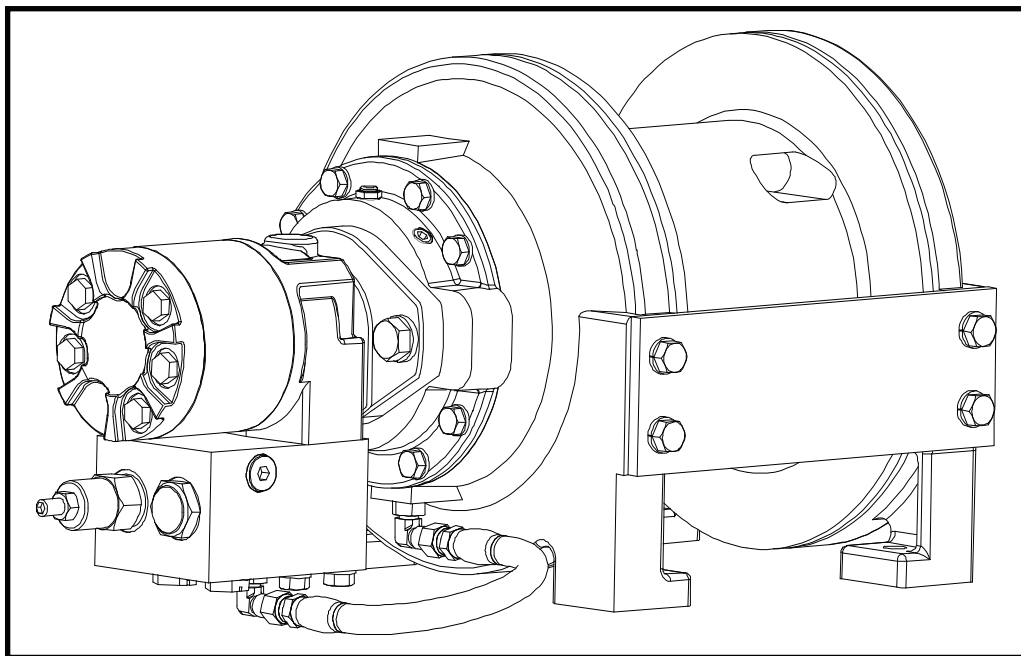




Authorized Distributor:  
Pacific Marine & Industrial  
www.pacificmarine.net  
info@pacificmarine.net

# BRADEN Gearmatic

## BG3B HYDRAULIC PLANETARY WINCH



## INSTALLATION, MAINTENANCE AND SERVICE MANUAL





## TABLE OF CONTENTS

	PAGE
FOREWORD.....	2
PARTS AND SERVICE.....	2
GENERAL SAFETY RECOMMENDATIONS.....	3
THEORY OF OPERATION.....	4
HYDRAULIC CIRCUIT.....	4
WINCH AND WIRE ROPE INSTALLATION.....	5-6
DIMENSIONAL DATA.....	6-7
PREVENTATIVE MAINTENANCE.....	7-8
RECOMMENDED GEAR OIL.....	9
WINCH EXPLODED VIEW DRAWING.....	10
PARTS KEY.....	11
TROUBLE SHOOTING.....	12-14
WINCH SERVICE.....	15
WINCH DISASSEMBLY.....	15
DRUM ASSEMBLY SERVICE.....	16
PLANET GEAR SERVICE.....	16
BRAKE CYLINDER ENDPLATE SERVICE.....	17
WINCH ASSEMBLY.....	18-20
REVERSING DRUM HOIST ROTATION.....	20
PERFORMANCE DATA.....	21
FASTENER TORQUE CHART.....	21
METRIC CONVERSION TABLE.....	Back Cover



# FOREWORD

Read and understand this entire publication before operating or servicing your BRADEN winch. Retain this manual for future reference.

The minimum service intervals specified are for operating hours of the prime mover.

The following service instructions have been prepared to provide assembly, disassembly and maintenance information for the Model BG3B series winch. It is suggested that before doing any work on these units, all assembly and disassembly instructions should be read and understood.

Some illustrations in this manual may show details or attachments which may be different from your winch. Also, some components may be removed for illustrative purposes.

Continuing product improvement may cause changes in your winch which may not be included in this manual. When a question arises regarding your winch or this manual, contact your nearest BRADEN dealer or the factory Service Department. Provide the complete winch model number and serial number when making inquiries. The model and serial numbers are stamped into the data plate attached to the tie plate as shown below.

Braden Technical Support Department

Phone: (918) 251-8511  
 08:00 to 16:30 CST  
 Monday thru Friday

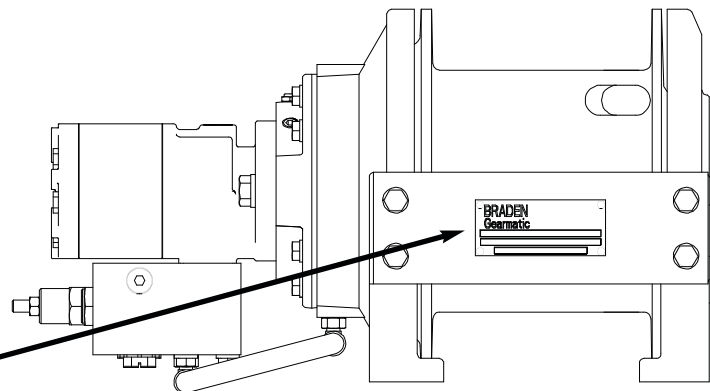
Fax: (918) 259-1575

Internet: [winch.service@pacar.com](mailto:winch.service@pacar.com)

# PARTS AND SERVICE

BRADEN provides parts and service through a network of authorized dealers. Parts and service are not available directly from the factory. For the name of your nearest dealer, consult your local phone directory or call us at the phone number shown above.

Serial Number and Model Number are stamped into the data plate located on the righthand side tieplate when viewing winch from motor end. Always refer to the Serial Number and Model Number when requesting information or service parts.



## EXPLANATION OF MODEL NUMBER

BG	3	B	05	080	01
BRADEN GEARMATIC	MAX RATING	DESIGN MODEL	GEAR RATIO	MOTOR SIZE	DRUM SIZE

- BG DESIGNATES BRADEN GEARMATIC**
- 3 DESIGNATES 3,000 LB (1,360 kg) FIRST LAYER LINE PULL (CONTINUOUS DUTY)**
- B DESIGNATES THE MODEL SERIES RELATING TO DESIGN CHANGES**
- 05 DESIGNATES TOTAL GEAR PRODUCTION**
- 080 DESIGNATES HYDRAULIC MOTOR DISPLACEMENT IN CU IN/REV  
DECIMAL POINT ELIMINATED (080 = 8.0 cu in./rev [131 cu cm])**
- 01 DESIGNATES THE DRUM**

# GENERAL SAFETY RECOMMENDATIONS

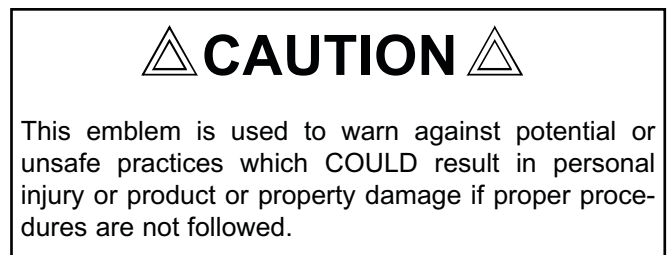
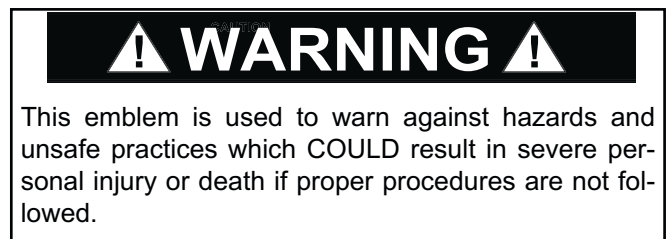
Safety for operators and ground personnel is of prime concern. Always take the necessary precautions to ensure safety to others as well as yourself. To ensure safety, the prime mover and winch must be operated with care and concern by the operator for the equipment, and a thorough knowledge of the machine's performance capabilities. The following recommendations are offered as a general safety guide. Local rules and regulations will also apply.



1. Read all warning tag information and become familiar with all controls **BEFORE** operating winch.
2. **NEVER** attempt to clean, oil or perform any maintenance on a machine with the engine running, unless instructed to do so in the service manual.
3. **NEVER** operate winch controls unless you are properly seated at the operators station on the prime mover and you are sure personnel are clear of the work area.
4. Assure that personnel who are responsible for hand signals are clearly visible and that the signals to be used are thoroughly understood by everyone.
5. Ground personnel should stay in view of the prime mover operator and clear of winch drum. **DO NOT** allow ground personnel near winch line under tension. A safe distance of at least 1½ times the length of the cable should be maintained. **NEVER** allow anyone to stand beneath a suspended load
6. On machines having hydraulically, mechanically and/or cable controlled equipment, be certain the equipment is either lowered to the ground or blocked securely before servicing, adjusting and/or repairing the winch. Always apply the prime mover parking brakes and lower equipment before dismounting the prime mover.
7. Inspect rigging, winch and hydraulic hoses at the beginning of each work shift. Defects should be corrected immediately.
8. Keep equipment in good operating condition. Perform scheduled servicing and adjustments listed in the "Preventive Maintenance" section of this manual.
9. An equipment warm-up procedure is recommended for all start-ups and is essential at ambient temperatures below +40°F. Refer to "Warm-up Procedure" listed in the "Preventive Maintenance" section of this manual.

10. Be sure of equipment stability before operating winch.
11. The winches described herein are neither designed nor intended for use or application to equipment used in the lifting or moving of persons.
12. **DO NOT** exceed the maximum pressure (PSI) or flow (GPM) stated in the winch specifications.
13. Operate winch line speeds to match job conditions.
14. Leather gloves should be used when handling winch cable.
15. **NEVER** attempt to handle winch cable when the hook end is not free.
16. When winding winch cable on the winch drum, **NEVER** attempt to maintain tension by allowing winch cable to slip through hands. Always use "hand-over-hand" technique.
17. **NEVER** use winch cable with broken strands. Replace winch cable.
18. **DO NOT** weld on any part of the winch.
19. **DO NOT** use knots to secure or attach winch cable.
20. Use recommended hydraulic oil and gear lubricant.
21. Keep hydraulic system clean and free from contamination at all times.
22. Use correct size cable anchor for cable and pocket in winch drum.
23. The BRADEN wire rope anchors are capable of supporting the rated load only when installed properly. For additional safety, **ALWAYS** maintain a minimum of five (5) wraps of wire rope on the drum.

