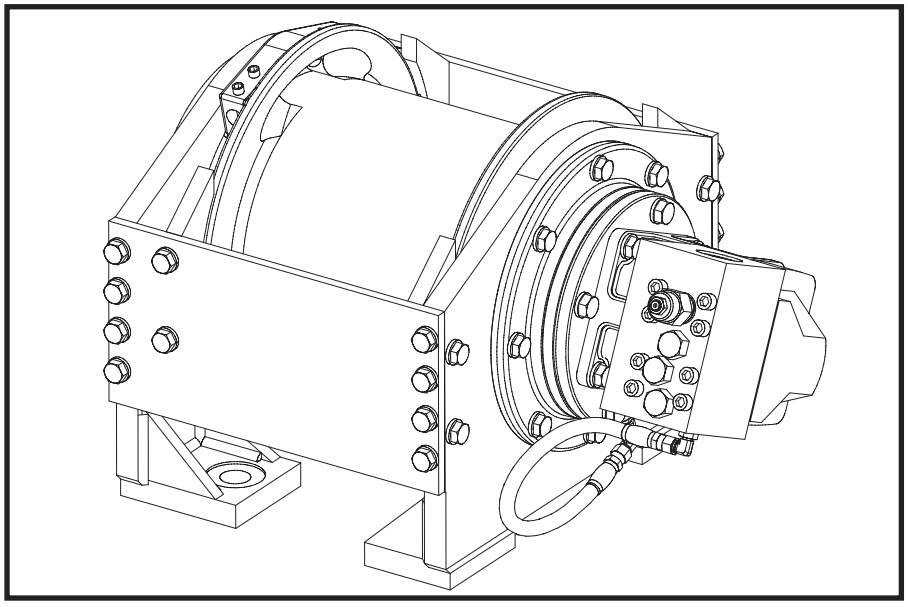
BRADEN

H20R
Recovery Winch



INSTALLATION, MAINTENANCE AND SERVICE MANUAL

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FOREWORD

Read this entire publication and retain it for future reference.

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

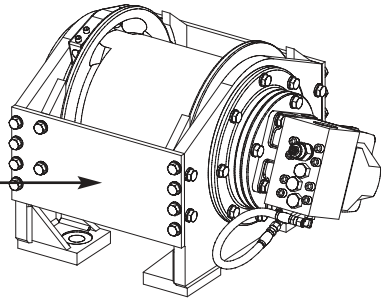
The following service instructions have been prepared to provide assembly, disassembly and maintenance information for the Braden Model H20R. It is suggested that before doing any work on this unit, all assembly and disassembly instructions should be read and understood.

Some pictures in this manual may show details or attachments that are different from your winch. Also, some components have been removed for illustrative purposes.

Whenever a question arises regarding your winch or this manual, please contact the Braden Technical Support Department via phone at (918)-251-8511, from 08:00 to 16:30 hours, CST, Monday through Friday, via fax at (918)-259-1575, or via email at winch.service@paccar.com, for the latest available information.

Model Number

Serial Number



Serial Numbers and Model Numbers are stamped into a data plate located on the tie plate. Always refer to the Serial Number and Model Number when requesting information or service parts..

EXPLANATION OF MODEL NUMBER

H 20 R SPL - 46 P 037 - 21

H	20	R	SPL	-	46	P	037	-	21
HOIST	MAX RATING	RECOVERY	DESIGN MODEL		GEAR RATIO	PLANETARY GEARING	MOTOR SIZE		DRUM OPTION

H	DESIGNATES HOIST
20	DESIGNATES 20,000 LB. APPROXIMATE FIRST LAYER LINE PULL
R	DESIGNATES RECOVERY
SPL	DESIGNATES THE MODEL IS A SPECIAL DESIGN
46	DESIGNATES TOTAL GEAR REDUCTION
P	DESIGNATES PLANETARY GEARING
037	DESIGNATES HYDRAULIC MOTOR DISPLACEMENT IN CU IN/REV (EXAMPLE 037 = 3.7 CU IN/REV)
21	DESIGNATES THE DRUM OPTION - SPECIAL DRUM

GENERAL SAFETY RECOMMENDATIONS

Safety and informational callouts used in this manual include:

⚠ WARNING ⚠

WARNING – This emblem is used to warn against hazards and unsafe practice which COULD result in severe personal injury or death if proper procedures are not followed.

⚠ CAUTION ⚠

CAUTION – This emblem is used to warn against potential or unsafe practices which COULD result in personal injury and product or property damage if proper procedures are not followed.

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. Be certain equipment (boom, mast, sheave blocks, pendants, etc.) is either lowered to the ground or blocked securely before servicing, adjusting, or repairing winch.
2. Be sure personnel are clear of work area BEFORE operating winch.
3. Read all warning and caution tag information provided for safe operation and service of winch.
4. Inspect rigging and winch at the beginning of each work shift. Defects should be corrected immediately.
5. Keep equipment in good operating condition. Perform scheduled servicing and adjustments listed in the "Preventive Maintenance" section of this manual.
6. An equipment warm-up procedure is recommended for all start-ups and essential at ambient temperatures below +40°F (4°C). Refer to "Warm-up Procedure" listed in the "Preventive Maintenance" section of this manual.
7. Operate winch line speeds to match job conditions.
8. Leather gloves should be used when handling wire rope.
9. Never attempt to handle wire rope when the hook end is not free. Keep all parts of body and clothing clear of cable rollers, cable entry area of fairleads, sheaves and winch drum.
10. When winding wire rope on the winch drum, never attempt to maintain tension by allowing wire rope to slip through hands. Always use "Hand-Over-Hand" technique.
11. Never use wire rope with broken strands. Replace wire rope.
12. Do not weld on any part of the winch.
13. Use recommended hydraulic oil and gear lubricant.
14. Keep hydraulic system clean and free from contamination at all times.
15. Use correct anchor method for wire rope and pocket in drum. Do not use knots to secure or attach wire rope. For additional safety, ALWAYS maintain a minimum of five (5) wraps of wire rope on the drum.
16. Never attempt to clean, oil or perform any maintenance on a machine with the engine or prime mover running, unless instructed to do so in this manual.
17. Never operate winch controls unless you are properly positioned at the operators station and you are sure personnel are clear of the work area.
18. Assure that personnel who are responsible for hand signals are clearly visible and that the signals to be used are thoroughly understood by everyone.
19. Ground personnel should stay in view of the operator and clear of winch drum. Do not allow ground personnel near winch line under tension.
20. Do not exceed the maximum pressure, PSI (kPa), or flow, GPM (LPM), stated in the winch specifications.
21. Install guarding to prevent personnel from getting any part of body or clothing caught at a point where the cable is wrapped onto the drum or drawn through guide rollers.
22. "Deadman" controls, which automatically shut off power to the winch whenever the operator leaves his station, should be installed whenever practicable.
23. Never allow anyone to stand under a suspended load.
24. Avoid sudden "shock" loads or attempting to "jerk" load free. This type of operation may cause heavy loads, in excess of rated capacity, which may result in failure of cable and winch.

THEORY OF OPERATION

DESCRIPTION OF WINCH

The winch has four basic component parts:

1. Winch base
2. Hydraulic motor and brake valve
3. Brake cylinder and motor support
4. Drum assembly

The drum assembly consists of three basic assemblies:

1. Drum with integral ring gear
2. Output planetary gear set
3. Primary planetary gear set

The hydraulic motor is bolted to the motor support which in turn is bolted to the brake cylinder and the base. The motor end of the drum, running on a ball bearing, is supported by the brake cylinder. The other end of the drum runs on a ball bearing on the support bolted to the base. The ring gear for both planetary sets is machined into the drum's inside surface.

WINCH OPERATION

The hydraulic motor drives the sun gear of the primary planetary gear set through the splined inner race of the brake clutch. When driven by the sun gear, the primary planet gears walk around the ring gear in the drum and drive the primary planet carrier.

The primary planet carrier drives the output planet sun gear which, in turn drives the output planet gears. The output planet carrier is splined to the bearing support and cannot rotate. Therefore, as the output planet gears are driven by the sun gear, they will drive the ring gear/drum.

DUAL BRAKE SYSTEM – DESCRIPTION

The dual brake system consists of a dynamic brake system and a static brake system.

The dynamic brake system has two operating components:

1. Brake valve assembly
2. Hydraulic motor

The brake valve is basically a counterbalance valve. It contains a check valve to allow free flow of oil to the motor in the hoisting direction and a pilot operated, spring-loaded spool valve that blocks the flow of oil out of the motor when the control valve is placed in neutral. When the control valve is placed in the lowering position, the spool valve remains closed until sufficient pilot pressure is applied to the end of the spool to shift it against spring pressure and open a passage. After the spool valve cracks open, the pilot pressure becomes flow-dependent and modulates the spool valve opening which controls the lowering speed.

Figures 2, 3 & 4 show a simplified version of the brake valve for illustrative purposes.

The static brake system has three operating components:

1. Spring Applied, Multiple Friction Disc Static Brake
2. Brake Clutch Assembly
3. Hydraulic Piston and Cylinder

Figure 2

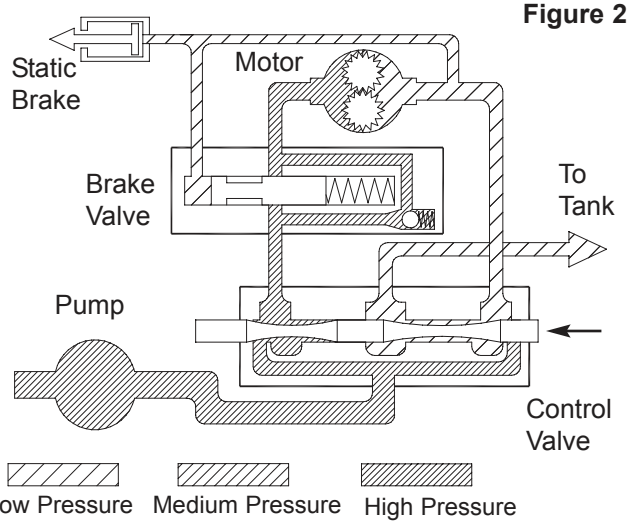


Figure 3

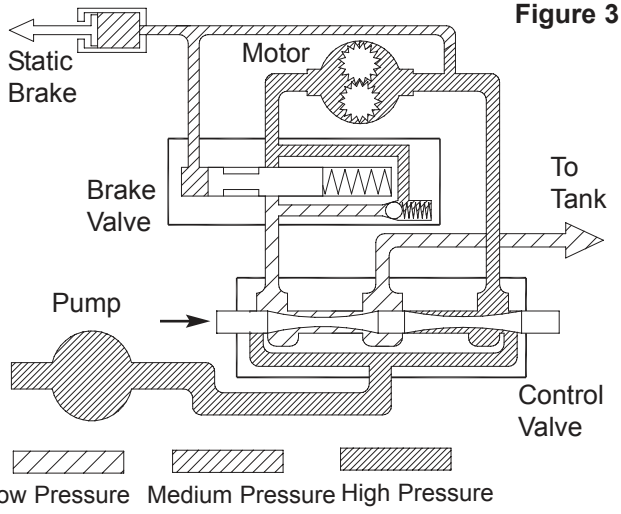
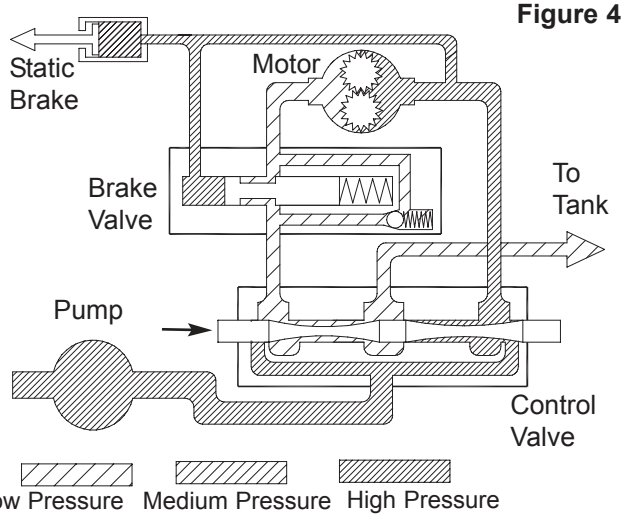


Figure 4



The static brake is released by the brake valve pilot pressure at a pressure lower than that required to open the pilot operated spool valve. This sequence assures that dynamic braking takes place in the brake valve and that little, if any, heat is absorbed by the friction brake.

