

# Team 9 BattleBot

Florida State University  
Tallahassee, FL

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TITLE:

## OPERATIONS MANUAL

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## 1.0 INTRODUCTION

This Operations Manual will present the guidelines and procedures for servicing and maintaining the BattleBot and all of its systems. Any parts, such as screws and nuts, are referred to by their Bill of Materials number. The Bill of Materials can be found in Appendix A.

Some conventions used in this document can be seen in Figure 1.1 and 1.2.

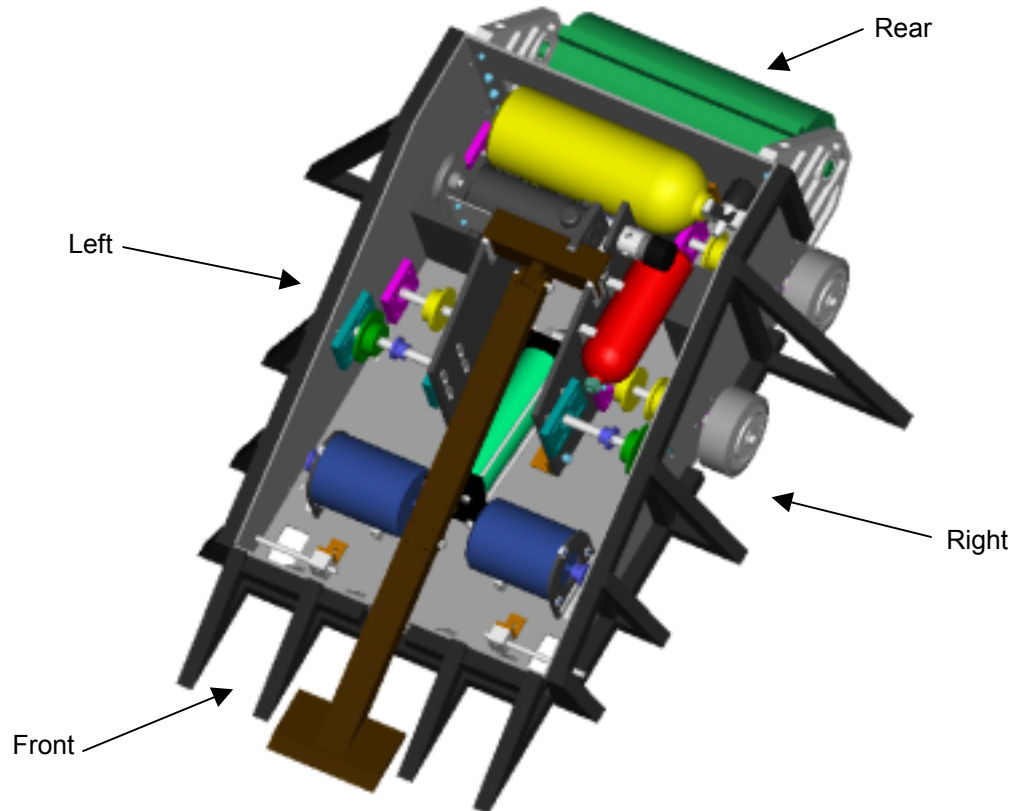


Figure 1.1 – BattleBot with Lifting Arm Down

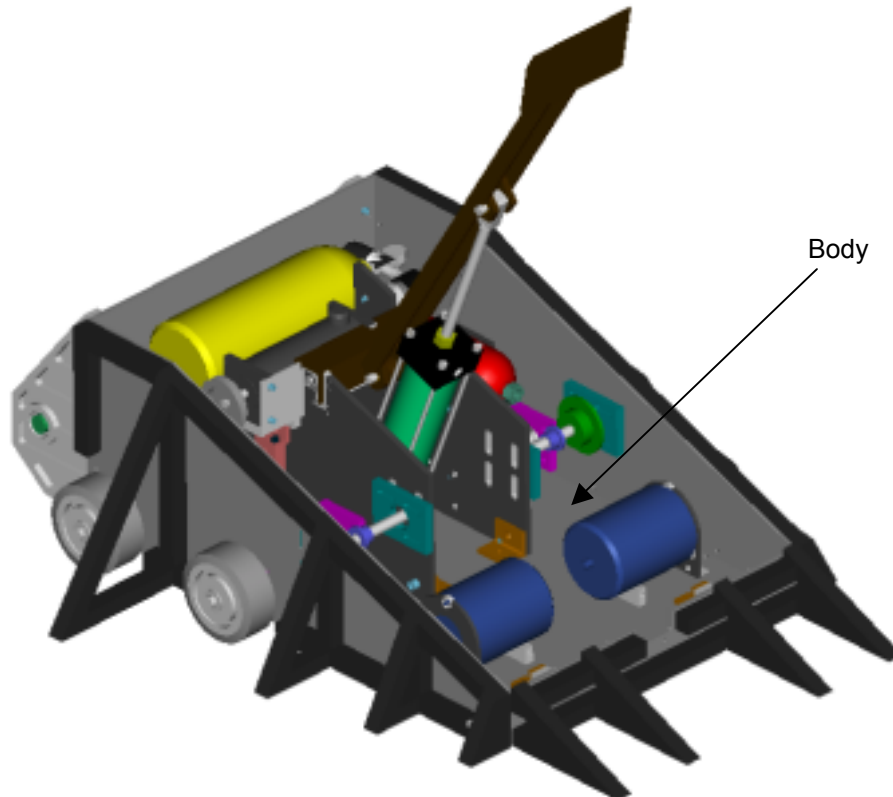


Figure 1.2 – BattleBot with Lifting Arm Up

## 2.0 OUTER COMPONENTS

### 2.1 Body Armor

All of the lexan panels that cover the outside of the robot are considered the body armor. They are attached using many flat head socket screws. Flat head screws are used to minimize damage from impacting other Bots.

∩ **Tools Required:**  
.125" allen wrench

← → **Disassembly**  
1. Using a .125" allen wrench, remove all screws.  
2. Lift off the desired panel.

→ ← **Assembly**  
1. Align the panel in the correct orientation over the holes.  
2. Using a .125" allen wrench, screw in all screws (BOM #3.2).

### 2.2 Armor Struts

The armor struts provide a place to attach the body armor and give structural support and rigidity to the body of the Bot as well as the body armor. They are thru bolted with nuts to the body by means of quarter inch socket head cap screws and the body armor is, in turn, attached to the armor struts by flat head screws tapped directly into the armor struts. The struts were constructed by welding square sections of chrom-moly into the desired shapes. The armor struts are shown in Figure 2.1.

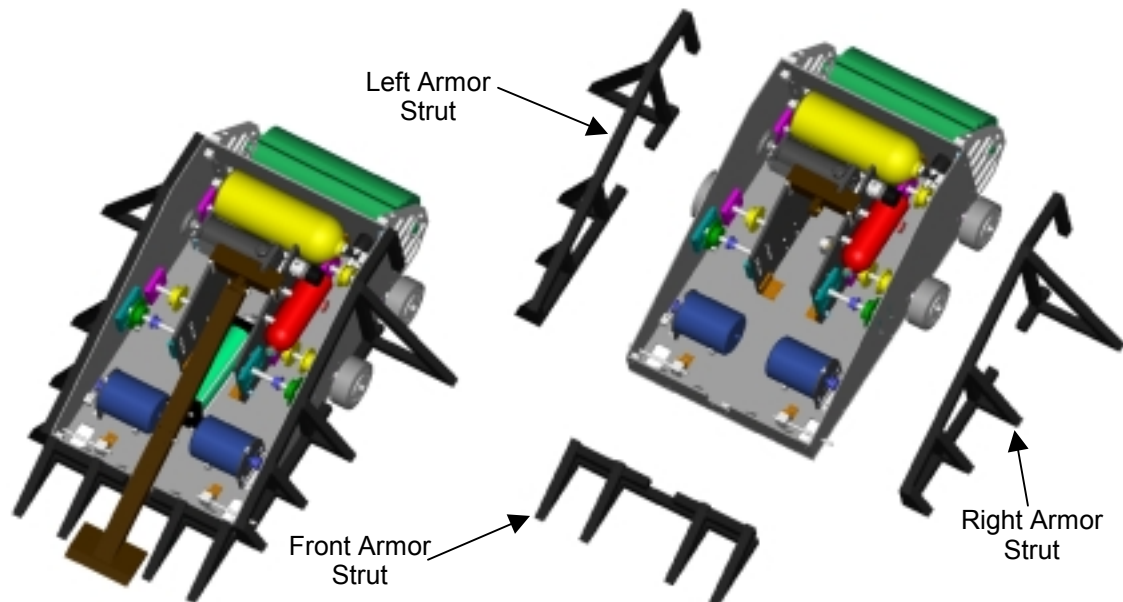


Figure 2.1 – Armor Struts

∩ **Tools Required:**

- 3/16" allen wrench
- 7/16" wrench or socket

← → **Disassembly**

1. Remove top body armor and armor over desired strut (Section 2.1).
2. Remove all screws holding the desired armor strut using a 3/16" allen wrench and a 7/16" wrench or socket.

→ ← **Assembly**

1. Align the armor strut with the mounting holes on the body of the Bot.
2. Insert each screw (BOM #3.4) through the armor strut and through the body.
3. Place a washer (BOM #3.7), then a lock nut (BOM #3.11) onto the screw and tighten using a 3/16" allen wrench and a 7/16" wrench or socket.
4. Replace all body armor (Section 2.1).

## 3.0 LIFTING ARM COMPONENTS

### 3.1 Lifting Arm

The lifting arm is a solid steel structure made up of many welded components. The arm pivots at its end on the saddle using a 1/2" pin that is held in place by cotter pins. The piston is attached to the lifting arm at the arm's center using another 1/2" pin that is also held in place by the cotter pins as seen in Figure 3.1.

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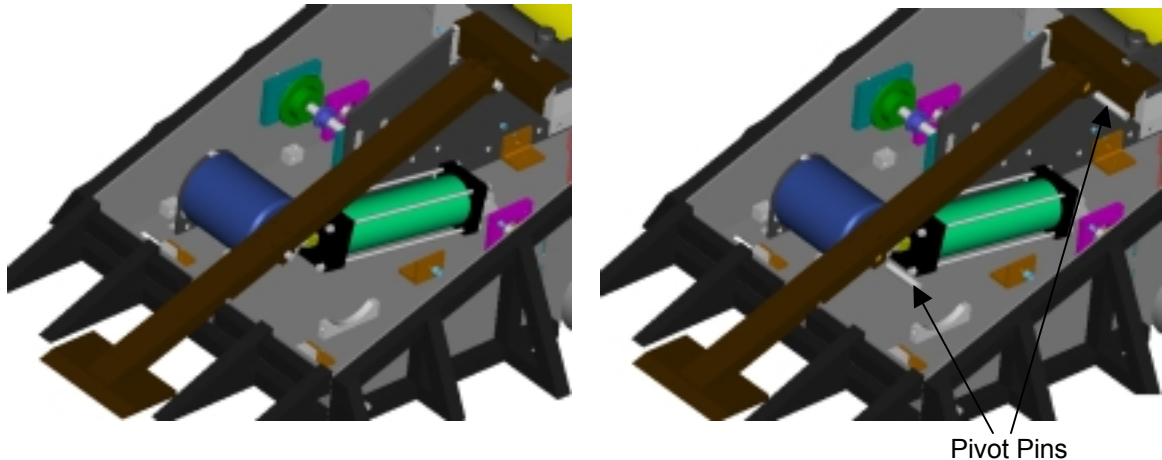


Figure 3.1 – Lifting Arm

≡ **Materials Required:**

3/32 Cotter pin (BOM #3.14), qty. 4

∩ **Tools Required:**

needle nose pliers  
hammer

← → **Disassembly**

1. Remove top body armor (Section 2.1).
2. Remove one cotter pin from either side of the pivot pin using needle nose pliers. Discard cotter pin.
3. Push pivot pin through bushings until it is free. It may be necessary to jiggle the arm or tap with a hammer.
4. Use this procedure to remove both the saddle and piston pins.

