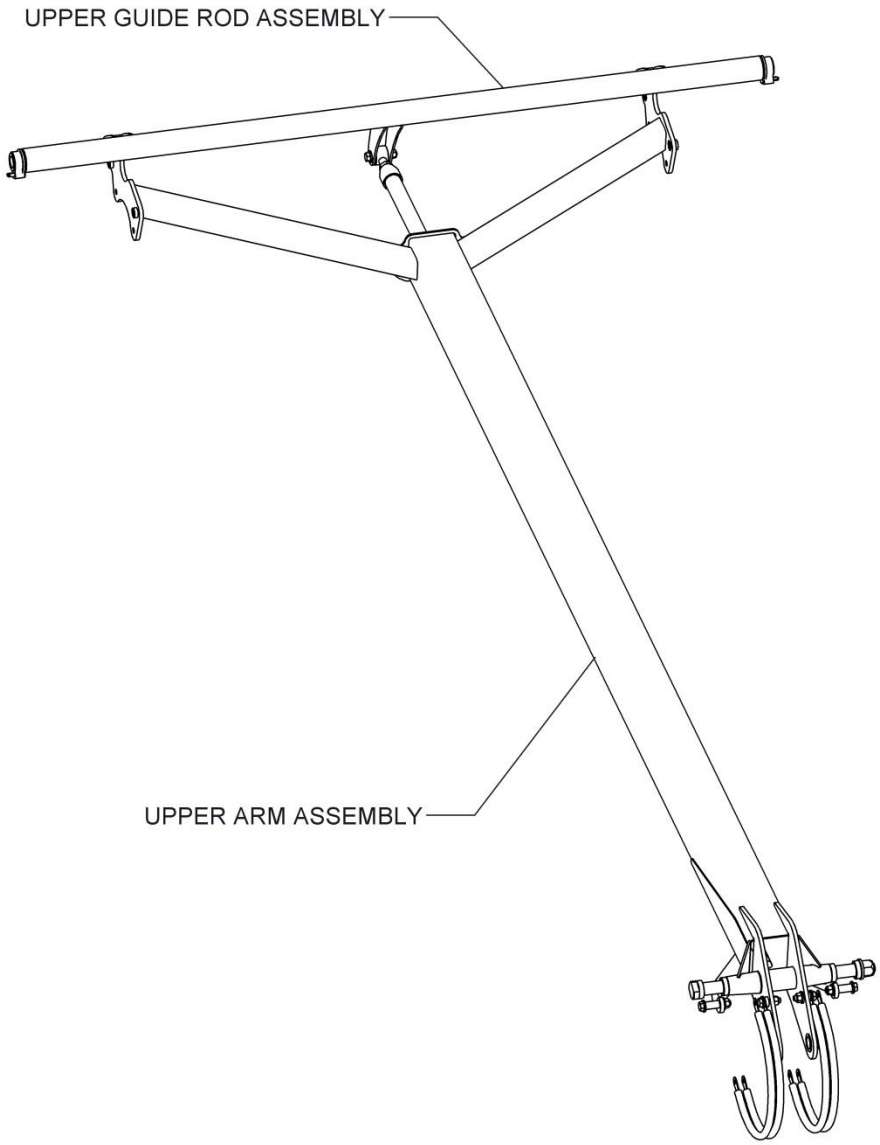

Figure 2-3: Upper Arm and Upper Guide Rod

2.4 Collector Head

The head assembly collects the current from the Overhead Catenary System (OCS). It includes two lightweight one-piece carbon assemblies and two aluminum end horns. The carbon assemblies collect the current and the end horns prevent the OCS from getting caught on the bottom side of the head in the event the OCS travels off the edge of the carbon. The head assembly utilizes an independent spring suspension with low sprung mass to permit high-speed responsiveness and excellent tracking to the OCS. See Figure 2-4.

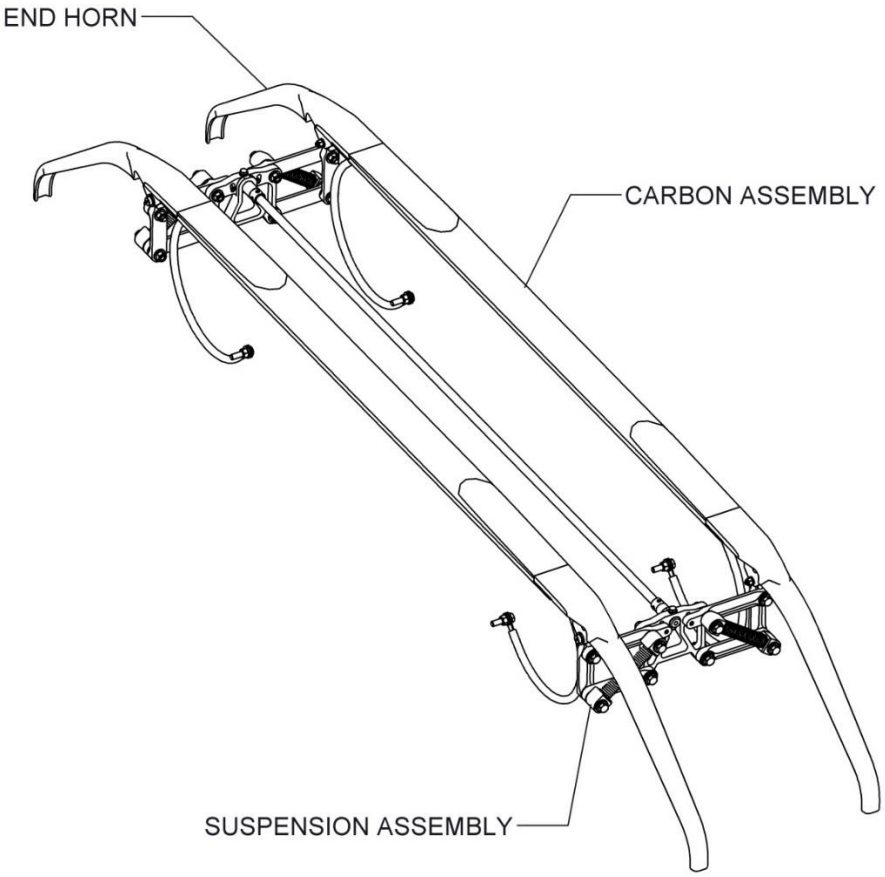

Figure 2-4: Collector Head Assembly

2.5 Damper

The damper limits the speed with which the collector head strikes the wire on raising and it controls the lowering speed and contact force to the down-stop bumpers. The damper also improves head tracking on the OCS, which ensures effective current collection performance at high speeds. See Figure 2-5.

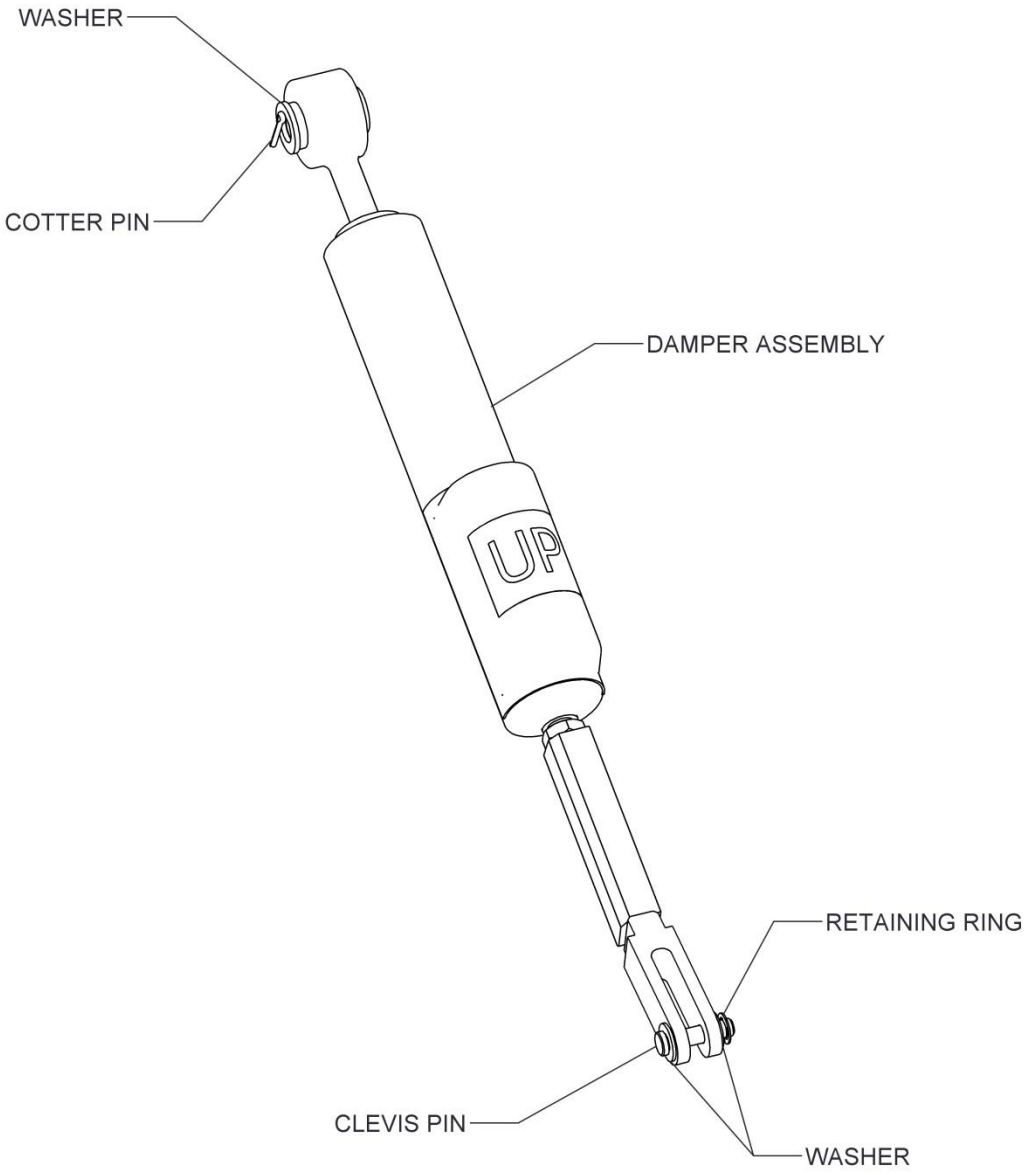

Figure 2-5: Damper and Hardware

2.6 Pantograph Raising and Lowering (Raising Spring Pack)

The collector head is raised by two springs working in tandem, in a spring-pack (Figure 2-6), which oppose the weight of the pantograph head and arms. In the lock-down position these springs are under tension and store the energy required to raise the pantograph. The springs track the catenary during operation and generate the upward force required to press the head against the OCS at 20 lbf +/-3.4 lbf (89N +/- 15N). On command from the train's cab the linear ball screw actuator retracts to allow the spring tension to raise the pantograph head. The guide tube, which is attached to the lower arm mounting bracket, is designed to slide back and forth over the shaft of the ball screw actuator to allow for vertical motion variations due to any variations in the OCS wire height (See Figure 2-7). This allows for the continuous OCS wire tracking without requiring any movement in or out of the ball screw actuator.

The raising springs are connected between the base frame and the lower arm and they are fully extended when the pantograph is in the lock-down position. As the pantograph rises, the length of the springs decreases. The upward force of the head is regulated by the kinematics of the pantograph design.

Lowering is achieved by an electric retraction system (See Figure 2-7) installed between the base frame and the lower arm. The retraction system's actuator is not active during wire tracking. When the pantograph lowering sequence is employed, the ball screw actuator shaft extends, opposing the forces generated by the raising springs, thereby lowering the pantograph head. The ball screw actuator shaft, when fully extended, places the pantograph in the lock-down position.

Refer to Section 3.1.3 of the Schematic and Narrative Manual for additional information on the electric retraction system.

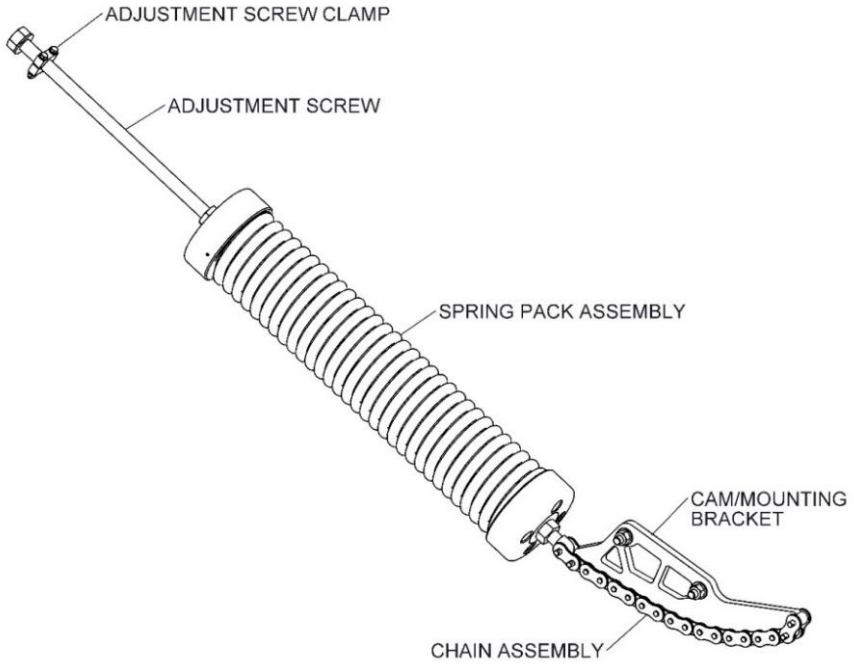

Figure 2-6: Spring Pack Assembly

2.7 Electric Retraction System

The electric retraction system runs on low voltage DC power. It is mounted between the base frame and the lower arm and is electrically insulated from the high voltage main assembly components by three (3) insulators. See Figure 2-7. The electric retraction system counters the lifting force exerted by the main spring.