The friction brake is a load holding brake only and has nothing to do with dynamic braking or rate of descent of a load.

The brake clutch is splined to the primary sun gear shaft between the motor and the primary sun gear. It will allow this shaft to turn freely in the direction to raise a load and lock up to force the brake discs to turn with the shaft in the direction to lower a load. Figures 5 and 6.

The hydraulic cylinder, when pressurized, will release the spring pressure on the brake discs, allowing the brake discs to turn freely.

Dual Brake System – Operation

When hoisting a load, the brake clutch which connects the motor shaft to the primary sun gear, allows free rotation. The sprag cams lay over and permit the inner race to turn free of the outer race. Figure 5. The friction brake remains fully engaged. The winch, in raising a load, is not affected by any braking action. Figure 2.

When the lifting operation is stopped, the load attempts to turn the primary sun gear in the opposite direction. This reversed input causes the sprag cams to instantly roll upward and firmly lock the shaft to the fully engaged friction brake. Figure 6.

When the winch is powered in reverse, to lower the load, the motor cannot rotate until sufficient pilot pressure is present to open the brake valve. Figures 3 & 4. The friction brake within the winch will completely release at a pressure lower than that required to open the brake valve. The extent to which the brake valve opens will determine the amount of oil that can flow through it and the speed at which the load will be lowered. Increasing the flow of oil to the winch motor will cause the pressure to rise and the opening in the brake valve to enlarge, speeding up the descent of the load. Decreasing this flow causes the pressure to lower and the opening in the brake valve to decrease thus slowing the descent of the load.

When the control valve is shifted to neutral, the pressure will drop and the brake valve will close, stopping the load. The friction brake will engage and hold the load after the brake valve has closed.

The friction brake receives very little wear in the lowering operation. All of the heat generated by the lowering and stopping of a load is absorbed by the hydraulic oil where it can be readily dissipated.

Figure 5 Static Friction Brake Applied

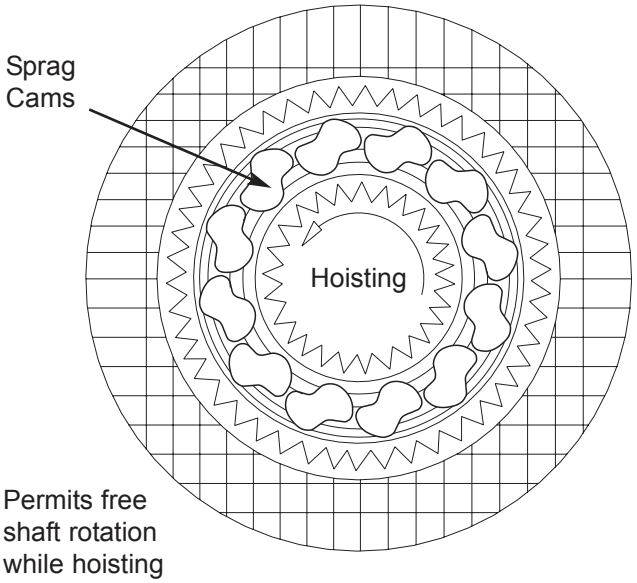
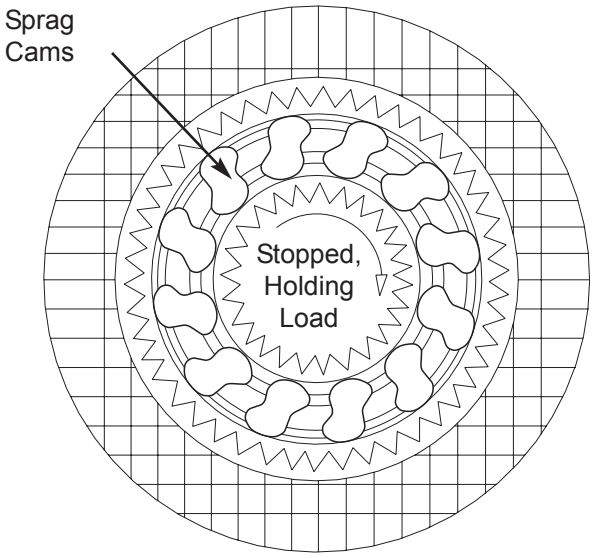
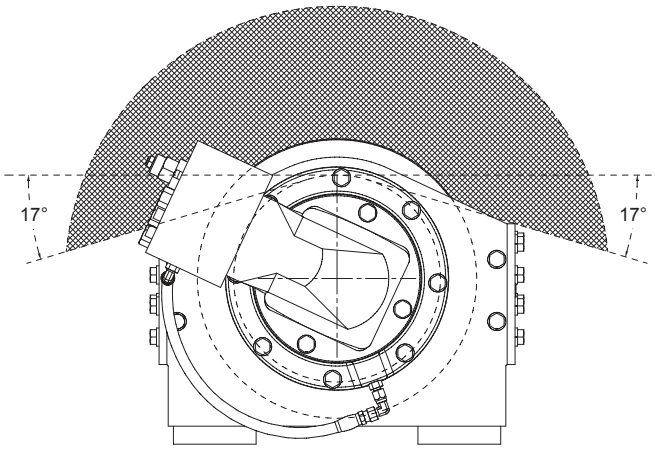


Figure 6
Static Friction Brake Applied



Load attempts to rotate shaft in opposite direction.
Brake clutch locks sun gear shaft to friction brake.

WINCH INSTALLATION

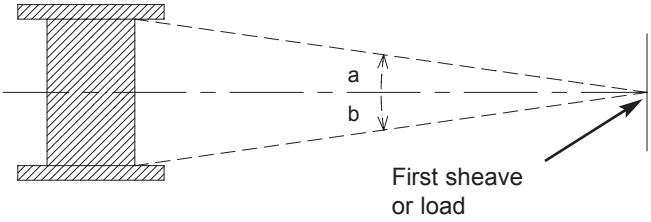


1. The winch must be mounted with the centerline of the drum in a horizontal position. Due to the design of the winch base group, the cable departure angle must only be in the shaded area as shown. When mounting the winch, use all four mounting holes with 1 in. grade 8 capscrews, hardened washers and nuts tightened to recommended torque.

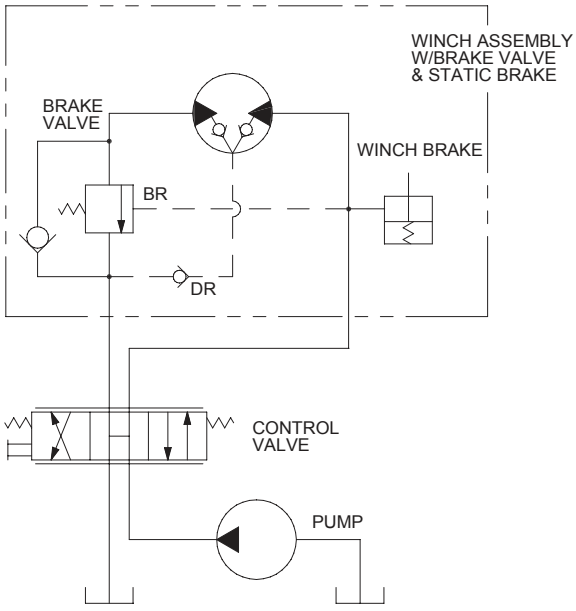
2. The winch must be mounted to a flat, rigid surface that will not flex when the winch is in use, causing binding in the gear train. Binding in the winch gear train will result in accelerated wear of internal components, reduced hoisting capacity and heat. If necessary, use shim stock under the winch mounting pads to ensure the surface is flat within 0.020 in. (0.5 mm).

3. The vent plug, installed in the drum bearing support, must always be located above the horizontal centerline. If the winch is mounted on a pivoting surface, be sure the vent plug remains above centerline.

4. Hydraulic lines and components that operate the winch should be of sufficient size to assure minimum back pressure at the winch. The motor must be externally drained directly to the reservoir to avoid motor shaft seal failure.



5. The winch must be mounted perpendicular to an imaginary line from the center of the winch to the first sheave to ensure even spooling. Make certain the fleet angle is between ½ and 1 ½ degrees.



6. 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 (often called open center, open port).

7. High quality hydraulic oil is essential for satisfactory performance and long hydraulic component life. Make certain the hydraulic oil used is the proper viscosity for your starting ambient temperature. Typically, the maximum cold weather start-up viscosity should not exceed 5000 SUS with a pour point 20°F (11°C) lower than the minimum anticipated temperature.

   Under continuous operating conditions, the oil temperature should not exceed 180°F (82°C). Optimum oil temperature is 120-140°F (49-60°C). Unless otherwise specified by the vehicle manufacturer, the hydraulic oil filter should have a 10 micron rating.

SPECIFICATIONS

Unit weight without wire rope, approximate . . . . . .500 lb. (227 kg)

Gear Ratio 41:1

Cable Drum Dimensions: -21 SPL Drum	
Barrel Diameter	10 in. (254 mm)
Flange Diameter	13.5 in. (343 mm)
Barrel Length	9.18 in. (233 mm)

Cable Storage Capacity			
Layer	1	2	3
9/16 in. (14 mm)	45 ft. (14 m)	94 ft. (29 m)	148 ft. (45 m)
5/8 in. (16 mm)	40 ft. (12 m)	85 ft. (26 m)	--

Gear Oil Capacity . . . . . .5 pints (2.4 liters)

RECOMMENDED FASTENER TORQUE

Higher and lower torque values 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.

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

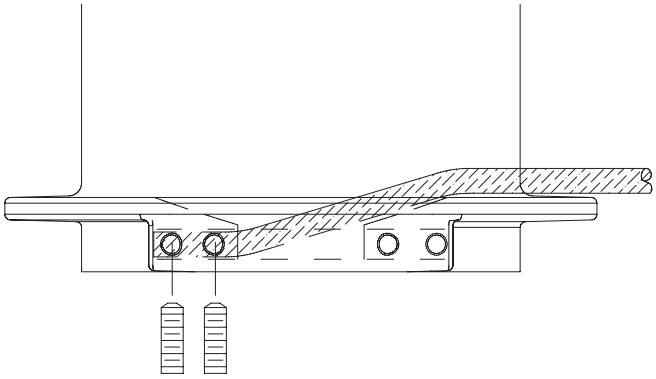
To convert lb. ft. to kg-m, multiply lb. ft. value by 0.1383.