→ ← **Assembly**

1. Be sure there is a cotter pin (BOM #3.14) in one end of the pivot pin. Align the lifting arm pivot with the saddle and insert the pin. It may be necessary to jiggle the arm or tap with a hammer.
2. Insert a new cotter pin (BOM #3.14) into the pivot pin and bend around with needle nose pliers.
3. Use the same procedure to attach the lifting arm to the piston.
4. Replace top body armor (Section 2.1).

## 3.2 Saddle

The saddle is composed of many components that are welded together. The saddle's function is to provide a place for the lifting arm to pivot. The pivot has a brass bushing. The saddle is attached to the left and right bulkheads with two socket head cap screws that are thru bolted. To provide stability, the saddle sits in two aluminum groves in the bulkhead as seen in Figure 3.2.

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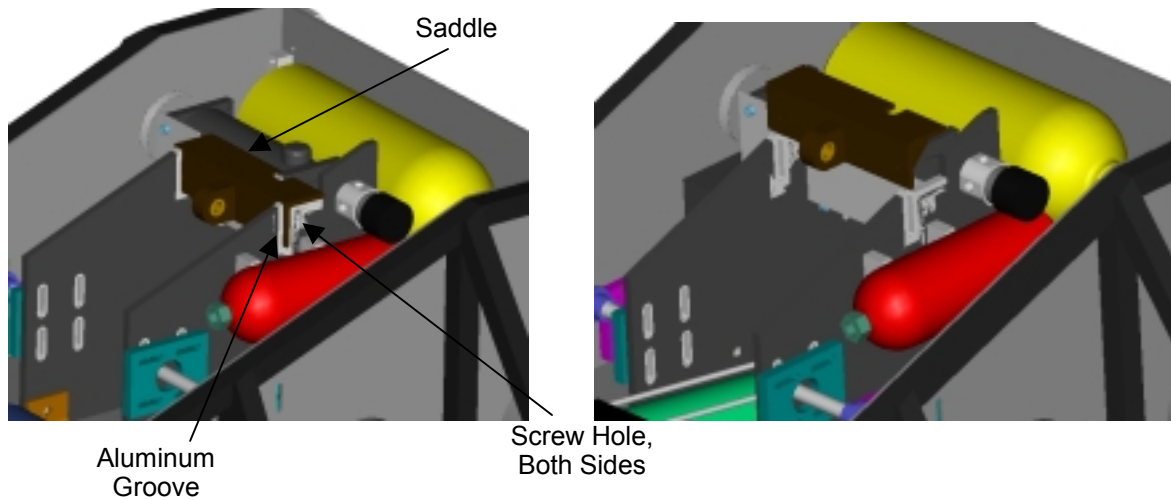


Figure 3.2 – Saddle

∩ **Tools Required:**

- 3/16" allen wrench
- 7/16" wrench

← → **Disassembly**

1. Remove top body armor (Section 2.1).
2. Remove lifting arm (Section 3.1).
3. Remove both screws that attach saddle to bulkheads using a 3/16" allen wrench and a 7/16" wrench.
4. Lift saddle vertically out of aluminum grooves.

→ ← **Assembly**

1. Drop saddle vertically into aluminum grooves.
2. Insert a screw (BOM #3.3) into the screw hole from the bulkhead side.
3. Screw a lock nut (BOM #3.11) onto the end of the screw and tighten.
4. Replace lifting arm (Section 3.1).
5. Replace top body armor (Section 2.1).

## 4.0 PNEUMATIC COMPONENTS

### 4.1 Reservoir Tank

The reservoir tank holds the air for the pneumatic system. The tank rests in round cutouts in the bulkheads in the rear of the Bot. The cutouts are covered with a 1/4" sheet of rubber to protect the bulkheads and cushion the tank. Two large hose clamps wrap around the tanks and over two horizontal bars between the bulkheads. When the hose clamp is tightened, the tank is pulled tight into the cutouts in the bulkheads as seen in Figure 4.1.

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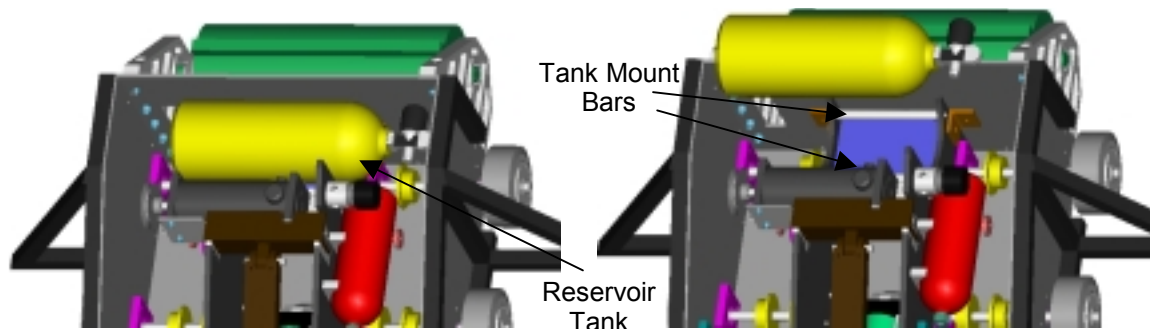


Figure 4.1 – Reservoir Tank

∩ **Tools Required:**

flathead screwdriver or 5/16" socket

← → **Disassembly**

1. Remove top body armor (Section 2.1).  
DANGER! Be sure reservoir tank valve is turned off by turning clockwise and system bleed valve is opened!
2. Remove hose fitting from tank valve by turning knob counterclockwise.
3. Loosen both hose clamp screws using a flathead screwdriver or 5/16" socket, but do not remove completely.
4. Push both hose clamps towards bottom end of tank (away from valve).
5. Pull tank out by valve at an angle to remove from Bot.

→ ← **Assembly**

1. Push tank through hose clamps bottom end first as seen in Figure 4.1.
2. Move both hose clamps so they are about 1" from each bulkhead.
3. Tighten both hose clamps using a flathead screwdriver or 5/16" socket.
4. Connect hose fitting to tank valve and tighten by turning clockwise.
5. Replace top body armor (Section 2.1).

#### 4.2 Reservoir Tank Mounting Bars

The reservoir tank mounting bars provide a place to secure the reservoir tank as well as provide structural rigidity to the bulkheads. They are secured at each end by screws that pass through the bulkheads as seen in Figure 4.2.

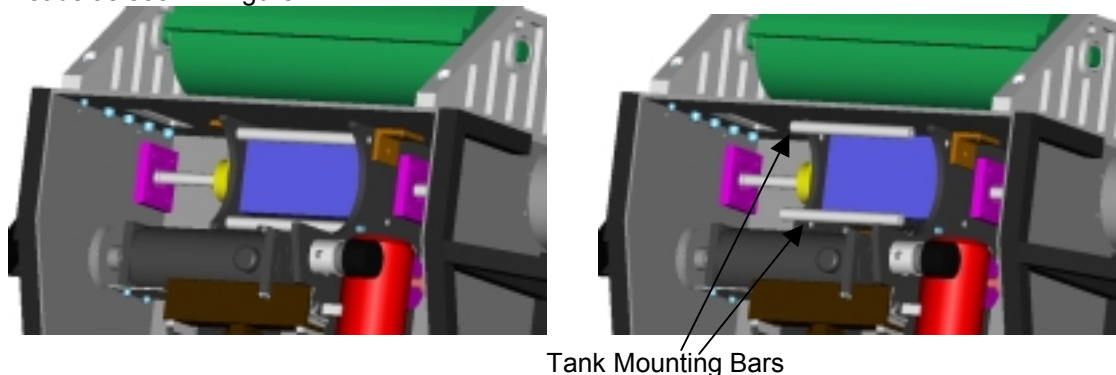


Figure 4.2 – Reservoir Tank Mounting Bars

∩ **Tools Required:**



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3/16" allen wrench  
pliers

← → **Disassembly**

1. Remove top body armor (Section 2.1).
2. Remove reservoir tank (Section 4.1).
3. Unscrew screws from each end of the tank mounting bars using a 3/16" allen wrench. Grip the bar with pliers if necessary.
4. Lift tank mounting bars out of Bot.

→← **Assembly**

1. Place both tank mounting bars through two hose clamps (BOM #3.1).
2. Align tank mounting bars with holes in bulkheads.
3. Insert a screw (BOM #3.4) into each screw hole from the bulkhead side and tighten with a 3/16" allen wrench. It may be necessary to hold bar with pliers. Repeat for each end of both tank mounting bars.
4. Replace reservoir tank (Section 4.1).
5. Replace top body armor (Section 2.1).

### 4.3 Regulator

The regulator drops the 2000 psi pressure from the reservoir tank to the 250 psi operating pressure of the pneumatic system. The high side of the regulator attaches to the reservoir tank and the low side goes to the buffer tank. The hoses use 1/4" NPT fittings. The regulator is located on the right bulkhead as seen in Figure 4.3.

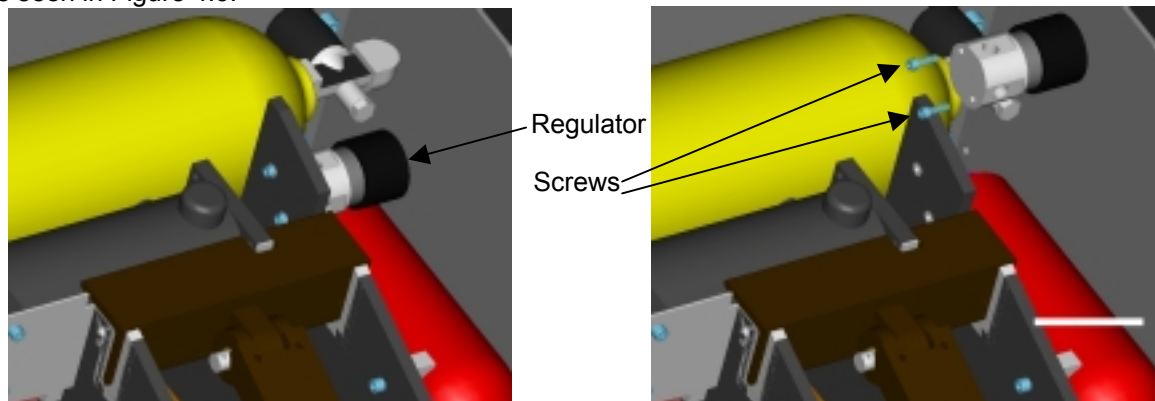


Figure 4.3 – Regulator

∩ **Tools Required:**

5/32" allen wrench  
7/16" flare nut wrench

← → **Disassembly**

1. Remove top body armor (Section 2.1).  
DANGER! Be sure reservoir tank valve is turned off by turning clockwise and system bleed valve is opened!
2. Unscrew hoses from high side and low side of regulator using 7/16" flare nut wrench.
3. Unscrew two screws from back side of regulator using a 5/32" allen wrench.
4. Remove regulator from Bot.

→← **Assembly**

1. Align regulator over holes as shown in Figure 4.3.

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2. Insert a screw (BOM #3.19) into each of the two screw holes from the bulkhead side and tighten with a 5/32" allen wrench.
3. Screw high side hose to the high side of the regulator and the low side hose to the low side of the regulator using a 7/16" flare nut wrench.  
CAUTION! Be sure the hose from the reservoir tank is attached to a port marked with an "H" and the hose leading to the buffer tank is attached to a port marked with an "L". Severe damage to the pneumatic system will result if attached incorrectly.
4. Replace top body armor (Section 2.1).

#### 4.4 Buffer Tank

The buffer tank is designed to hold air at the operating pressure of the pneumatic system to help the piston deploy faster. Air enters from the regulator and pressurizes the tank to 250 psi. When the piston is engaged, the air goes from the buffer tank into the piston along with air from the regulator. This tank helps to reduce the pressure drop in the system when the piston is actuated. Two 3/8 NPT hoses attach to the tank by way of a T-fitting. The buffer tank sits in two aluminum cradles that are attached to the right bulkhead. Two large hose clamps pass between the cradles and bulkhead and around the buffer tank. When the hose clamps are tightened, the buffer tank is pulled tightly into the cradles as seen in Figure 4.4.