Safety informational callout's used in this manual include:



# THEORY OF OPERATION

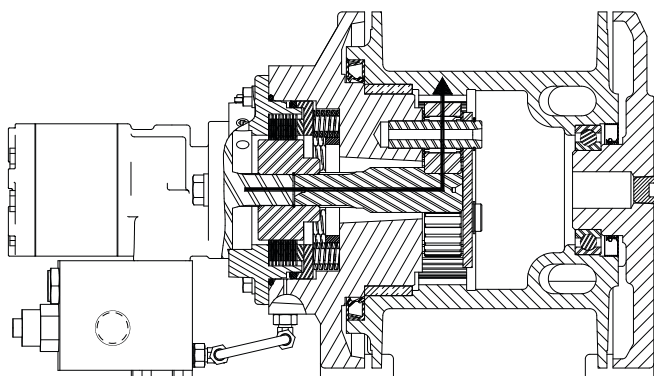
## DESCRIPTION OF WINCH

The winch has three basic assemblies:

1. Hydraulic motor, brake valve block and counterbalance cartridges.
2. Static brake assembly.
3. Cable drum assembly.

The hydraulic motor is bolted to the motor adapter which in turn is bolted to the brake cylinder end plate of the winch. The cable drum assembly is supported on the motor end by a bronze bushing and on the support end by a roller bearing. The ring gear for the single planetary reduction set is machined into the inside of the cable drum. The cable drum features two anchor pockets for winding cable on the drum in either direction.

## PLANETARY GEAR TRAIN



The hydraulic motor shaft is directly splined to the brake coupling which is connected to the sun gear of the planetary reduction set. The planet carrier is splined to the bearing support end plate and cannot rotate. The hydraulic motor rotates the brake coupling and sun gear, driving the planet gears which in turn drive the ring gear/cable drum.

## DUAL BRAKE SYSTEM

### Dynamic Brake

The dynamic brake system consists of two basic components.

1. Brake valve block with counterbalance and check valve cartridges.
2. Hydraulic motor.

The counterbalance cartridges are installed into a brake valve block which also contains an internal shuttle valve. The shuttle valve directs hydraulic pressure to the brake release port of the winch when the winch is operated in either direction.

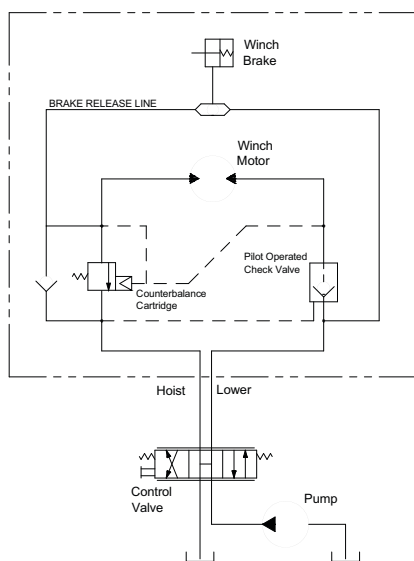
### Static Brake

The static brake consists of three basic components.

1. Spring applied, multiple friction disk brake pack.
2. Solid brake coupling.
3. Hydraulic brake cylinder and spring plate.

The brake pack consists of alternatively stacked friction and steel brake disks. The steel brake disks are externally splined to the motor adapter and cannot rotate. The friction disks are internally splined to the brake coupling. When the winch is not being operated, spring force compresses the

## HYDRAULIC CIRCUIT



**WINCH CONTROL CIRCUIT  
SINGLE SPEED  
BRAKE EFFECTIVE BOTH DIRECTIONS**

brake pack and locks the brake coupling to the motor adapter, preventing the gear train or cable drum from rotating in either direction. The solid brake coupling makes the static brake "effective both directions". This means the static brake must be released before the winch can operate in either the hoist or lower direction.

The static brake is released by pilot pressure applied to the brake cylinder. It releases at a pressure lower than that required to open the pilot operated counterbalance cartridge. This sequence assures that dynamic braking is done by the counterbalance cartridge and that little, if any, heat is absorbed by the friction brake.

The static or friction brake is primarily a load holding brake and will provide dynamic braking only during extremely slow operation when there is insufficient flow and pressure to open the counterbalance cartridge.

## OPERATION

Since the static brake on this winch is "effective both directions", the brake must be hydraulically released to operate the winch in either the hoist or lower direction.

When the winch is powered in either direction, the motor cannot rotate until sufficient pilot pressure is present to open the counterbalance cartridge. The friction brake will completely release at a pressure lower than required to open the counterbalance cartridge. The extent to which the cartridge opens will determine the amount of oil that can flow through it and the speed at which the cable drum will turn. Increasing the flow of oil to the winch motor will cause the pressure to rise and the opening in the cartridge to enlarge, speeding up the cable drum. Decreasing the flow causes the pressure to drop and the opening in the cartridge to decrease, slowing down the cable drum.

When the control valve is returned to the neutral or center position, pressure will rapidly drop and the counterbalance cartridge will close, stopping the load. The friction brake will engage and hold the load after the cartridge is closed.

## WINCH AND WIRE ROPE INSTALLATION

1. The winch should be mounted with the centerline of the cable drum in a horizontal position. The mounting plane of the winch may be rotated in any position around this centerline providing the vent in the motor adapter is above the centerline of the cable drum. The vent should be as close to top dead center as possible.
2. When mounting the winch, use all four (4) mounting holes and grade eight (8) bolts and nuts. Evenly tight-

en the nuts to the torque in the "Recommended Torque" chart. Refer to "Dimensional Drawing" for bolt hole size and pattern.

It is important that the winch is mounted on a surface that will not flex when the winch is in use, and cause binding of the gear train. Binding in the gear train will result in accelerated wear and heat. Also, the mounting surface should be flat with  $\pm 0.020$  inches. If necessary, install shims under the winch mounting pads to achieve even mounting.

3. The hydraulic lines and components that operate the winch should be of sufficient size to assure minimum back pressure at the winch. The back pressure at the motor must not exceed 100 psi (690 kPa) to maintain full brake system design factor and optimum motor seal life.

The winch directional control valve must be a three position four way valve with a motor spool such that when the valve is in the center position both work ports are open to tank (open center, open port).

4. High quality hydraulic oil is essential for satisfactory performance and long hydraulic system component life. Oil having 150 to 330 SUS viscosity at 100° F (38° C) and viscosity index of 100 or greater will give good results under normal temperature conditions. The use of an oil having a high viscosity index will minimize cold start trouble and reduce the length of warm-up periods. A high viscosity index will minimize changes in viscosity with corresponding changes in temperature.

Maximum cold weather start-up viscosity should not exceed 5,000 SUS with a pour point at least 20° F (11° C) lower than the minimum ambient temperature.

Under continuous operating conditions the temperature of the oil at any point in the system must not exceed 180°F (82°C). 120°F (49°C) to 140°F (60°C) is generally considered optimum.

### *In general terms:*

For continuous operation at ambient temperatures between 50°F (10°C) and 110°F (43°C), use SAE 20W; for continuous operation between 10°F (-12°C) and 90°F (32°C), use 10W; for applications colder than 10°F (-12°C), contact the BRADEN Service Department. The use of multi-viscosity oils is generally not recommended.

5. The hydraulic oil filter should have a 10 micron nominal rating and be full flow type.
6. The vent plug in the motor adapter must be located close to top dead center as possible. If the winch is

mounted on a pivoting surface, the vent plug must remain above the centerline of the cable drum to prevent gear oil leakage.

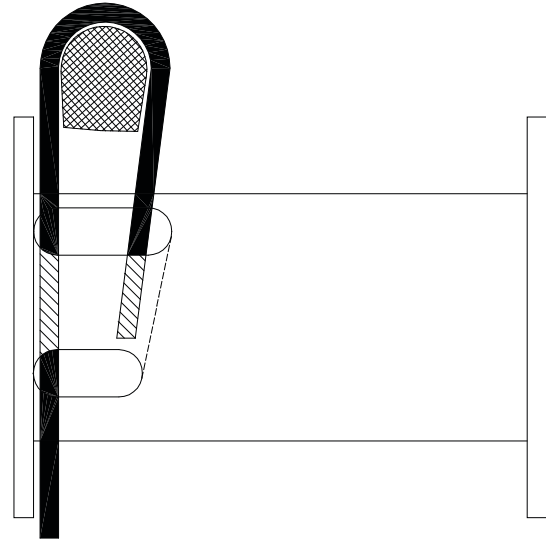
7. Refer to "Dimensional Drawing" for relationship between drum rotation and which port is pressurized.

## WIRE ROPE INSTALLATION

Since the static brake on this winch is "effective both directions", cable can be wound onto the drum in either direction. The cable drum has two anchor pockets to accommodate this.\*

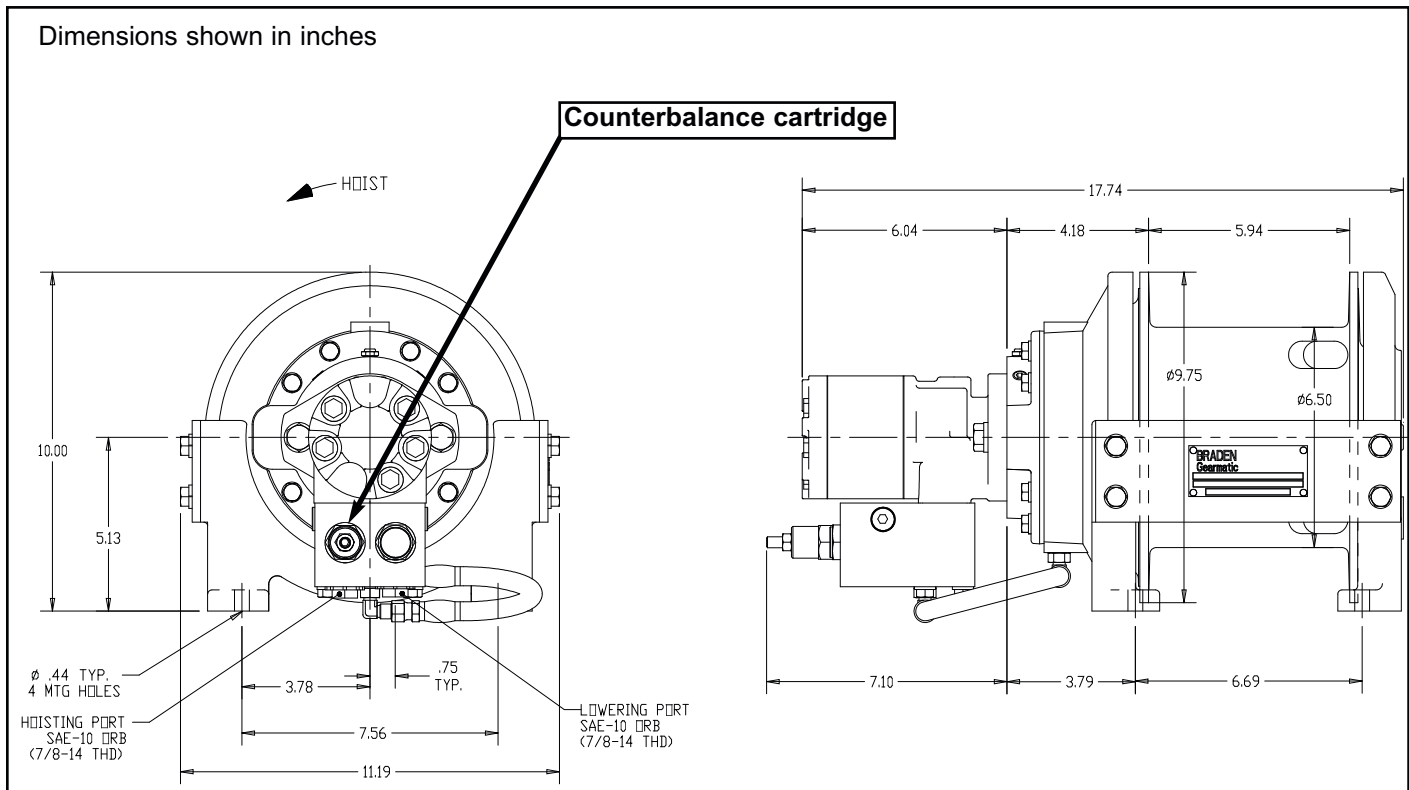
Take the free end of the wire rope and insert it through the small opening of the anchor pocket you are going to use. Loop the wire rope and push the free end about three-fourths of the way back through the pocket. Install the cable anchor with the small end toward the drum, then pull the slack out of the wire rope. The cable anchor will slip into the pocket and secure the wire rope to the drum. A minimum of five (5) wraps of wire rope should remain on the cable drum at all times. Refer to "General Safety Recommendations" for additional information.