When retracted the retraction system is retained in the lowest position by a holding brake in the motor. See Figure 2-7. This mechanical locking brake is effective even when electrical power is interrupted and it does not inhibit raising the pantograph with the manual crank.

The drive motor is powered from the low voltage DC car supply through the electrical connection. See Figure 2-7. The retraction system contains two magnetic limit switches (Lower Limit Switch, Upper Limit Switch) that provide momentary signals to stop the motor drive at the fully up and fully down positions. See Figure 2-7. These two limit switches are normally closed and will open when they contact the magnet that travels back and forth inside the ball screw actuator. When the limit switches open they interrupt the circuit, providing the signal to the car to stop the motor. The ball screw travels between the fully up and fully down positions that are set by the limit switches. The ball screw does not stop at any other position in-between.

The Actuator Guide Tube provides the ability for the pantograph to move in relation to the motor drive assembly along the Actuator Guide Shaft. When the pantograph is raised the motor drive assembly follows the lower arm. When the pantograph is lowered, the Actuator Guide Shaft extends into the Guide Tube to force the pantograph downward. The Actuator Guide Tube rides on the Actuator Guide Shaft with wear bushings at the interface.

Refer to Section 3.1.3 of the Schematic and Narrative Manual for additional information on the electric retraction system.

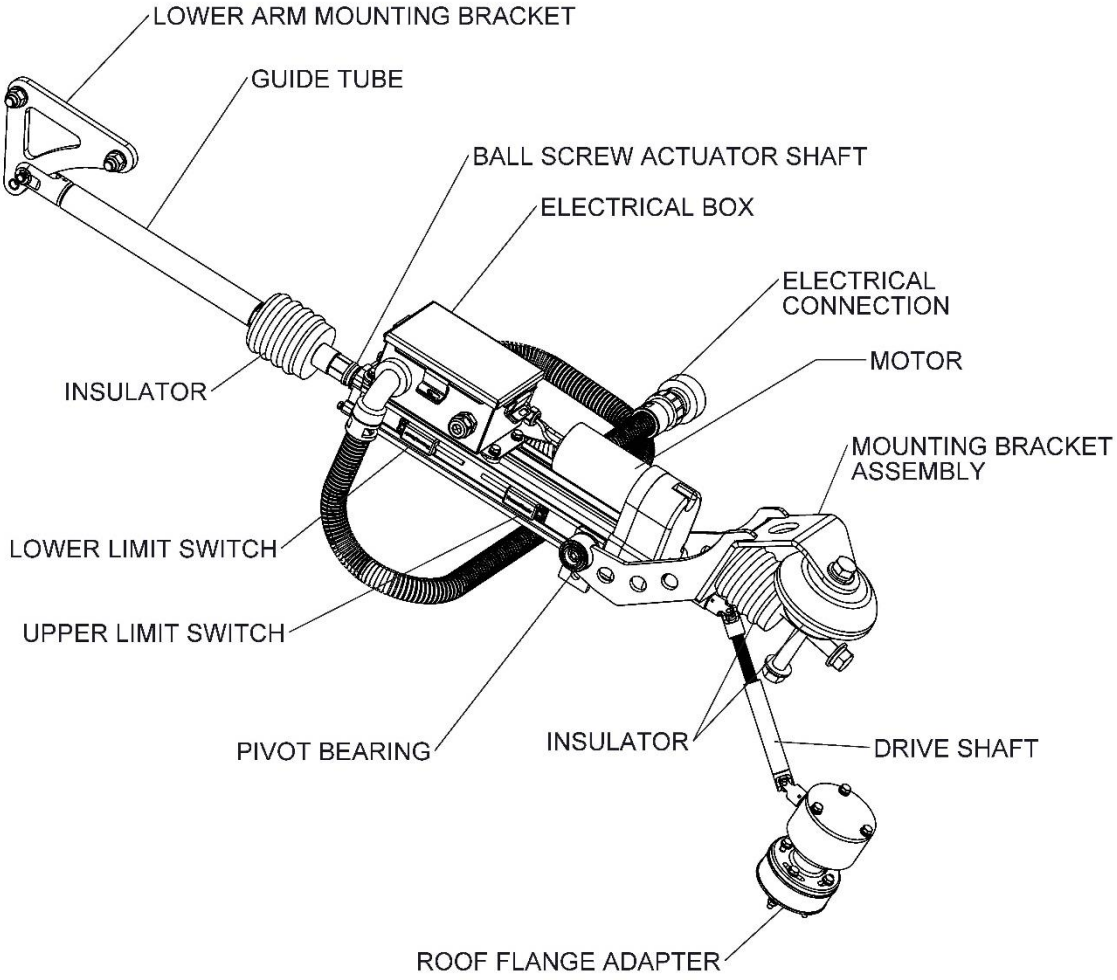

Figure 2-7: Electric Retraction System

2.8 Auto-Drop Device

The Auto Drop Device (A.D.D.) is a safety device that allows the pantograph to drop down, away from the OCS, in the event of a collision with an obstruction. The A.D.D. consists of a shear pin assembly located at the connecting joint of the base frame and lower guide rod. If the collector head strikes a hard obstruction, the excessive force is transmitted through the guide rods into the shear pin, shearing the pin and breaking the connection between the guide rods bar and the base frame. The cable tension is relaxed by the breaking of the shear pin. The cable tension assembly spring extends by the release of the cable assembly tension, unhooking the spring release assembly. This action triggers a mechanism to release the tension of the lifting springs, causing the primary spring to release its load. The absence of this spring assisted force allows the collector head to drop due to its own weight where it rests on the base frame down stops. See Figure 2-8.

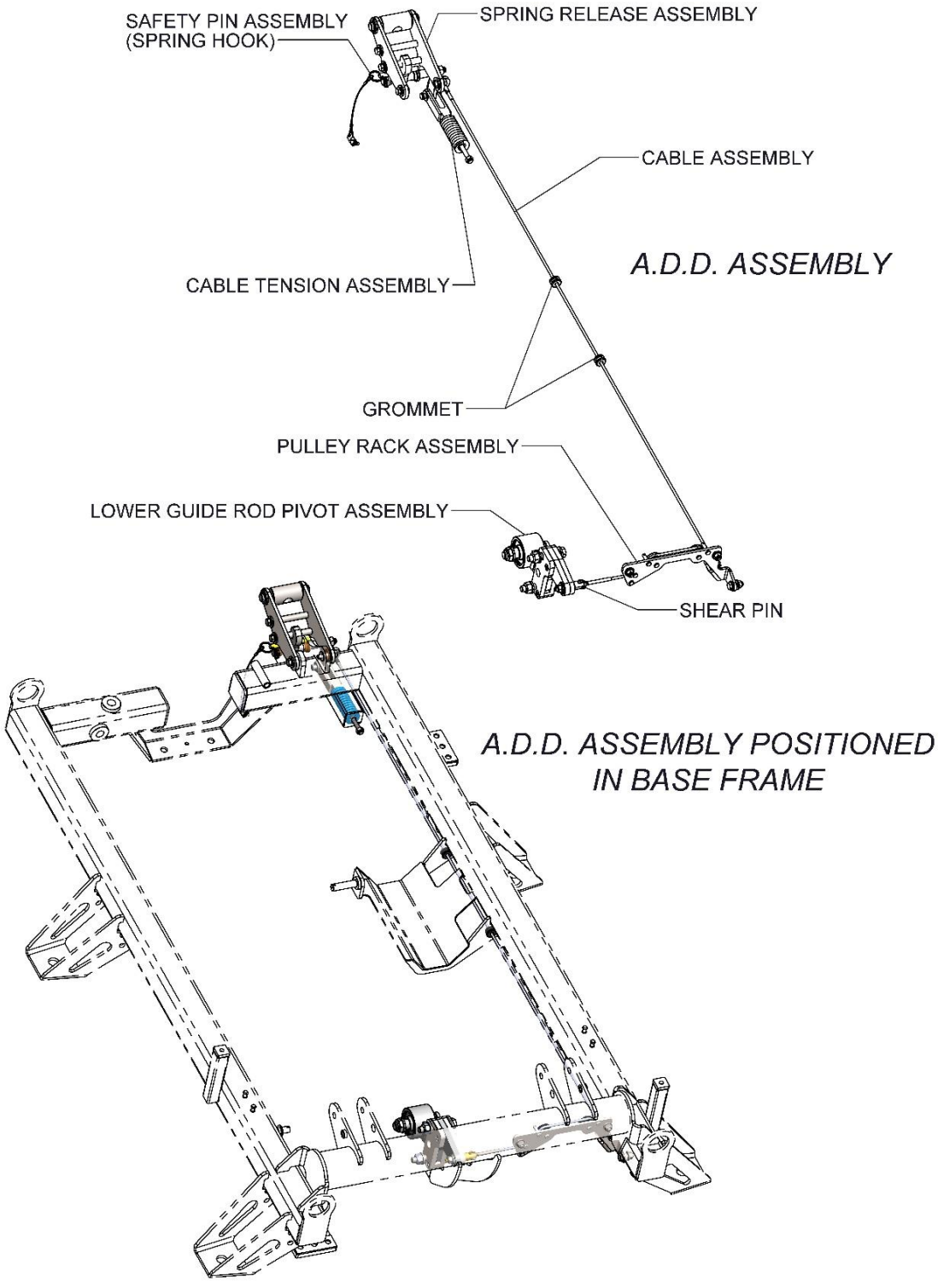

Figure 2-8: Auto-Drop Device

2.9 Manual Crank

A manual crank, insulated to protect against stray voltage, is provided for use from inside the car to lower and raise the pantograph in the absence of electrical power. See Figure 2-9.

The manual crank is stored in the A-unit articulation locker. See Figure 2-10. An access opening to connect the manual crank to the pantograph gear box is provided in the roof of the car. See Figure 2-11. The manual crank is inserted through this access opening and into a connection point in the bottom of the gearbox for the spindle drive.

A gear box is connected to the pantograph spindle drive. When the manual crank is turned (less than 3 lbs. of torque) the pantograph is raised or lowered. Maintain an upward force on the manual crank and turn clockwise to raise or counter-clockwise to lower the pantograph.

When the pantograph reaches the lowered position, an increase in the cranking force will be noticed. The sound of the pantograph contacting the impact bumpers can also be heard. This indicates that the pantograph is lowered and no further turning is necessary.

WARNING

TO AVOID POSSIBLE DAMAGE, DO NOT OVER WIND AFTER THE PANTOGRAPH IS COMPLETELY LOWERED.

When the pantograph reaches the raised position, an increase in force will be noticed. Use caution when manually raising the pantograph. It is possible to extend the pantograph beyond the normal stop position if excessive force is applied. If in question, it would be helpful to use an observer standing outside of the car.

It is recommended to manually raise the pantograph only high enough to achieve electrical contact with the catenary. After power has been re-established to the car systems and batteries, the pantograph should be lowered and raised again using the electric retraction system. This will ensure the pantograph has been raised to the correct point determined by the raised limit switch.

2.10 Current Conduction

Current is carried by the structural members of the pantograph. Pivot bearings are bypassed by employing flexible shunts attached to copper bushings.