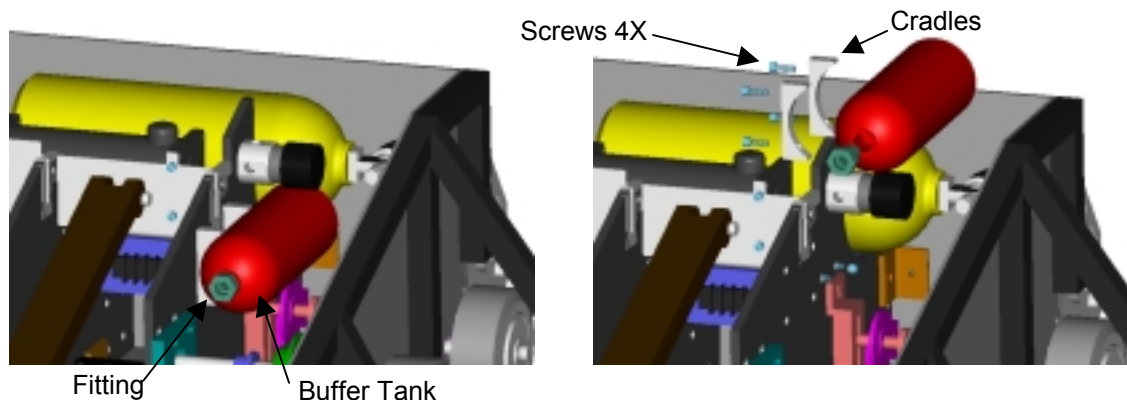


Figure 4.4 – Buffer Tank

#### ∩ Tools Required:

- 3/16" allen wrench
- flathead screwdriver or 5/16" socket
- 9/16" flare nut wrench
- 1" wrench

#### ← → Disassembly

1. Remove top body armor (Section 2.1).
2. Remove lifting arm (Section 3.1) only if removing cradles.
3. Remove saddle (Section 3.2) only if removing cradles.  
DANGER! Be sure reservoir tank valve is turned off by turning clockwise and system bleed valve is opened!
4. Unscrew T-fitting from buffer tank using a 9/16" flare nut wrench. It may be necessary to hold the buffer tank fitting in place with a 1" wrench.
5. Loosen both hose clamp screws using a flathead screwdriver or 5/16" socket, but do not remove completely.
6. Pull buffer tank from Bot from end where T-fitting was connected.

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7. Unscrew two screws from back side of each cradle using a 3/16" allen wrench. Repeat for second cradle.
8. Remove two cradles and two hose clamps from Bot.

#### →← Assembly

1. Align holes in two hose clamps with holes in two cradles.
2. Align cradles with holes in right bulkhead.
3. Insert a screw (BOM #3.4) into each of the two screw holes from the bulkhead side and tighten with a 3/16" allen wrench. Repeat for second cradle.
4. Insert buffer tank, bottom end first, into the two hose clamps.
5. Tighten both hose clamps using a flathead screwdriver or 5/16" socket.
6. Screw T-fitting into buffer tank using a 9/16" flare nut wrench.
7. Replace saddle (Section 3.2).
8. Replace lifting arm (Section 3.1).
9. Replace top body armor (Section 2.1).

#### 4.5 Piston

The piston is attached to the bottom of the body with a 1/2" pin. The 1/2" pin is inserted into a bracket that is welded to the body. The bracket has a brass bushing. The end of the piston rod is attached to the lifting arm with a 1/2" pin. The bracket on the lifting arm also has a brass bushing. The pneumatic hoses are screwed into the 3/8 NPT fittings on each end of the piston cylinder. The piston can be seen in Figure 4.5.

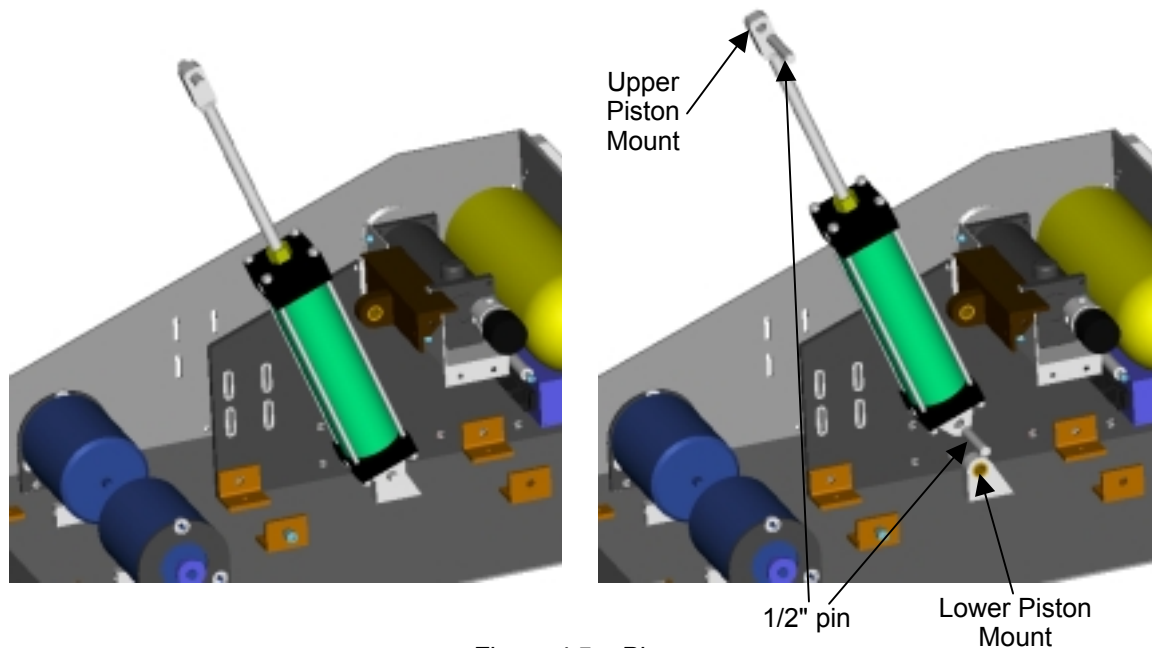


Figure 4.5 – Piston

≡ **Materials Required:**  
3/32 Cotter pin (BOM #3.14), qty. 3

∩ **Tools Required:**  
9/16" flare nut wrench  
needle nose pliers  
hammer

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## ← → **Disassembly**

1. Remove top body armor (Section 2.1).
2. Remove lifting arm (Section 3.1).
3. Remove both hoses from piston using a 9/16" flare nut wrench.
4. Remove cotter pin from the lower piston bracket using needle nose pliers.
5. Push pivot pin through bushing until it is free. It may be necessary to jiggle the piston or tap pin with a hammer.

## →← **Assembly**

1. Align piston over the lower piston bracket.
2. Insert pin into piston and through the bracket.
3. Insert a new cotter pin (BOM #3.14) into the pin and bend around with needle nose pliers.
4. Attach both hoses to piston and tighten using a 9/16" flare nut wrench.
5. Replace lifting arm (Section 3.1).
6. Replace top body armor (Section 2.1).

## 4.6 Operating the Pneumatic System

The pneumatic system stores nitrogen in the reservoir tank. A regulator drops the pressure of the tank from the 2000 psi maximum to the 250 psi working pressure. The nitrogen then fills the buffer tank at the operating pressure. When the piston is activated, the air flows from both the buffer tank and the regulator into the piston. This extends and retracts the lifting arm.

**DANGER!** When the lifting arm is activated, it moves with great force and speed! Serious injury or death can result from contacting the lifting arm when it is in motion!

The pressure of the system is controlled by turning the black knob on the regulator. The pressure of the regulator is displayed on a gage between the regulator and buffer tank. This pressure should be set at 250 psi maximum.

**CAUTION!** Setting the pressure of the regulator above 250 psi will cause equipment damage!

The pressure of the reservoir tank is displayed on a gage between the reservoir tank and regulator. By rule, the pressure can not exceed 2000 psi. The reservoir tank has a valve and a removable hose connection. The reservoir tank valve should remain closed at all times the Bot is being serviced, stored or transported.

**DANGER!** Failure to close the reservoir tank valve when the Bot is being serviced, stored or transported can cause serious injury or death as well as equipment damage!

## ↑ **Bringing Pneumatic System Online**

1. Remove top body armor (Section 2.1).
2. Power up electrical system (Section 8.4).
3. Unscrew regulator (counterclockwise) until the spring force is removed (this lowers the outlet pressure).
4. Close the bleed valve located between the regulator and buffer tank.
5. Ensure the removable hose connection is securely attached to the reservoir tank and that the vent screw on the hose connection is closed by screwing clockwise full.
6. Slowly open the tank valve until it stops. Then turn back 1/4 turn.
7. Slowly raise the operating pressure to the desired level as observed on the gage between the regulator and buffer tank. Do not exceed 250 psi.

**CAUTION!** Setting the pressure of the regulator above 250 psi will cause serious equipment damage!

8. Replace top body armor (Section 2.1).



### Taking Pneumatic System Offline

1. Remove top body armor (Section 2.1).
2. Close the reservoir tank valve.
3. Slowly open the bleed valve located between the regulator and buffer tank. This will vent the air from the system.
4. Open the vent screw on the removable hose connection to vent any remaining air.
5. Power down electrical system (Section 8.4).
6. Replace top body armor (Section 2.1).

## 5.0 DRUM COMPONENTS

### 5.1 Drum Motor

The drum motor spins the drum on the rear of the BattleBot by means of a V-belt. The ratio of the pulleys is 1:1. To remove the tension in the V-belt, the drum motor must be removed. The drum motor is mounted on a bracket that is made from a single piece of aluminum bent into shape. The drum is secured to the mount by four socket head cap screws and the mount is secured to the bulkheads as seen in Figure 5.1.

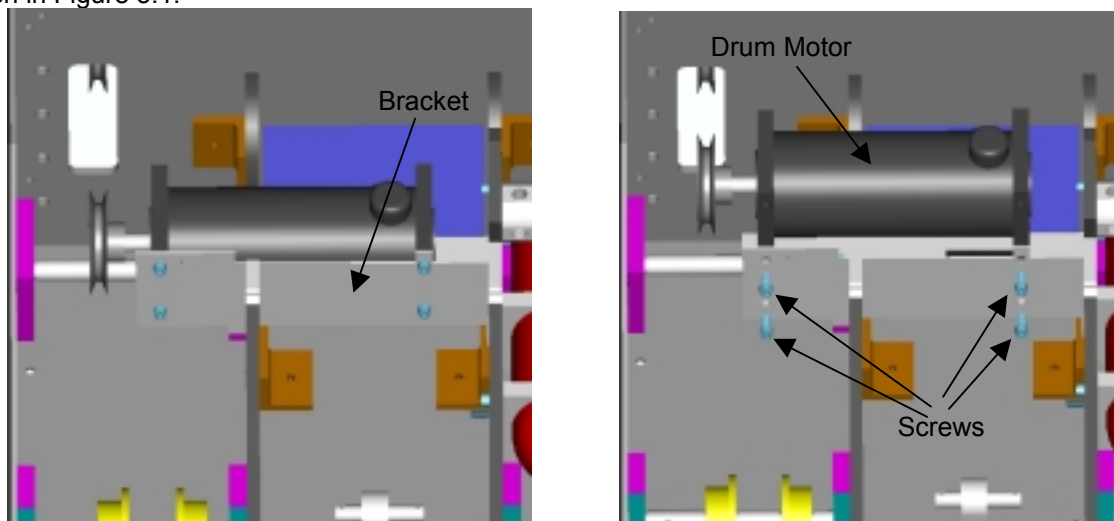


Figure 5.1 – Drum Motor



### Tools Required:

- 3/16" allen wrench

### ← → Disassembly

1. Remove top body armor (Section 2.1).
2. Remove lifting arm (Section 3.1).
3. Remove saddle (Section 3.2).
4. Remove reservoir tank (Section 4.1).
5. Using a 3/16 allen wrench, remove all four screws that attach drum motor to the motor mount.
6. Tilt drum motor towards rear of Bot and remove the belt from the pulley.
7. Disconnect the two electrical wires at their connector.
8. Lift motor free of mount.