\* Correctly installed wire rope is positioned such that the cable comes over the top of the drum toward the counterbalance cartridge



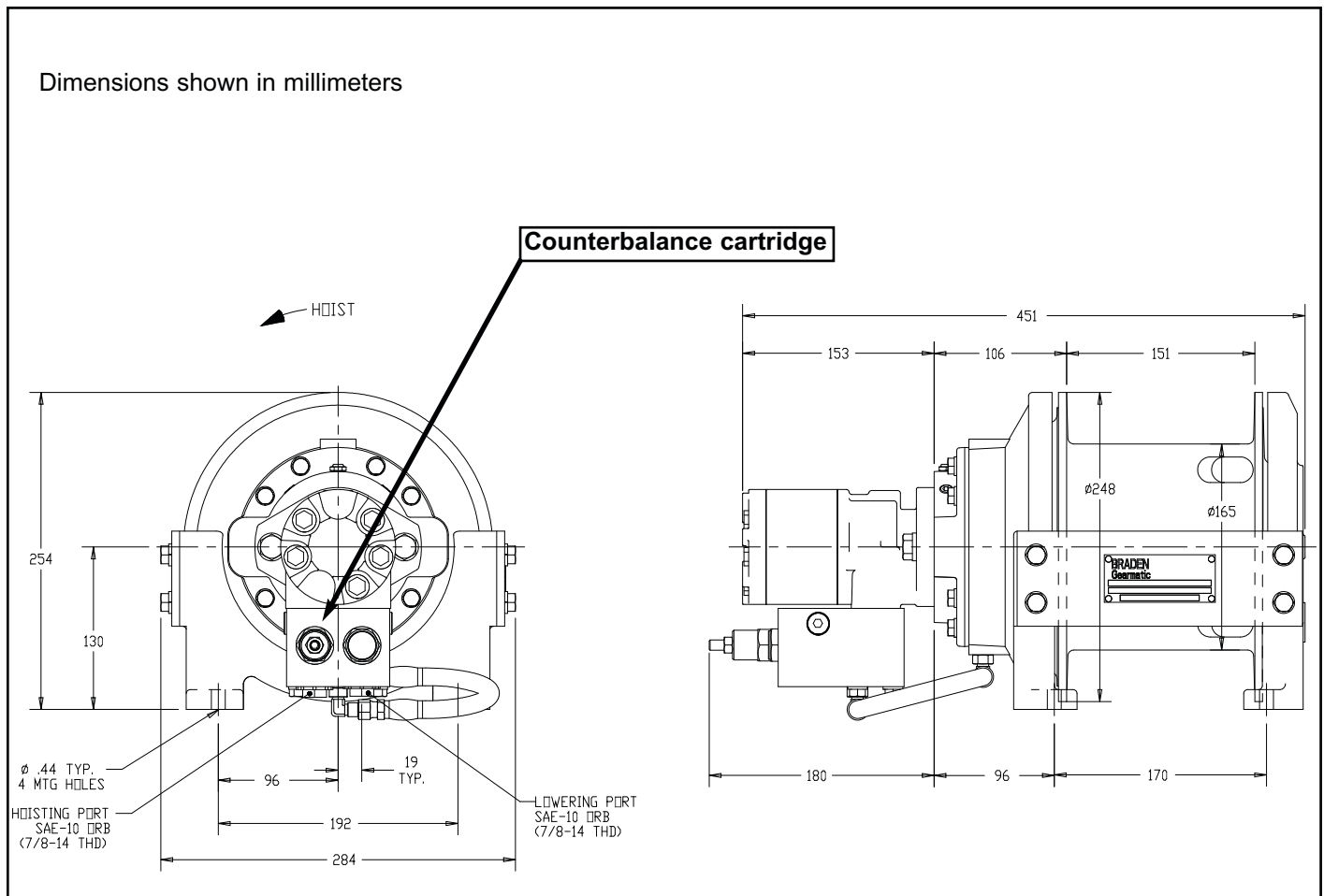
The standard cable anchor wedge supplied with the winch is intended for 5/16 to 1/2 in. (8 to 13 mm) wire rope.

## DIMENSIONAL DATA (Inches)





# DIMENSIONAL DATA (Millimeters)



## PREVENTIVE MAINTENANCE

A regular program of preventive maintenance for your planetary winch is strongly recommended to minimize the need for emergency servicing and promote safe, reliable winch operation.

Field experience supported by engineering tests, indicates the three (3) service procedures listed below are the **MOST** critical to safe, reliable winch operation and must be observed.

- **Regular Gear Oil Changes** - every 1000 hours or six (6) months.
- **Use of Proper Gear Oil** - recommended type for prevailing ambient temperature.
- **Periodic Disassembly and Inspection of All Wear Items** - The following minimum service intervals are specified for operating hours of the prime mover.

### 1. Oil Level

The gear oil level should be checked every 500 operating hours, three (3) months, or whenever an oil leak is detected; whichever occurs first. To check the oil level, remove the large plug located in the center of the drum support. The oil should be level with the bottom of this opening. If additional oil is needed, refer to "Recommended Planetary Gear Oil" for correct oil type. Winch gear oil capacity is approx. 2 pints (1 liter.)

### 2. Oil Change

The gear oil should be changed after the first 1,000 operating hours or six (6) months, whichever occurs first. The gear oil should then be changed once every 2,000 operating hours or every 12 months, whichever occurs first. The gear oil must be changed to remove wear particles that impede the reliable and safe operation of the brake clutch and erode bearings, gears and seals. Failure to change gear oil at these suggested minimum intervals may contribute to intermittent brake slippage which could result in property damage, severe personal injury or death.



Authorized Distributor:  
**Pacific Marine & Industrial**  
[www.pacificmarine.net](http://www.pacificmarine.net)  
[info@pacificmarine.net](mailto:info@pacificmarine.net)

The gear oil should also be changed whenever the ambient temperature changes significantly and an oil from a different temperature range would be more appropriate. Oil viscosity with regard to ambient temperature is critical to reliable brake operation. Make certain that the gear oil viscosity used in your winch is correct for your prevailing ambient temperature. Failure to use the proper type and viscosity of planetary gear oil may contribute to brake slippage which could result in property damage, severe personal injury or death. Refer to "Recommended Planetary Gear Oil" (chart located on page 9 of this manual) for additional information.

To change gear oil follow the procedure listed below:

- a. Remove the wire rope from the cable drum and wind onto a cable storage spool. Tag and remove the hoses from the hydraulic motor then remove the winch from the crane.

### **CAUTION**

The winch weighs approximately 130 lb (59 kg). Use adequate lifting equipment.

- b. Place the winch on a sturdy work surface with the motor end facing up. Remove the two capscrews that secure the motor to the brake cylinder and lift off the hydraulic motor. Use a hoist to tip the winch over and drain the gear oil into a suitable container. Recycle or dispose of used oil in an environmentally responsible manner.
- c. After the oil has drained out of the gear cavity, stand the winch back up with the motor facing up. Into the open brake cylinder, pour in two pints (1 l) recommended gear oil then install the motor onto the brake cylinder. Tighten the capscrews to recommended torque.
- d. Install winch onto crane. Evenly tighten all four capscrews to recommended torque. Install the motor hoses. Install the wire rope as recommended on page 6 of this manual.

### 3. Vent Plug

The vent plug is located in the motor adapter. It is very important to keep this vent clean and unobstructed. Whenever gear oil is changed remove vent plug, clean in solvent and reinstall.

Do not paint over the vent or replace with a solid plug.

### 4. Hydraulic System

The original filter element should be replaced after the first fifty (50) hours of operation, then every 500 operating hours or three (3) months, or in accordance with the equipment manufacturer's recommendations.

### 5. Wire Rope

Inspect entire length of wire rope according to wire rope manufacturer's recommendations.

### 6. Mounting Bolts

Tighten all winch base mounting bolts to recommended torque after the first one hundred (100) hours of operation, then every 1000 operating hours or six (6) months, whichever occurs first.

### 7. Warm-up Procedure

A warm-up procedure is recommended at each start-up and is essential at ambient temperatures below +40°F (4°C). The prime mover should be run at its lowest recommended RPM with the hydraulic winch control valve in neutral allowing sufficient time to warm up the system. The winch should then be operated at low speeds, forward and reverse, several times to prime all lines with warm hydraulic oil, and to circulate gear lubricant through the planetary gear sets.

### **WARNING**

Failure to properly warm up the winch, particularly under low ambient temperature conditions, may result in temporary brake slippage due to high back pressures attempting to release the brake, which could result in property damage, severe personal injury or death.

### 8. Recommended Planetary Gear Oil

Field experience, supported by extensive engineering tests, indicates the use of the proper planetary gear oil is essential to reliable and safe operation of the brake and obtaining long gear train life. (chart located on page 9 of this manual)

### 9. Inspection

In applications governed by ANSI specification number B30.5c1987 and API Recommended Practice RP 2D section 3, we recommend that the winch be disassembled for a thorough inspection of all wear items every 2,000 hours of operation or twelve (12) months, whichever occurs first.



Authorized Distributor:  
**Pacific Marine & Industrial**  
www.pacificmarine.net  
info@pacificmarine.net

## RECOMMENDED PLANETARY GEAR OIL

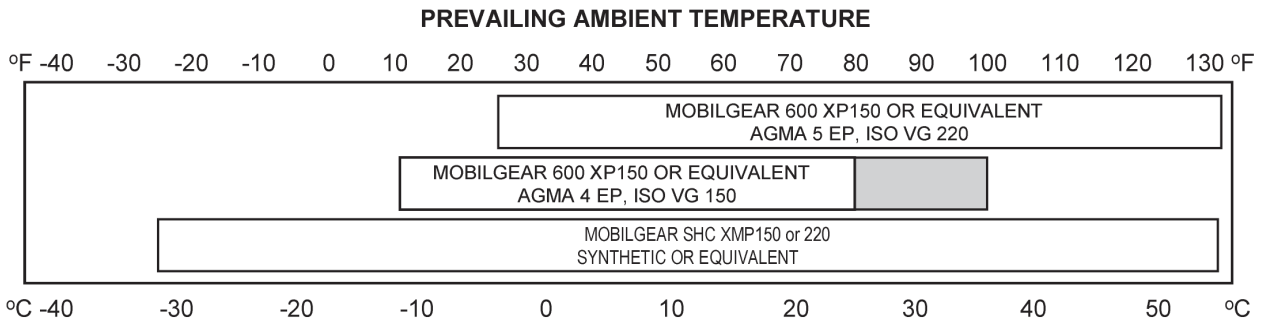
Field experience, supported by engineering endurance tests, indicates the use of the proper gear oil and a program of regular preventive maintenance will help provide extended gear train life and reliable hoist brake performance. For this reason, BRADEN has published the following specifications to assist in determining which lubricant is best suited to your application.