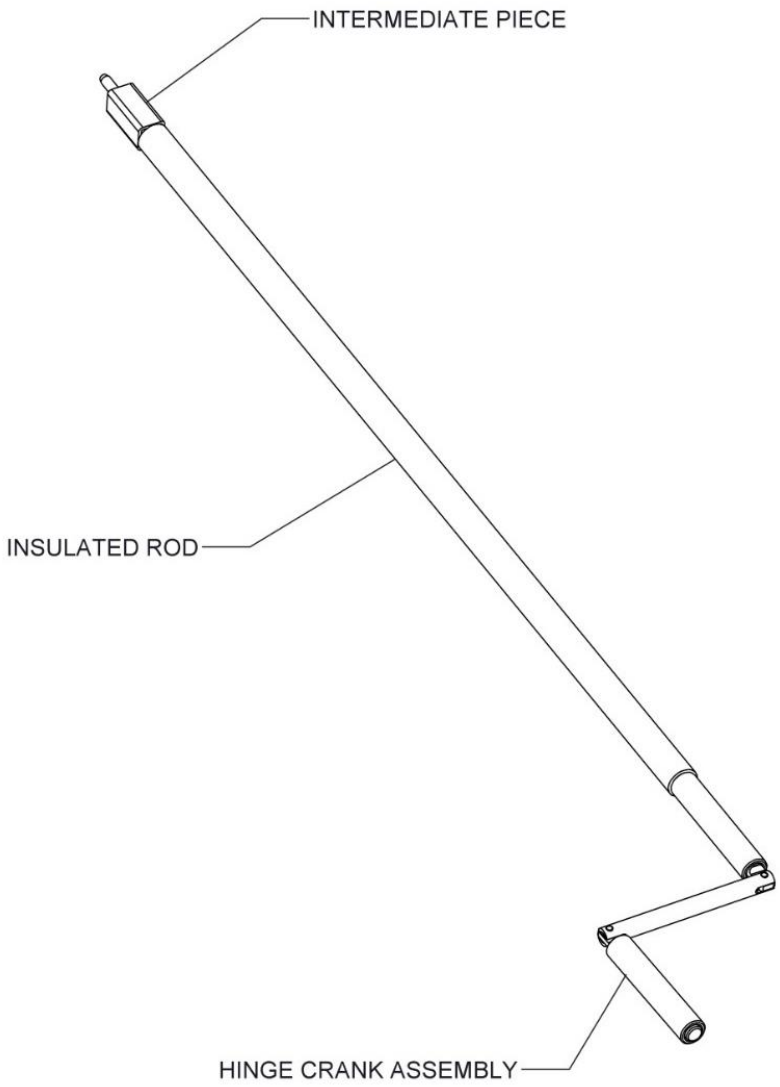

Figure 2-9: Manual Crank Assembly

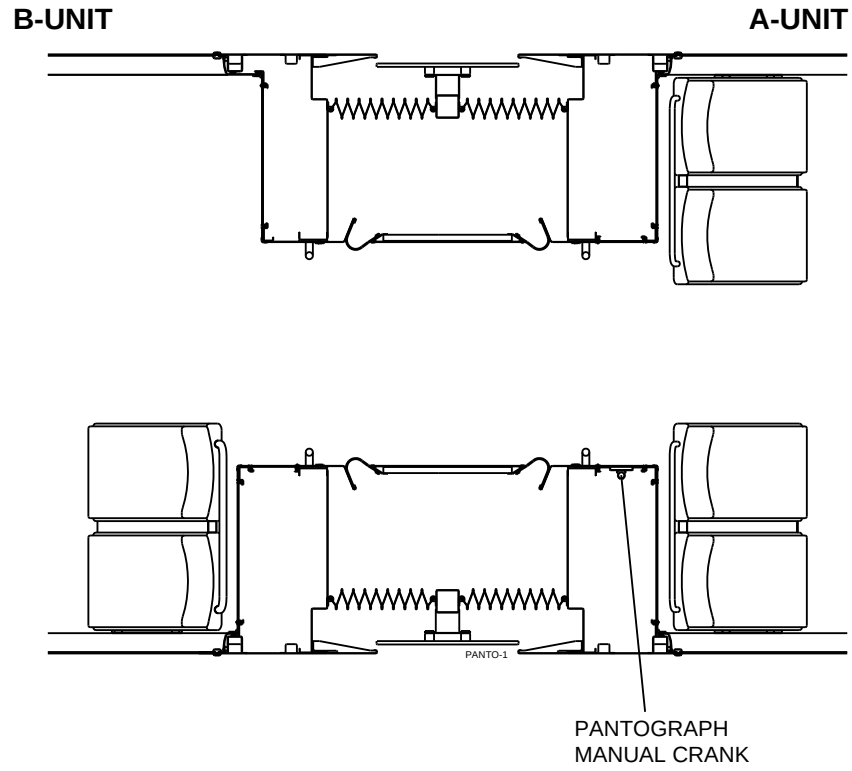

Figure 2-10: Manual Crank Storage

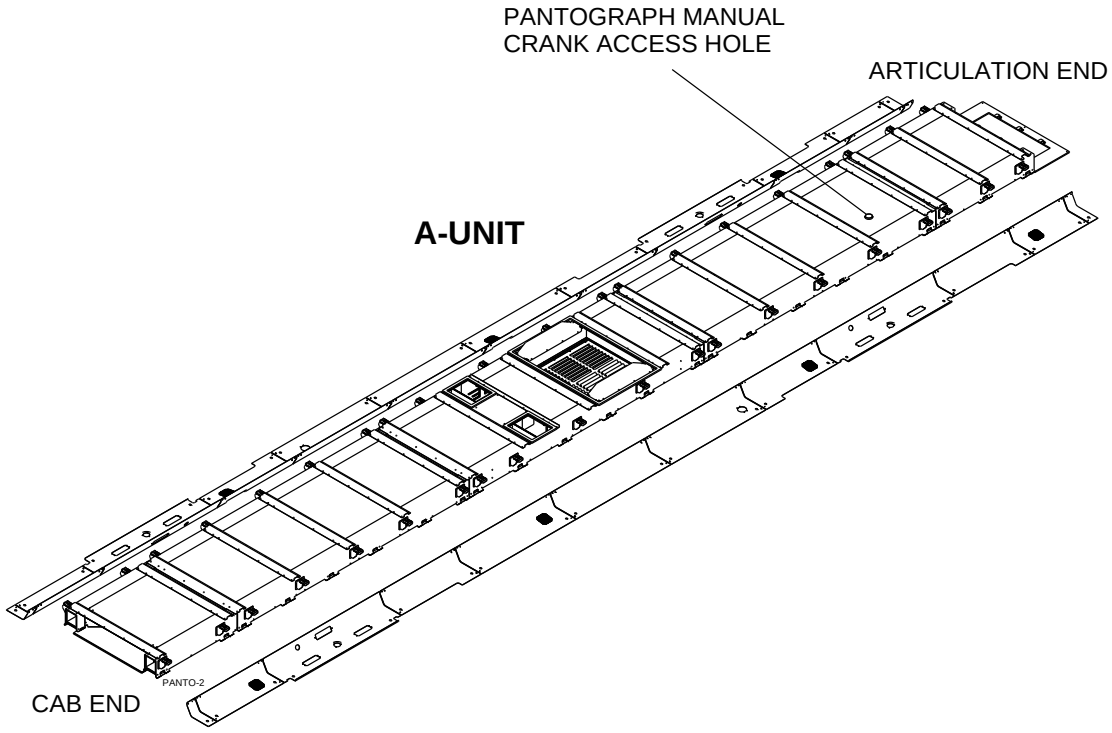

Figure 2-11: Manual Crank Roof Connection

CHAPTER 3.0

SPECIAL TOOLS AND MATERIALS

3.1 Introduction

There are no special tools or materials required for pantograph maintenance. All tools specified in this manual are common hand tools readily available and do not require custom engineering or manufacturing.

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CHAPTER 4.0

SCHEDULED MAINTENANCE

4.1 Recommended Inspection & Maintenance Intervals

Based on annual mileage of 120,000

Table 4-1. Recommended Inspection & Maintenance Intervals

Maintenance Interval	Part Description	Scheduled Maintenance Task	Section 0800 Pantograph Running Maintenance & Servicing Manual Section Reference
10,000 miles	Pantograph	Inspect for raise/lower operation	4.3
10,000 miles	Base frame	Inspect for physical/arcing damage	4.3
10,000 miles	Arm assemblies	Inspect for physical/arcing damage	4.3
10,000 miles	Head assembly	Inspect for physical/arcing damage	4.3
10,000 miles	Shunts & bolts	Inspect for condition & tightness	4.3
10,000 miles	Collector head	Inspect for physical/arcing damage	4.4
10,000 miles	Carbons	Inspect for wear, cracking, chips	4.4
10,000 miles	Shunts & bolts	Inspect for condition & tightness	4.4
10,000 miles	End horns	Inspect for physical damage, cracks	4.4
30,000 miles	Contact force	Inspect for head contact force	4.5
30,000 miles	Head rests	Inspect for physical damage, cracks	4.6
30,000 miles	Down Stop bumper	Inspect for physical damage, cracks	4.6
30,000 miles	Spring chain	Inspect for physical damage, grease	4.7
120,000 miles	Spindle drive	Inspect for physical damage, wear	4.8
120,000 miles	Insulators	Inspect for physical damage, cracks	4.9
600,000 miles	Pantograph	Complete Overhaul	See HRMM

4.2 Safety Pin Procedure

Due to the amount of energy stored in the raising springs/ A.D.D. system, it is always necessary to install the rear safety pin when performing any maintenance to prevent the quick release of this energy. Failure to install the safety pins can result in serious injury while performing maintenance on the pantograph. The pin shown below has not been inserted into the pantograph. The projection line from the pin in the below image shows the insertion point. The Safety Pin has a detent retainer (not a hole). See Figure 4-1.

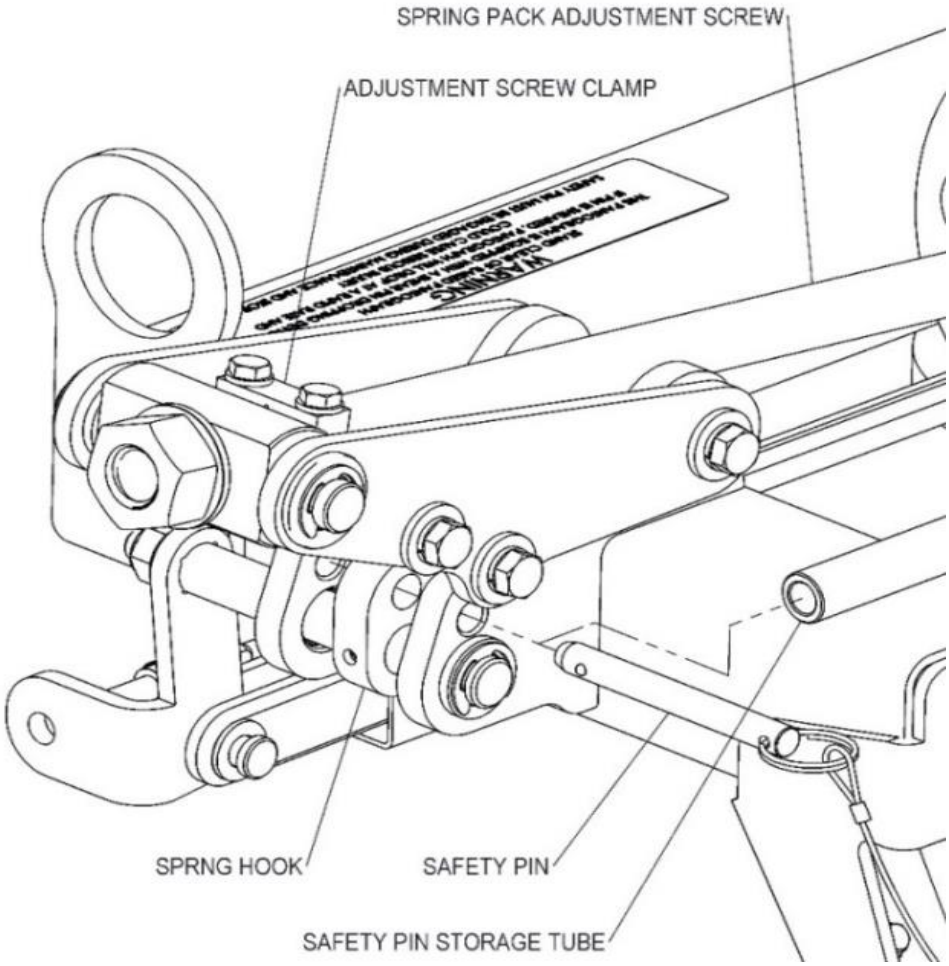

Figure 4-1: Safety Pin Installation

4.3 Inspect Pantograph Assembly & Shunts

1. Raise and lower the pantograph using cab console raise/lower switch to confirm operation. Listen to the lowering motor assembly. The motor should travel through the full range of motion with no grinding or unusual noises.
2. Inspect for physical damage to the base frame, arms, and head.
3. Inspect for arcing damage to the base frame, arms, and head.
4. Inspect all shunts for signs of fraying, overheating, crimps, or other damage. Shunt fastening bolts should be tight. Replace damaged shunts per Section 7.4.
5. General inspection for loose hardware and damaged components.

4.4 Inspect Collector Head

1. Visually inspect the carbons for wear. Ensure that there is at least 1/8 in (3.2 mm) of remaining carbon material. If the carbon has worn beyond this limit, replace the carbon assembly. See Figure 4-2.
2. If the carbon is cracked or if a segment is loose on the carrier, replace the carbon assembly.
3. If there are any chips on the running surface that are wider than 3/8 in (9.5 mm), longer than 3/4 in (19.1 mm) or deeper than 1/4 in (6.4 mm), replace the carbon assembly.
4. Inspect the support members of the collector head assembly for signs of arcing or damage.
5. Inspect the collector head shunts for signs of fraying, overheating, compromised crimps or other damage.
6. Inspect all bolts on the carbon assembly. Tighten to 90 in-pounds.
7. Inspect end horns for cracking in the metal. If cracks are visible in the metal the end horn should be replaced per Section 7.6.

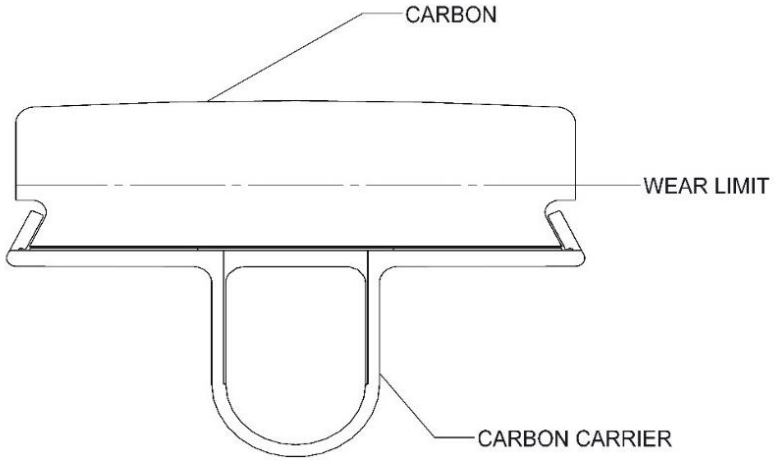

Figure 4-2: Carbon Wear

4.5 Inspect Contact Force

1. Raise the pantograph and disconnect the damper from the pantograph by removing the clevis pin and two washers that attach the damper to the lower arm. See Figure 4-3.