### → ← Assembly

1. Connect two electrical wires at their connector.
2. Tilt drum motor towards rear of Bot and place the belt over the pulley.

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3. Align drum motor with screw holes in bracket.
4. Screw four screws (BOM #3.16) into the holes and tighten.
5. Replace saddle (Section 3.2).
6. Replace lifting arm (Section 3.1).
7. Replace reservoir tank (Section 4.1).
8. Replace top body armor (Section 2.1).

## 5.2 Drum Motor Mount

The drum motor mount is made up of a piece of aluminum bent to shape. The bracket mounts to the right bulkhead directly with two socket head cap screws. On the left side, the bracket mounts to a mounting block with two socket head cap screws which is in turn screwed to the left bulkhead with two socket head cap screws as seen in Figure 5.2.

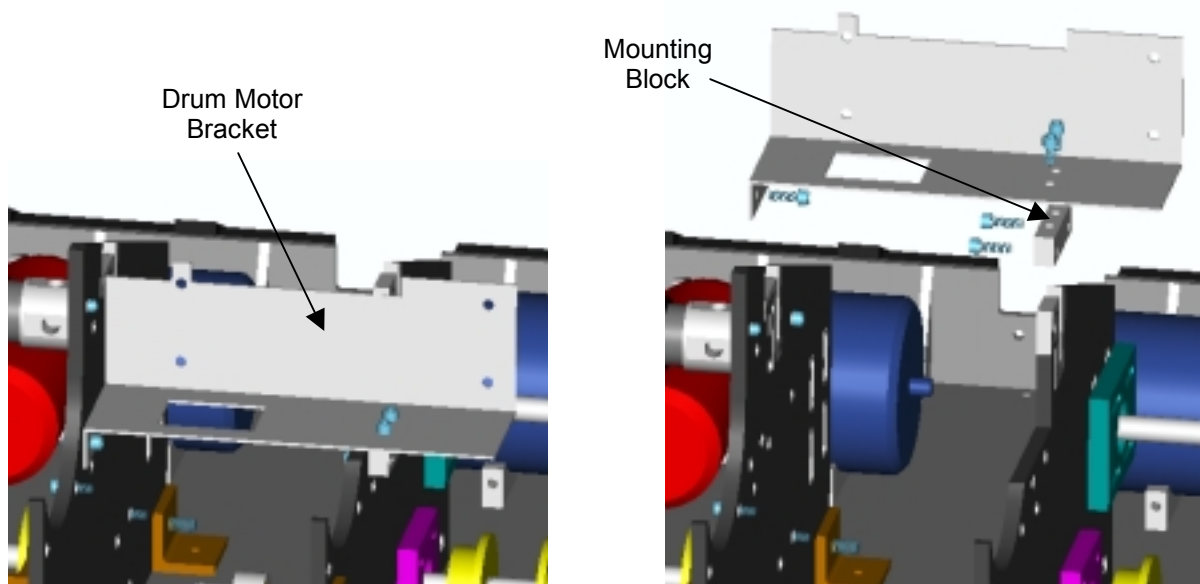


Figure 5.2 – Drum Motor Mount

- ∩ **Tools Required:**  
3/16" allen wrench  
7/16" wrench or socket

### ← → Disassembly

1. Remove top body armor (Section 2.1).
2. Remove lifting arm (Section 3.1).
3. Remove saddle (Section 3.2).
4. Remove reservoir tank (Section 4.1).
5. Remove drum motor (Section 5.1).
6. Unscrew the two screws that attach the bracket to the mounting block using a 3/16" allen wrench.
7. Unscrew the two screws that attach the bracket to the right bulkhead with a 3/16" allen wrench and 7/16" wrench or socket.
8. Remove bracket.
9. If necessary, unscrew the two screws that hold the mounting block to the left bulkhead with a 3/16" allen wrench and a 7/16" wrench or socket.
10. Remove mounting block.

## →← Assembly

1. If the mount block was removed, align it over the holes in the left bulkhead, insert two screws (BOM #3.4) through the bulkhead and then into the mounting block. Tighten using a 3/16" allen wrench and a 7/16" wrench or socket.
2. Align the bracket over the holes in the right bulkhead and the mounting block.
3. Insert two screws (BOM #3.4) through the bracket and into the right bulkhead.
4. Place a washer (BOM #3.7) and lock nut (BOM #3.11) on each screw and tighten using a 3/16" allen wrench and a 7/16" wrench or socket.
5. Insert two screws (BOM #3.16) through the bracket, screw into the mount block and tighten using a 3/16" allen wrench.
6. Replace drum motor (Section 5.1).
7. Replace saddle (Section 3.2).
8. Replace lifting arm (Section 3.1).
9. Replace reservoir tank (Section 4.1).
10. Replace top body armor (Section 2.1).

## 5.3 Drum

The drum consists of hollow steel cylinder that is welded on each end with a shaft running through the middle. A sprocket is attached to the shaft. The drum assembly is held in place with two drum mounts that are in turn, bolted to the rear of the Bot as seen in Figure 5.3. The shaft spins in two roller bearings that are press fit into the mounts. To release the tension in the drum belt, the drum motor must be removed (Section 5.1).

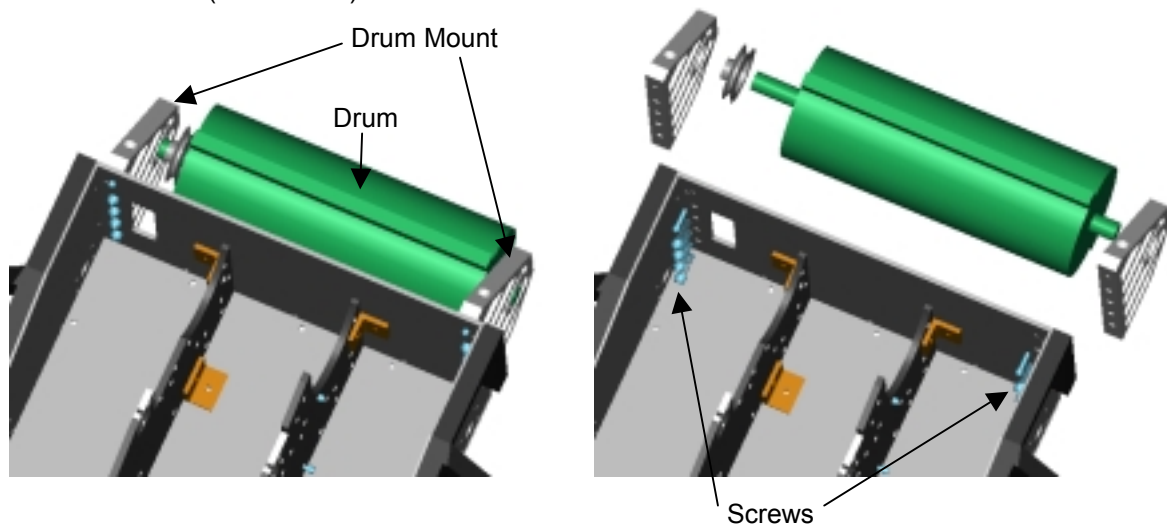


Figure 5.3 – Drum and Mount Assembly

## ∩ Tools Required:

- 3/16" allen wrench
- 5/16" allen wrench
- 7/16" socket
- hammer or press

## ← → Disassembly

1. Remove top body armor (Section 2.1).
2. Remove reservoir tank (Section 4.1).
3. Remove drum motor (Section 5.1).



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4. Unscrew the two top bolts holding each drum mount to the body using a 3/16" allen wrench and 7/16" socket.
5. Unscrew each of the four bolts holding each drum mount to the body using a 5/16" allen wrench.
6. Remove the drum and mounts as one assembly.
7. Remove the mounts from the ends of the shaft. They may have to be tapped with a hammer.
8. Unscrew the set screws in the sprocket to remove it from the shaft.
9. If necessary to remove the bearings, use a press.

#### →← Assembly

1. Place the sprocket on the long end of the shaft as shown in Figure 5.3 and snug set screw.
2. Wrap the belt loosely around the sprocket.
3. Insert the mounts on each end of the shaft. They may have to be tapped with a hammer or use a press.
4. Align mounts with holes on rear of Bot. It may be necessary to adjust the position of the mounts on the shafts.
5. Insert four screws (BOM #3.6) into the lower four holes in the body and tighten using a 5/16" allen wrench. Repeat for second mount.
6. Insert a screw (BOM #3.17) through the body of the Bot, then through the mount, in the top hole. Place a lock nut (BOM #3.11) on the screw and tighten using a 3/16" allen wrench and a 7/16" wrench or socket. Repeat for the second mount.
7. Replace the drum motor (Section 5.1). While installing the drum motor, check the alignment of the drum motor sprocket and the sprocket on the drum shaft. Adjust the sprocket on the drum shaft so it is inline with the drum motor sprocket.
8. Replace reservoir tank (Section 4.1).
9. Replace top body armor (Section 2.1).

## 6.0 DRIVE TRAIN COMPONENTS

### 6.1 Tensioning Compound Shaft Chains

The compound shafts are the tensioning mechanisms for the chain between the motor and compound shaft, as well as the chain between the compound shaft and front wheel shaft. The compound shaft rotates in bearings pressed into the adjustable bearing blocks. The adjustable bearing blocks tighten the chains by moving up and down as well as forward and backward as seen in Figure 6.1.

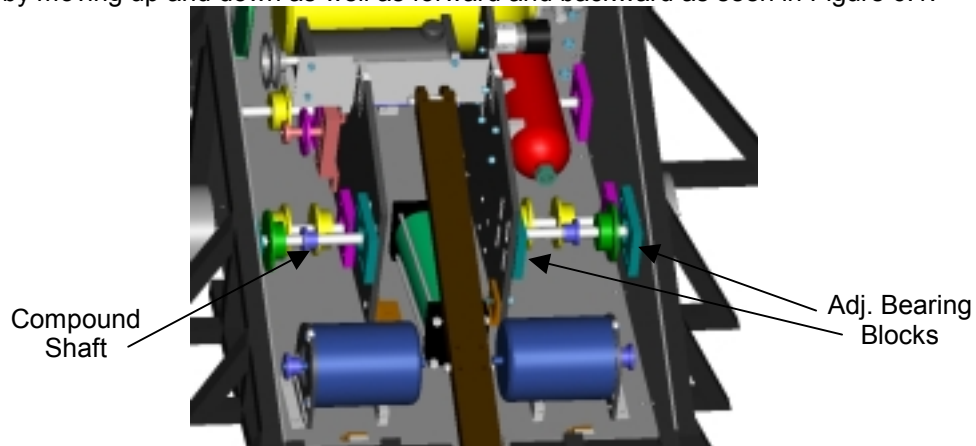


Figure 6.1 – Adjustable Bearing Blocks and Compound Shaft



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- ∩ **Tools Required:**  
3/16" allen wrench  
7/16" wrench or socket

- ↑ **Tightening Compound Shaft Chains**
1. Remove top body armor (Section 2.1).
  2. Loosen all eight mounting screws using a 3/16" allen wrench and 7/16" wrench or socket.
  3. Pull up evenly on the compound shaft until both chains are tight.
  4. Tighten all eight mounting screws using a 3/16" allen wrench and 7/16" wrench or socket.
  5. Replace top body armor (Section 2.1.)

- ↓ **Loosening Compound Shaft Chains**
1. Remove top body armor (Section 2.1).
  2. Loosen all eight mounting screws using a 3/16" allen wrench and 7/16" wrench or socket.
  3. Move compound shaft so the desired chain becomes loose.

## 6.2 Tensioning Front and Rear Wheel Shaft Chains

The chain between the front wheel shaft and rear wheel shaft is tensioned by a tension device located between them. This device has an idler sprocket that is in mesh with the chain and pushes down on the chain. A nut on the top of the tension device can be turned to move the idler sprocket up and down, thus tightening or loosening the chain as seen in Figure 6.2. For removing the tensioner, see Section 6.7.