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

WIRE ROPE INSTALLATION

Prepare the end of the wire rope as recommended by the wire rope manufacturer. Insert the free end of the wire rope through the opening in the drum flange. Push the wire rope into the anchor pocket until the end of the wire rope is even with the outer edge of the pocket. Install the set screws and tighten until the wire rope deforms under the set screws and the wire rope is held securely. Apply a light load of approximately 500 lb. (227 kg) to the wire rope as the new wire rope is wound onto the cable drum.

The set screw anchor system is designed for use only with 9/16 - 5/8 in. (14-16 mm) wire rope.



⚠ WARNING ⚠

The set screw wire rope anchor system is not capable of supporting the rated load. Always MAINTAIN a minimum of five wraps of wire rope on the cable drum. If the wire rope is fully reeled out, the wire rope may slip out of the drum causing a loss of load control which may result in property damage, injury or death. We suggest that the last 5-6 wraps of wire rope be painted bright red to serve as a visual warning.

PREVENTIVE MAINTENANCE

A regular program of preventive maintenance for your planetary hoist is strongly recommended to minimize the need for emergency servicing and promote safe, reliable hoist operation. The user of Braden products is responsible for hoist inspection, testing and maintenance with frequency dependent upon the severity of the hoist duty cycle and thoroughness of the preventive maintenance program in effect.

⚠ WARNING ⚠

Any time a hoist exhibits erratic operation and/or unusual noise, the hoist must be taken out of service until it is inspected and serviced by a qualified technician. Continued operation of a hoist with a defect in a critical component may lead to loss of load control, property damage, injury or death.

A record of written, dated and signed inspections, load tests, maintenance and repairs or modifications must be kept readily available in an appropriate location for a minimum of five years.

Inspections procedures for hoists are divided into five general categories based upon the hoist usage or duty cycle, which in turn determines different, appropriate intervals for inspections. The usage categories must be assigned by the hoist user/owner on a consistent unit-by-unit basis. The five hoist usage categories are as follows:

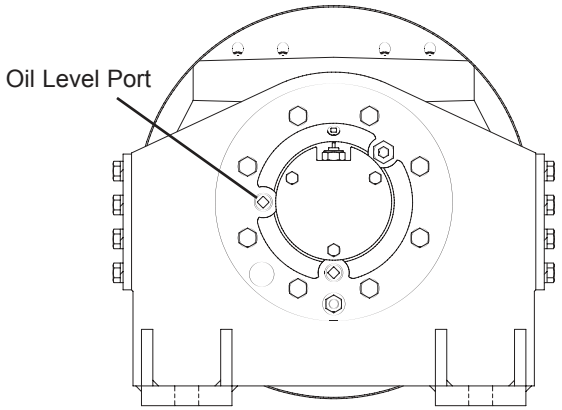
Idled: - The hoist has not been used for three months.
Infrequent Usage - The hoist is used less than ten hours per month based on a three month average.
Moderate Usage - Hoist used 10-50 hours per month based on a three month average.
Heavy Usage - Hoist used 50-200 hours per month.
Severe Duty - Hoist is operated more than 200 hours per month OR where 50% of the lifts exceed 75% of the Braden rated capacity for the hoist.

The following chart lists the inspections that are required for each type of usage category.

INSPECTION / USAGE CATEGORY	PRE-USE DAILY INSPECTION	SEMI-ANNUAL INSPECTION	ANNUAL INSPECTION	TEAR-DOWN INSPECTION
IDLED Not used for 3 months	REQUIRED BEFORE PLACED IN SERVICE	REQUIRED BEFORE PLACED IN SERVICE	--	REQUIRED IF MAINTENANCE & REPAIR HISTORY UNKNOWN
INFREQUENT USAGE less than ten hours per month	REQUIRED	REQUIRED	REQUIRED	5 YEARS 3 YEARS IF NOT SUBJECT TO FULL INSPECTION PROGRAM
MODERATE USAGE 10-50 hours per month	REQUIRED	REQUIRED	REQUIRED	4 YEARS 2 YEARS IF NOT SUBJECT TO FULL INSPECTION PROGRAM
HEAVY USAGE 50-200 hours per month	REQUIRED	REQUIRED	REQUIRED SEMI-ANNUALLY (6 months)	3 YEARS 1.5 YEARS IF NOT SUBJECT TO FULL INSPECTION PROGRAM
SEVERE USAGE 200+ hours per month or 50% of lifts exceed 75% rated capacity	REQUIRED	REQUIRED QUARTERLY (3 months)	REQUIRED SEMI-ANNUALLY (6 months)	1 YEAR

Pre-Use or Daily Inspection:

Must include but is not limited to the following inspections that will be performed prior to placing the hoist into service and then as necessary during extended operation. This inspection must be performed by a qualified technician.



1. Check for external oil leaks and repair as necessary. This is extremely important due to the accelerated wear that will result from insufficient lubricating oil in the hoist. Check the oil level monthly if no external oil leaks are detected.

   Check the oil level by removing the plug located at the 9 o'clock position on the drum bearing support housing. The oil level must be at the bottom of the level plug port.

2. Check the hydraulic fittings and hoses for leaks, chaffing, deterioration or excessive corrosion and repair as required.

3. Visually inspect for corroded, loose or missing fasteners and tighten or replace as required.

4. Inspect the entire length of wire rope and rigging as recommended by the wire rope and rigging manufacturer.

5. Inspect all safety devices such as anti-two-blocking switches and limit switches and repair as required.

6. A warm-up procedure is recommended at each start-up and is essential at ambient temperatures below 40°F (4°C). The engine should be run at low RPM with the hoist control valve in neutral allowing sufficient time to warm up the hydraulic system. The hoist should then be operated without a load, at low speeds, raise then lower several times to prime all lines with warm hydraulic oil and to circulate gear lubricant through the planetary gear train.

⚠ WARNING ⚠

Failure to properly warm up the hoist, particularly under low ambient conditions, may result in temporary brake slippage due to thick gear oil in the brake clutch assembly or hydraulic system back-pressure attempting to release the brake, which could result in property damage, injury or death..

Semi-Annual Inspection (every six months):

Must include but is not limited to the following inspections performed by a qualified technician.

1. Perform the Pre-Use inspection.

2. Take a lubricant sample as described later in this section and analyze it for wear metals content, correct viscosity, lubricant deterioration, moisture and other contaminants. If the oil sample contains a high amount of metallic particles, the hoist must be taken out of service to undergo a tear-down inspection.
   Note: Oil analysis can not detect nor warn against a fatigue failure.

3. Perform a brake test as described later in this section.

4. Inspect/tighten all hoist mounting fasteners to recommended torque.

5. Service the hydraulic system oil and filters as recommended by the vehicle manufacturer.

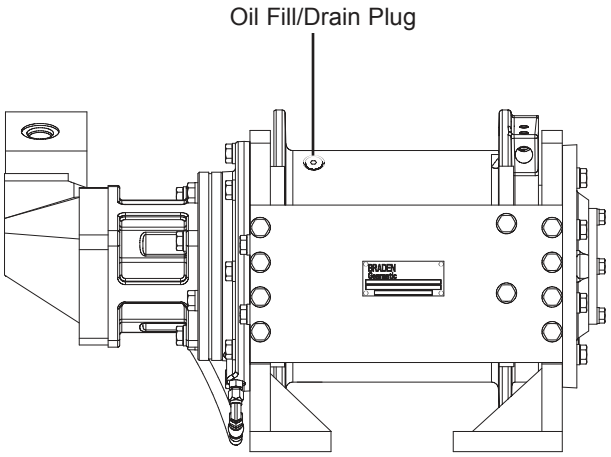
Annual Inspection:

Must include but not limited to the following inspections that must be performed by a qualified technician.

1. Perform the Pre-Use and Semi-Annual inspections.

2. Change hoist gear cavity lubricating oil after an oil sample has been taken as described later in this section. Refill the hoist to the proper level with recommended lubricant. Refer to "Recommended Planetary Hoist Gear Oil" later in this section for more information.

Oil change instructions:



1. Remove wire rope from drum until fill/drain plug is visible on cable drum barrel. Rotate drum barrel to place the plug at the bottom, 6 o'clock position. Remove the plug and capture the gear oil in a suitable container. Recycle or dispose of used oil in an environmentally responsible manner. While the oil is draining, collect oil from mid-stream for oil analysis.

2. Rotate drum to place the drain/fill plug at the top, 12 o'clock position. Fill winch to the level plug found on the drum bearing support with recommended oil. Oil fill capacity is 5 pints (2.4 liters). Install plug securely after refilling gear cavity.

3. Reel wire rope back onto drum while maintaining at least 300 - 500 lb. (136-226 kg) tension.

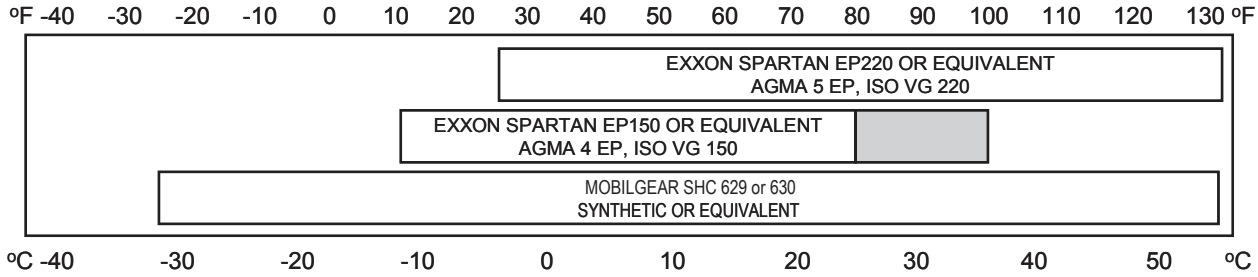
4. Remove the vent relief plug located in the drum bearing support housing. Clean the vent relief plug in solvent and reinstall. Do not paint over the plug. Drum seal leaks will result if the relief vent hole is restricted.

RECOMMENDED PLANETARY HOIST GEAR OIL

⚠ 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.

PREVAILING AMBIENT TEMPERATURE



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

Texaco Meropa 150, previously used as factory fill, may no longer be widely available due to current market conditions. As of mid-year 2002, planetary hoists are factory filled with Exxon Spartan EP150, or equivalent. The chart below relates the Texaco products to 4 currently available oils. Consult your oil supplier for other equivalent oils if required.

Texaco	Exxon	Mobil	Shell	Chevron
Meropa 150	Spartan EP 150	Mobilgear 629	Omala 150	Gear Compounds EP 150
Meropa 220	Spartan EP 220	Mobilgear 630	Omala 220	Gear Compounds EP 220

9/2002

TROUBLESHOOTING

⚠ WARNING ⚠

If a hoist ever exhibits any sign of erratic operation, or load control difficulties (load creeping down or chattering) appropriate troubleshooting tests and repairs must be performed immediately. Continued operation of a hoist with a defect may result in property damage, injury or death.