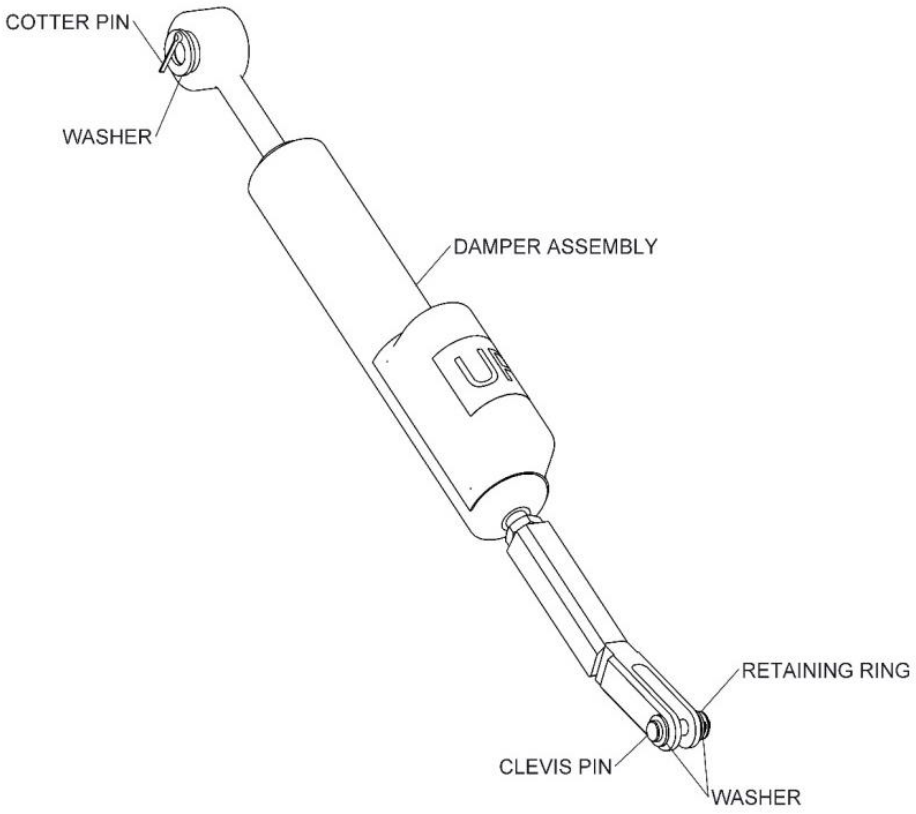

Figure 4-3: Damper and Hardware

2. Using a spring force scale and a rope tied around the cross-tube, confirm that the contact force meets the values summarized in Table 4-2. If the contact forced falls outside this range, adjust the raising springs per Section 5.1.

Table 4-2. Contact Force

Measurement Height From Bottom Of Mounting Feet To Top Of Carbons	Nominal Contact Force	Force Tolerance
17.7 inches (450 mm)	20 lbs (89 N)	+/- 3.4lbs (15N)
81.8 inches (2078 mm)	20 lbs (89 N)	+/- 2.3lbs (10N)
145.9 inches (3706 mm)	20 lbs (89 N)	+/- 3.4lbs (15N)

3. Reconnect the damper to the pantograph by installing the clevis pin and two washers.

4.6 Inspect Head Rests and Down Stop Bumpers

1. Inspect for missing, cracked, or otherwise damaged, head rests and stop bumpers.

4.7 Inspect Spring Chain

1. Wipe grease and debris from the spring chain (Figure 2-6) using a clean dry lint free rag to allow for visual inspection.
2. The chain under normal conditions should be in tension. Inspect for damaged links, (Figure 4-4), rust, and that the chain is straddling the cam properly. Inspect the cam for abnormalities (chain rubbing, dimples, etc.). Dimples/indentations over 1/32” are considered to be excessive wear. Replace the chain and/or cam if damage, excessive wear, or rust is found.
3. With the pantograph in the lockdown position, coat all exposed surfaces of the spring chain with a No. 2 lithium complex grease (Figure 4-5). Apply grease coating liberally.

Figure 4-4: Hints for Damaged Links or Cam

Figure 4-5: Spring Chain Grease

4.8 Inspect Spindle Drive

1. Remove dirt and grease from the motor, electrical box, limit switches, and actuator shaft. The actuator shaft should have a clean chrome finish. See Figure 4-6.
2. With pantograph in the lockdown position, inspect the actuator shaft for straightness and any damage. Replace the spindle drive unit if the shaft is bent or otherwise damaged.
3. Verify that the limit switches are securely in place and that the locking screws are tightened.
4. Inspect the condition of the wires coming from the limit switches to the electrical box. Replace the limit switch if the cable is damaged. It is important that the cables remain waterproof.
5. Inspect the pivot bearings. Verify screws are tight by setting torque wrench to 36 ft-lbs (80% of 45 ft-lbs. specification) and attempting to tighten. If found to be loose, pivot screws should be replaced with new pivot screws and torqued to 45 ft-lbs. Refer to Section 0800 of the Heavy Repair Maintenance Manual, Section 3.6.

4.9 Inspect Insulators

1. Check all insulators, four mounting insulators and three spindle drive insulators, for damage or buildup of dirt.
2. Clean insulators with a grease dissolving detergent.
3. Insulators that are cracked or chipped should be replaced. Insulators that have a rough surface due to exposure to the elements and cannot be cleaned should be replaced.

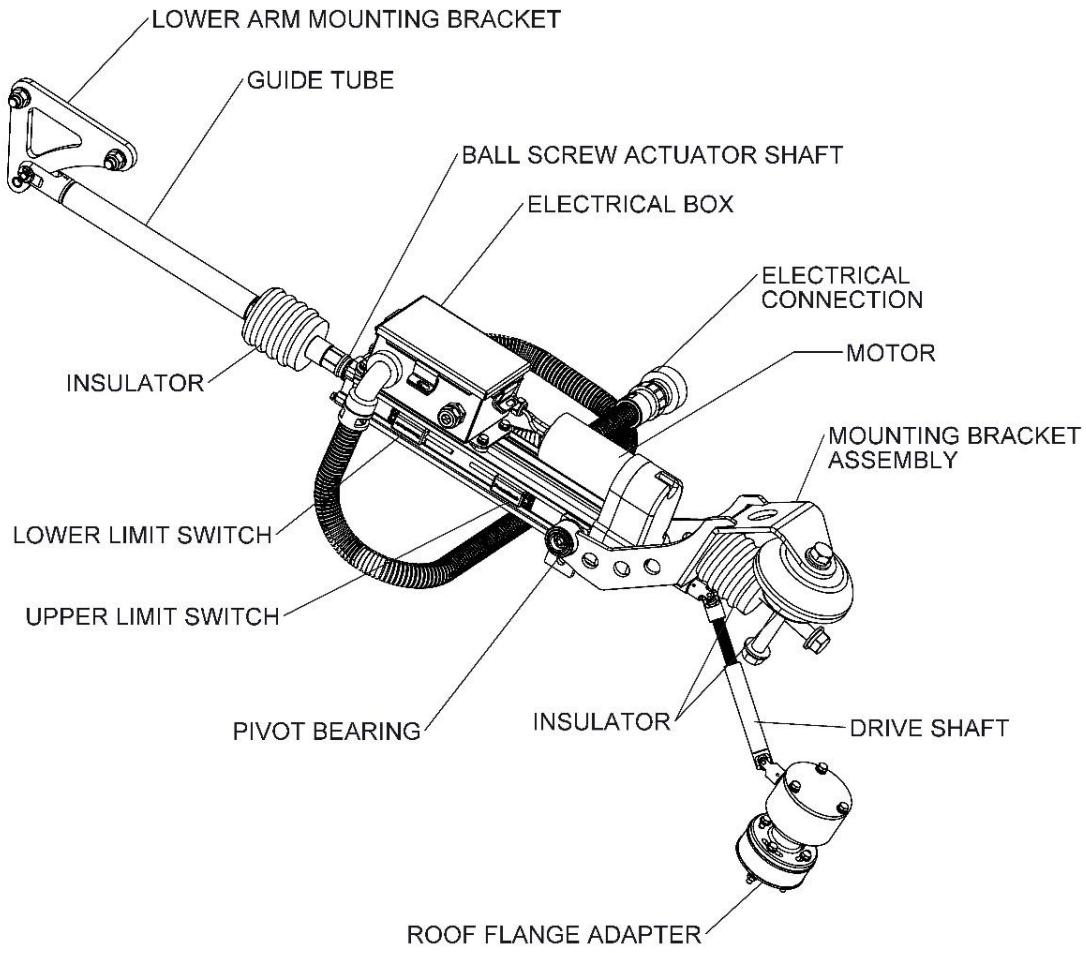

Figure 4-6: Spindle Drive

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CHAPTER 5.0

CORRECTIVE MAINTENANCE

5.1 Adjust Raising Spring

1. Install the rear safety pin to prevent the accidental tripping of the A.D.D. device. Failure to do this can result in serious injury!
2. Disconnect damper by removing the clevis pin and two washers at the lower arm. See Figure 4-3.
3. Loosen the jam nut at the outer end of raising spring strain bolt using a 1¼ open end wrench.
4. Turn the spring adjustment screw using a 1¼ open end wrench to either lengthen (increase force) or shorten (reduce force) the raising spring. A coating of anti-seize lubricant on the threads can make this adjustment easier. Note – the adjustment screw clamp will spin in place while the spring adjustment screw is being turned. It is not necessary to remove the clamp to adjust the raising spring.
5. Adjust the contact force per Table 4-2 above.
6. After the adjustment is complete, tighten the jam nut to mechanics feel.
7. Reconnect the damper to the pantograph by installing the clevis pin and two washers. Refer to Figure 4-3.
8. Remove the safety pin and place in holder when the pantograph is ready.

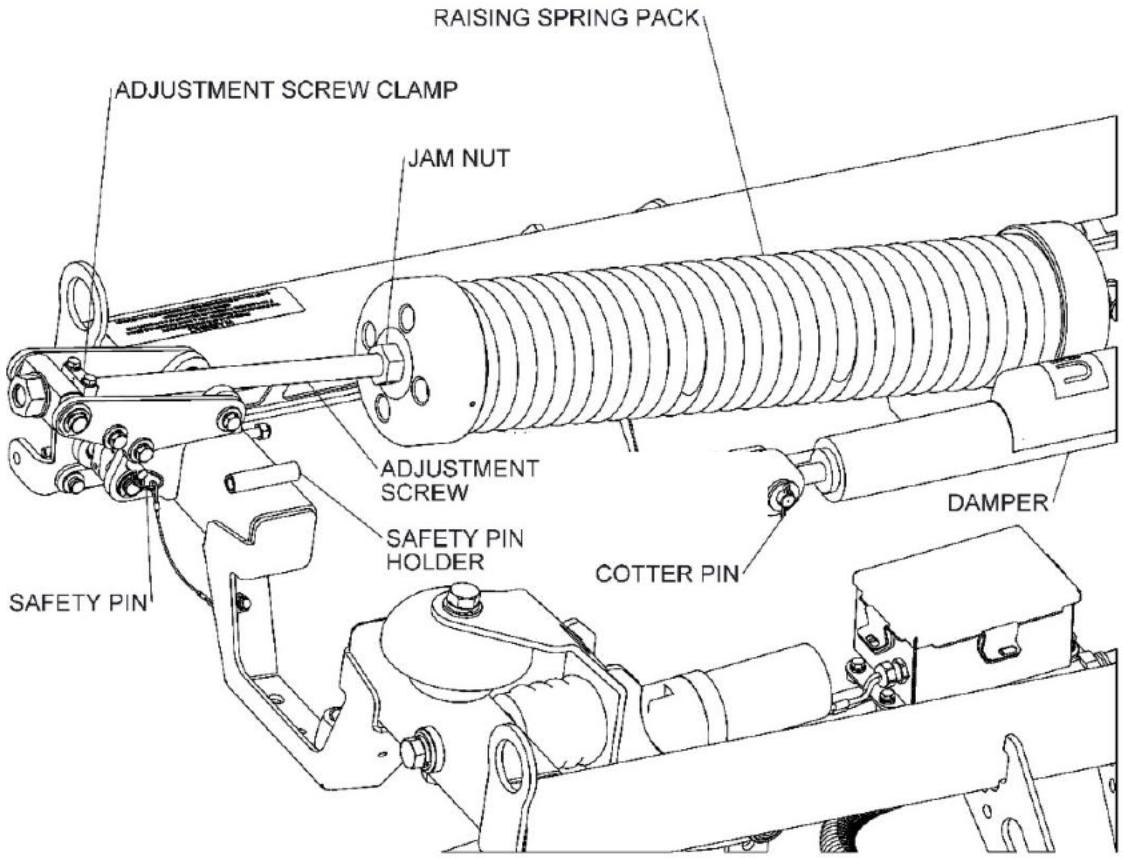

Figure 5-1: Adjust Raising Spring

5.2 Adjust Spindle Drive

5.2.1 Adjust Lowering Sensor

1. Install the rear safety pin to prevent the accidental tripping of the A.D.D. device. See Section 4.2. Failure to do this can result in serious injury!
2. Apply moderate downward pressure on the head assembly and release the safety latch from the cross tube. See Figure 2-1.
3. From the lockdown position either activate the up command from the car controls to raise the pantograph or use the manual crank to retract the spindle drive approximately half way.
4. If raising using the manual crank the pantograph will rise slowly. The position of the spindle drive shaft will control the height of the head. If raising using the car controls the pantograph will rise on command from the car.

5. When the pantograph is raised activate the down command from the car controls. The pantograph will move downward toward the lockdown position. The pantograph is in lockdown position when the upper arm touches the apex bumpers. See Figure 2-1. If the lowering sensor is set too high the pantograph will not reach lockdown position. If the pantograph does not reach lockdown position move the lowering sensor toward the spindle drive shaft end (toward the front of the pantograph). Tighten one of the two retaining screws on the lowering sensor. See Figure 5-2. Repeat this sequence as necessary in small increments until the lowering sensor is adjusted so the head reaches lockdown position and the motor turns off. The motor will turn off as intended when the car receives the signal from the lowering sensor that the pantograph has reached position. When the correct position is reached tighten both retaining screws. Tighten to mechanics feel, there is not torque requirement for these screws. The motor has an over-running clutch that can handle this case, however the pantograph should be immediately raised to prevent over stressing the system.
6. Remove the safety pin from the rear of the pantograph and store in the holder on the base frame. Refer to Section 4.2.