### ⚠ WARNING ⚠

Failure to use the proper type and viscosity of planetary gear oil may contribute to intermittent brake clutch slippage which could result in property damage, severe personal injury or death. Some gear lubricants contain large amounts of EP (extreme pressure) and anti-friction additives which may contribute to brake clutch slippage or damage to brake friction discs or seals. Oil viscosity with regard to ambient temperature is also critical to reliable brake clutch operation. Our tests indicate that excessively heavy or thick gear oil may contribute to intermittent brake clutch slippage. Make certain that the gear oil viscosity used in your hoist is correct for your prevailing ambient temperature.

For simplicity, BRADEN has listed available products in each temperature range that have been tested and found to meet our specifications. This is not to say that other lubricant brands would not perform equally as well.

If the following lubricant brands are not available in your area, make certain your lubricant vendor supplies you with oil that is equivalent to those products listed below.



**i** **NOTE:** SHADED TEMPERATURE RANGE IN THE CHART ABOVE NOT RECOMMENDED FOR SEVERE APPLICATIONS SUCH AS: OFFSHORE CRANES, SUSTAINED FAST DUTY CYCLES OR FREQUENT LIFTING.

Planetary hoists are factory filled with Mobilgear 600 XP 150, or equivalent. Consult your oil supplier for other equivalent oils if required.

Mobil	Shell	Chevron	Texaco
Mobilgear 600 XP 150	Omala 150	Gear Compounds EP 150	Meropa 150
Mobilgear 600 XP 220	Omala 220	Gear Compounds EP 220	Meropa 220

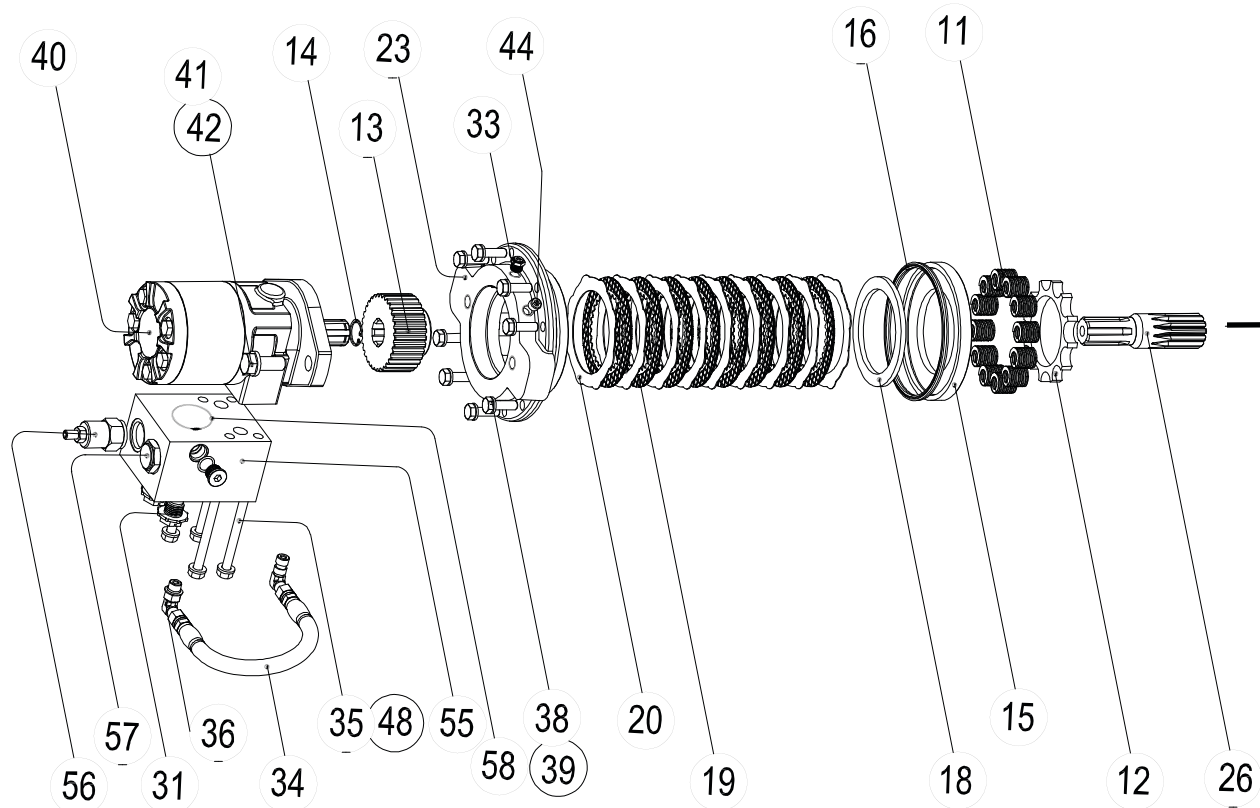


Authorized Distributor:  
Pacific Marine & Industrial  
www.pacificmarine.net  
info@pacificmarine.net

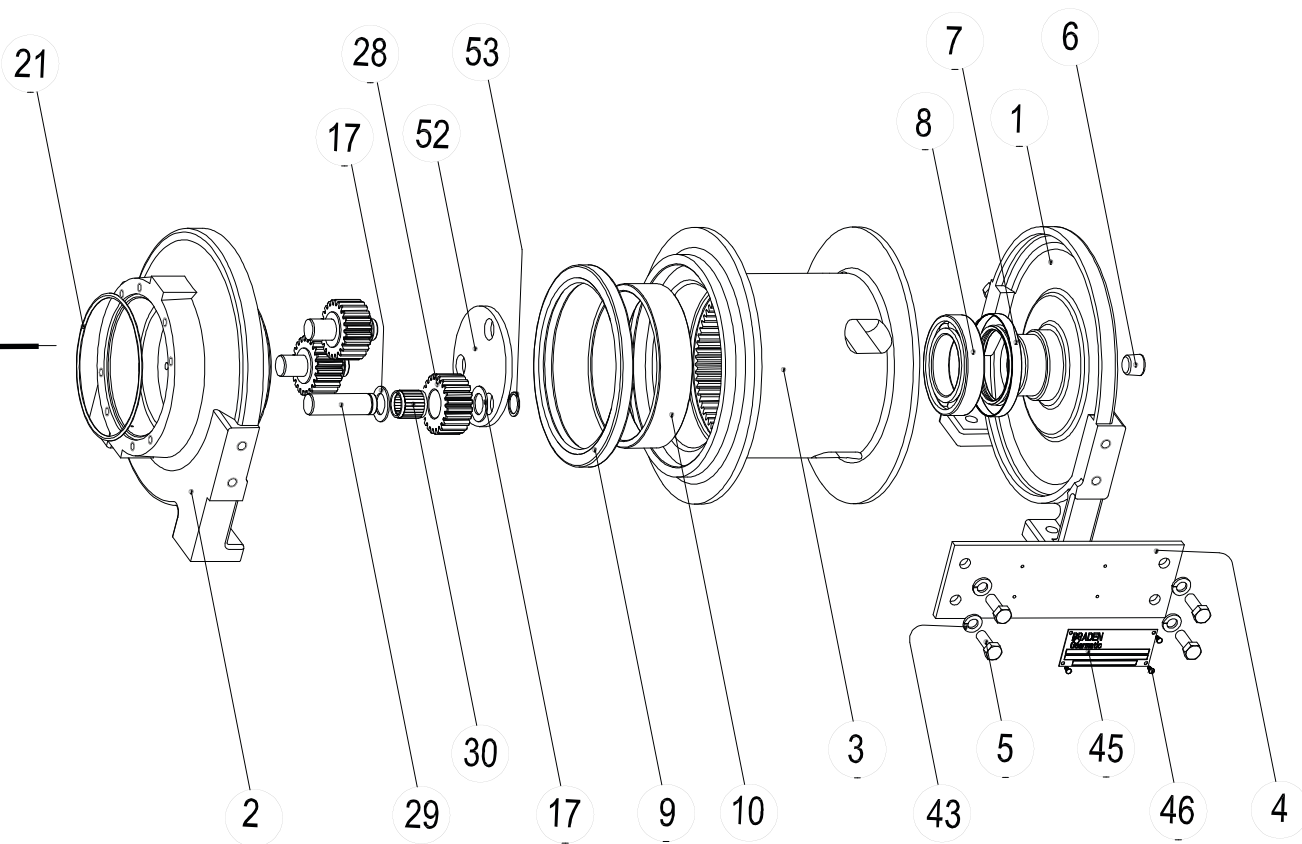
# BRADEN BG3 HYDRAULIC PLANETARY WINCH COMPONENTS



Authorized Distributor:  
 Pacific Marine & Industrial  
 www.pacificmarine.net  
 info@pacificmarine.net



ITEM	DESCRIPTION	PART NO	QTY
1	BEARING SUPPORT ENDPLATE	105722	1
2	BRAKE CYLINDER ENDPLATE	105724	1
3	CABLE DRUM	105723	1
4	TIEPLATE	105758	2
5	CAPSCREW 3/8-16 X 1 HEX HEAD GD8	104309	8
6	PLUG, PIPE 1/2-14	19045	1
7	OIL SEAL	25582	1
8	BALL BEARING	25917	1
9	OIL SEAL	105960	1
10	BUSHING- PRESSED IN DRUM	105789	1
11	SPRING	26094	12
12	SPRING LOCATOR	100136	1
13	BRAKE COUPLING	29929	1
14	SNAP RING	27535	1
15	SPRING PLATE	25552	1
16	U-CUP SEAL	25594	1
17	BEARING RACE-THRUST	24913	6
18	BRAKE PLATE SPACER	25550	1
19	FRICION DISC	25541	8
20	BRAKE DISC	102314	9
21	O-RING	70138	1
22	GASKET (NOT SHOWN, SEATS #40 & # 23)	23108	1
23	MOTOR ADAPTER	105706	1
26	SUN GEAR	105783	1
28	PLANET GEAR	100001	3
29	PLANET PIN	105781	3