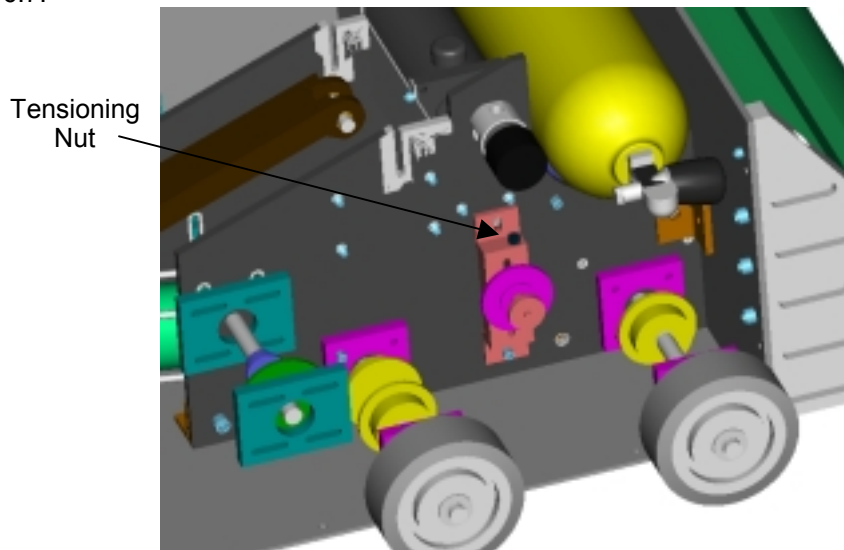


Figure 6.2 – Tension Device for Front and Rear Wheel Shaft

- ∩ **Tools Required:**  
1/2" wrench or socket

- ↑ **Tightening Compound Shaft Chains**
1. Remove top body armor (Section 2.1).
  2. Remove buffer tank (Section 4.4) if necessary to reach tension screw underneath.
  3. Turn tensioning nut clockwise to tension chain using 1/2" wrench or socket. Be sure not to over tension the chain as this will cause premature wear.
  4. Replace buffer tank (Section 4.4).
  5. Replace top body armor (Section 2.1.).

- ↓ **Loosening Compound Shaft Chains**

1. Remove top body armor (Section 2.1).
2. Remove buffer tank (Section 4.4) if necessary to reach tension screw underneath.
3. Turn tensioning nut counterclockwise to loosen chain using 1/2" wrench or socket.
4. Replace buffer tank (Section 4.4).
5. Replace top body armor (Section 2.1).

## 6.3 Drive Motors

The two drive motors provide power to the wheels on either side of the Bot through a chain drive system. The motors are controlled by a speed controller mounted in the rear of the Bot (Section 8.2). The motors are mounted in the front of the Bot on either side. The rear side sits in a cradle. A hose clamp is attached to the sides of the cradle with two screws. The clamp is wrapped around the motor and when the screw is tightened, the motor is pulled tightly into the cradle. The front of the motor is attached to a motor mount by three screws. The motor has bolts that protrude through holes in the motor mount. Nuts are then tightened to secure the motor. A 10 tooth sprocket is placed on the motor shaft and secured with two set screws as seen in Figure 6.3.

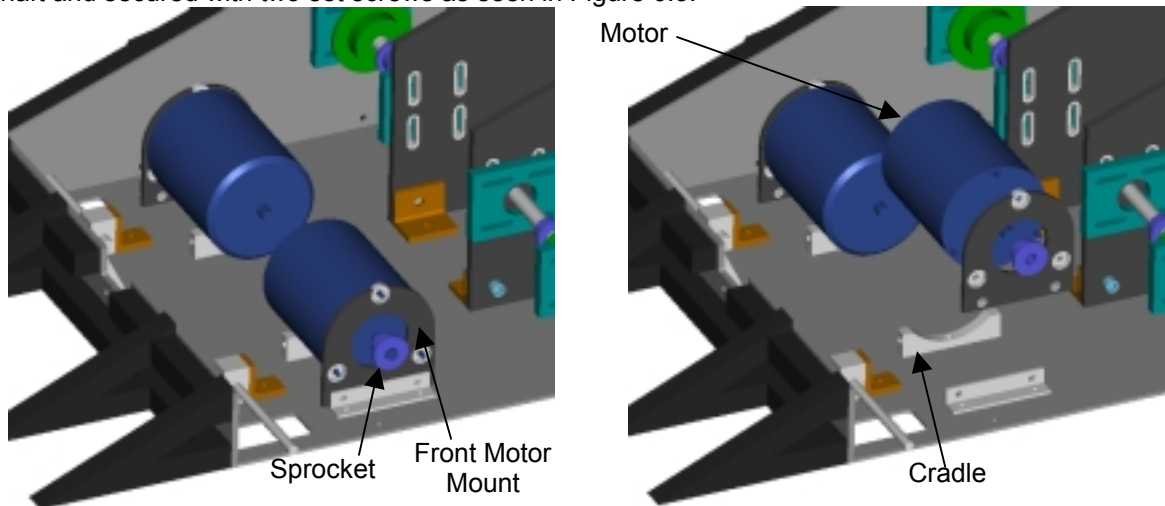


Figure 6.3 – Drive Motors

### ∩ Tools Required:

- 3/16" allen wrench
- 5/32" allen wrench
- 7/16" socket
- 8 mm socket
- flathead screwdriver or 5/16" socket

### ← → Disassembly

1. Remove top body armor (Section 2.1).
2. Manually raise lifting arm out of the way.
3. Loosen the chain (Section 6.1) and remove chain from motor sprocket.
4. Unscrew the three nuts holding the motor to the front motor mount using an 8mm socket wrench.
5. Loosen the hose clamp using a flathead screwdriver or 5/16" socket.
6. Remove one of the screws holding the hose clamp to the cradle using a 3/16" allen wrench.
7. Disconnect the two wires at their connector.

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8. Pull the hose clamp up away from the motor. At the same time, pull the motor back away from the front motor mount to disengage the screws and lift the motor up out of the Bot.
9. If removing the sprocket, loosen the two set screws with a 5/32" allen wrench and pull sprocket free from shaft.
10. If removing the front motor mount, unscrew the two screws holding the bottom of the mount to the bracket on the bottom of the Bot using a 3/16" allen wrench and a 7/16" wrench or socket.
11. Pull front motor mount free from Bot.

#### ←← **Assembly**

1. Align front motor mount with bracket on bottom of Bot. Be sure the front motor mount is oriented such that the recessed cavity in the three large inserts is facing out as seen in Figure 6.3.
2. Insert two screws (BOM #3.16) into each hole on the bottom of the front motor mount from the bracket side. Place a lock nut (BOM #3.11) on the screw and tighten using a 3/16" allen wrench and a 7/16" wrench or socket.
3. Align one end of the hose clamp with the hole in the cradle. Insert a screw (BOM #3.16) and tighten with a 3/16" allen wrench.
4. Place sprocket on shaft and snug set screws using a 5/32" allen wrench.
5. Attach the two wires at their connector.
6. Pull the hose clamp up away from the motor. At the same time, lower the motor onto the cradle and slide towards the front motor mount engaging the three screws in the holes.
7. Place a lock nut (BOM #3.13) on each of the protruding screws and tighten with an 8mm socket.
8. Wrap the hose clamp around the motor and align with hole in cradle. Insert a screw (BOM #3.16) and tighten with a 3/16" allen wrench.
9. Tighten the hose clamp using a flathead screwdriver or 5/16" socket.
10. Place the chain over the motor sprocket and check the alignment with the 25 tooth sprocket on the compound shaft. Adjust the motor sprocket as necessary and tighten both set screws using a 5/32" allen wrench.
11. Tighten the chain (Section 6.1).
12. Manually lower the lifting arm if it was raised.
13. Replace top body armor (Section 2.1).

## 6.4 Compound Shaft

The compound shaft is part of the chain system whose sole purpose is to gear down the speed of the motor. The compound shaft consists of a shaft with a 25 tooth and 10 tooth sprocket attached to the shaft with a key, set screws and E-rings. The shaft rotates in two sealed roller bearings that are pressed into the adjustable bearing blocks as seen in Figure 6.4.

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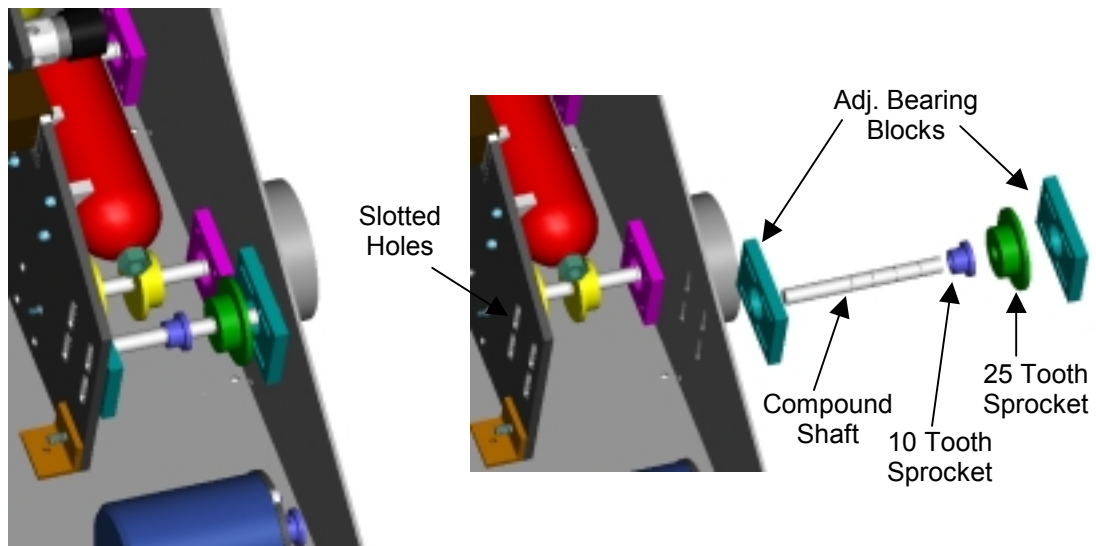


Figure 6.4 – Compound Shaft and Adjustable Bearing Blocks

- ≡ **Materials Required:**  
Key (BOM #1.7), qty. 2  
E-rings (BOM #1.8), qty. 4

- ∩ **Tools Required:**  
3/16" allen wrench  
1/8" allen wrench  
7/16" socket  
hammer or press  
flathead screwdriver

← → **Disassembly**

1. Remove top body armor (Section 2.1).
2. Loosen chains (Section 6.1).
3. Remove all four screws on each adjustable bearing block using a 3/16" allen wrench and a 7/16" wrench or socket.
4. Push both adjustable bearing blocks towards the sprockets as far as they will go.
5. Twist the shaft vertical and allow the chains to fall free.
6. Pull the compound shaft out of the Bot.
7. If removing an adjustable bearing block, simply pull it off the shaft. It may be necessary to tap with a hammer or use a press. If necessary to remove the bearing, use a press to force the bearing from its hole.
8. If removing a sprocket, remove the adjustable bearing block (Step 7).
9. Remove the E-rings by prying with a screwdriver. Discard if damaged.
10. Loosen both set screws using a 1/8" allen wrench.
11. Pull the sprocket off the shaft. It may be necessary to tap with a hammer or use a press.
12. Pull the key from the key slot and discard if damaged.

→← **Assembly**

1. Insert a key (BOM #1.7) into each key slot.
2. Place the sprockets on the shaft as seen in Figure 6.4. It may be necessary to use a hammer or press.
3. Tighten both set screws using a 1/8" allen wrench.
4. Clip E-rings (BOM #1.8) onto both sides of each sprocket.