5.2.2 Adjust Raising Sensor

1. Install the rear safety pin to prevent the accidental tripping of the A.D.D. device. See Section 4.2. Failure to do this can result in serious injury!
2. From the lockdown position activate the up command from the car controls. The pantograph will rise to the maximum height.
3. Measure from the top of carbons to the bottom of the base frame insulator. Recommend using a flat bar to span the carbons and fix the tape measure in between the two carbons. Determine if the pantograph maximum height needs to be increased or decreased per Figure 5-3.
4. To increase the maximum height, loosen the retaining screws on the raising sensor and move the sensor toward the motor end of the spindle drive (toward the rear of the pantograph). Tighten one of the two retaining screws on the raising sensor. See Figure 5-2. Repeat this sequence as necessary in small increments until the raising sensor is adjusted so the head reaches the correct maximum height. When the correct position is reached tighten both retaining screws. Tighten to mechanics feel. There is no torque requirement for these screws.
5. To reduce the maximum height, loosen the retaining screws on the raising sensor and move the sensor toward the spindle drive shaft end of the spindle drive (toward the front of the pantograph). Tighten the one of the two retaining screws on the raising sensor. See Figure 5-2. Repeat this sequence as necessary in small increments until the raising sensor is adjusted so the head reaches the correct maximum height. When the correct position is reached tighten both retaining screws.

6. If the raise sensor is incorrectly adjusted and the pantograph rises above the maximum design height, the fourth bar could impact the inside of the lower arm. Limit the upward motion by a rope and raise the pantograph slowly by hand to prevent damage. Once the height is verified the pantograph should be operated normally without the rope and the height verified.
7. Remove the safety pin from the rear of the pantograph and store in the holder on the base frame. Refer to Section 4.2.

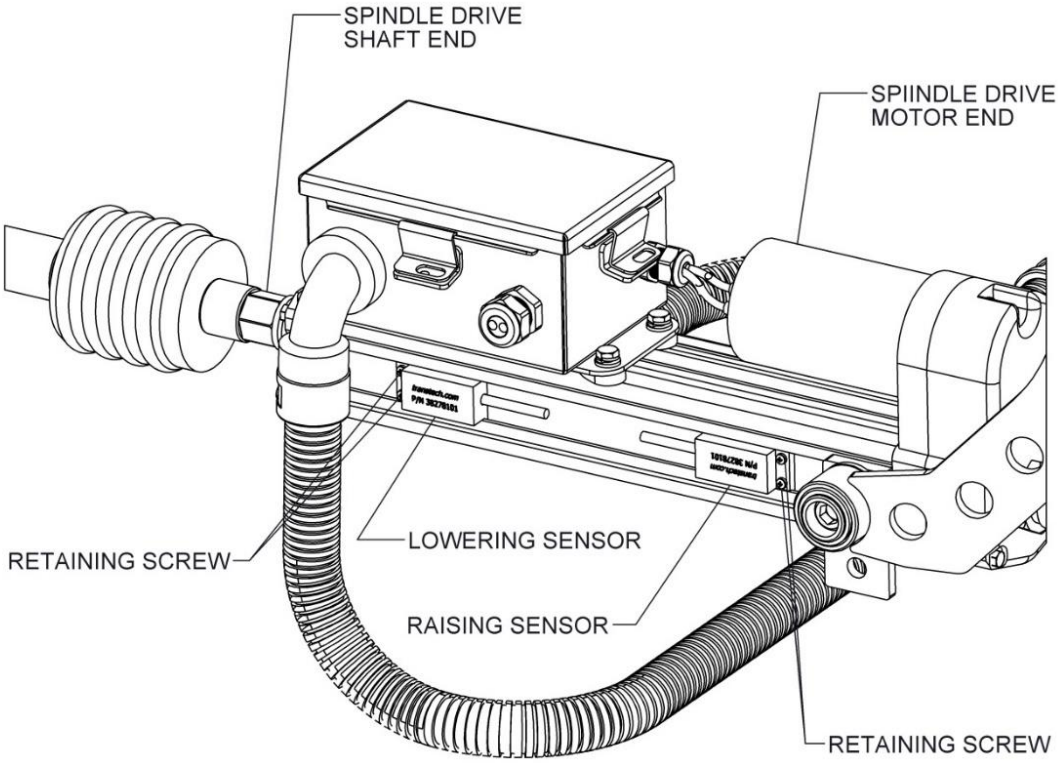

Figure 5-2: Spindle Drive Sensors

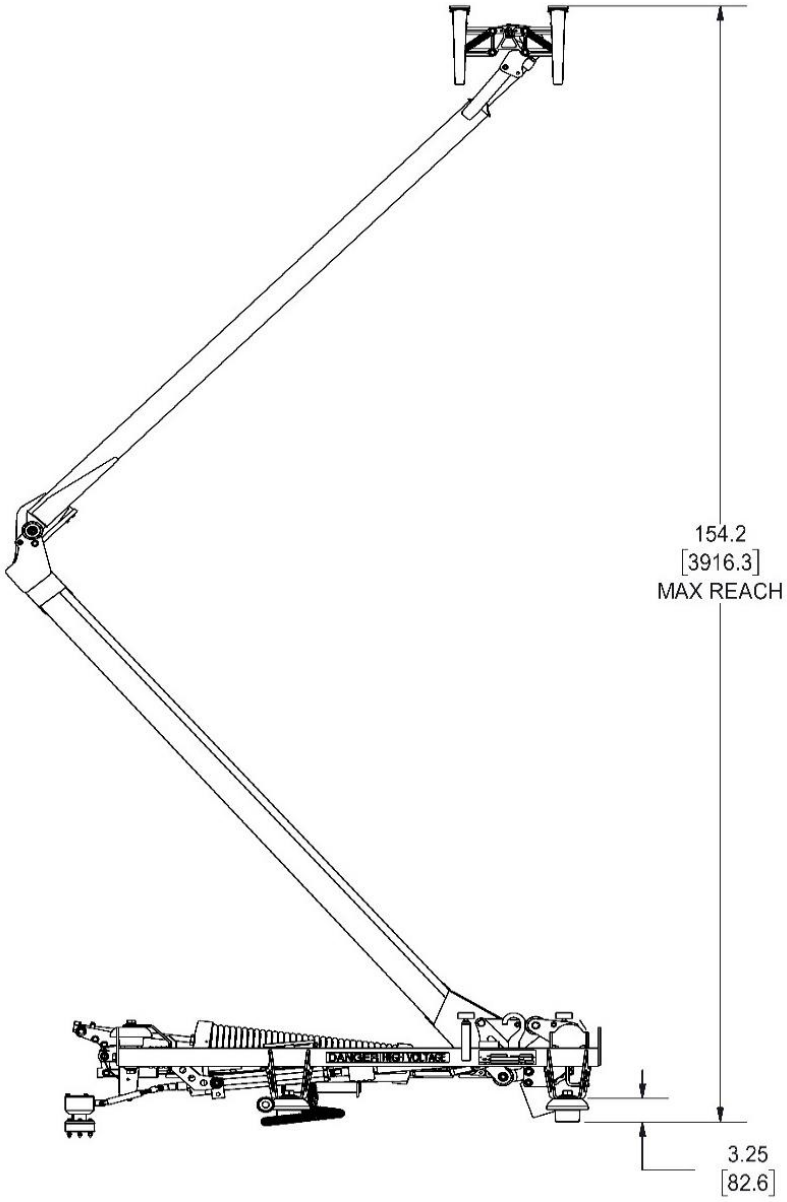

Figure 5-3: Maximum Height Adjustment

5.3 Adjust Damper

Keep the damper rotated to the proper position with the “UP” label on top when the damper is in the installed/horizontal position. The only exception to this is when the damper is being rotated for adjustment. See Figure 5-4.

When the adjustment is complete the damper must be pulled back (shortening the piston rod) and rotated so that the “UP” label is on top. This will have no effect on the adjustment because the adjustment can only occur when the damper is full extended and engaged.

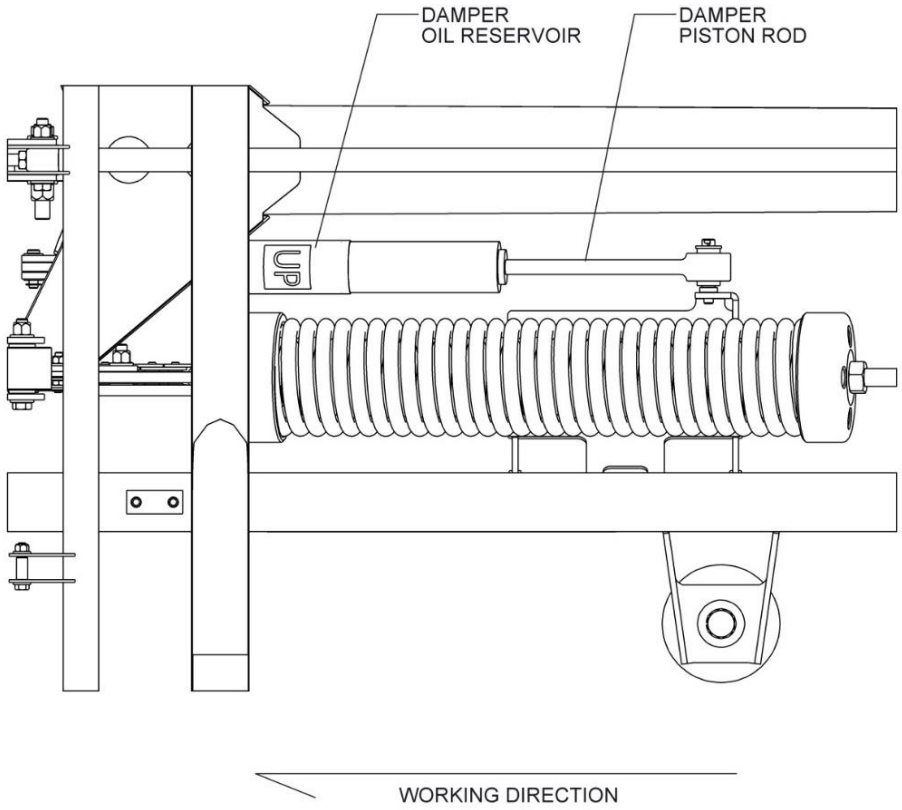

Figure 5-4: Adjust Damper

1. Disconnect the damper from the end located near the chain by removing the clevis pin and two washers. See Figure 4-3.
2. With the disconnected end of the damper facing away from you, push the damper away from the connected end so that the rod fully extends.
3. Rotate the damper counter-clockwise until a click is heard and felt. While keeping a slight tension on the damper/rod, continue rotating the damper in a counter-clockwise direction until the damper comes to a stop and will not rotate any further. The damper is now adjusted to its lowest damping rate. Conversely, rotating the rod to a fully clockwise position will adjust the damper to the maximum damping rate.
4. A total of three rotations are available for damper adjustment.
5. After adjusting the rod to minimum damping rate, while keeping slight tension on the damper/rod, rotate the damper 1 ½ turns clockwise to the damper's mean damping rate.
6. Pull back on the damper to shorten the piston rod until it is fully compressed.
7. Reconnect the damper's extension arm to the pantograph by installing the clevis pin and two washers. See Figure 4-3.
8. For this pantograph, with the damper set at the mean position, the raising and lowering times in Section 5.4 should be achieved. If the raising and lowering times in Section 5.4 are not achieved with the damper at the mean setting, adjust the damper as necessary per the above instructions.

5.4 Adjust Pantograph Raising and Lowering Times

1. To measure raising and lowering times the pantograph must be able to reach max extended height. If the pantograph is under a catenary this may not be possible.
2. With the pantograph in the fully down position, initiate the raise command. The pantograph should rise to max extended height in less than or equal to 7 seconds. Measure the time with a timer. If incorrect, refer to Section 5.3.
3. Initiate command to lower the pantograph. The pantograph should be in the fully down position from max extended height in less than or equal to 8 seconds. Measure the time with a timer. If incorrect, refer to Section 5.3.

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CHAPTER 6.0

LUBRICATION

6.1 Chain Cleaning and Lubrication

1. Install the rear safety pin to prevent the accidental tripping of the A.D.D. device. Failure to do this can result in serious injury!
2. Refer to Section 4-7 for detailed instructions on cleaning and lubricating the spring chain.
3. Remove the safety pin and place in holder when the pantograph is ready, and no further work is required.

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CHAPTER 7.0

COMPONENT REMOVAL AND INSTALLATION

7.1 Torque Plan

Fasteners size 1/4" (M6) and smaller are tightened per normal engineering practice to experienced mechanic's feel. All fasteners 5/16" (M8) and larger, and listed specialty hardware, are to be torqued per the table below using a calibrated torque wrench during all maintenance procedures described within this document.

Table 7-1. Recommended Torque Values

Size	Torques Value
1/4" (M6)	10 ft-lbs (14 N-m)
5/16" (M8)	18 ft-lbs (24 N-m)
3/8" (M10)	36 ft-lbs (49 N-m)
1/2" (M12)	60 ft-lbs (81 N-m)
5/8" (M16)	80 ft-lbs (109 N-m)
3/4" (M20)	130 ft-lbs (176 N-m)

7.2 Pantograph Installation Procedure

1. To install a pantograph onto the car roof:

a. The pantograph must be in the lock down position with the rear safety pin inserted and the safety hook over the cross tube to lift the pantograph.

2. Connect the lifting straps to the four base frame lifting brackets.

a. Raise the pantograph onto the car roof.

b. Install the four bolts (3/4-10), with lock washers and flat washers that attach the pantograph to the rooftop insulators. Torque the four bolts to 130 ft-lbs (176 N-m).

c. Install the four bolts (3/4-10), with lock washers and flat washers that attach the pantograph insulators to the car roof. Torque the four bolts to 130 ft-lbs (176 N-m). If the insulators are already installed to the car roof then skip this step.

d. Verify the power take-off plate and power cable terminals are clean. Apply Noalox brand anti-oxidant joint compound, or equivalent, to the power take-off plate. Connect the power cables to the power take-off plate using two plain washers, a lock washer, nut, and M10-35 bolts. Torque the bolts to 36 ft-lbs (49 N-m).

3. Remove tie-wraps holding the head to the base frame.

4. Connect the electric drive motor Veam connector to the car.
5. Connect the manual crank gearbox to the car roof.

a. Bolt the gear box flange and spacer to the car roof flange using the four supplied M6 x 60 bolts, nuts, and two gaskets. Torque the bolts to 10 ft-lbs (14 N-m). Ensure there is gasket on both sides of the spacer. These gaskets and bolts are supplied with the gearbox and spacer.