ITEM	DESCRIPTION	QTY
30	ROLLER BEARING	3
31	SHIPPING PLUG	2
33	RELIEF VALVE 7.5-15 PSI	1
34	HOSE ASSY	1
35	CAPSCREW, 5/16-18 X 3 HEX HEAD GD8	4
36	ELBOW FITTING	2
38	CAPSCREW, 5/16-18 X 1 HEX HEAD GD8	8
39	LOCKWASHER, 5/16 SPLIT	8
40	HYD MOTOR	1
41	CAPSCREW, 1/2-13 X 1 1/4 HEX HEAD GD8	2
42	LOCKWASHER, 1/2 SPLIT	2
43	LOCKWASHER, 3/8 SPLIT	8
44	PLUG, PIPE 1/8-27	2
45	NAMEPLATE, GH5, PD5 WINCHES	1
46	DRIVE SCREW	4
48	WASHER, 5/16 HARDENED	4
52	PLATE, PLANET RETENSION	1
53	SNAP RING	3
-	BRAKE VALVE ASSY(PARTS 55, 56, 57 BELOW)	1
55	MANIFOLD	1
56	CBV CARTRIDGE	1
57	PILOT OPERATED CHECK VALVE	1
-	CABLE WEDGE (NOT SHOWN)	1



# TROUBLE SHOOTING

TROUBLE	PROBABLE CAUSE	REMEDY
---------	----------------	--------

<p><b>A.</b></p> <p>Winch will not pull maximum load.</p>	<ol style="list-style-type: none"> <li>1. System relief valve may be set too low.</li> <li>2. If this trouble occurs suddenly after working at maximum pull, a particle of dirt may be lodged under the system relief valve, holding it partially open. If this is the cause, a considerable loss in line speed may be noticed as the load on the cable is increased.</li> <li>3. If the pump is belt driven, the belt may be slipping.</li> <li>4. The oil level in the reservoir may be too low. The suction line may be restricted or have an air leak causing cavitation at the inlet port. This will cause the pump to make a whining noise.</li> <li>5. The winch may be mounted on an uneven or flexible surface which causes distortion of the winch base and binding of the gear train. Binding in the gear train will absorb horsepower needed to generate the rated line pull and cause heat.</li> <li>6. Be certain hydraulic system temperature is not more than 180°F (82°C). Excessive hydraulic oil temperatures increase motor internal leakage and reduce motor performance.</li> <li>7. Winch line pull rating is based on 1st layer of wire rope. Expected line pull may be in excess of winch rating.</li> <li>8. After all the causes listed above have been investigated and it is found that the winch will stall at maximum pressure without developing the maximum pull on the bare drum, the trouble may be in the winch.</li> </ol>	<p>Install a pressure gauge in the haul-in port and apply a stall pull on the winch. If pressure is low, increase relief valve setting until recommended pressure is obtained.</p> <p>NOTE: If pressure does not increase in proportion to adjustment, relief valve may be contaminated or worn out. In either case, the relief valve may require disassembly or replacement.</p> <p>Remove relief valve, disassemble and clean parts thoroughly in a suitable solvent. Reassemble and install relief valve. Reset pressure according to specifications.</p> <p>Check belts when pump is at full PSI (kPa) (stall pull on winch). Tighten belts if they are found to be slipping.</p> <p>Check oil level in the reservoir. Check the suction line for damage, externally and internally. Replace suction line if necessary.</p> <p>Reinforce mounting surface.</p> <p>If necessary, use steel shim stock to level winch.</p> <p>First loosen, then evenly retighten all winch mounting bolts to recommended torque.</p> <p>Same as remedy for A-5.</p> <p>Same as remedy for B-4</p> <p>Refer to winch performance charts for additional information.</p> <p>Install a pressure gauge in the motor haul-in port and apply a stall pull on the winch. If the pressure is up to maximum and the bare drum line pull is less than the specified line pull, the trouble will be in the winch.</p> <p>Disassemble winch according to disassembly instructions and check that gear train turns freely. If gear train is found to be satisfactory, inspect the hydraulic motor, according to the service instructions for the hydraulic motor.</p>
---	---	---



# TROUBLE SHOOTING

TROUBLE	PROBABLE CAUSE	REMEDY
<b>A.</b>	9. Rigging and sheaves not operating efficiently.	Perform rigging and sheave service as recommended by manufacturer.
<b>B.</b> Considerable reduction in line speed.	1. Same as A-2. 2. Same as A-4. 3. Same as A-6. 4. If this trouble has increased gradually, the hydraulic pump or winch motor may be worn.	Same as remedy for A-2. Same as remedy for A-4. Same as remedy for A-5 & B-4. Remove and inspect pump. If satisfactory, consult the disassembly instructions for the winch and remove and inspect the motor according to the service instructions for the hydraulic pump.
<b>C.</b> Reverse speed is slower than forward speed.	1. Control valve may be restricted in its travel. 2. Same as A-1. 3. Oil may be too thick causing a high resistance to rotation at the brake plates and causing the relief valve to by-pass. 4. Same as F-1.	Check the travel of the control valve spool. The spool travel should be the same in both directions. Same as remedy for A-1. Follow warm-up procedure in "Preventive Maintenance" section.  Same remedy for F1.
<b>D.</b> Brake will not hold when control valve is returned to neutral after lifting a load.	1. Excessive system back pressure acting on the brake release port.  2. Friction brake will not hold due to worn or damaged brake disks.	Install a pressure gauge at the "pay-out" port of the hydraulics motor. Operate the pump at full throttle and monitor pressure in "neutral" and haul-in positions. If the pressure is greater than 50 PSI (345 kPa), check for restrictions in the return line from the winch to the control valve and the control valve to the reservoir.  Disassemble winch to inspect/replace worn parts.
<b>E.</b> Brake will not control or stop the load when lowering.	1. Same as D-2 or 2. 2. Winch is being overloaded.  3. After the causes listed above have been investigated and found to be satisfactory, the trouble may be in the winch.	Same as remedy for D-1 or 2. Install a pressure gauge at the haul-in port and apply a stall pull on the winch. If the pressure is higher than the maximum specified PSI, reduce the pressure.  Disassemble the brake assembly according to the disassembly instructions. Inspect the brake springs, and brake plates.



# TROUBLE SHOOTING

TROUBLE	PROBABLE CAUSE	REMEDY
<p><b>F.</b> The winch will not lower the load or not lower the load smoothly.</p>	<ol style="list-style-type: none"> <li>1. The friction brake may not be releasing as a result of a defective brake cylinder seal. NOTE: If the brake cylinder seal is defective you will usually notice oil leaking from the winch vent plug.</li> <li>2. Friction brake will not release as a result of damaged brake disks.</li> <li>3. Same as B-4.</li> <li>4. Same as A-3.</li> <li>5. Same as A-5.</li> <li>6. Control valve handle being operated too quickly.</li> <li>7. Insufficient gear oil in cable drum.</li> <li>8. Control valve does not have good metering characteristics.</li> </ol>	<p>Disassemble and inspect the brake cylinder seal.</p> <p>Disassemble brake to inspect brake disks.</p> <p>Same as remedy for B-4. Same as remedy for A-3. Same as remedy for A-5.</p> <p>Operate control valve smoothly when starting and stopping a load. Conduct operator training as required.</p> <p>Remove oil level plug and check oil level. Fill to proper level.</p> <p>See "Winch Installation" section for control valve specifications.</p>
<p><b>G.</b> The winch runs hot.</p>	<ol style="list-style-type: none"> <li>1. Same as A-5.</li> <li>2. Be certain that the hydraulic system temperature is not more than 180° F., 345° C. Excessive hydraulic oil temperatures may be caused by:               <ol style="list-style-type: none"> <li>A. Plugged heat exchanger.</li> <li>B. Too low or too high oil level in hydraulic reservoir.</li> <li>C Same as A-1.</li> <li>D Hydraulic pump not operating efficiently.</li> </ol> </li> <li>3. Excessively worn or damaged internal winch parts.</li> <li>4. Same as F-7.</li> </ol>	<p>Same as remedy for A-5.</p> <p>Thoroughly clean exterior and flush interior. Fill/drain to proper level.</p> <p>Same as remedy for A-1. Remove and inspect pump.</p> <p>Check suction line for damage. If pump is belt driven, belts may be slipping. Replace/tighten belts. Same as remedy for F-7.</p>
<p><b>H.</b> Winch "chatters" while raising rated load.</p>	<ol style="list-style-type: none"> <li>1. Same as A-1.</li> <li>2. Same as B-4.</li> <li>3. Hydraulic oil flow to motor may be too low.</li> <li>4. Same as F-6.</li> </ol>	<p>Same as remedy for A-1. Same as remedy for B-4. Increase pump rpm.</p> <p>Same as remedy for F-6.</p>



# WINCH SERVICE

## FOREWORD TO WINCH SERVICE

Before any part is removed from the winch, all service instructions should be read and understood.

Work in a clean, dust free area as cleanliness is of utmost importance when servicing hydraulic equipment.

Remove wire rope prior to removing winch from crane.

Inspect all replacement parts, prior to installation, to detect any damage which might have occurred in shipment.

Use only genuine BRADEN replacement parts for optimum results. Never reuse expendable parts such as oil seals and O-rings.

Inspect all machined surfaces for excessive wear or damage...before reassembly operations are begun.

Lubricate all O-rings and oil seals with gear oil prior to installation.

Use a sealing compound on the outside surface of oil seals and a light coat of thread sealing compound on pipe threads. Avoid getting thread compound inside parts or passages which conduct oil.

Thoroughly clean all parts in a good grade of non-flammable safety solvent. Wear protective clothing as required.

Refer to exploded view drawing for item numbers used in service procedures.

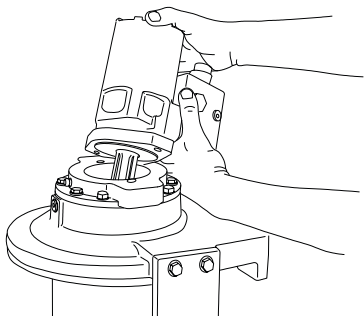
**⚠ WARNING ⚠**

DO NOT CLEAN BRAKE FRICTION DISKS IN SOLVENT. SOLVENT MAY CAUSE DAMAGE TO FRICTION MATERIAL WHICH MAY RESULT IN BRAKE FAILURE AND LOSS OF LOAD CONTROL.

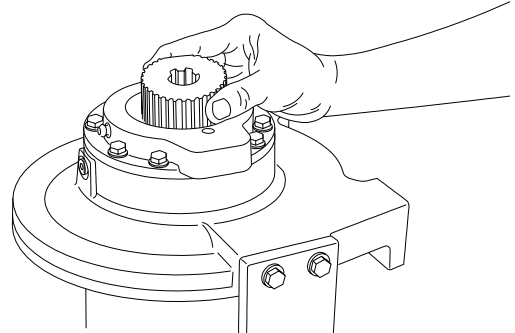
- Perform all applicable trouble shooting operations BEFORE disassembling winch.

## WINCH DISASSEMBLY

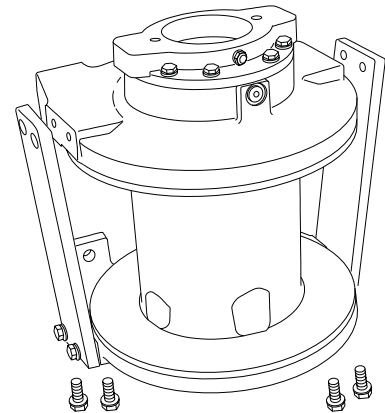
1. Disconnect all hoses and fittings at the winch.