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5. Insert the compound shaft into each adjustable bearing block. Move adjustable bearing blocks as close as possible to the sprockets.
6. Lower the compound shaft vertically into Bot and twist through both chains so they are over the shaft.
7. Place chains onto sprockets.
8. Move adjustable bearing blocks towards ends of shafts until they touch the bulkhead and side of the body.
9. Insert four screws (BOM #3.3) into each of the adjustable bearing blocks from the bearing block side and then through slotted holes in bulkhead. Place a washer (BOM #3.7) and lock nut (BOM #3.11) on each screw and tighten using a 3/16" allen wrench and a 7/16" wrench or socket.
10. Tighten chains (Section 6.1).
11. Replace top body armor (Section 2.1).

## 6.5 Front Wheel Shaft

The front wheel shaft holds and spins the front wheel. The shaft consists of two 21 tooth sprockets attached to the shaft with a key, set screws and E-rings. The wheel is attached to the shaft with a key and E-rings. The shaft transmits the power from the motor to the front wheel directly and to the rear wheel shaft via another chain as seen in Figure 6.5.

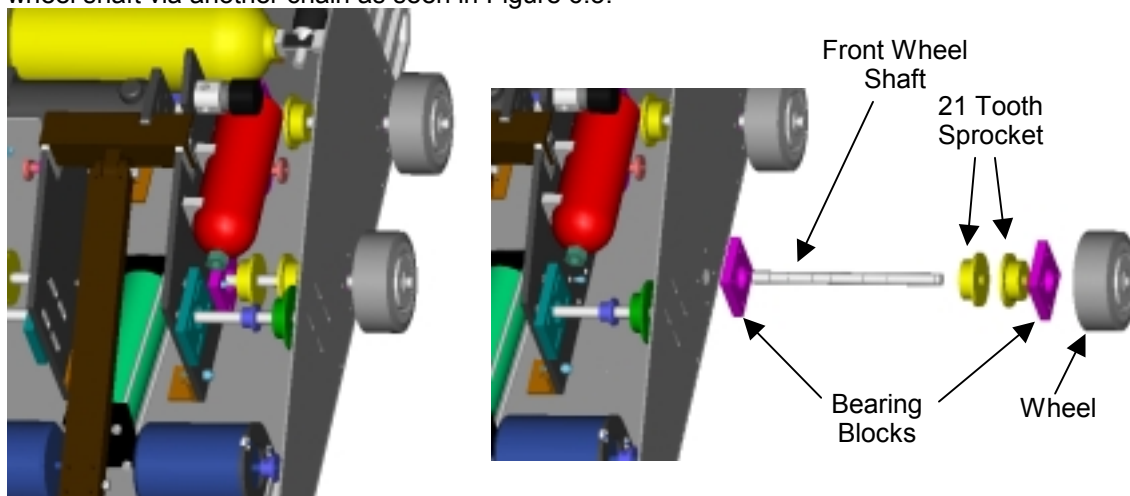


Figure 6.5 – Front Wheel Shaft

- ≡ **Materials Required:**  
Key (BOM #1.7), qty. 3  
E-rings (BOM #1.8), qty. 7

- ∩ **Tools Required:**  
3/16" allen wrench  
1/8" allen wrench  
7/16" socket  
hammer or press  
flathead screwdriver

- ← → **Disassembly**
1. Remove top body armor (Section 2.1).
  2. Loosen chains (Sections 6.1 and 6.2).

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3. Remove chains from sprockets.
4. Remove the E-rings by prying with a screwdriver. Discard if damaged.
5. Loosen both set screws using a 1/8" allen wrench.
6. Pull wheel side of shaft out of Bot while pushing sprockets off shaft inside of Bot. When the key is exposed on the first sprocket, remove it from the shaft. Remove the second key in the same manner. If the keys are damaged, discard.
7. Sprockets can now be lifted from Bot if necessary.
8. If the wheel must be removed from the shaft, remove E-rings from shaft by prying with a screwdriver. Discard if damaged.
9. Pull the wheel from the shaft. It may be necessary to tap with a hammer or use a press.
10. If removing a bearing block, unscrew all four screws from bearing block using a 3/16" allen wrench and 7/16" wrench or socket. If necessary to remove the bearing, use a press to force the bearing from its hole.

## ←← Assembly

1. Insert four screws (BOM #3.3) into each of the bearing blocks from the bearing block side. Place a washer (BOM #3.7) and lock nut (BOM #3.11) on each screw and snug using a 3/16" allen wrench and a 7/16" wrench or socket.
2. Insert a key (BOM #1.7) into the wheel key slot as shown in Figure 6.5.
3. Place the wheel on the shaft as seen in Figure 6.5. It may be necessary to use a hammer or press.
4. Clip E-rings (BOM #1.8) onto both sides of the wheel.
5. Insert the front wheel shaft into the outside bearing block from the outside of the Bot. Be sure to thread the shaft through both chains.
6. Place the first sprocket on the shaft as seen in Figure 6.5.
7. Before the key slot is covered, insert a key (BOM #1.7) into the key slot.
8. Repeat for the second sprocket.
9. Press the shaft all the way into the inside bearing block until it stops. It may be necessary to loosen the screws on the bearing blocks to correct the alignment. Tighten screws after shaft is aligned using a 3/16" allen wrench and a 7/16" wrench or socket.
10. Align the sprockets on the shaft over the keys and tighten set screws using a 1/8" allen wrench.
11. Clip all E-rings (BOM #1.8) onto shaft.
12. Place chains onto sprockets.
13. Tighten chains (Sections 6.1 and 6.2).
14. Replace top body armor (Section 2.1).

## 6.6 Rear Wheel Shaft

The rear wheel shaft holds and spins the rear wheel. The shaft consists of a 21 tooth sprocket attached to the shaft with a key, set screws and E-rings. The wheel is attached to the shaft with a key and E-rings. The shaft transmits the power from the front wheel shaft to rear wheel shaft via a chain as seen in Figure 6.6.

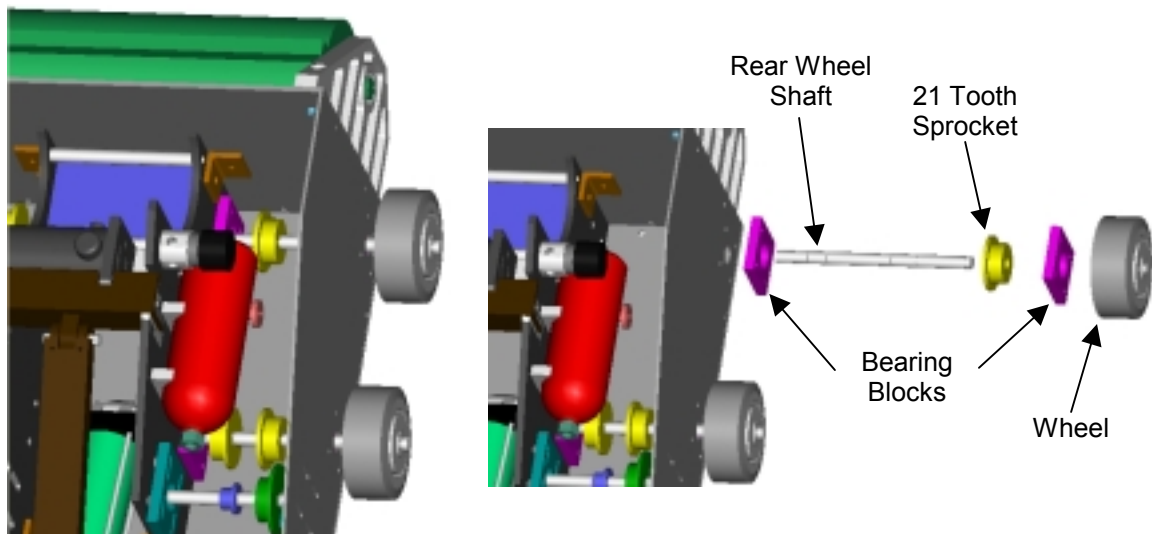


Figure 6.6 – Rear Wheel Shaft

- ≡ **Materials Required:**  
Key (BOM #1.7), qty. 2  
E-rings (BOM #1.8), qty. 5

- ∩ **Tools Required:**  
3/16" allen wrench  
1/8" allen wrench  
7/16" socket  
hammer or press  
flathead screwdriver

← → **Disassembly**

1. Remove top body armor (Section 2.1).
2. Loosen chains (Sections 6.2).
3. Remove chain from sprockets.
4. Remove the E-rings by prying with a screwdriver. Discard if damaged.
5. Loosen both set screws using a 1/8" allen wrench.
6. Pull wheel side of shaft out of Bot while pushing sprocket off shaft inside of Bot. When the key is exposed on the sprocket, remove it from the shaft. If the key is damaged, discard.
7. The sprocket can now be lifted from Bot if necessary.
8. If wheel must be removed from shaft, remove E-rings from shaft by prying with a screwdriver. Discard if damaged.
9. Pull the wheel from the shaft. It may be necessary to tap with a hammer or use a press.
10. If removing a bearing block, unscrew all four screws from bearing block using a 3/16" allen wrench and 7/16" wrench or socket. If necessary to remove the bearing, use a press to force the bearing from its hole.

→ ← **Assembly**

1. Insert four screws (BOM #3.3) into each of the bearing blocks from the bearing block side. Place a washer (BOM #3.7) and lock nut (BOM #3.11) on each screw and snug using a 3/16" allen wrench and a 7/16" wrench or socket.
2. Insert a key (BOM #1.7) into the wheel key slot as shown in Figure 6.6.
3. Place the wheel on the shaft as seen in Figure 6.6. It may be necessary to use a hammer or press.
4. Clip E-rings (BOM #1.8) onto both sides of the wheel.



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5. Insert the rear wheel shaft into the outside bearing block from the outside of the Bot. Be sure to thread the shaft through the chain.
6. Place the sprocket on the shaft as seen in Figure 6.6.
7. Before the key slot is covered, insert a key (BOM #1.7) into the key slot.
8. Press the shaft all the way into the inside bearing block until it stops. It may be necessary to loosen the screws on the bearing blocks to correct the alignment. Tighten screws after shaft is aligned using a 3/16" allen wrench and a 7/16" wrench or socket.
9. Align the sprocket on the shaft over the key and tighten set screws using a 1/8" allen wrench.
10. Clip all E-rings (BOM #1.8) onto shaft.
11. Place chain onto sprocket.
12. Tighten chains (Sections 6.2).
13. Replace top body armor (Section 2.1).

## 6.7 Manual Tensioner

The manual tensioner is used to tension the chain between the front and rear wheel shafts. It consists of a vertically moveable idler sprocket that meshes with the chain between the two shafts. The idler sprocket has its own sealed bearing so lubrication of the bearing is not necessary. The tension is adjusted by means of a screw on the top of the tensioner (Section 6.2). The tensioner can be seen in Figure 6.7.

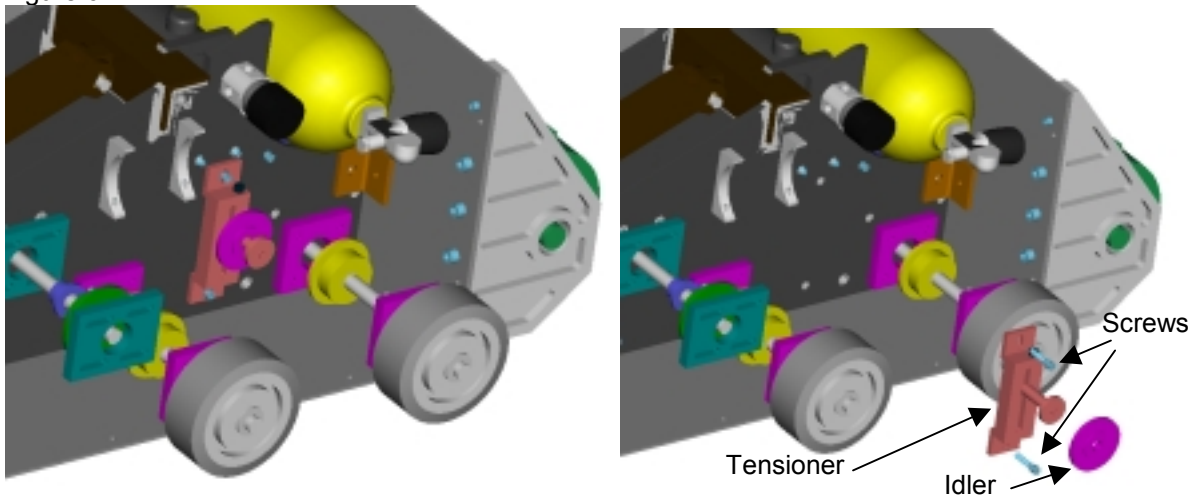


Figure 6.7 – Manual Tensioner

- ∩ **Tools Required:**
- 3/16" allen wrench
  - 7/16" wrench or socket
  - hammer or press

### ← → Disassembly

1. Remove top body armor (Section 2.1).
2. Remove buffer tank (Section 4.4) if removing right side tensioner.
3. Loosen chains (Sections 6.2).
4. Remove the two bolts holding the manual tensioner to the bulkhead using a 3/16" allen wrench and 7/16" wrench or socket.
5. Lift the tensioner vertically from the Bot.