6. Connect the gearbox drive shaft to drive motor.

a. The gearbox drive shaft connects to the shaft on the back of the lowering motor. The drive motor shaft has a flat machined on the circumference for one of the two set screws to tighten to. The second set screw is oriented at 90 degrees for secondary support of the primary screw.

b. Apply Loctite 242 to both set screws on the gearbox drive shaft coupler. Slide the drive shaft onto the motor shaft. Align one of the set screws with the flat on the shaft and tighten that set screw first. Then tighten the second set screw.

c. There must be a minimum 1/16” +/- 1/32” gap between the drive shaft coupler and motor housing when installed. This gap should be maintained or the coupling will rub on the motor. See Figure 7-1.

d. Ensure the shaft is not binding between the gear box and the motor before proceeding. This gearbox will always spin even when the pantograph is raised and lowered electrically using the car controls.

e. Rotate the gearbox with the manual crank handle in both directions to verify the drive shaft moves freely and does not bind.

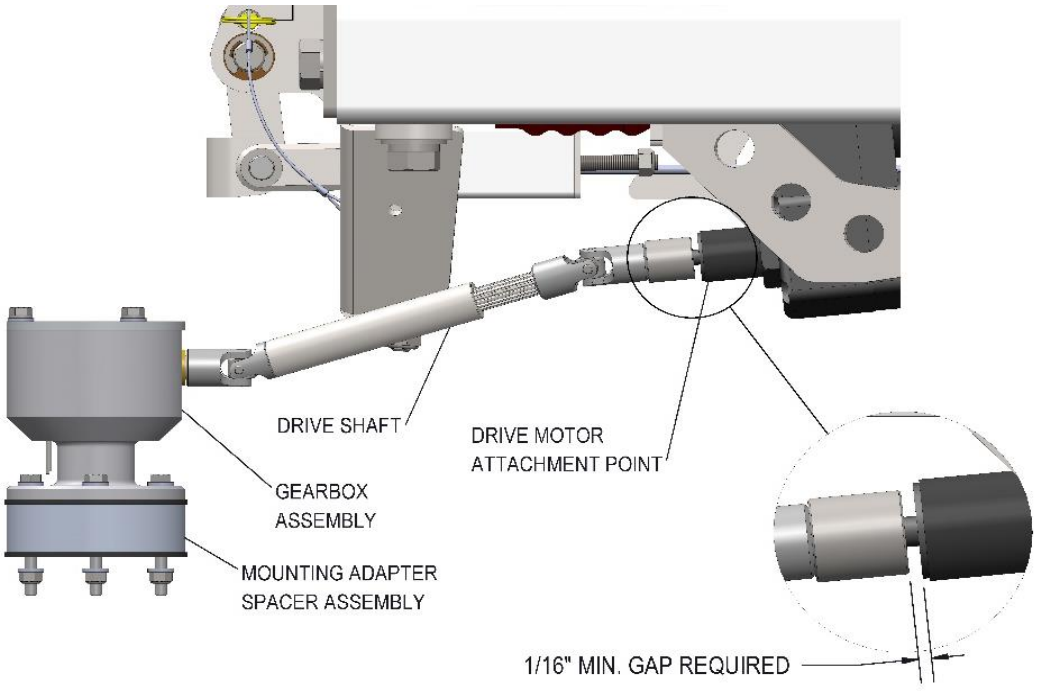

Figure 7-1: Drive Shaft – Gear Box Assembly

7. Remove the shipping bolt shown in Figure 7-2. Keep the shipping bolt in the event the pantograph is removed from the car roof and shipped via truck to another location in the future.

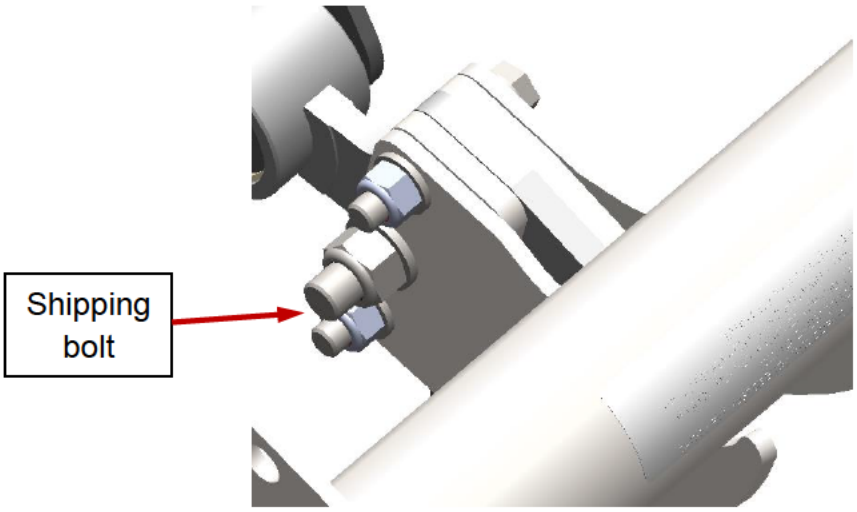

Figure 7-2: Shipping Bolt

8. Raise and lower the pantograph several times from the car's cab to confirm proper pantograph operation. Observe the pantograph during this raising and lowering to listen for abnormal sounds and watch for smooth operation.
9. Locate the spring release safety pin on the rear of the pantograph. Pull it out of the spring release pivot bracket and insert the pin in the safety pin retainer.

7.3 Pantograph Removal Procedure

1. Put the pantograph in the lockdown position. The pantograph must not be lifted when in the raised position.
2. Install the rear safety pin and place the safety hook is over the cross tube.
3. Disconnect the electric drive motor Veam connector from the car.
4. Disconnect the power cables from the power take-off plate.
5. Disconnect the gearbox drive shaft from the pantograph.
6. Connect lifting straps to the four base frame lifting brackets. Refer to Figure 2-1 for location of lifting brackets.
7. Remove four bolts holding the pantograph to the rooftop insulators.
8. Lift the pantograph off the car roof and lower to ground level.

7.4 Replace Shunts

1. Take note of the current mounting position and orientation of the shunt to be replaced.
2. Remove the existing hardware from each end of the shunt. Discard the lock nuts and the shunt. Retain the bolt and washers for re-use.
3. Clean the pantograph contact pads with a non-scratching scour pad.
4. Apply Noalox brand anti-oxidant joint compound, or equivalent, between the contact pads and shunt terminals.
5. Secure the shunt to the pantograph using new lock nuts and existing washers and bolts. Torque the bolts to 90 inch-pounds.
6. After replacement, move the pantograph up and down through the full operating range and confirm that the shunts do not rub against each other or a frame member. If necessary, adjust the position/angle of the shunt terminal on the contact pad and re-check.
7. When servicing shunts it is recommended to check the power take-off plate from the pantograph to the car. Follow the same steps listed above to inspect the pantograph power take-off plate.

7.5 Replace Collector Head Subassembly

1. Disconnect shunts per Section 7.4. If you're re using the shunts leave the shunts attached to the pantograph and disconnect the shunts from the carbon assembly.
2. Remove the nylock hex nut, bolt, and washers. See Figure 7-3. Discard the hex nuts. These are nylock nuts that must be replaced.
3. Remove the head from the cross tube and set to the side.
4. Place the new head assembly onto the cross tube and check that the pivot points are properly seated.
5. Insert the bolt, washers, and new nylock nut into the head assembly.
6. Tighten the bolts to 10 ft-lbs.
7. Reconnect the shunts per Section 7.4.
8. Rotate the head to check for proper head pivot.
9. Push down on the carbons to check for proper head suspension function.

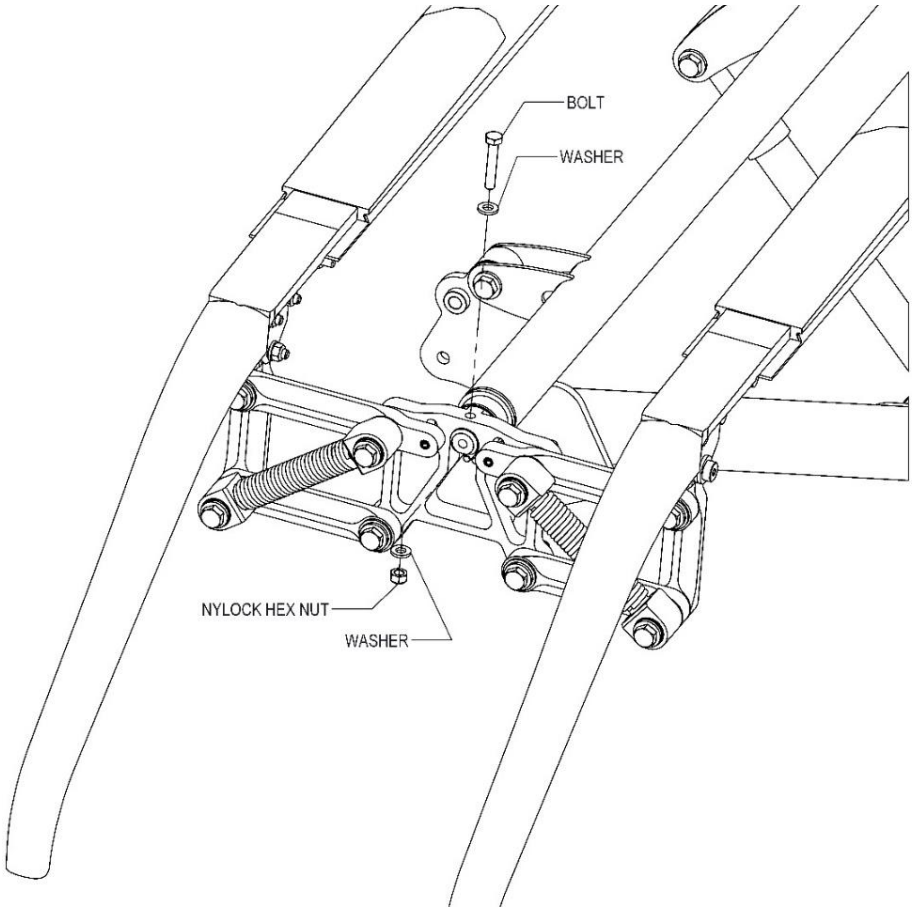

Figure 7-3: Collector Head

7.6 Replace Carbon Carrier Assembly

1. Install the rear safety pin to prevent the accidental tripping of the A.D.D. device.
2. Remove bolts, hex nuts, and washers that retain the shunts to the carbon carrier assembly. Discard the hex nuts. These are nylock nuts that must be replaced. See Figure 7-4.
3. Remove the remaining bolts, hex nuts, and washers that hold the carbon carrier to the end horns.
4. The carbon carrier should drop down away from the end horns.
5. Insert new carbon carrier, aligning with end horn mounting holes. Re-install bolts, washers, and new hex nuts to secure the end horns, carbon carriers, and shunts. Apply conductive grease to all shunt connections.
6. Align the top edge of the carbon assembly with the top edge of the end horn using a straight edge. The top surfaces of the carbon and the end horn need to be flush.
7. Torque the bolts that connect the carbon carriers to the end horns to 90 inch-pounds. Check all connections.
8. Remove safety pin and stow it.

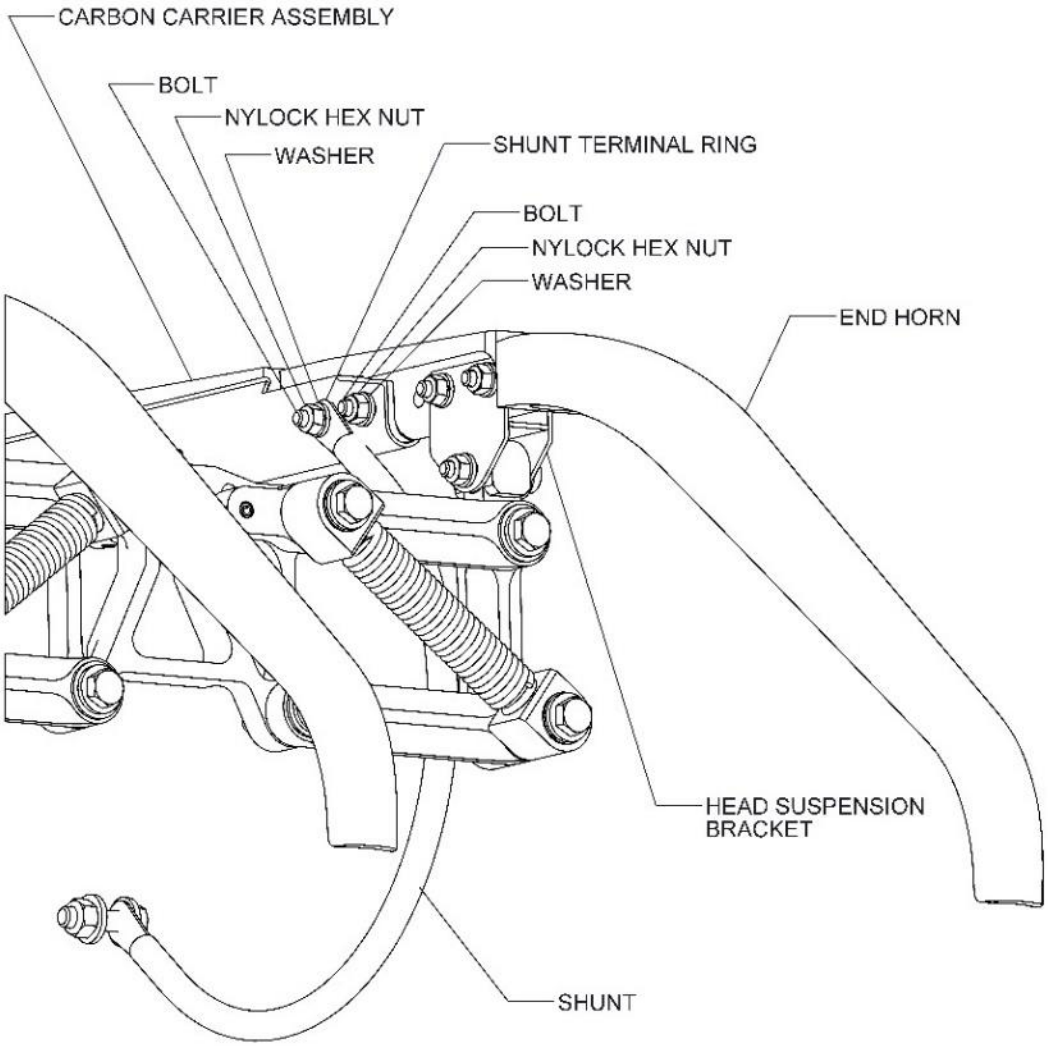

Figure 7-4: Carbon Strip Replacement

7.7 Replace Spindle Drive Assembly

1. Install the rear safety pin to prevent the accidental tripping of the A.D.D. device. Failure to do this can result in serious injury!
2. This procedure is performed with the pantograph in the down and manually latched position.
3. Disconnect the VEAM connector from the car interface connection.
4. Disconnect the gearbox drive shaft from the back of the motor shaft. This requires a 10-32 allen wrench.