2. Stand the winch on the bearing support plate. Remove the brake release tube assembly (34) between the brake valve block and the brake cylinder end plate. Remove the capscrews (41) and lockwashers (42) which secure the motor (40) to the motor adapter (23), and lift the motor out of the motor adapter. Remove and discard the gasket installed on the pilot of the motor.



3. Remove the brake coupling (13) and sun gear (26) from the winch.



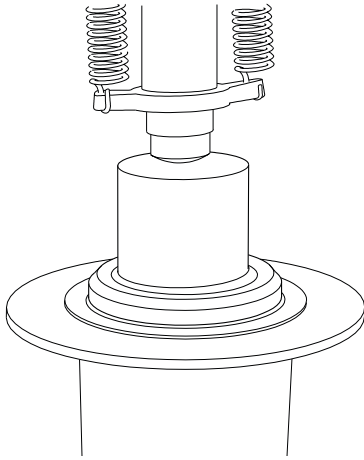
4. Remove the four capscrews (5) and lockwashers (43) holding the tieplates (4) to the brake cylinder endplate. The drum is supported on the endplate by a large bushing. Carefully separate the endplate assembly from the drum. The endplate assembly includes the static brake and the planet gear set.
5. Remove the other four capscrews and lockwashers holding the tieplates to the bearing support endplate. Separate the drum from the bearing support endplate.



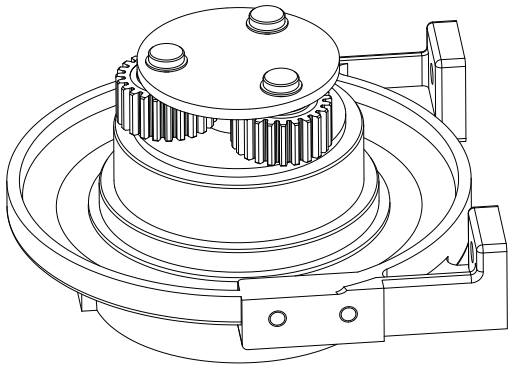
Authorized Distributor:  
Pacific Marine & Industrial  
www.pacificmarine.net  
info@pacificmarine.net

## DRUM ASSEMBLY SERVICE

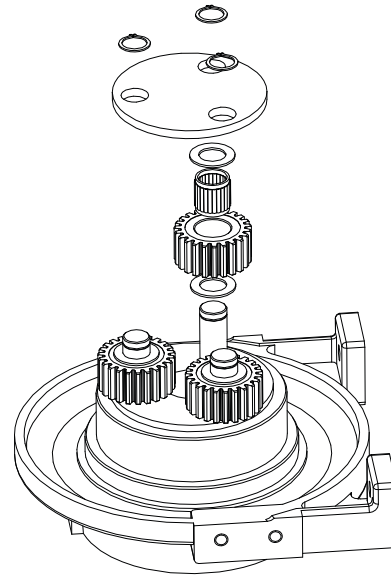
1. Remove the bearing and seal from the support end of the drum, and the seal from the motor end. Check the ring gear teeth (machined into the inside surface of the drum) for nicks, spalling or excessive wear. Replace the drum if wear is greater than 0.015 in. (0.4 mm) when compared to unworn area of teeth. Clean and inspect the drum support bushing and replace if it exhibits signs of excessive wear. The drum bushing needs to be replaced when the inside diameter has worn to 5.270 in. (134 mm). Press out the worn bushing. Clean the inside surface of the drum. Apply non-hardening sealant to the outside surface of the bushing and press into drum.



2. Install a new bearing in the drum if replacement is necessary. Apply a non-hardening sealant on the outside diameter of each new seal and press the seals into the drum, using a flat plate to avoid distortion.



spalling, corrosion, discoloration, material displacement or abnormal wear, the bearing should be replaced. Likewise, the cage should be inspected for unusual wear or deformation, particularly the cage bars. If there is any damage that will impair the cage's ability to separate, retain and guide the rollers properly, the bearing should be replaced. The thrust washer contact areas should be free from any surface irregularities that may cause abrasions or friction. The gears and shafts should be inspected for abnormal wear or pitting. Replace if necessary. Measure the drum bushing support journal on the brake cylinder end-plate. Replace the brake cylinder end-plate if the drum bushing support journal has worn to less than 5.247 in. (133.3 mm).



2. Install a thrust washer onto one of the planet gear pins. Place a roller bearing assembly and a planet gear onto the pin. Set another thrust washer on top of the gear. Repeat this procedure for the other two planet gear assemblies.
3. Place the planet gear retaining plate onto the three planet gear pins. Install a new retaining ring onto each of the three pins. Be sure the retaining rings are properly seated in the grooves of the pins.

## PLANET GEAR SERVICE

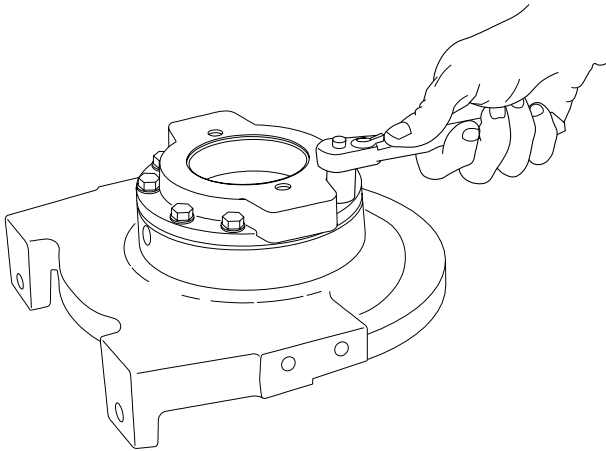
1. The planet gears are mounted on pins in the brake cylinder endplate. Remove the three retaining rings that hold the planet gear retaining plate in place. Lift the retaining plate from the planet gear pins. Remove the planet gear, roller bearing and two thrust washers from each pin. Thoroughly clean all parts and inspect for damage and wear. The bearing rollers should not exhibit any irregularities. If the rollers show any sign of

### CAUTION

Failure to properly seat the retaining rings may result in the retaining plate and planet gears sliding off of the pins. This may result in severe damage to internal winch parts and loss of control.

# BRAKE CYLINDER ENDPLATE SERVICE

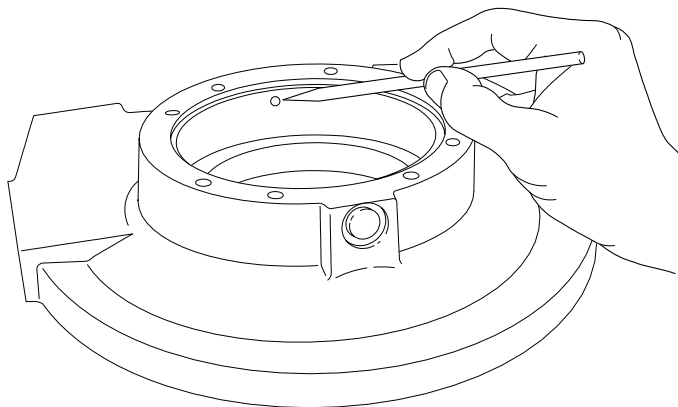
Disassembly and Inspection.



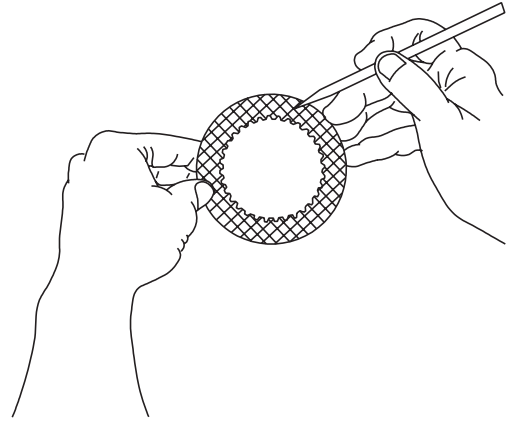
1. Remove the capscrews and lockwashers holding the motor adapter to the endplate.

**NOTE:** The capscrews in the motor adapter should be evenly removed in 1 or 2 turn increments since the motor adapter is under spring tension.

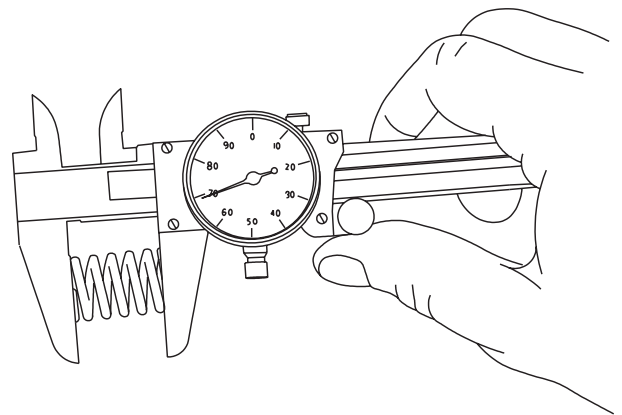
Install 2 capscrews and a short piece of chain into the motor mounting holes. Using the chain as a handle, lift the motor adapter out of the endplate. Remove and discard the O-ring from the motor adapter. Remove and discard the brake piston seal. Remove brake plate spacers, steel discs, friction discs, spring plate, springs and spring spacer.



- 2 Thoroughly clean and inspect all parts at this time. Check brake piston sealing surfaces on motor adapter and brake cylinder endplate. Be sure the brake release port in the endplate (shown above) is free of contamination. Remove the vent plug from the motor adapter, clean in solvent and reinstall. DO NOT paint over the vent or replace it with a solid plug.



3. Place each friction disc on a flat surface and check for distortion with a straight edge. Friction material should appear even across entire surface with groove pattern visible. Replace friction disc if splines are worn to a point, disc is distorted, friction material is worn unevenly or groove pattern is worn away. Place each steel disc on a flat surface and check for distortion with a straight edge. Check surface for signs of material transfer or heat. Replace steel disk if splines are worn to a point, disc is distorted or heat discolored.



4. Check free length of each brake spring. Minimum free length is 15/16 inch (23.8 mm). Check springs for any signs of cracking or failure. If a brake spring must be replaced for any reason, then **ALL** brake springs must be replaced.

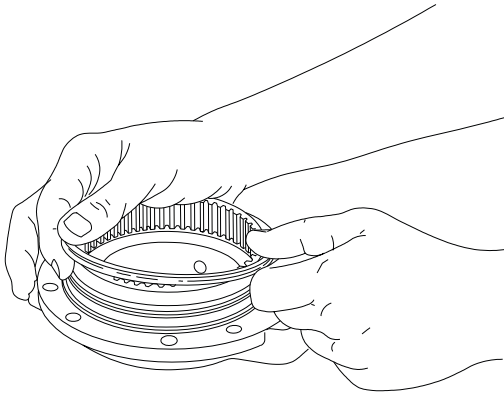
## ⚠ CAUTION ⚠

Failure to replace brake springs as a set may cause uneven brake application pressure and repeated brake spring failure which may result in reduced brake holding capacity.