TROUBLE	PROBABLE CAUSE	REMEDY
A The hoist will not lower the load or not lower the load smoothly.	1. The problem could be a plugged internal orifice or leaking cartridge body seal ring on the counter-balance valve. If a small piece of contamination entered the counter-balance (CB) valve cartridge, it may be restricting the hydraulic signal to open the valve. The pressure may be going too high or the smooth action of the CB valve may be impaired. If the cartridge body seals are leaking, the pilot signal pressure may be lost or the oil flow that the CB valve is modulating is able to return to tank without the proper control allowing the load to lower too early or too quickly.	Remove the counter-balance cartridge from the valve body and inspect condition of body seal rings. Disassemble valve body and flush with clean solvent to remove contamination. Assemble valve using new seal rings on CB valve cartridge. Install an accurate 0-1000 PSI (0-6900 kPa) test gauge in the brake release hose. With no load on the hoist, slowly move the control lever into the lowering position and record the pressure when the drum begins to turn in the lowering direction. The static brake will release at approximately 350 PSI (2415 kPa) and the CB valve should open at approximately 650-750 PSI (4480-5170 kPa).
	2. 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 find oil leaking from the winch vent plug.	Check brake cylinder seal as follows: A. Disconnect the swivel tee from the brake release port. Connect a hand pump with accurate 0-2000 psi gauge and shut-off valve to the –4 J.I.C. fitting in the brake release port. B. Apply 1000 psi to the brake. Close shut-off valve and let stand for five (5) minutes. C. If there is any loss of pressure in five (5) minutes, the brake cylinder should be disassembled for inspection of the sealing surfaces and replacement of the seals. Refer to “Motor Support-Brake Cylinder Service”.
	3. Friction brake will not release as a result of damaged brake discs.	Disassemble brake to inspect brake discs. Check stack-up height as described in “Motor Support-Brake Cylinder Service”.
B Oil leaks from vent plug.	1. Same as A2. 2. Motor seal may be defective as a result of high back pressure or contaminated oil.	Same as A2. Motor case drain back pressure must not exceed 40 psi (275 kPa). Inspect hydraulic system for a restriction in the return line to the reservoir. Be sure plumbing is properly sized to winch motor. Oil analysis may indicate contamination has worn motor shaft and seal. Thoroughly flush entire hydraulic system and install new filters and oil. Install new motor seal.

TROUBLE	PROBABLE CAUSE	REMEDY
C The brake will not hold a load with the control lever in neutral.	1. Excessive system back pressure acting on the brake release port.	System back-pressure must not exceed 100 psi (690 kPa). Inspect hydraulic system for restriction in the circuit from the motor to the reservoir.
	2. Friction brake will not hold due to worn or damaged brake discs.	Same as Remedy 3 of Trouble A3.
	3. Brake clutch is slipping.	Improper planetary gear oil may cause the brake clutch to slip. Drain old gear oil and flush winch with solvent. Thoroughly drain solvent and refill winch with recommended planetary gear oil listed in “Preventive Maintenance”. Brake clutch may be damaged or worn. Disassemble and inspect brake clutch as described in “Brake Clutch Service”.
D The winch will not hoist the rated load.	1. 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 hoist the rated load and cause heat.	Reinforce mounting surface. If necessary, use shim stock to level winch. Refer to “Winch Installation”. First loosen, then evenly retighten all winch mounting bolts to recommended torque.
	2. System relief valve may be set too low. Relief valve needs adjustment or repair.	Check relief pressure as follows: A. Install an accurate gauge into the inlet port of the brake valve. B. Apply a stall pull load on the winch while monitoring pressure. C. Compare gauge reading to winch specifications. Adjust relief valve as required. 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.
	3. Be certain hydraulic system temperature is not more than 180°F (82°C). Excessive hydraulic oil temperatures increase motor and pump internal leakage and reduce performance.	Same as remedies for Trouble D1 & D2. Same as remedies for Trouble E2.
	4. Winch line pull rating is based on 1st layer of wire rope.	Refer to winch performance charts for additional information.
	5. Rigging and sheaves not operating efficiently.	Perform rigging service as recommended by rig manufacturer.

TROUBLE	PROBABLE CAUSE	REMEDY
E		
The winch runs hot.	1. Same as D1.	Same as remedies for Trouble D1.
	2. Be certain that the hydraulic system temperature is not more than 180°F (82°C). Excessive hydraulic oil temperatures may be caused by:	
	A. Plugged heat exchanger.	Thoroughly clean exterior and flush interior.
	B. Too low or too high oil level in hydraulic reservoir.	Fill/drain to proper level.
	C. Same as D2.	Same as remedies for Trouble D2.
	D. Hydraulic pump not operating efficiently.	Engine low on horsepower or R.P.M. Tune/adjust prime mover. Check suction line for damage. Pump worn. Replace pump.
	3. Excessively worn or damaged internal winch parts.	Disassemble winch to inspect/replace worn parts.
F		
Winch "chatters" while raising rated load.	1. Same as D2. 2. Hydraulic oil flow to motor may be too low. 3. Controls being operated too quickly.	Same as remedies for Trouble D2. Same as remedies for Trouble E2. Conduct operator training as required.
G		
The wire rope does not spool smoothly on the drum.	1. The winch may be mounted too close to the main sheave, causing the fleet angle to be more than 1-1/2 degrees.	Check mounting distance and fleet angle. Reposition winch as required.
	2. The winch may not be mounted perpendicular to an imaginary line between the center of the cable drum and the first sheave.	Refer to "Winch Installation".
	3. Could possibly be using the wrong lay rope. There is a distinct advantage in applying rope of the proper direction of lay. When the load is slacked off, the several coils on the drum will stay closer together and maintain an even layer. If rope of improper lay is used, the coils will spread apart each time the load is removed. Then, when winding is resumed, the rope has a tendency to criss-cross and overlap on the drum. The result is apt to be a flattened and crushed rope.	Consult wire rope manufacturer for recommendation of wire rope that best suits your application.
	4. The winch may have been overloaded, causing permanent set in the wire rope.	Replace wire rope and conduct operator/rigger training as required.

DISASSEMBLY OF WINCH

1. Remove the wire rope from the cable drum and rotate the drum until the fill/drain plug is at the bottom, six o'clock position. Remove the drain plug and capture the gear oil in a suitable container. Recycle or dispose of used oil in an environmentally responsible manner. Install the drain plug.

2. Label the hydraulic hoses as they are removed from the hoist motor. Install plugs in the open hoses and motor ports to reduce entrainment of dirt in the open port.

⚠ CAUTION ⚠

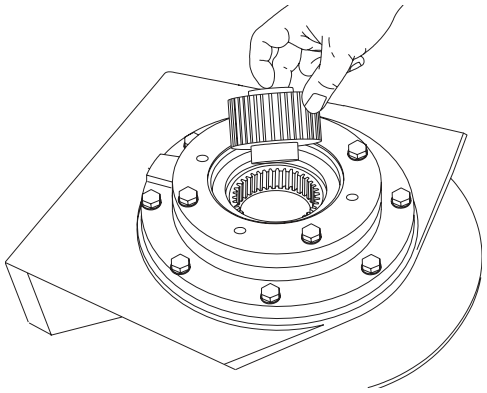
The H20R hoist weighs approximately 500 pounds (227 kg). Use adequate lifting equipment.

3. Remove the hoist mounting fasteners and lift the hoist from the mount. Begin disassembly by placing the hoist on a stable work surface with the motor end facing up. Secure the hoist in this position to prevent it from falling and causing injury.

⚠ WARNING ⚠

All disassembly and assembly MUST be performed with the motor end facing up. The thrust washer located under the input sun gear may become dislodged if components are removed while the hoist is in the horizontal position. The dislodged thrust washer may become trapped in the hoist gear train and cause a catastrophic failure that may result in loss of load control, property damage injury or death.

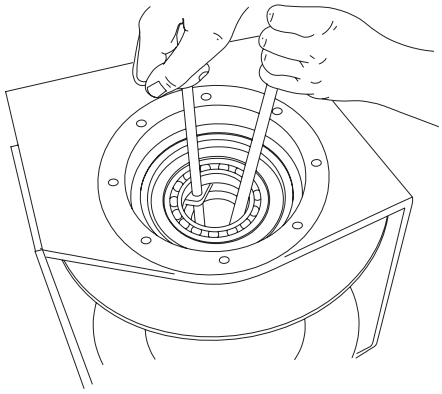
4. Remove the hose that connects the brake valve to the brake release port. Remove the fasteners securing the motor to the brake cylinder assembly. Lift the motor straight up to disengage the motor shaft from the brake clutch assembly.



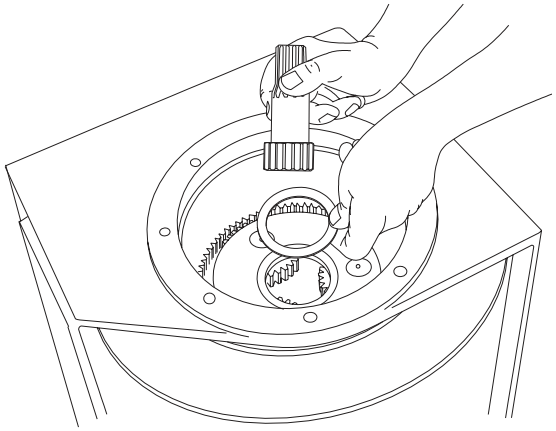
5. Remove the brake clutch assembly from the brake cylinder assembly. Refer to "Brake Clutch Service" section for additional information.

6. Place an alignment mark on the brake cylinder and the hoist end-bracket to ensure the correct position of the brake cylinder on the end-bracket is maintained. Remove the eight capscrews that secure the brake cylinder to the hoist end-bracket. Install two ½-13 in. eye-bolts into the motor mounting holes and lift the brake cylinder out of the hoist end-bracket. Be careful to avoid damaging the seal surfaces of the brake cylinder. Refer to "Brake Cylinder Service" for additional information.

7. Remove the capscrews that secure the two tie-plates to the hoist end-brackets and remove the tie-plates and the motor end end-bracket.

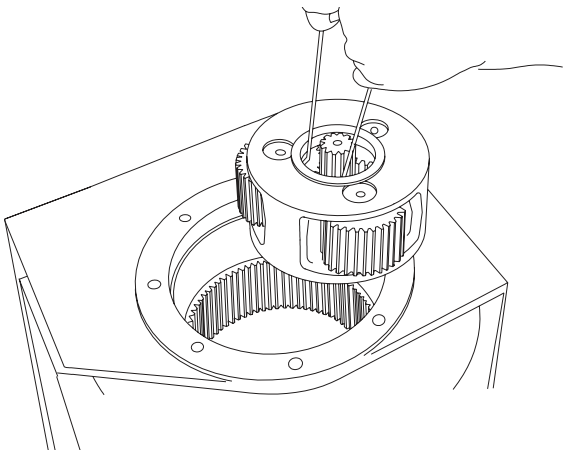


8. Install two 3/8-16 in. eye-bolts into the drum closure or use two heel-type pry bars placed between the primary planet carrier and the drum closure, pry upward to remove the drum closure. Remove the seal and bearing from the drum closure as required.



9. Remove the primary sun gear and thrust washer from the primary planet carrier. Remove the primary planet carrier from the drum. The planet shafts are tapped for ¼-20 in. lifting bolts for convenience. Lifting hooks may also be fabricated from steel bar. Refer to "Planet Carrier Service" for additional information.