5. Remove the clevis pin and retaining ring that secure the actuator shaft to the lower arm. Allow this end to rest on the train car top. See Figure 7-5.

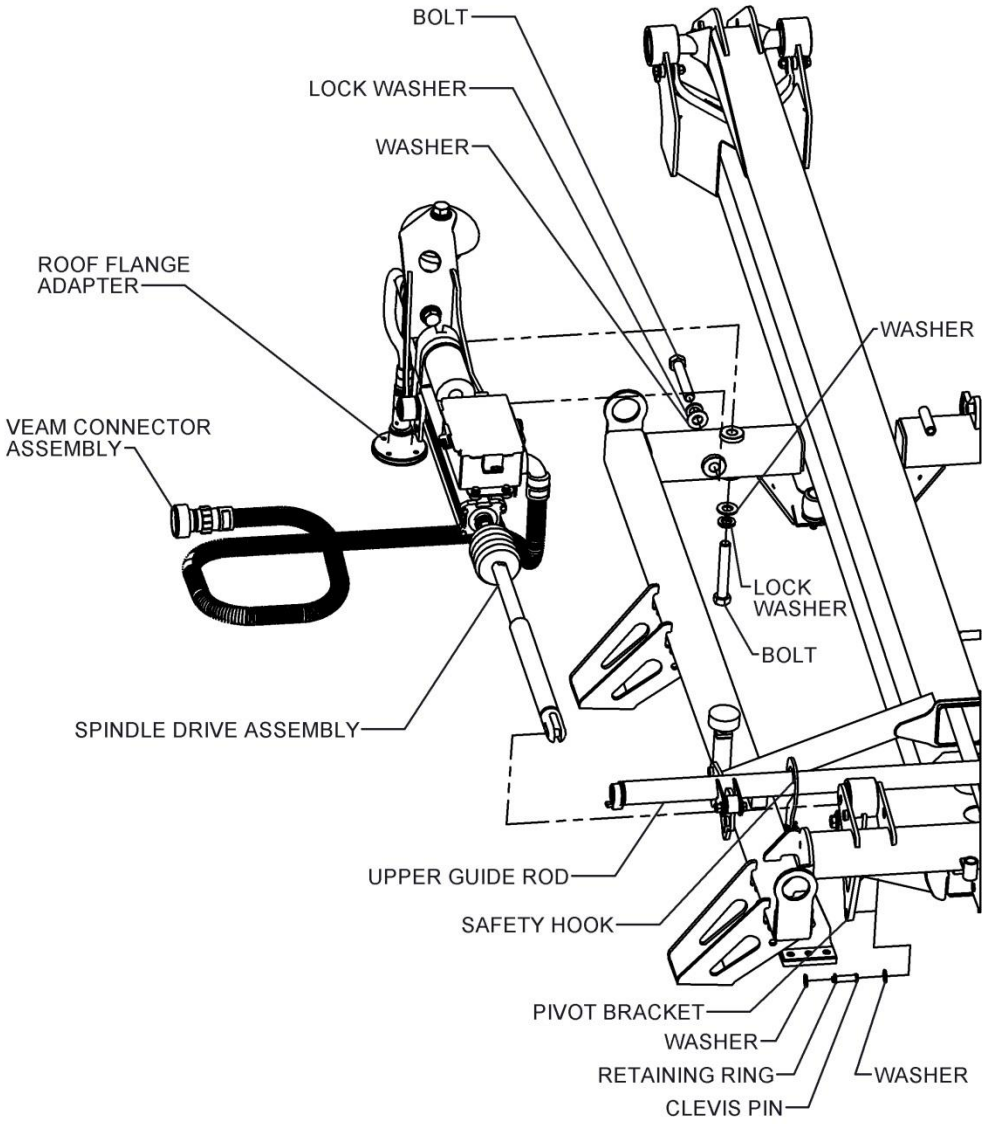

Figure 7-5: Spindle Drive Replacement

6. Use a 15/16” wrench to remove the two 5/8-11 bolts that secure the spindle drive mounting insulators to the pantograph.
7. With the replacement actuator in hand, align the actuator so that the insulators align with the mounting holes in the base frame, insert the retaining bolts and use a 15/16” socket to tighten to 89 ft-lbs (121 N-m)
8. Reconnect the gearbox shaft to the back of the motor shaft. Apply thread locker to the set screw and tighten the set screw with a 10-32 allen wrench.

9. Extend the actuator by using manual crank, so that the holes of the clevis align with the hole in the raise/lower lever, allowing the clevis pin to be inserted. Install the clevis pin and retaining clip.
10. Re-install the VEAM connector and lock.
11. Adjust the lowering and raising sensors per the instructions in Section 5.2.

7.8 Replace Damper Subassembly

1. Install the rear safety pin to prevent the accidental tripping of the A.D.D. device. Failure to do this can result in serious injury!
2. The correct mounting orientation is with the “UP” label facing up.
3. Remove the cotter pin from the damper located near the spring.
4. Remove the clevis pin and two washers from the damper located near the chain.
5. Slide the damper from the mounting pin.
6. With replacement damper in hand, and the UP decal in the up position, install the eye end of the damper onto the damper mounting pin. Install washer and new cotter pin.
7. Extend the clevis end of the damper as required (requires significant effort) align the holes in the damper’s clevis with the holes in the mounting tab.
8. Install clevis pin, washers, and retaining ring.
9. Measure raising and lowering times. If the damper needs adjustment to get proper raising and lowering times, refer to Section 5.3.

7.9 Replace Spring-Pack Subassembly

1. Install the rear safety pin to prevent the accidental tripping of the A.D.D. device. See Section 4.2. Failure to do this can result in serious injury!
2. With the pantograph in the down position apply the safety hook.
3. Remove tension on the spring by loosening the jam nut from the spring pack assembly and turning the tension screw counter-clockwise. Loosen the tension screw until the spring tension is completely removed. See Figure 7-7.
4. Remove the tension screw. The spring should drop into the cradle, recommend holding the bottom of the spring with your hand for support.
5. Remove the cotter pin that holds the master link onto the cam.
6. Remove the retaining pin.

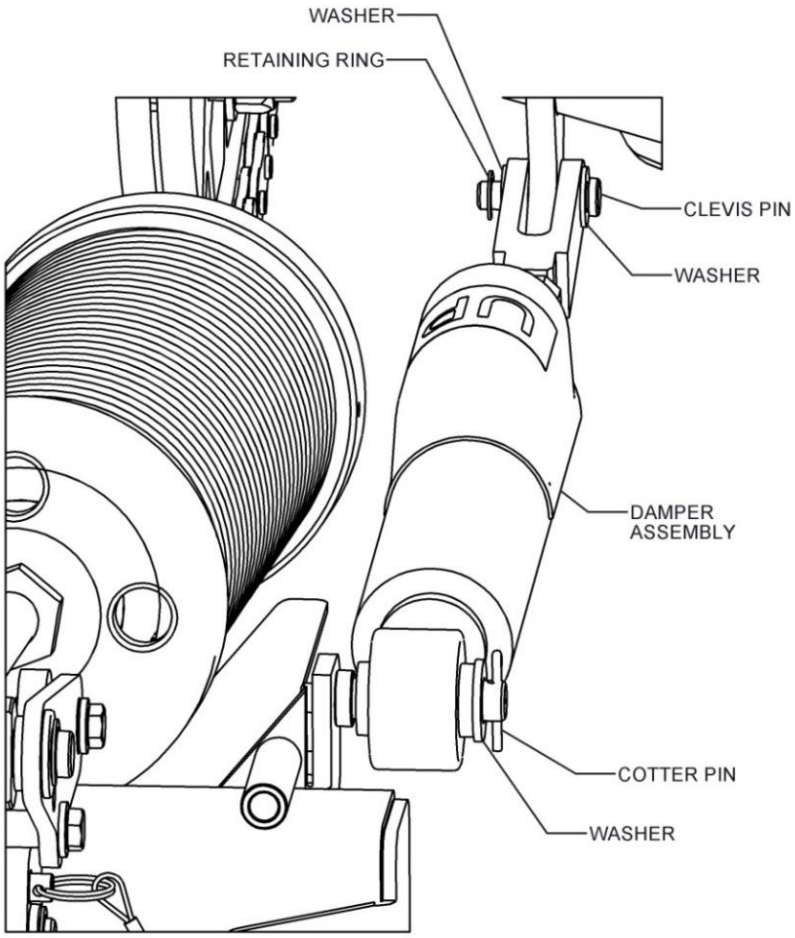

Figure 7-6: Damper Replacement

7. The spring can now be removed from the area.
8. Place the replacement spring assembly into the cradle with the chain oriented toward the cam.
9. Install the chain onto the cam by aligning the hole in the master link with the hole in the cam.
10. Insert the retaining pin and cotter pin to hold the chain to the cam.
11. Apply anti-seize compound to the adjustment screw threads.
12. Thread the adjustment screw into the spring pivot trunnion and into the spring pack assembly.
13. Unlatch the pantograph head.
14. Attach a rope, at least 10 feet long, to the cross-tube for subsequent step.
15. Using a wrench tighten the adjustment screw until the pantograph head raises to full extension. DO NOT USE AN IMPACT WRENCH, this may damage the spring!

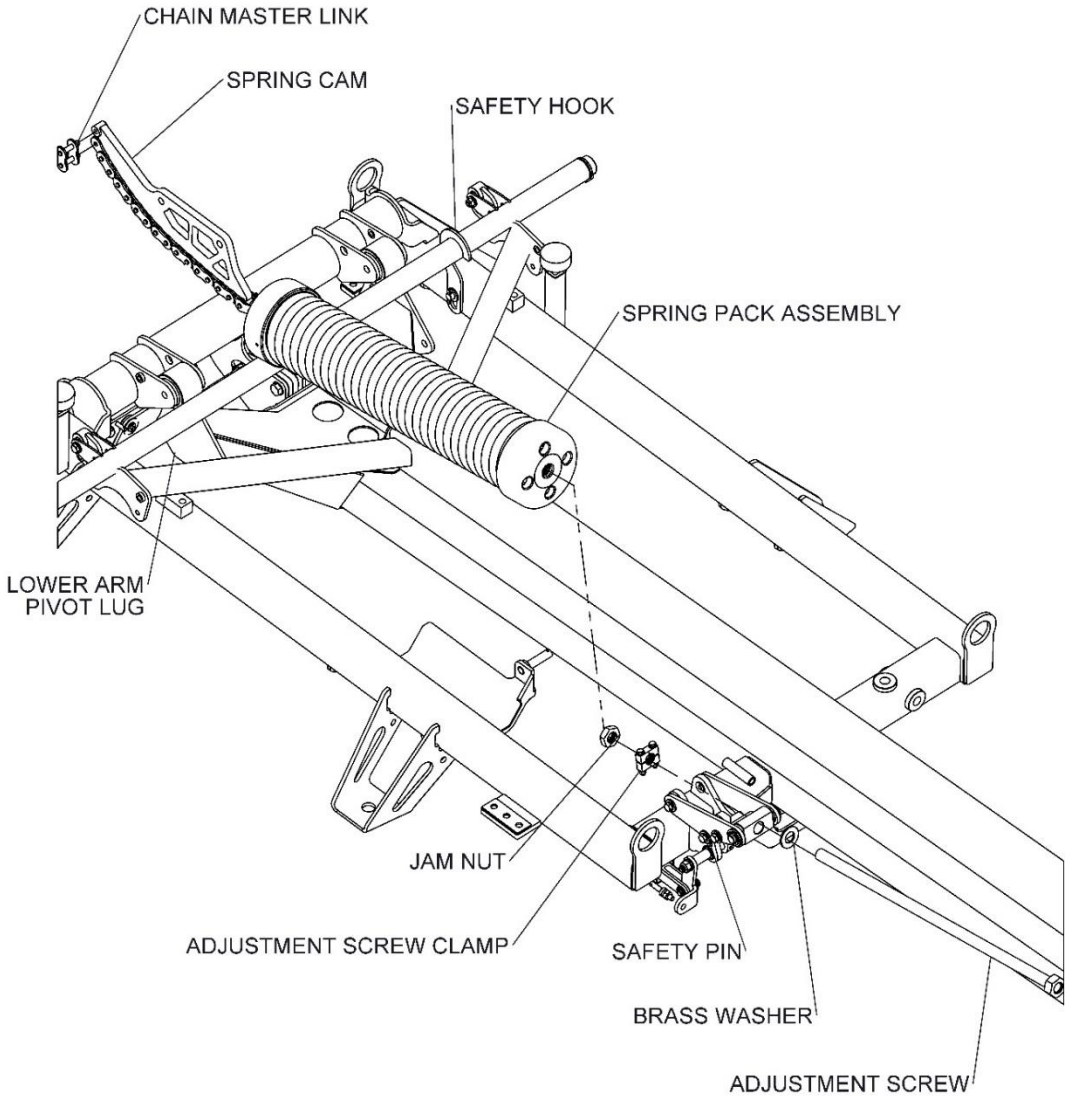

Figure 7-7: Spring Pack Replacement

16. Adjust the raising spring tension per Section 5.4 in this manual.
17. Tighten the jam nut.
18. Remove the rope.
19. Remove the safety pin from the rear of the pantograph and store in the holder on the base frame. Refer to Section 4.2.
20. Installation is complete.