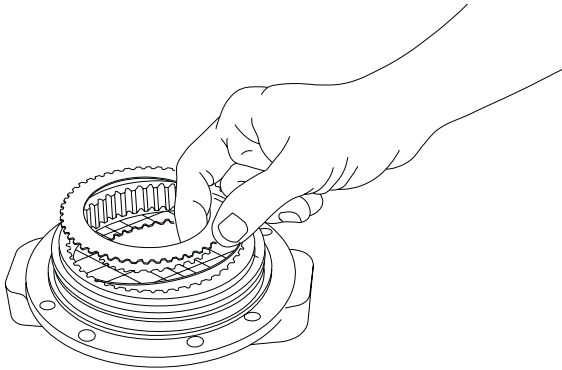


Authorized Distributor:  
Pacific Marine & Industrial  
www.pacificmarine.net  
info@pacificmarine.net

# WINCH ASSEMBLY

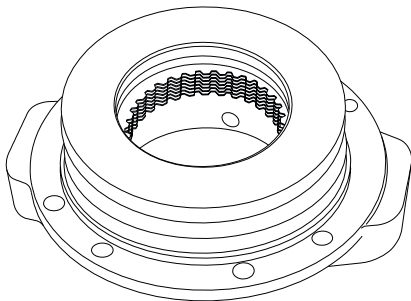


1. Place the motor adapter on workbench with the motor mounting surface down. Install a new O-ring (21). Lubricate the brake piston seal (16) with petroleum jelly or hydraulic oil and install on the motor support with the seal lip down, as shown above.

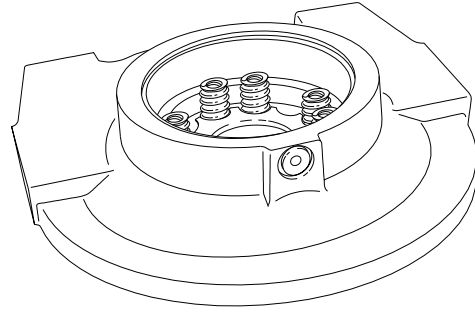


2. Insert a steel disc (20) into the motor adapter, followed by a friction disc (19). Alternately install steel and friction discs until eight (8) friction discs and nine (9) steel discs have been installed. Finish with a steel disc on top.

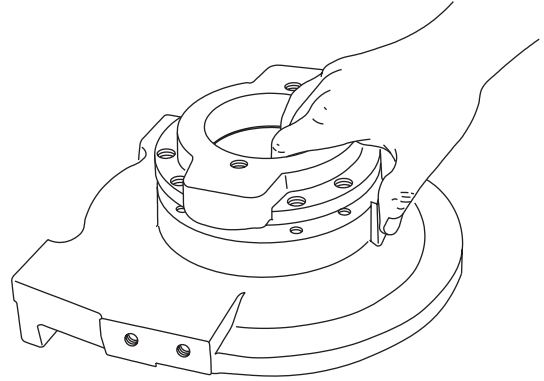
NOTE: It is good practice to lubricate the discs in gear oil prior to assembly.



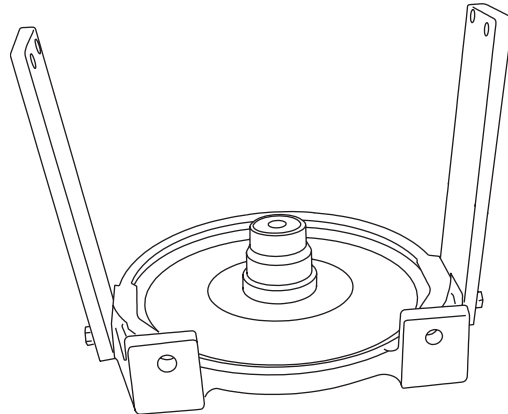
3. Install the brake plate spacer (18) and the brake piston (15) as shown.



4. Install the spring spacer (12) and the twelve (12) springs (11) into the brake cylinder end plate (2).



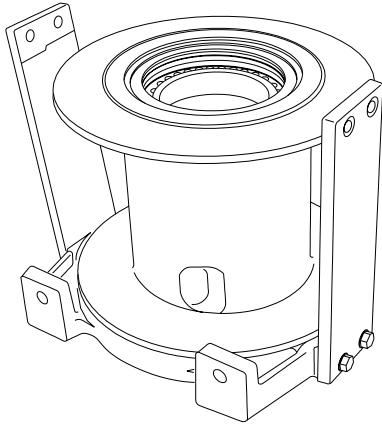
5. While holding the motor adapter and brake assembly together, turn it over and install into the brake cylinder end plate. Install the eight (8) capscrews (38) and lockwashers (39) but do not tighten them at this time.



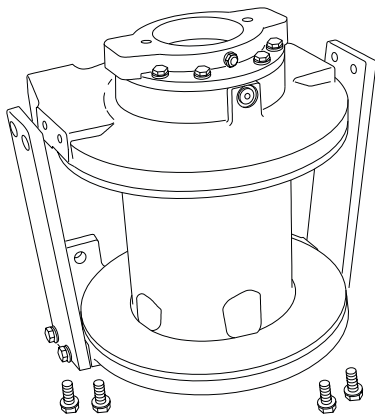
6. Loosely attach the two tie plates (4) to the bearing support end plate using capscrews (4) and lockwashers (43).



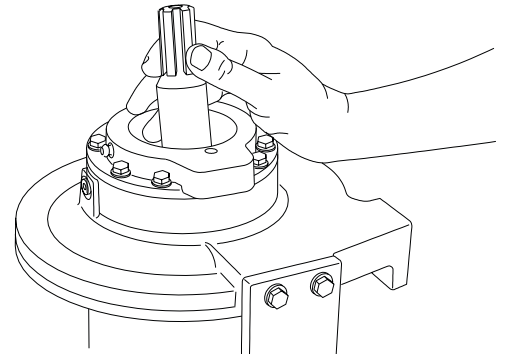
Authorized Distributor:  
**Pacific Marine & Industrial**  
[www.pacificmarine.net](http://www.pacificmarine.net)  
[info@pacificmarine.net](mailto:info@pacificmarine.net)



- Lubricate the bearing support and sealing surface with petroleum jelly or gear oil and place the cable drum (3) on the bearing support endplate. Check that the drum rotates freely on the bearing.

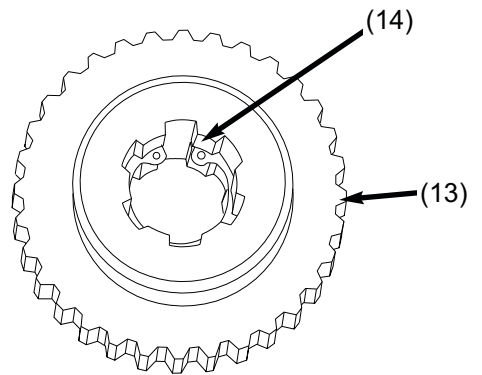


- Lubricate the bushing support and sealing surface on the brake cylinder endplate and install the endplate assembly onto the drum while meshing the planet gears with the ring gear.
- Fasten the two tie plates to the endplate with cap-screws (5) and lockwashers (43), and torque all eight (8) tie plate capscrews to their proper value. Check that the drum turns freely in both directions without binding or any interference.



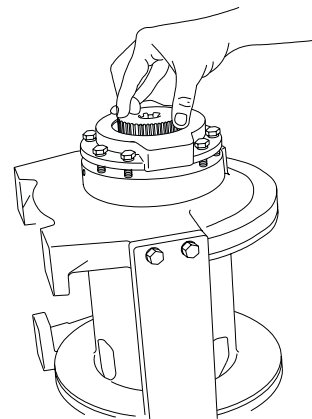
- Install the sun gear (26), meshing with the teeth on the planet gears in the drum.

- Install the brake coupling into the brake pack with the flat end of the coupling toward the motor. Turn the



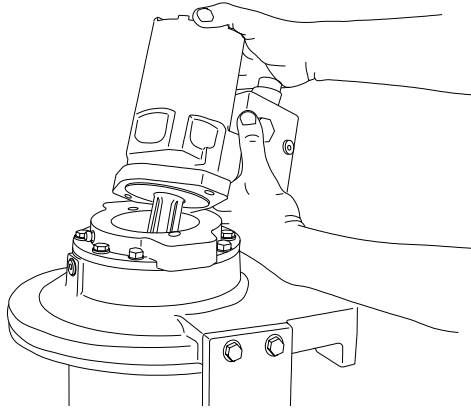
**⚠ WARNING ⚠**

Be certain the retaining ring (14) is seated in the groove in the splined bore of the brake coupling (13). This retaining ring will keep the brake coupling correctly positioned in the center of the friction brake pack. Binding of the brake or brake failure may occur if this retaining ring is omitted.

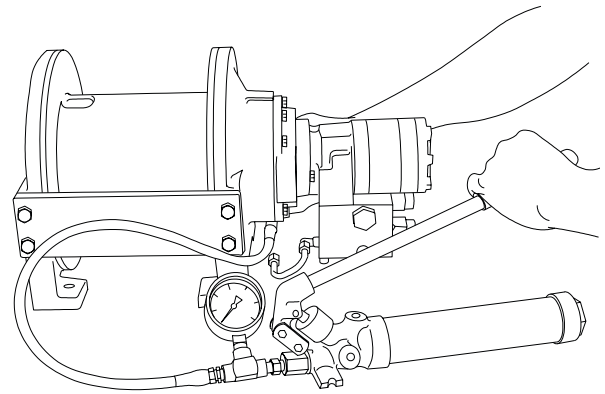


Authorized Distributor:  
**Pacific Marine & Industrial**  
[www.pacificmarine.net](http://www.pacificmarine.net)  
[info@pacificmarine.net](mailto:info@pacificmarine.net)

coupling back and forth to align the outer splines with the brake disc splines. The coupling must engage all the brake discs and the retaining ring in its center must rest on the sun gear. Evenly tighten the eight (8) cap-screws around the motor adapter one turn at a time until the motor adapter is firmly seated to the endplate. Torque the capscrews to their proper value.



12. Install a new gasket (22) on the motor pilot. Install the motor onto the motor adapter with two capscrews (41) and lockwashers (42). Torque the capscrews to their proper value.



13. Install a hand pump with an accurate 0-2,000 psi (0-13,800 kPa) gauge and shut-off valve to the brake release port on the brake cylinder endplate. Apply 1,000 psi (6,900 kPa) to the brake and close the shut-off valve. Let the brake stand for five (5) minutes. If there is any loss of pressure, the brake pack should be disassembled for inspection of the sealing surfaces and the brake piston. Release the pressure, remove the hand pump and install the brake release tube (34) between the brake valve block (24) and the brake release port.