10. Remove the output sun gear and thrust washer from the output planet carrier.



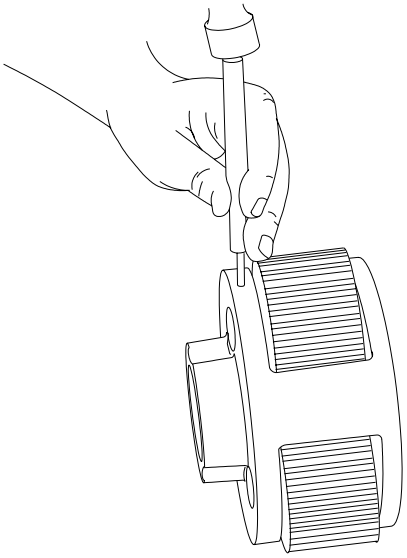
11. Remove the output planet carrier from the drum. The planet shafts are tapped for ¼-20 in. lifting bolts for convenience. Lifting hooks may also be fabricated from steel bar. Refer to "Planet Carrier Service" for additional information.

12. Lift the cable drum off of the drum bearing support and end-bracket. Remove the seal and drum bearing as required. Thoroughly clean and inspect the ring gear, machined into the inside surface of the drum, for nicks, spalling or excessive wear. Replace the drum if the gear wear is more than .015 in. (0.4 mm) when compared to an unworn area of the ring gear.

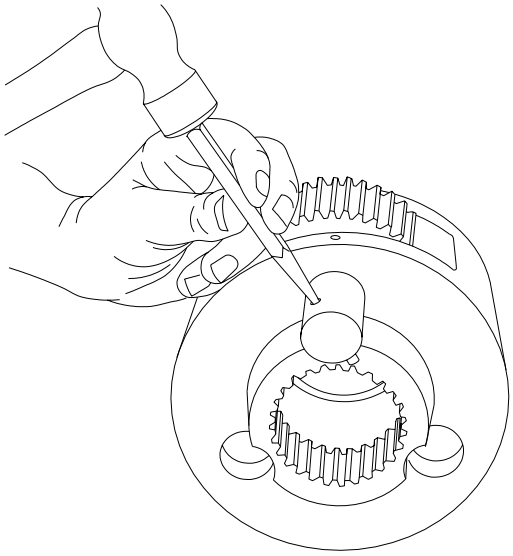
PLANET CARRIER SERVICE

OUTPUT PLANET CARRIER

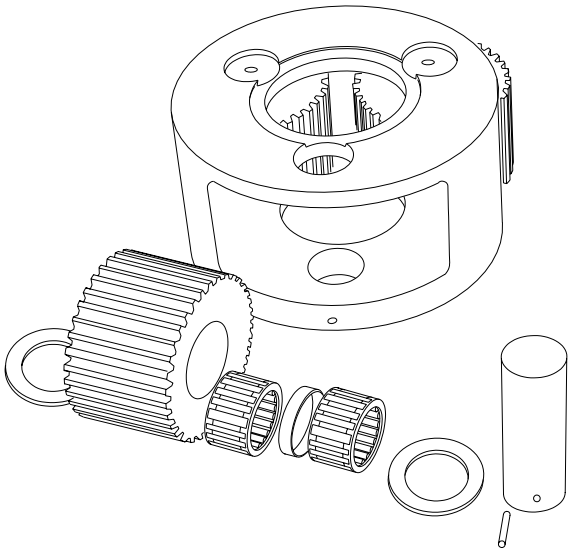
DISASSEMBLY



1. Remove the planet gears by driving the roll pins into the center of the planet shafts.

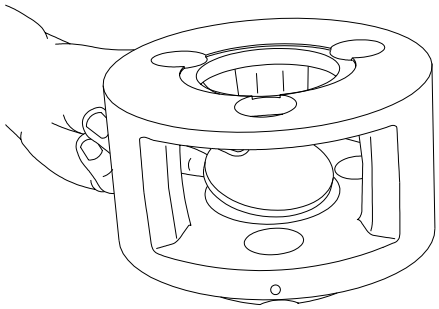


2. Use a punch to drive the roll pins from the planet shafts. Do not reuse the roll pins.

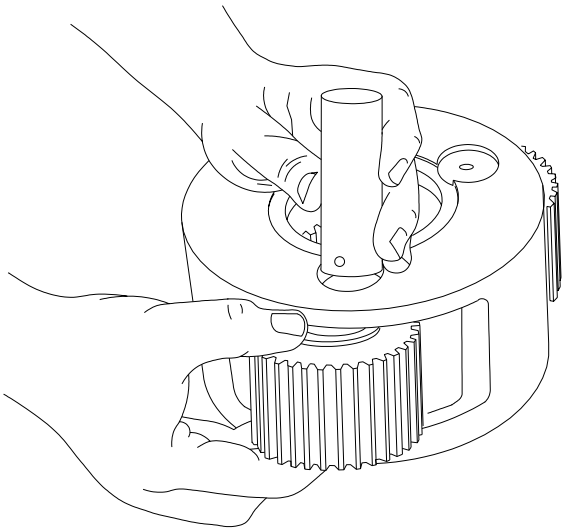


3. Now you can remove the planet shafts, bearings, spacer, thrust washers and gears. Thoroughly clean all parts and inspect for damage and wear. The bearing rollers should not exhibit any irregularities. If the rollers show any sign of spalling, corrosion, discoloration, material displacement or abnormal 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.

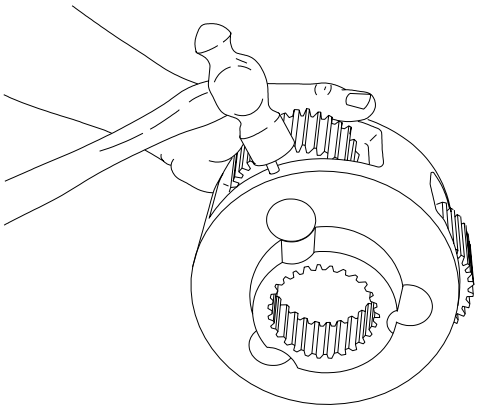
ASSEMBLY



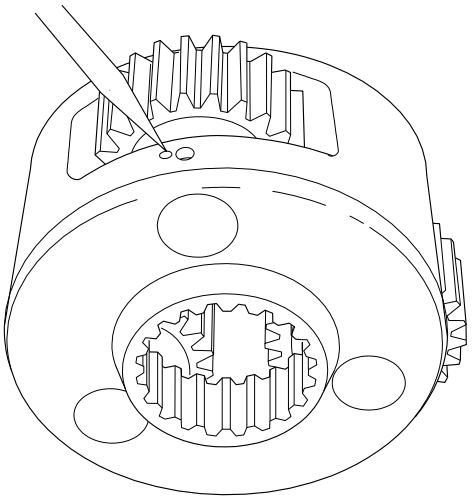
1. Place the output planet carrier on workbench with splined coupling side down. Install output thrust plate in center of carrier.



2. Insert two (2) bearings and a bearing spacer into a gear with the spacer between the bearings. Place a thrust washer on each side of the gear and position in a carrier opening. Slide the shaft through the carrier, thrust washer, bearing-gear sub-assembly and remaining thrust washer.



3. Carefully align the pin hole in the carrier with the hole in the planet gear shaft and drive the roll pin into place. Always use NEW roll pins. When properly positioned, 50% of the roll pin will engage the planet gear shaft and 50% will remain in the planet carrier.



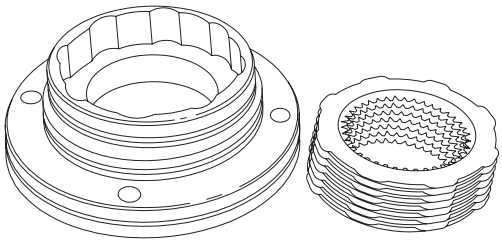
4. Note that the roll pin is slightly recessed in the carrier when properly installed. With a center punch, stake the carrier next to the pin hole as shown. This will distort the hole so the pin will not back out. Repeat these steps for each of the three planet gears.

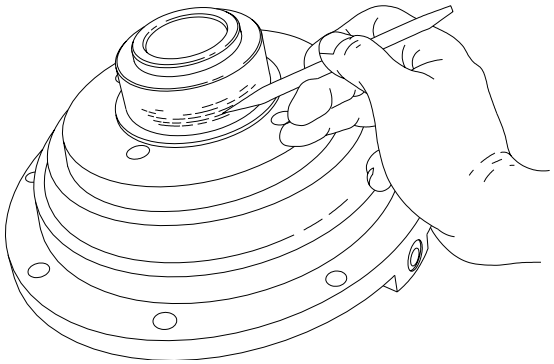
PRIMARY PLANET CARRIER

1. To service the primary planet carrier, the steps are the same as for the output carrier except there is only one bearing for each gear and no bearing spacer.

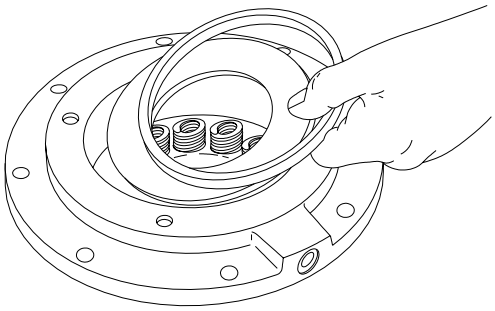
BRAKE CYLINDER SERVICE

DISASSEMBLY





1. Place an alignment mark on the motor support and the brake cylinder before removing the motor support. The alignment mark will aid reassembly and ensure the position of the motor on the hoist is maintained. Remove the four capscrews that secure the motor support to the brake cylinder.

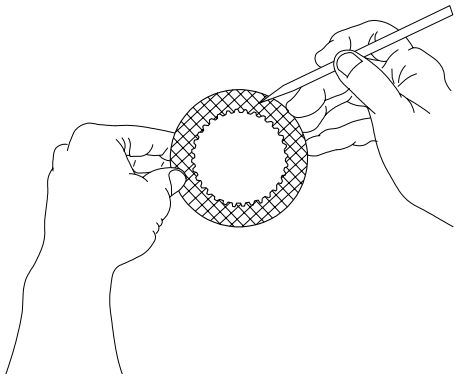


2. Remove the brake discs and spacer ring followed by the piston back-up ring, pressure plate, springs and spring separator.

Clean and Inspect

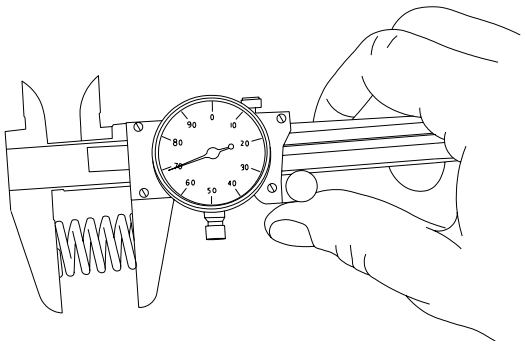
1. Thoroughly clean and inspect all parts at this time. Check brake piston sealing surfaces on brake cylinder and motor support for wear that may cause seal leaks. Smooth small scratches with emory cloth. Replace the cylinder if there are course scratches or excessive wear in the seal surface. Make certain the brake release oil port is clean. The opening of the port must have a slight chamfer to prevent cutting the seal. It is a good practice to smooth the edge of the port with emory cloth.