7.10 Replace Down-Stop Bumper

1. Install the rear safety pin to prevent the accidental tripping of the A.D.D. device. Refer to Section 4.2. Failure to do this can result in serious injury!
2. Refer to Figure 7-8, simply pry upward on the defective down stop bumper to remove, and discard.
3. To install new bumper, align bosses on frame with holes in bumper and apply downward pressure. The bumper should snap into place.
4. Remove the safety pin and place it in the holder on the base frame. Refer to Section 4.2.

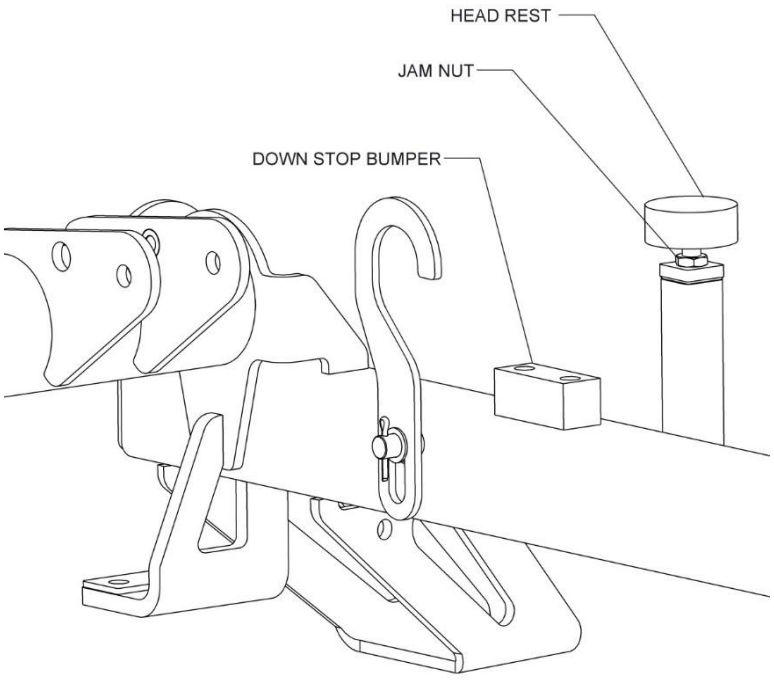

Figure 7-8: Down Stop and Head Rest

7.11 Replace Head Rest

1. Install the rear safety pin to prevent the accidental tripping of the A.D.D. device. Failure to do this can result in serious injury!
2. Loosen the jam nut and remove the head rest from the head rest mount.
3. Remove the jam nut from old head rest.
4. Screw the jam nut onto new head rest.
5. Screw the new head rest into the head rest mount.
6. Use either a digital or bubble level and place across the front and back carbons. One side of the level will rest on the front carbon, the other side of the level will rest on the rear carbon. Place the level in the center of the carbons as viewed from left to right.

7. With the pantograph head into lockdown position and the head level, adjust the new head rest so it just touches the bottom of the carbon carrier. The head rest will not put upward pressure on the carbon, just hold the head level.
8. Tighten the jam nut.
9. After the new head rest is installed verify that the head is level front to back. See step 6 above.
10. Remove the safety pin and place it in the holder on the base frame. Refer to Section 4.2.

7.12 Replace Shear Pin

1. Completely de-tension the spring pack. Hold the end of the spring pack nearest the back of the pantograph to keep the spring from rotating. Use a 1 ¼" wrench to loosen the jam nut away from the spring pack. Turn the jam nut away from the spring pack end cap. Mark on the adjustment screw the position of the spring pack end cap, you will use this mark in step 10 below. Can use a piece of tape for this mark. Use a 1 ¼" wrench and turn the adjustment screw counter-clockwise to de-tension the spring. Continue turning the adjustment screw until the coils of the spring are touching with no tension left in the spring.
2. Rotate the spring pack pivot assembly back into position as shown in Figure 7-9.
3. Remove the locknut from the die spring rod. Replace with a regular M8 hex nut and washer.
4. Compress the die spring by turning the M8 hex nut. This will rotate the ADD spring hook into position. Tighten until ADD hook is firmly seated against ADD pivot spacer.
5. Disconnect the cable assembly from the broken shear pin by removing the clevis pin. Remove broken shear pin and both shear bushings from Auto Drop Assembly. It may be necessary to lift-up on the knuckle between the lower and upper arms to relieve forces holding the shear pin in the Auto Drop Assembly.
6. Install two new shear bushings, shear pin, washer and hex nut. Refer to Figure 7-9 for position of shear pin. Use the correct washers that come with the shear pin. Using incorrect washers will result in the shear pin not being centered and will compromise its function.
7. Ensure that the cable assembly is passing through each pulley on the pulley rack as shown in Figure 7-9. Loosen the cable at the spring pack pivot assembly.
8. Connect the cable assembly to the new shear pin using the clevis pin. Tighten the cable at the spring pack pivot assembly.
9. Install the safety pin to prevent accidental tripping of the A.D.D. device. Refer to Section 4.2. Failure to do this can result in serious injury!
10. Remove the M8 regular nut and washer from the die spring rod. Assemble new M8 locknut. The nut should be at the end of the rod with two threads through the nut.

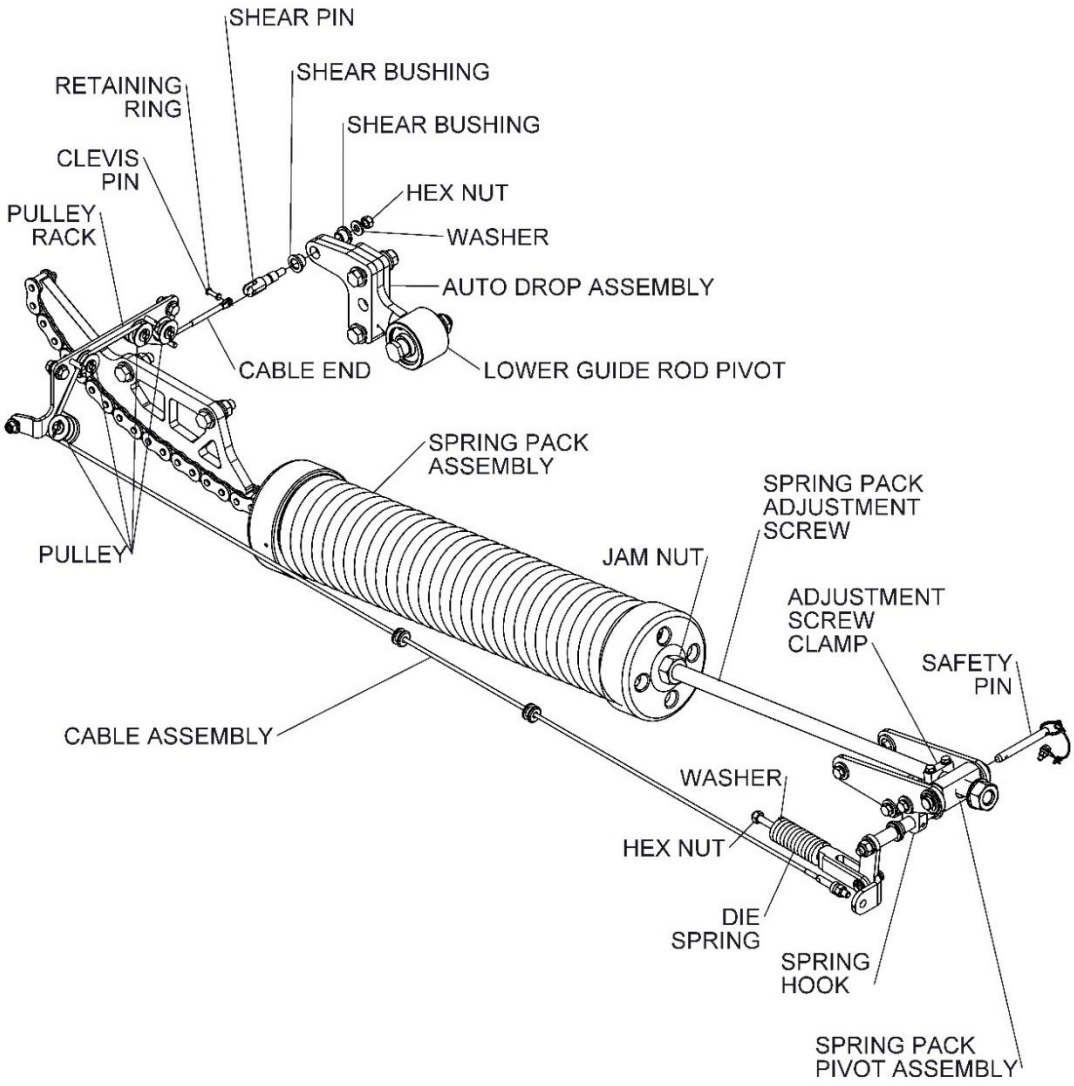

Figure 7-9: Shear Pin Replacement

11. Tension the spring pack. Hold the end of the spring pack nearest the back of the pantograph to keep the spring from rotating. Use a 1 ¼” wrench and turn the adjustment screw clockwise to re-tension the spring. Turn the adjustment screw until the spring pack is in the position of the mark you put on the adjustment screw in step 2 above. If you applied tape for the mark then remove the piece of tape after the spring is in position.
12. Holding the end of the spring pack use a 1 ¼” wrench to tighten the jam nut against the spring pack end cap. Tighten the jam nut to mechanics feel, no torque required.
13. Check head contact force per Section 5.1.
14. Remove rear safety pin and restore to normal operation condition.

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CHAPTER 8.0

TROUBLESHOOTING GUIDE

Table 8-1. Troubleshooting Guide

Symptom	Probable Cause	Tests and Checks	Corrective Action
Pantograph does not raise when operated from the cab	Electric lowering motor not retracting	Check that motor has power	Replace Lowering Motor Assembly as necessary
		Check location/operation of limit switches on ball screw actuator	Adjust/replace limit switch as necessary per RMM
	Safety hook is over the cross tube on the head assembly	Check that the safety hook is not latched over the cross tube	Unlatch the safety hook from the cross tube
	ADD system has been activated	Inspect the ADD system for a broken shear pin	Replace ADD shear pin per RMM
	Raising springs are not adjusted properly	Measure contact force	Adjust raising springs per RMM
	Manual crank gearbox is binding	Check gearbox orientation to ensure correct, check bolts for tightness, raise pantograph with manual crank	Replace gearbox or lowering motor assembly as required
Pantograph doesn't rise to correct height	Improper raising spring force	Check pantograph contact force	Adjust raising springs per RMM
	Upper limit switch on ball screw is out of adjustment	Visual check of limit switch and height measurement	Adjust limit switch per RMM
Pantograph doesn't lower when operated from the cab	Electric lowering motor not extending	Check that motor has power	Replace Lowering Motor Assembly as necessary
		Check location of lower limit switch on ball screw	Adjust limit switch as necessary per RMM
	Raising springs tension too high	Measure contact force	Adjust raising springs per RMM
Pantograph will rise partially, but not completely to maximum extension	Raising springs tension too low	Measure contact force	Adjust raising springs per RMM
	Damper adjustment too stiff	Test pantograph raising	Adjust damper per RMM
	Electric motor limit switch not set correctly	Check switch setting per RMM	Verify that the limit switch screws are tight
Pantograph will lower partially, but not completely to latched position	Lowering cylinder seized Electric motor limit switch not set correctly	Manually pull down on the pantograph's upper arm. If the piston doesn't move, the air cylinder is seized	Replace the lowering air cylinder
	Foreign object obstructing the pantograph	Inspect for the presence of foreign obstructions	Remove the obstruction
	Raising springs are not adjusted properly	Measure contact force.	Adjust raising springs

Table 8-1. Troubleshooting Guide (cont'd.)

Symptom	Probable Cause	Tests and Checks	Corrective Action
Pantograph lowers too slowly	Damper adjustment too stiff	Test pantograph lowering time	Adjust damper per RMM
Pantograph rises too fast	Damper inoperative	Test pantograph raising and lowering times	Replace damper
	Damper adjustment too loose	Test pantograph raising and lowering times	Adjust damper per RMM
	Raising springs not adjusted properly	Measure contact force	Adjust raising springs
Pantograph rises too slowly	Damper not adjusted properly	Test pantograph raising and lowering times	Adjust damper
	Raising springs not adjusted properly	Measure contact force	Adjust raising springs
Excessive wear rate on collector carbons	Damper adjustment too stiff	Test pantograph raising and lowering times	Adjust damper per RMM
	Damper seized	Test pantograph raising and lowering times	Replace damper per RMM
	Improper raising spring tension	Measure contact force	Adjust raising springs per RMM
Pantograph makes a grinding noise during raising and lowering	Manual gearbox coupler rubbing against lowering motor housing	Verify there is a gap between the coupler and lowering motor housing	Ensure installation instructions specify to leave a gap
	Lowering motor guide shaft is damaged	Visual inspection of the guide shaft – must be shiny & smooth	Remove & replace the lowering motor
	Spindle drive clutch engaged, overload	Measure force being applied to spindle drive	Replace lowering motor if not able to meet its 1000lbf spec
	Spindle drive clutch engaged, end of stroke limit	Check limiting switch function and position	Reposition or replace spindle drive limiting switches per RMM

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