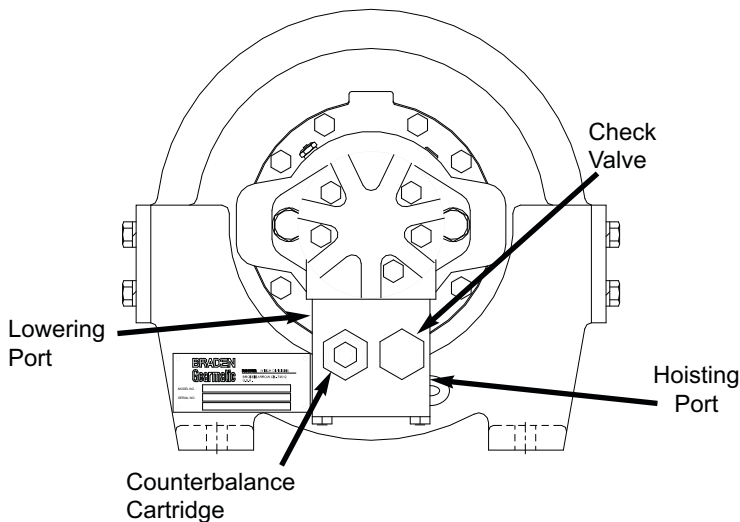
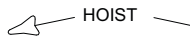
## Reversing Direction of drum rotation

To change direction of rotation on units with only one counterbalance cartridge, the cartridge and check valves positions must be reversed.

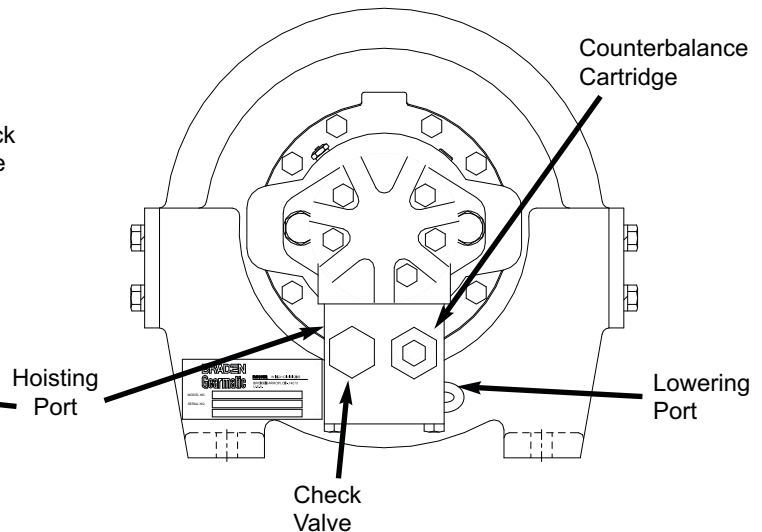
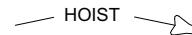
See drawings below for correct cartridge and check valve positions.

**NOTE:** The check valve has the appearance of a plug, while the counterbalance cartridge has an adjusting screw and jam nut.

### OVERWIND



### UNDERWIND



Authorized Distributor:  
Pacific Marine & Industrial  
www.pacificmarine.net  
info@pacificmarine.net

ACCUMULATIVE ROPE CAPACITY IN FEET (METERS)								
ROPE SIZE Inch (mm)	LAYER							
	1	2	3	4	5	6	7	8
3/16 (5)	54 (16)	111 (34)	172 (52)	236 (72)	303 (92)	373 (114)	446 (136)	522 (159)
1/4 (6)	41 (12)	85 (26)	132 (40)	182 (55)	235 (72)	291 (89)		
5/16 (8)	33 (10)	69 (21)	108 (33)	150 (46)	195 (59)			
3/8 (10)	28 (9)	59 (18)	93 (28)	130 (40)				
1/2 (13)	21 (6)	45 (14)	72 (22)					
9/16 (14)	19 (6)	41 (12)						
5/8 (16)	17 (5)	37 (11)						
3/4 (19)	14 (4)	31 (9)						

**PERFORMANCE CHART**

ROPE SIZE IN. (MM)	LAYER	080 MOTOR 8.0 CU IN. DISP 2488 psi @ 15 gpm	
		LINE PULL lb (kg)	LINE SPEED fpm (mpm)
3/8 (10)	1	3000 (1364)	140 (43)
	2	2700 (1227)	155 (47)
	3	2460 (1118)	170 (52)
	4	2260 (1027)	186 (57)

NOTE: Pressure shown is across motor. \*\*= This layer does not comply with ANSI Spec. B30.5C Par.5-1.3.2c for 1/2 in. exposed flange

**RECOMMEND FASTENER TORQUE**

Higher or lower torques for special applications will be specified such as the use of spanner nuts, nuts on shaft ends, jam nuts and where distortion of parts or gaskets is critical.

Lubricated Torque values based on use of SAE 30wt engine oil applied to threads and face of bolt or nut.

Avoid using thread lubricants as the applied torque may vary by 10-40% depending upon product used.

**RECOMMENDED FASTENER TORQUE**

Bolt Dia. Inches	Thds Per Inch	Torque (LB-FT)			
		Grade 5		Grade 8	
		Dry	Lubed	Dry	Lubed
1/4	20	8	6	12	9
	28				
5/16	18	17	13	24	18
	24				
3/8	16	31	23	45	35
	24				
7/16	14	50	35	70	50
	20				
1/2	13	75	55	110	80
	20				
9/16	12	110	80	150	110
	18				
5/8	11	150	115	210	160
	18				

Bolt Dia. Inches	Thds Per Inch	Torque (LB-FT)			
		Grade 5		Grade 8	
		Dry	Lubed	Dry	Lubed
3/4	10	265	200	380	280
	16				
7/8	9	420	325	600	450
	14				
1	8	640	485	910	680
	14				
1 1/8	7	790	590	1290	970
	12				
1 1/4	7	1120	835	1820	1360
	12				
1 3/8	6	1460	1095	2385	1790
	12				
1 1/2	6	1940	1460	3160	2370
	12				

# METRIC CONVERSION TABLE

**MULTIPLY: BY: TO GET: MULTIPLY: BY: TO GET:**

LINEAR					
inches (in.)	X 25.4	= millimeters (mm)	millimeters (mm)	X 0.3937	= inches (in.)
feet (ft.)	X 0.3048	= meters (m)	meters (m)	X 3.281	= feet (ft.)
miles (mi.)	X 1.6093	= kilometers (km)	kilometers (km)	X 0.6214	= miles (mi.)
AREA					
inches <sup>2</sup> (sq.in.)	X 645.15	= millimeters <sup>2</sup> (mm <sup>2</sup> )	millimeters <sup>2</sup> (mm <sup>2</sup> )	X 0.000155	= inches <sup>2</sup> (sq.in.)
feet <sup>2</sup> (sq.ft.)	X 0.0929	= meters <sup>2</sup> (m <sup>2</sup> )	meters <sup>2</sup> (m <sup>2</sup> )	X 10.764	= feet <sup>2</sup> (sq.ft.)
VOLUME					
inches <sup>3</sup> (cu.in.)	X 0.01639	= liters (l)	liters (l)	X 61.024	= inches <sup>3</sup> (cu.in.)
quarts (qts.)	X 0.94635	= liters (l)	liters (l)	X 1.0567	= quarts (qts.)
gallons (gal.)	X 3.7854	= liters (l)	liters (l)	X 0.2642	= gallon (gal.)
inches <sup>3</sup> (cu.in.)	X 16.39	= centimeters <sup>3</sup> (cc)	centimeters <sup>3</sup> (cc)	X 0.06102	= inches <sup>3</sup> (cu.in.)
feet <sup>3</sup> (cu.ft.)	X 28.317	= liters (l)	liters (l)	X 0.03531	= feet <sup>3</sup> (cu.ft.)
feet <sup>3</sup> (cu.ft.)	X 0.02832	= meters <sup>3</sup> (m <sup>3</sup> )	meters <sup>3</sup> (m <sup>3</sup> )	X 35.315	= feet <sup>3</sup> (cu.ft.)
fluid ounce (fl.oz.)	X 29.57	= milliliters (ml)	milliliters (ml)	X 0.03381	= fluid ounce (fl.oz.)
MASS					
ounces (oz.)	X 28.35	= grams (g)	grams (g)	X 0.03527	= ounces (oz.)
pounds (lbs.)	X 0.4536	= kilograms (kg)	kilograms (kg)	X 2.2046	= pounds (lbs.)
tons (2000 lbs.)	X 907.18	= kilograms (kg)	kilograms (kg)	X 0.001102	= tons (2000 lbs.)
tons (2000 lbs.)	X 0.90718	= metric tons (t)	metric tons (t)	X 1.1023	= tons (2000 lbs.)
tons (long) (2240 lbs.)	X 1013.05	= kilograms (kg)	kilograms (kg)	X 0.000984	= tons (long) (2240 lbs.)
PRESSURE					
inches Hg (60°F)	X 3600	= kilopascals (kPa)	kilopascals (kPa)	X 0.2961	= inches Hg (60°F)
pounds/sq.in. (PSI)	X 6.895	= kilopascals (kPa)	kilopascals (kPa)	X 0.145	= pounds/sq.in. (PSI)
pounds/sq.in. (PSI)	X 0.0703	= kilograms/sq.cm. (kg/cm <sup>2</sup> )	kilograms/sq.cm. (kg/cm <sup>2</sup> )	X 14.22	= pounds/sq.in. (PSI)
pounds/sq.in. (PSI)	X 0.069	= bars	bars	X 14.5	= pounds/sq.in. (PSI)
inches H <sub>2</sub> O (60°F)	X 0.2488	= kilopascals (kPa)	kilopascals (kPa)	X 4.0193	= inches H <sub>2</sub> O (60°F)
bars	X 100	= kilopascals (kPa)	kilopascals (kPa)	X 0.01	= bars
POWER					
horsepower (hp)	X 0.746	= kilowatts (kW)	kilowatts (kW)	X 1.34	= horsepower (hp)
ft.-lbs./min.	X 0.0226	= watts (W)	watts (W)	X 44.25	= ft.-lbs./min.
TORQUE					
pound-inches (in.-lbs.)	X 0.11298	= newton-meters (N-m)	newton-meters (N-m)	X 8.851	= pound-inches (in.-lbs.)
pound-feet (ft.-lbs.)	X 1.3558	= newton-meters (N-m)	newton-meters (N-m)	X 0.7376	= pound-feet (ft.-lbs.)
pound-feet (ft.-lbs.)	X .1383	= kilograms/meter (kg-m)	kilogram/meter (kg-m)	X 7.233	= pound-feet (ft.-lbs.)
VELOCITY					
miles/hour (m/h)	X 0.11298	= kilometers/hour (km/hr)	kilometers/hour (km/hr)	X 0.6214	= miles/hour (m/h)
feet/second (ft./sec.)	X 0.3048	= meter/second (m/s)	meters/second (m/s)	X 3.281	= feet/second (ft./sec.)
feet/minute (ft./min.)	X 0.3048	= meter/minute (m/min)	meters/minute (m/min)	X 3.281	= feet/minute (ft./min.)
TEMPERATURE					
°Celsius = 0.556 (°F - 32)			°Fahrenheit = (1.8 X °C) + 32		
COMMON METRIC PREFIXES					
mega	(M)	= 1,000,000 or 10 <sup>6</sup>	deci	(d)	= 0.1 or 10 <sup>-1</sup>
kilo	(k)	= 1,000 or 10 <sup>3</sup>	centi	(c)	= 0.01 or 10 <sup>-2</sup>
hecto	(h)	= 100 or 10 <sup>2</sup>	milli	(m)	= 0.001 or 10 <sup>-3</sup>
deka	(da)	= 10 or 10 <sup>1</sup>	micro	(µ)	= 0.000.001 or 10 <sup>-6</sup>