2. Check the oil seal and bearing surfaces on the outside of the brake cylinder for damage, wear or rust. Replace cylinder as required.



3. Place the friction discs on a flat surface and check for distortion with a straight edge. The friction material should appear even across the entire surface with the groove pattern visible. Replace the friction discs if the splines are worn to a point, the disc is distorted, the friction material is worn unevenly or the groove pattern is worn away.

4. Place the steel separator discs on a flat surface and check for distortion with a straight edge. Check the surface for signs of material transfer or heat. Replace the steel separator discs if they are distorted or heat discolored.



5. Measure the brake spring free-length; minimum free-length is 1 3/16 in. (30.2 mm). Inspect springs for any sign of cracking or fatigue failure. If a spring must be replaced for any reason, then ALL brake springs must be replaced as a set.

⚠ WARNING ⚠

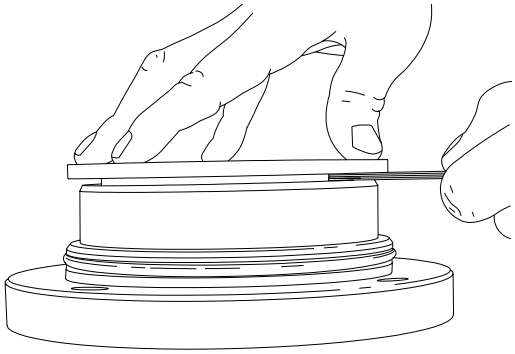
Failure to replace brake springs as a set may result in uneven brake application pressure and repeated brake spring failure from the older springs.

Brake spring failure could result in a catastrophic winch failure from the metal fragments passing through the gear train. A gear train failure may result in loss of load control, property damage injury or death.

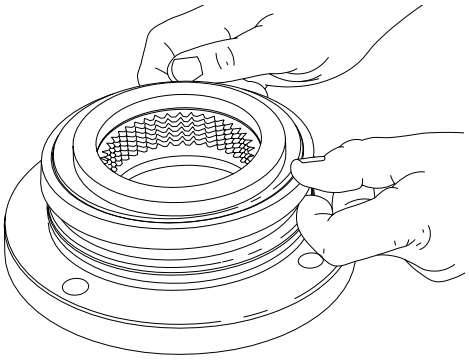
ASSEMBLY

1. Begin brake cylinder assembly by placing the motor support on the workbench with the motor mounting surface down. Install a new o-ring and back-up ring in the groove. Install the back-up ring close to the motor mounting surface with the cupped side facing the o-ring.

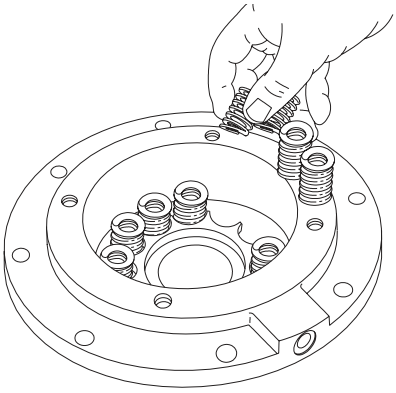
2. Insert first a steel separator disc into the motor support followed by a friction disc then alternate steel and friction discs until seven friction and eight steel discs have been installed. Finish with a steel disc on top. It is a good practice to pre-lubricate the discs with hydraulic oil or light motor oil prior to assembly. Install the spacer ring on top of the last steel brake disc.



3. Place the pressure plate on top of the brake spacer ring. Hold the pressure plate down firmly by hand and measure the clearance in three places, between the motor support and pressure plate. The average gap must measure between .153 in. (4 mm) maximum and .080 in. (2 mm) minimum. If the gap exceeds the maximum limit, there may be too many brake discs in the stack-up or the discs are distorted. If the gap is less than the minimum, there are too few discs in the stack-up or the discs are worn. If the number of discs in the stack is correct and they are not worn, then an extra steel separator disc may be added to the stack to achieve the proper clearance dimension. When the stack height is correct, remove the pressure plate and continue assembly.



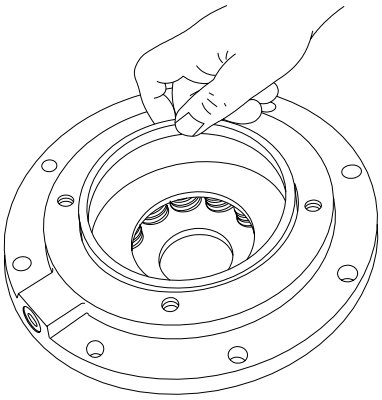
4. Lubricate the brake piston seal and motor support sealing surface with gear oil or hydraulic oil. Install a new piston seal onto the motor support with the seal lip facing down.



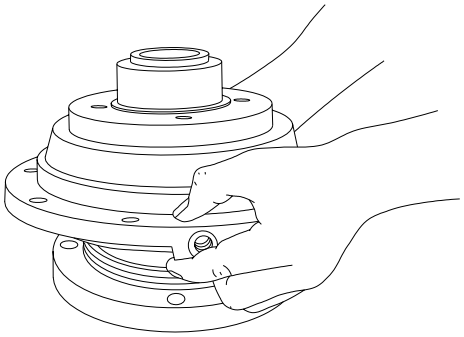
5. Install the spring spacer and springs.

⚠ WARNING ⚠

Always use the molded spring spacer. The brake springs must be properly positioned by the spring spacer. Failure to install the spring spacer may allow the springs to contact each other and become damaged. This could result in loss of load control, property damage, injury or death.

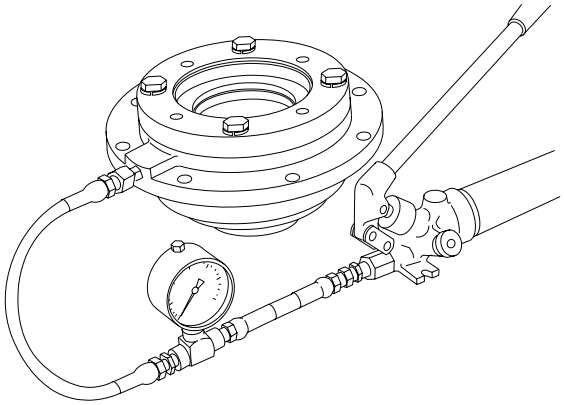


6. Install the pressure plate into the brake cylinder followed by the brake piston back-up ring. The close-fitting piston back-up ring may be depressed slightly to one side to lodge the back-up ring in the brake cylinder bore and temporarily hold the pressure plate and springs in place while you lower the brake cylinder over the motor support.



7. Apply gear oil to the entire sealing surface of the brake cylinder and piston seal. Install the brake cylinder over the motor support being careful to avoid damaging the piston seal or motor support o-ring. A press may be necessary to avoid cocking the brake cylinder during installation. Install the motor support capscrews and evenly tighten to recommended torque.

BRAKE CYLINDER PRESSURE TEST



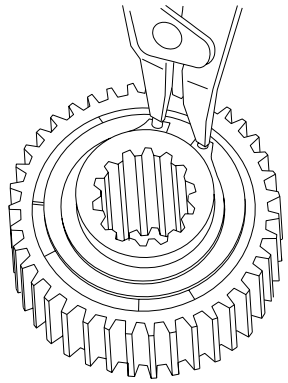
1. Install the –4 J.I.C. fitting into the brake release port. Connect a hand pump with accurate 0-2000 psi (0-13,800 kPa) gauge and shut-off valve to this fitting. Apply 1000 psi (6,900 kPa) to the brake. Close shut-off valve and let stand for five (5) minutes. If there is any loss of pressure in five (5) minutes, the brake cylinder should be disassembled for inspection of the sealing surfaces and brake piston.

2. WHILE PRESSURE IS APPLIED AND THE BRAKE RELEASED, install the brake clutch assembly in the brake pack, short end of the inner race toward motor. Turn the clutch back and forth as you align the outer race splines with the brake disc splines.

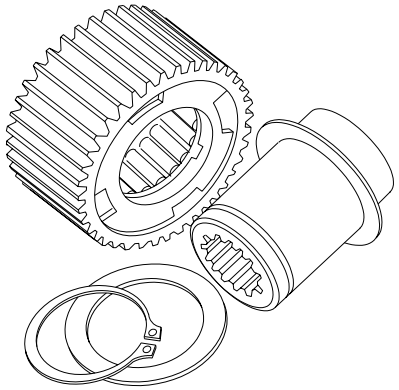
3. Release the pressure on the brake cylinder then remove the brake clutch assembly. The brake cylinder assembly is now complete and ready to be installed in the winch.

BRAKE CLUTCH SERVICE

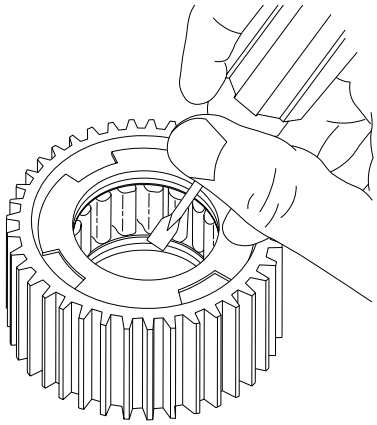
DISASSEMBLY



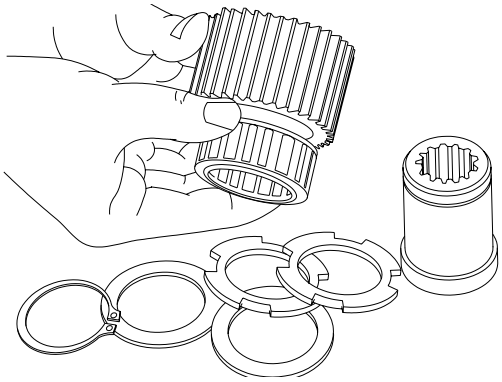
1. Remove the snap ring and sprag bushing retainer from one end only.



2. Pull the inner race out. Examine the race for scoring, wear or indentations caused by the sprag cams.



3. Use a screwdriver and mallet to remove the sprag bushing from one end of the outer race. There are four special cut-outs in the bushing for this purpose. Be careful not to damage the bushing inside surface. If a bushing's inside surface is damaged or shows wear, replace it.

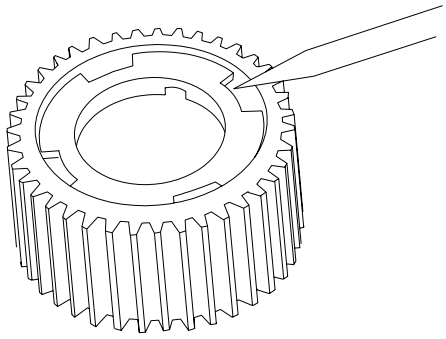


4. Next, slide the sprag clutch out, inspect the sprag clutch closely for abnormal wear, cracks, pitting or corrosion. Check small clips for breakage or bright spots; the signs of excessive wear. Unless the outer race or remaining sprag bushing is damaged or shows excessive wear, there is no need for further disassembly. If disassembly is necessary, remove the bushing according to the procedure covered in Step No. three (3). All brake clutch assembly parts should be thoroughly cleaned and inspected before assembly.