6. If removing the idler sprocket, pull from tensioner shaft. It may be necessary to tap with a hammer or use a press.

→← **Assembly**

1. Press the idler sprocket onto the tensioner shaft. It may be necessary to tap with a hammer or use a press.
2. Lower the tensioner into Bot and align with the two mounting holes in the bulkhead.
3. Insert two screws (BOM #3.4) into each of the holes from the tensioner side. Place a washer (BOM #3.7) and lock nut (BOM #3.11) on each screw and tighten using a 3/16" allen wrench and a 7/16" wrench or socket.
4. Move idler sprocket as necessary on tensioner shaft to align and mesh with chain.
5. Tighten chains (Section 6.2).
6. Replace buffer tank (Section 4.4).
7. Replace top body armor (Section 2.1).

## 7.0 BULKHEADS

The bulkheads serve as a place to mount components inside the Bot. They are made from a cored carbon fiber laminate which is very light, but also very easy to crush. To prevent this, aluminum inserts are used where screws pass through the bulkhead.

**CAUTION!** Do not tighten any screws where there is no insert!

The bulkheads are attached to the body with brackets that are welded to the body. The bulkheads are thru bolted to these brackets as seen in Figure 7.1.

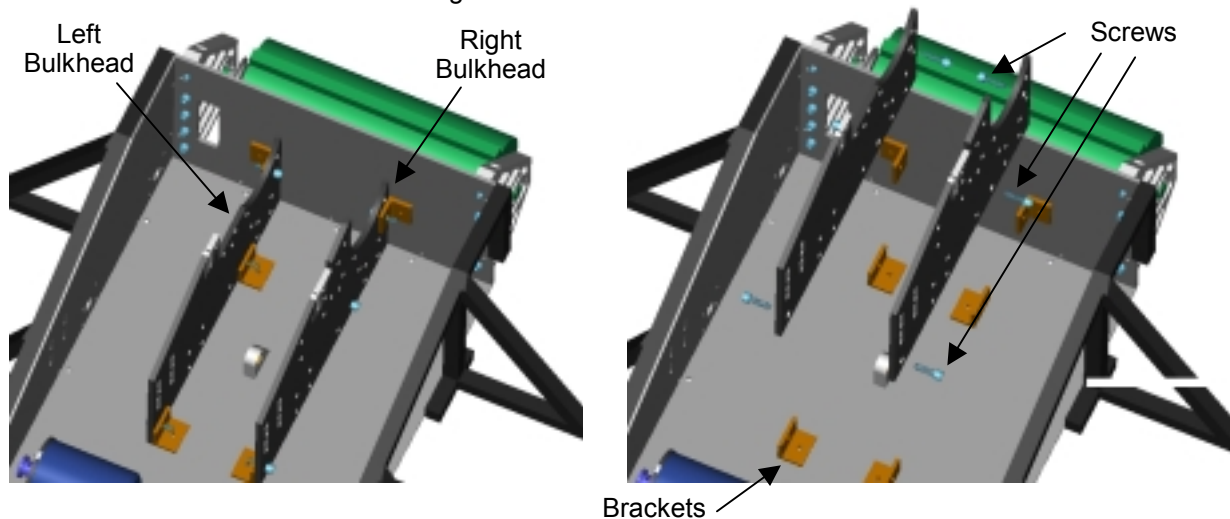


Figure 7.1 – Bulkheads

- ∩ **Tools Required:**
- 5/16" allen wrench
  - 9/16" wrench or socket

← → **Disassembly**

1. Remove top body armor (Section 2.1).
2. Remove reservoir tank (Section 4.1).
3. Remove reservoir tank mounting bars (Section 4.2).

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4. Remove buffer tank (Section 4.4).
5. Remove regulator (Section 4.3).
6. Remove lifting arm (Section 3.1).
7. Remove saddle (Section 3.2).
8. Remove drum motor bracket (Section 5.2).
9. Loosen chains (Section 6.1 and 6.2).
10. Remove compound shaft (Section 6.4).
11. Remove front wheel shaft (Section 6.5) and bearing blocks.
12. Remove rear wheel shaft (Section 6.6) and bearing blocks.
13. Remove manual tensioner (Section 6.7).
14. Remove speed controller (Section 8.2).
15. Unscrew all three bolts on each bulkhead using a 5/16" allen wrench and a 9/16" wrench or socket.
16. Remove bulkhead from Bot.

→← **Assembly**

1. Align bulkhead with screw holes in brackets as shown ion Figure 7.1.
2. Insert three screws (BOM #3.6) into each of the holes from the bracket side. Place a washer (BOM #3.8) and lock nut (BOM #3.12) on each screw and tighten using a 5/16" allen wrench and a 9/16" wrench or socket.
3. Replace speed controller (Section 8.2).
4. Replace manual tensioner (Section 6.7).
5. Replace rear wheel shaft (Section 6.6) and bearing blocks.
6. Replace front wheel shaft (Section 6.5) and bearing blocks.
7. Replace compound shaft (Section 6.4).
8. Tighten chains (Section 6.1 and 6.2).
9. Replace drum motor bracket (Section 5.2).
10. Replace saddle (Section 3.2).
11. Replace lifting arm (Section 3.1).
12. Replace regulator (Section 4.3).
13. Replace buffer tank (Section 4.4).
14. Replace reservoir tank mounting bars (Section 4.2).
15. Replace reservoir tank (Section 4.1).
16. Replace top body armor (Section 2.1).

## 8.0 ELECTRICAL COMPONENTS

### 8.1 Batteries

The batteries are located between the front and rear wheel shafts on either side of the Bot. Their purpose is to provide power to the drive and drum motors. The two 12 V batteries are wired in series such that the system operates at 24V. The batteries are shown in Figure 8.1.

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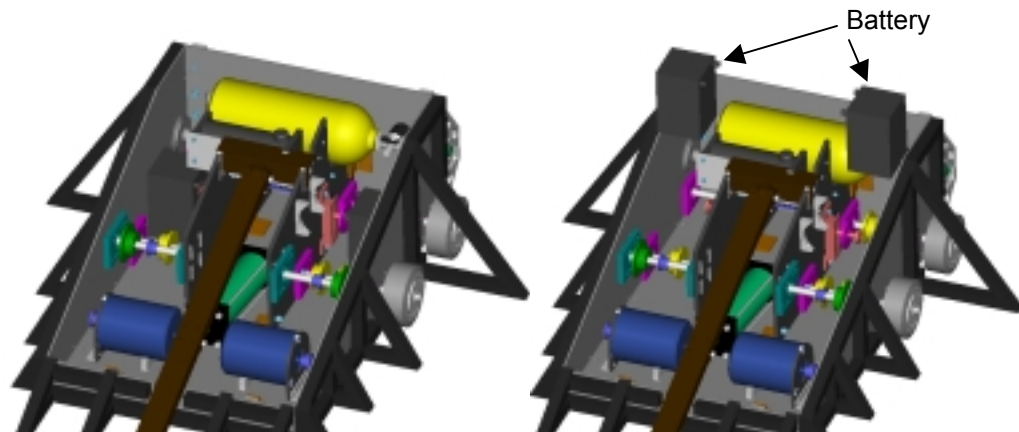


Figure 8.1 – Batteries

- ∩ **Tools Required:**  
5/32" allen wrench

← → **Disassembly**

1. Remove top body armor (Section 2.1).
2. Remove buffer tank (Section 4.4) if removing battery on right side.
3. Remove regulator (Section 4.3) if removing battery on right side.
4. Disconnect wire at connector.
5. Unscrew the screw holding the battery strap using a 5/32" allen wrench.
6. Lift battery up to remove.

→ ← **Assembly**

1. Lower battery into Bot and align with cradle.
2. Wrap battery strap around battery and insert screw into screw hole. Tighten using a 5/32" allen wrench.
3. Reconnect wire at connector.
4. Replace regulator (Section 4.3).
5. Replace buffer tank (Section 4.4).
6. Replace top body armor (Section 2.1).

## 8.2 Speed Controller

The Vantec RDFR38E speed controller takes power from the batteries and transmits the correct amount of power to the two drive motors based on inputs from the remote control. The speed controller is full of sensitive electronics and is mounted on vibration isolators between the two bulkheads of the Bot to prevent damage as seen in Figure 8.2.

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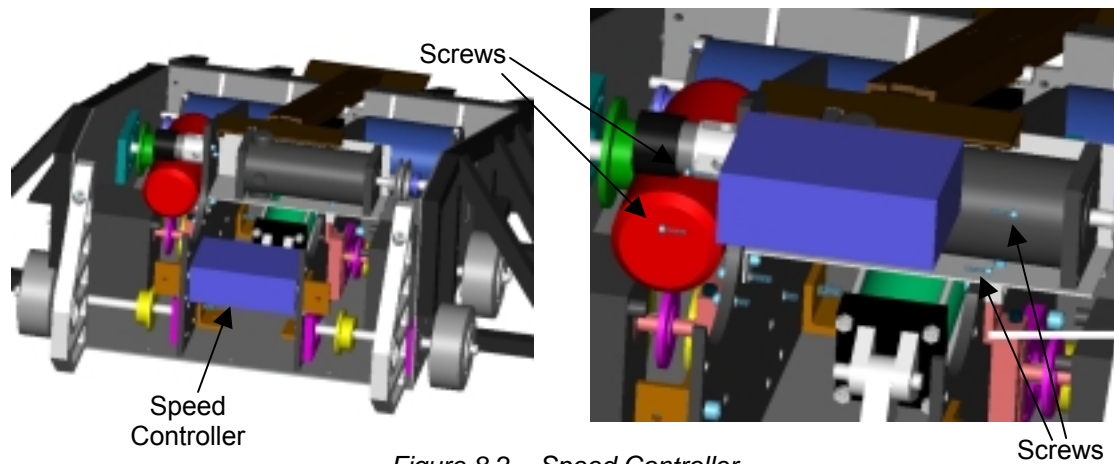


Figure 8.2 – Speed Controller

≡ **Materials Required:**

Rubber washers (BOM #3.9), qty. 8

∩ **Tools Required:**

7/64" allen wrench

← → **Disassembly**

1. Remove top body armor (Section 2.1).
2. Remove reservoir tank (Section 4.1).
3. Remove reservoir tank mounting bars (Section 4.2).
4. Disconnect all wires from wiring block on front of speed controller.
5. Unscrew two screws on both sides of the speed controller using a 7/64" allen wrench.
6. Discard rubber washers.
7. Lift speed controller up to remove.

→ ← **Assembly**

1. Lower speed controller and align with holes in bulkheads. Be sure wiring block is facing forward.
2. Place a rubber washer (BOM #3.9) onto each screw (BOM #3.18). Insert the screw into the hole in the bulkhead. Place two washers on the screw between the speed controller wall and the inside of the bulkhead (there should be washers on the screw on both sides of the bulkhead). Tighten using a 7/64" allen wrench. Repeat for all four screws.
3. Reconnect all wires at wiring block.
4. Replace reservoir tank mounting bars (Section 4.2).
5. Replace reservoir tank (Section 4.1).
6. Replace top body armor (Section 2.1).