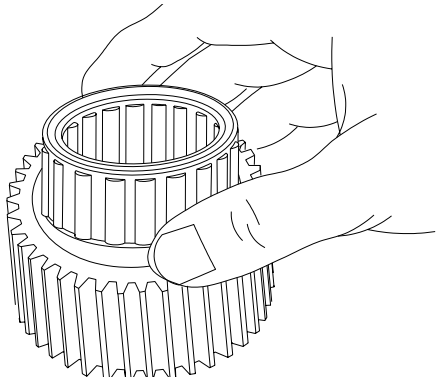
⚠ WARNING ⚠

The polished surfaces of the races and sprag cams must be perfectly smooth to insure positive engagement of the clutch. The slightest defect may reduce brake clutch effectiveness, which may lead to loss of load control and result in property damage, personal injury or death. It is generally recommended to replace the entire brake clutch assembly if any component is defective.

ASSEMBLY

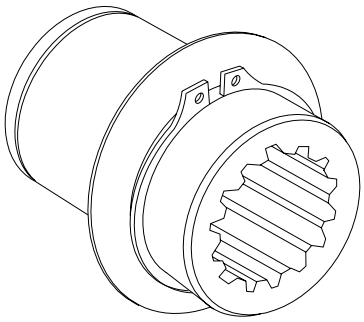


1. Press a sprag bushing into the outer race, using a mechanical or hydraulic press. A flat plate of approximately the same diameter as the bushing flange outside diameter should be placed between the press and bushing during assembly to protect the bushing. Be certain the bushing flange is against the shoulder in the outer race.

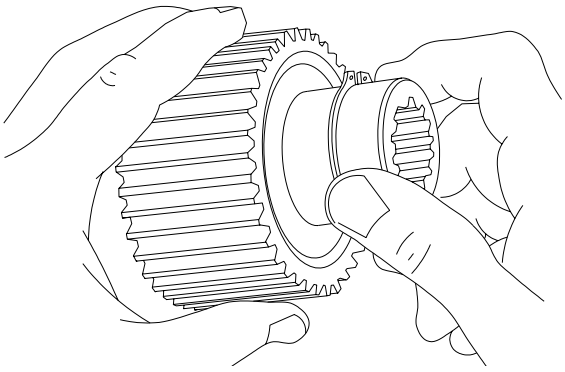


2. Turn the assembly over and install the sprag clutch in the bore of the outer race.

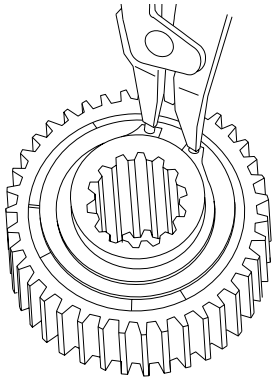
3. Press the remaining bushing into the race. Again, make sure the bushing is against the shoulder.



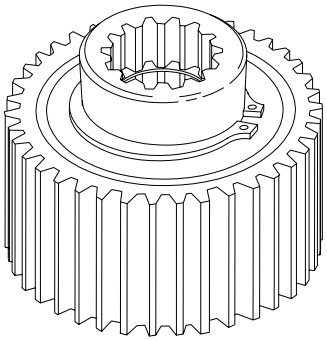
4. Next, install a sprag bushing retainer, then a snap ring on the inner race. Be sure the snap ring is seated in the snap ring groove.



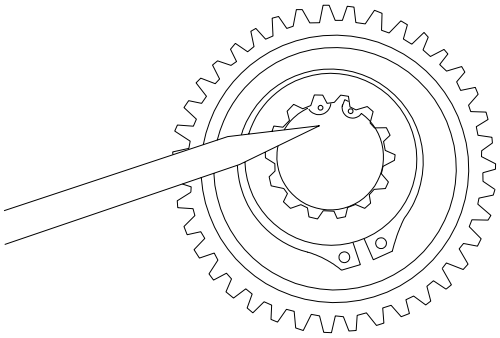
5. Slide the inner race through the bushings and sprag clutch (the race will have to be rotated in the freewheeling direction to start it through the sprag clutch). If the inner race will not go through the bushings, the bushings have probably been damaged and should be replaced.



6. Turn the assembly over with the snap ring down. Install the second retainer and snap ring. Make certain the snap ring is seated in the groove properly.



7. This is a completed brake clutch assembly.



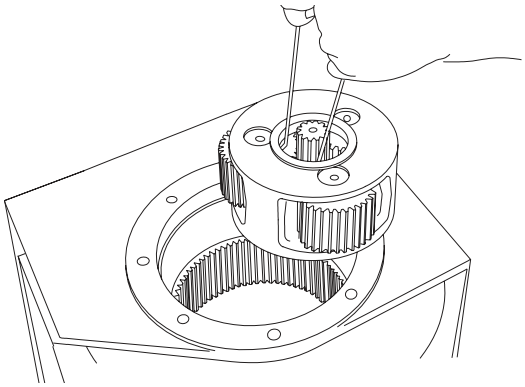
⚠ WARNING ⚠

Be certain the snap ring is seated in the groove in the splined bore of the inner race. This snap ring will keep the brake clutch assembly correctly positioned in the center of the friction brake pack. Binding of the brake or brake failure may occur if this snap ring is omitted.

WINCH ASSEMBLY

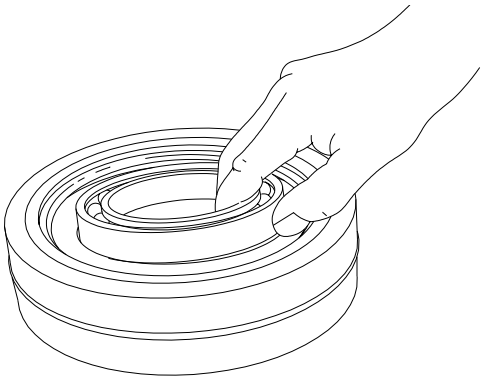
1. Install a new bearing in the drum if replacement is necessary. Apply non-hardening sealant to the outside diameter of the new seal and press the seal into the drum using a flat steel plat to prevent damage to the seal. Install the seal with the spring side of the seal next to the bearing. Be sure the drain plug is installed securely.

2. Place the drum bearing support/end-bracket on the workbench with the splined torque shaft facing up. Lubricate the drum bearing support seal and bearing surfaces with light grease or gear oil. Install the drum onto the bearing support being careful to avoid damaging the seal.



3 Install the output sun gear into the output planet carrier. Install the output planet carrier thrust washer into the shallow counter-bore in the output planet carrier. Install the output planet carrier into the drum. You must engage the planet gear teeth with the ring gear teeth and the planet carrier splines with the torque shaft splines.

4. Install the primary sun gear and thrust washer into the primary planet carrier. Install the primary planet carrier into the drum. You must engage the planet gear teeth with the ring gear teeth and the planet carrier splines with the output sun gear.



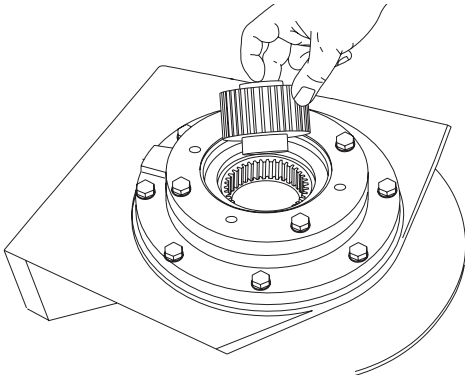
5. Install a new bearing in the drum closure as required. Apply non-hardening sealant to the outside diameter of the oil seal and press it into the drum closure using a flat steel plate to avoid distortion. Install the seal with the spring side toward the bearing. Install a new o-ring in the groove on the outside diameter of the closure.

6. Lubricate the o-ring and drum opening with light grease or gear oil and install the drum closure with the seal side facing away from the gear train.

7. Place the motor end-bracket onto the drum and install the two tie plates that connect the drum bearing support end-bracket to the motor end-bracket. Start all capscrews and tighten just hand tight at this time.

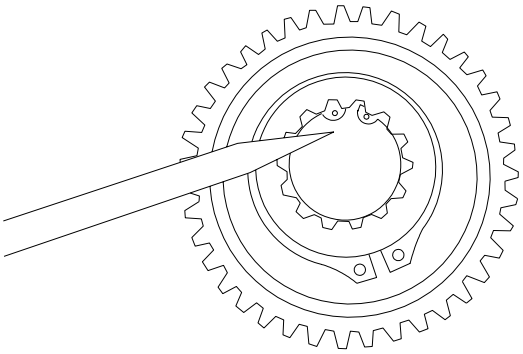
8. Lubricate the pilot diameter, bearing and sealing surfaces of the brake cylinder and carefully install the brake cylinder into the drum closure and end-bracket. Install the eight capscrews that secure the brake cylinder to the end-bracket and tighten them only hand tight at this time.

9. Evenly tighten the 16 tie plate capscrews to 110 lb.-ft. (149 N-m) torque. Evenly tighten the eight brake cylinder capscrews to 110 lb.-ft. (149 N-m) torque.



10. Install the brake clutch assembly into the brake cylinder with the short end of the inner race toward the hydraulic motor. If the brake clutch outer race does not align with the brake discs or the inner race will not align with the input sun gear, install a hand pump to the brake release port and apply 1000 PSI to release the brake. This will permit easy alignment of the clutch, discs and sun gear. The snap ring installed in the inner race of the brake clutch should rest upon the input sun gear. This signifies that the clutch has passed through all of the brake discs and is centered in the brake pack.

    When installed correctly, the inner race will turn freely of the outer race in the direction the drum turns to pull wire rope in. If the clutch freewheels in the wrong direction, disassemble the clutch and reverse the inner race. Refer to "Brake Clutch Service" section of this manual for more information.



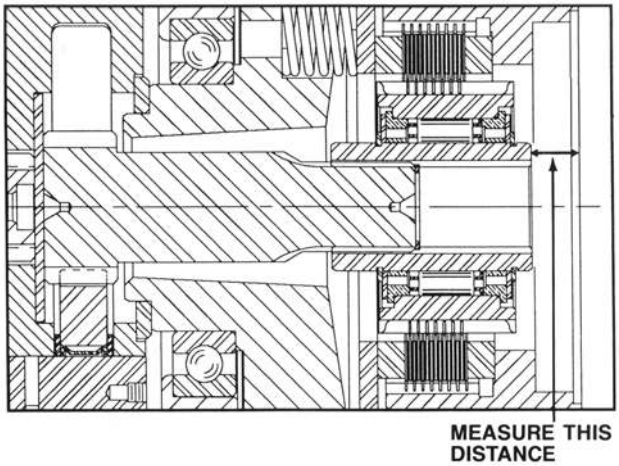
⚠ WARNING ⚠

Be certain the snap ring is seated in the groove in the splined bore of the inner race. This snap ring will keep the brake clutch assembly correctly positioned in the center of the friction brake pack. Binding of the brake or brake failure may occur if this snap ring is omitted. Brake failure may result in loss of load control, property damage, injury or death.