### 8.3 Remote Control

A Futaba T6XA remote control was used to control the Bot as seen in Figure 8.3.

## BattleBot Remote Control

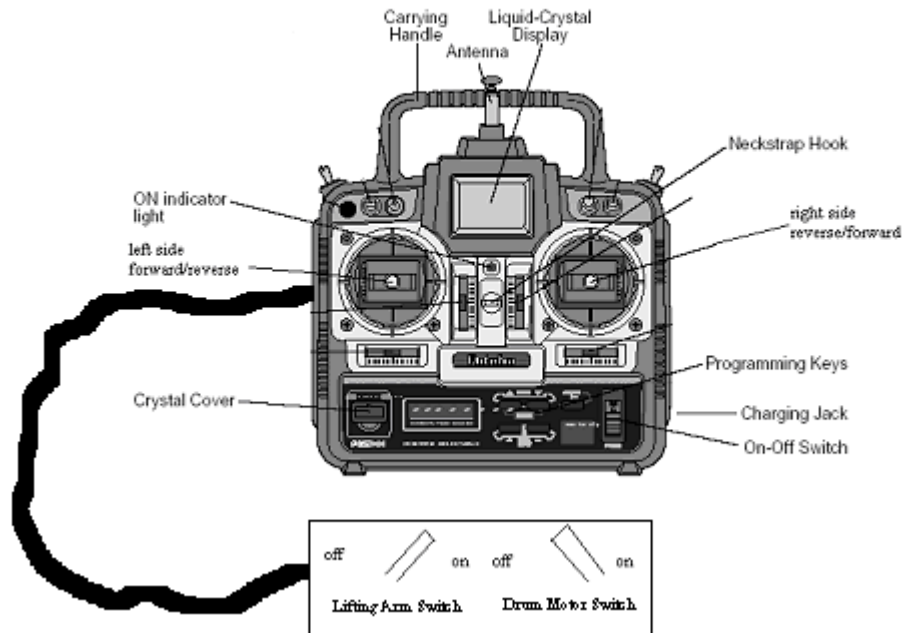


Figure 8.3 – BattleBot Remote Control

This type of controller is typically used to fly model airplanes, but some simple programming and servomotor modifications enabled it to function as the control for the Bot. This system has a six-channel transmitter, an eight channel receiver, two servomotors, receiver battery, switch harness with charging jack, extension cord, and an AC battery charger. The transmitter and receiver will work on several different frequencies: 29, 35, 36, 40, 41, 50, 60 or 72 Mhz band.

A Vantec RDFR38E speed controller (Section 8.2) controls the left and right side directional joysticks. RDFR stands for radio-controlled duel forward and reversing. This enables the Bot to have tank like movement. The speed controller will use two of the eight receiver channels. They may also be configured without mixing to be two independent speed controls. This lets you control your vehicle with two joysticks, one for each motor. Inside an RDFR are two rugged forward/reverse speed controls coupled together through special logic that generates the differential right and left motor rotation needed to guide the vehicle. When a command that changes direction is received the brake is quickly sequenced to first bring the motor to a halt, then slowly brings the power up to the commanded speed. This forced sequencing minimizes motor "plugging" and stress on mechanical components. The Bot drives like a tank with differential steering. To drive forward press both joysticks forward. To reverse, press both back. To turn right, press the right joystick farther forward than the left, and vice versa to turn left. The farther the joysticks are pressed, the faster the motors will run.

**DANGER!** The Bot is very heavy and moves fast. Running into a person can cause serious injury or death. Be sure everyone in the area is aware of where the Bot is at all times.

The two switches attached to the remote will actuate the lifting arm (Section 3.0) and turn the drum motor on and off (Section 5.0). By flipping the switch marked lifting arm up, the lifting arm will rise. Flipping it down will cause the lifting arm to come down. In the same manner, flipping the drum motor switch will up will turn on the drum motor and flipping it down will turn it off.

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DANGER! The spinning drum and lifting arm can cause serious injury or death if they contact a person. Be sure everyone is well clear of both items before activating.

## 8.4 Operating the Electrical System

The electrical system is made up of two main parts. The first is the 24V main power system that powers the motors and solenoid valves. This system has one main power switch located on the left bulkhead. The second system powers the receiver. This has a power switch also on the left bulkhead. Both switches must be on to run the Bot and both must be off when the Bot is stored.

### ↑ **Powering Up the Electrical System**

1. Remove top body armor (Section 2.1).
2. Move the switch marked "Main Power" to the "ON" position.
3. Move the switch marked "Receiver" to the "ON" position.
4. Move the power switch on the Remote Control to the "ON" position.
5. Replace top body armor (Section 2.1.).

### ↓ **Powering Down the Electrical System**

1. Remove top body armor (Section 2.1).
2. Move the power switch on the Remote Control to the "OFF" position.
3. Move the switch marked "Receiver" to the "OFF" position.
4. Move the switch marked "Main Power" to the "OFF" position.
5. Replace top body armor (Section 2.1.).

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## APPENDIX A – BILL OF MATERIALS

Number	Description	Vendor	Part #	Qty.	Price	Extended
1.1	10 tooth sprocket, #35 ANSI, 5/8 bore	McMaster	6280K112	2	6.56	13.12
1.2	21 tooth sprocket, #35 ANSI, 5/8 bore	McMaster	6280K124	6	12.06	72.36
1.3	25 tooth sprocket, #35 ANSI, 5/8 bore	McMaster	6236K22	2	13.40	26.80
1.4	10 tooth sprocket, #35, 3/8 unfinished bore	McMaster	6793K117	2	5.38	10.76
1.5	19 tooth idler sprocket, #35, 1/2 bore	McMaster	6663K22	2	14.68	29.36
1.6	Manually Adjustable Tensioner, 1/2 bore	McMaster	6265K5	2	43.60	87.20
1.7	Keys (pkg of 10) 3/16 square, 3/4 long	McMaster	98870A130	2 pk	2.86	5.72
1.8	E style retaining rings, 5/8 shaft (pkg 100)	McMaster	98407A140	1 pk	10.81	10.81
1.9	#35 ANSI Roller Chain (2 8-foot pieces)	McMaster	6261K531	16 ft	2.11	33.76
1.10	#35 ANSI Roller Chain Connecting Link	McMaster	6261K191	10	0.55	5.50
1.11	Chain Break for #25-60 Chain	McMaster	6051K15	1	17.63	17.63
					Total	313.02
	<b>Pneumatics</b>					
2.1	BB-1 Regulator, Adj 0-700 psi, .25 NPT	Flow Tech	BB-13AH1KEA4	1	177.00	177.00
2.2	Luxfer 4 cu. Ft. Medical grade Tank (Buffer)	Luxfer	M004	2	35.00	70.00
2.3	2-way, 24V Solenoid Valve, 3/8 NPT, brass	Skinner Valve	73212BN3SN00N0C111C2	4	124.99	499.96
2.4	Piston, 3.5" bore, 8 in stroke	Hydraulic Sup.	VP10EACA1FN08000	1	160.00	160.00
2.5	Braided hose	Capital Rubber	Donation	0	0.00	0.00
					Total	906.96
	<b>Assembly Parts</b>					
3.1	Hose clamp, 3.625 - 6.5" dia, 10 pk.	McMaster	5415K37	1 pk	9.83	9.83
3.2	Flat head Socket Cap Screw 10-32, 3/8" 100 pk.	McMaster	91253A001	1 pk	9.25	9.25
3.3	SHCS 1/4-20, 1.25" 100 pk	McMaster	91251A544	1 pk	13.99	13.99
3.4	SHCS 1/4-20, .75" 100 pk	McMaster	91251A540	1 pk	11.94	11.94
3.5	SHCS 1/4-20, 1.75" 25 pk.	McMaster	91251A548	2 pk	5.00	10.00
3.6	SHCS 3/8-16, 1.25", 25 pk.	McMaster	91251A626	1 pk	5.87	5.87
3.7	Flat Round Washer, Blk Oxide, 1/4", 100 pk.	McMaster	96765A140	2 pk	4.21	8.42
3.8	Flat Round Washer, Blk Oxide, 3/8", 100 pk.	McMaster	96765A150	1 pk	5.91	5.91
3.9	Neoprene washer, #6, 100 pk.	McMaster	90133A005	1 pk	5.91	5.91
3.10	Hex nut, 1/4-20, 100 pk.	McMaster	90490A029	1 pk	1.19	1.19
3.11	Lock nut, 1/4-20, 25 pk.	McMaster	97135A210	4 pk	6.80	27.20
3.12	Lock nut, 3/8-16, 20 pk.	McMaster	97135A230	1 pk	7.88	7.88
3.13	Lock nut, M5 (metric), 100 pk.	McMaster	93625A200	1 pk	5.23	5.23
3.14	3/32" Cotter pin, 1" long, 100 pk.	McMaster	98338A140	1 pk	1.08	1.08
3.15	ABEC 1 Steel, double seal, R10 bearing	McMaster	60355K91	10	6.55	65.50
3.16	SHCS 1/4-20, .5"	Donation		8	0.00	0.00
3.17	SHCS 1/4-20, 2"	Donation		2	0.00	0.00
3.18	SHCS #6-32, .75"	Donation		4	0.00	0.00
3.19	SHCS #10-32, .625"	Donation		2	0.00	0.00
					Total	189.20

# Team 9 BattleBot

Florida State University  
Tallahassee, FL

DATE 3/20/2003	DOCUMENT NAME	OPERATIONS MANUAL REV -
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<b>Material</b>						
4.1	Polycarbonate .220 X 48 X 96	Laird Plast.	181393	2	250.00	500.00
4.2	Carbon Fiber, 3/8" and 1/4" sheet	MC Gill		2	55.00	110.00
4.3	HR Flat Bar 1.5 X .75	Metal Super.	HF0000075150	2 in	0.24	0.48
4.4	HR Flat Bar 1.5 X .375	Metal Super.	HF0000037150	6 in	0.09	0.52
4.5	Al 6061 Square Stock .75	Metal Super.	AQAM00007500	20 in	0.18	3.63
4.6	Al Hex Stock 1.0	Metal Super.	AHAB00010000	3 in	0.19	0.58
4.7	HR Angle 2 X 2 X .25	Metal Super.	HA0000252020	14 in		0.00
4.8	HR Angle 1 X 1 X .125	Metal Super.	HA0000121010	5 in		0.00
4.9	CR Flat Bar 1018 2 X .5	Metal Super.	CFCA00500200	8 in		0.00
4.10	CR Flat Bar 1018 2 X .75	Metal Super.	CFCA00750200	14 in		0.00
4.11	CR Round 1018 .5	Metal Super.	CRCA00005000	18 in		0.00
4.12	HR C-channel C2	Metal Super.	HC0000025702	31 in		0.00
4.13	HR Plate 8 X .375	Metal Super.	HF0000037800	7 in		0.00
4.14	Al Angle 6061 1.5 X 1.5 X .25	Metal Super.	AAAMAR251515	24 in		0.00
4.15	Al Angle 6061 .75 X .75 X .125	Metal Super.	AAAMAR120707	12 in		0.00
4.16	Al Plate 6061 8 x .25	Metal Super.	AFAM00250800	15 in		0.00
4.17	Al Round 6061 .625	Metal Super.	ARAM00006250	14 in		0.00
4.18	Al Flat Bar 6061 4 X .5	Metal Super.	AFAM00500400	48 in		0.00
4.19	Al Flat Bar 6061 6 X .5	Metal Super.	AFAM00500600	24 in		0.00
4.20	Al Flat Bar 6061 4 X .375	Metal Super.	AFAM00375400	30 in		0.00
4.21	CR Round 1018 .625	Metal Super.	CRCA00006250	84 in		0.00
				Total 4.7-4.21		134.79
4.22	Al 5/32 plate	Donation		3	0.00	0.00
4.23	Al 6061 .25 plate	Donation		2	0.00	0.00
				Total		749.99
				<b>Total</b>		<b>2159.17</b>