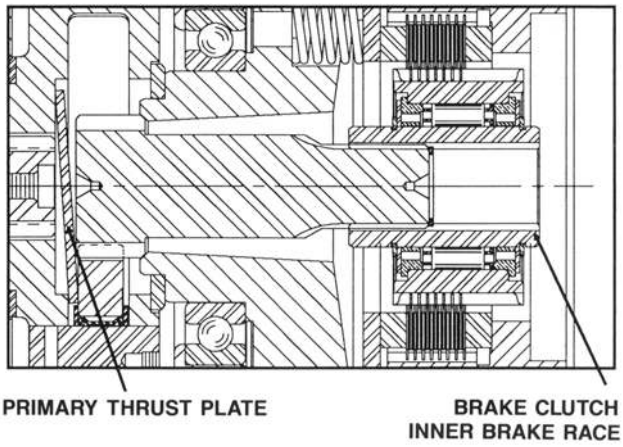
This is a convenient time to add the five pints (2.4 liters) of recommended gear oil to the winch gear cavity. Refer to the "Recommended Lubricant" chart for more information.

⚠ CAUTION ⚠

Care must be taken to assure the primary thrust plate remains properly located in its counterbore when the motor is installed for the first time, or is being reinstalled on the winch. It is possible for the primary thrust plate to drop out of its counterbore and become wedged between the planet gears and the planet carrier. If the winch is operated with the primary thrust plate wedged between primary gears and the planet carrier, or with a thrust washer out of position, severe damage to internal winch components could result.



Measure the distance from the motor mounting surface to the inner brake race. With all components properly installed, this distance should be 11/16 in. (17.5 mm) to 3/4 in. (19.1 mm). If this distance is less than 9/16 in. (14.3 mm), the primary spacer may be positioned as shown below and should be checked.

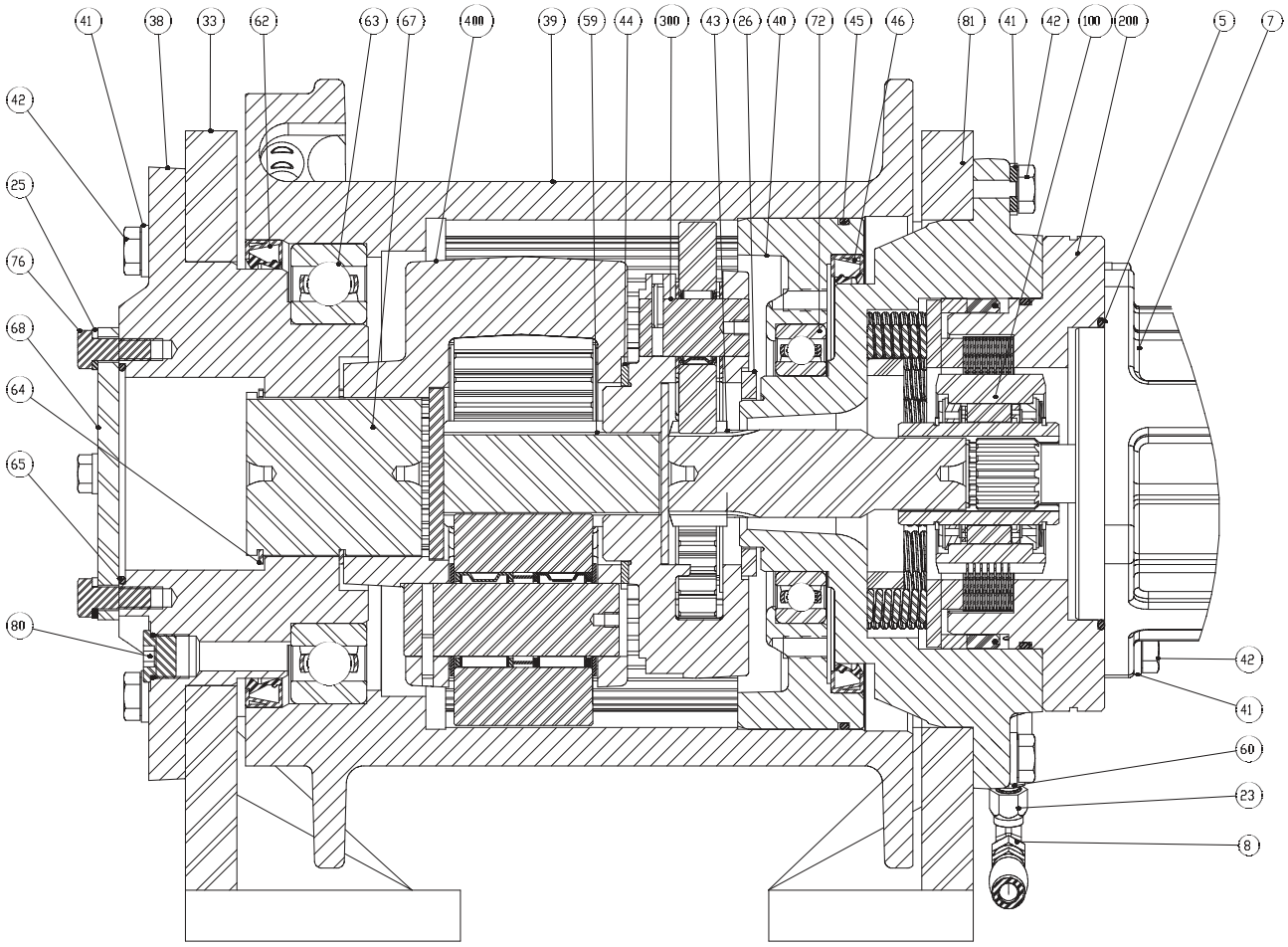


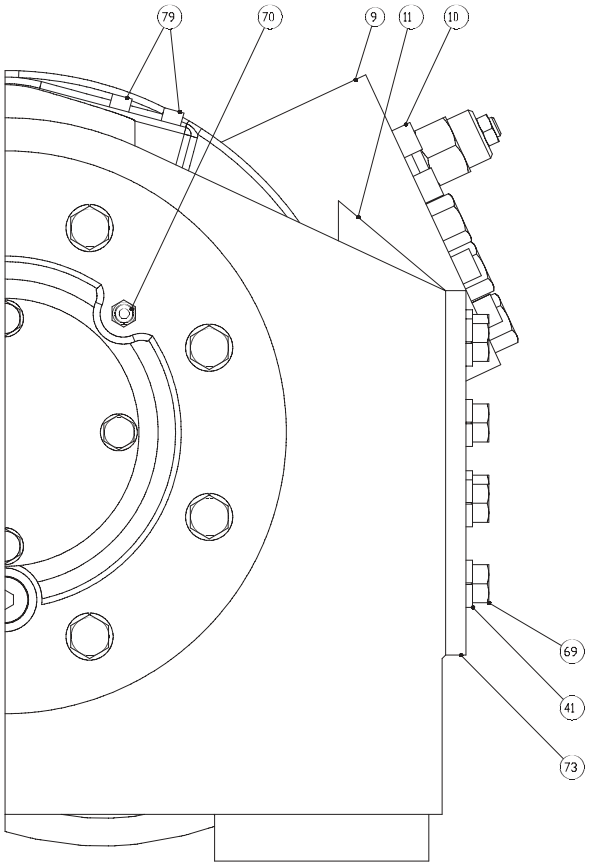
The primary thrust plate is shown wedged between the planet gears and the planet carrier. Note that the primary sun gear and the entire brake clutch assembly have moved to the right (toward the hydraulic motor).

11. Install a new o-ring onto the motor pilot. Lubricate the pilot o-ring and install the motor onto the motor adapter. Evenly tighten the capscrews to 110 lb.-ft. (149 N-m) torque.

12. Install the hoses that connect the brake valve and motor to the brake cylinder. After the winch assembly is complete, check all fasteners and fittings for proper torque.

BRADEN H20R (05559) COMPONENTS

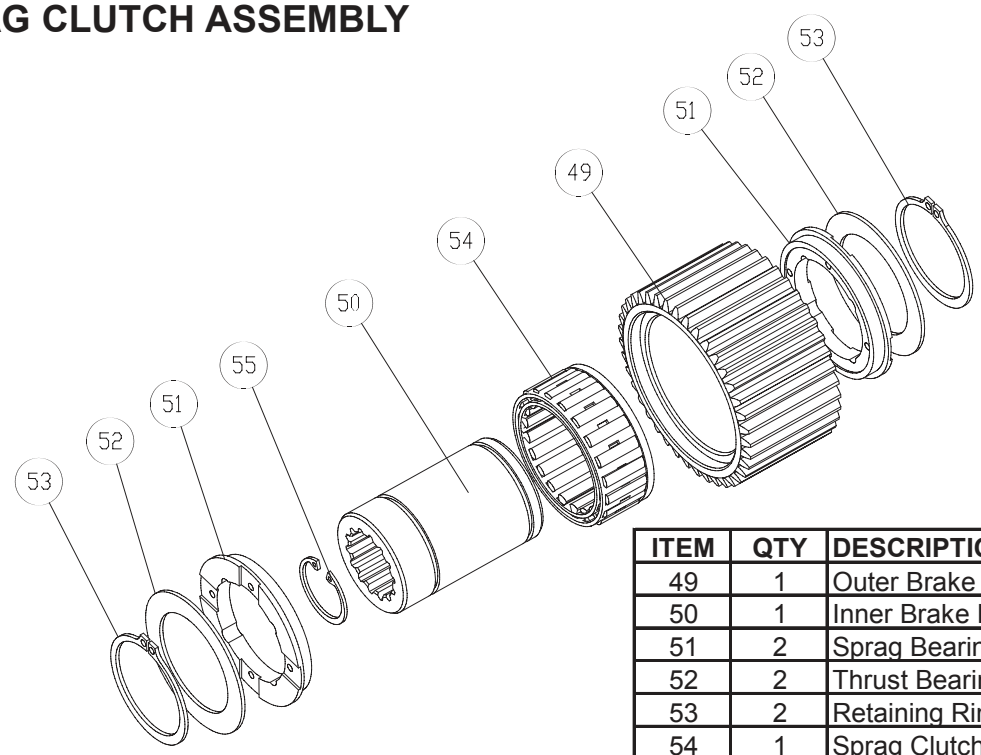




BRADEN H20R (05559) PARTS KEY

ITEM	QTY	DESCRIPTION
100	1	Sprag Clutch Assembly
200	1	Brake Cylinder Assembly
300	1	Primary Planet Carrier Assembly
400	1	Output Planet Carrier Assembly
5	1	O-Ring
7	1	Hydraulic Motor
8	1	Hose Assembly
9	1	Counterbalance Valve
10	8	Capscrew, Socket Hd (3/8 - 16 X 5 G8)
11	4	Cable Guard
23	1	Swivel Nut
25	4	Lockwasher (3/8 Z)
26	1	Thrust Washer
33	1	Support End Plate
38	1	Bearing Support
39	1	Cable Drum
40	1	Drum Closure
41	44	Lockwasher (1/2 Z)
42	24	Capscrew (1/2 - 13 X 1-1/2 G8 Z)
43	1	Primary Sun Gear
44	1	Thrust Washer
45	1	O-Ring
46	1	Seal
59	1	Output Sun Gear
60	1	Adapter
62	1	Seal
63	1	Bearing Support
64	2	Retaining Ring
65	1	O-Ring
67	1	Torque Shaft
68	1	End Cover
69	20	Capscrew (1/2 - 13 X 1-1/4 G8 Z)
70	1	Vent Plug
72	1	Bearing
73	2	Tie Plate
76	4	Capscrew (3/8 - 16 X 1 G8 Z)
79	2	Socket Head Setscrew
80	1	O-Ring Flush Plug
81	1	Motor End Plate

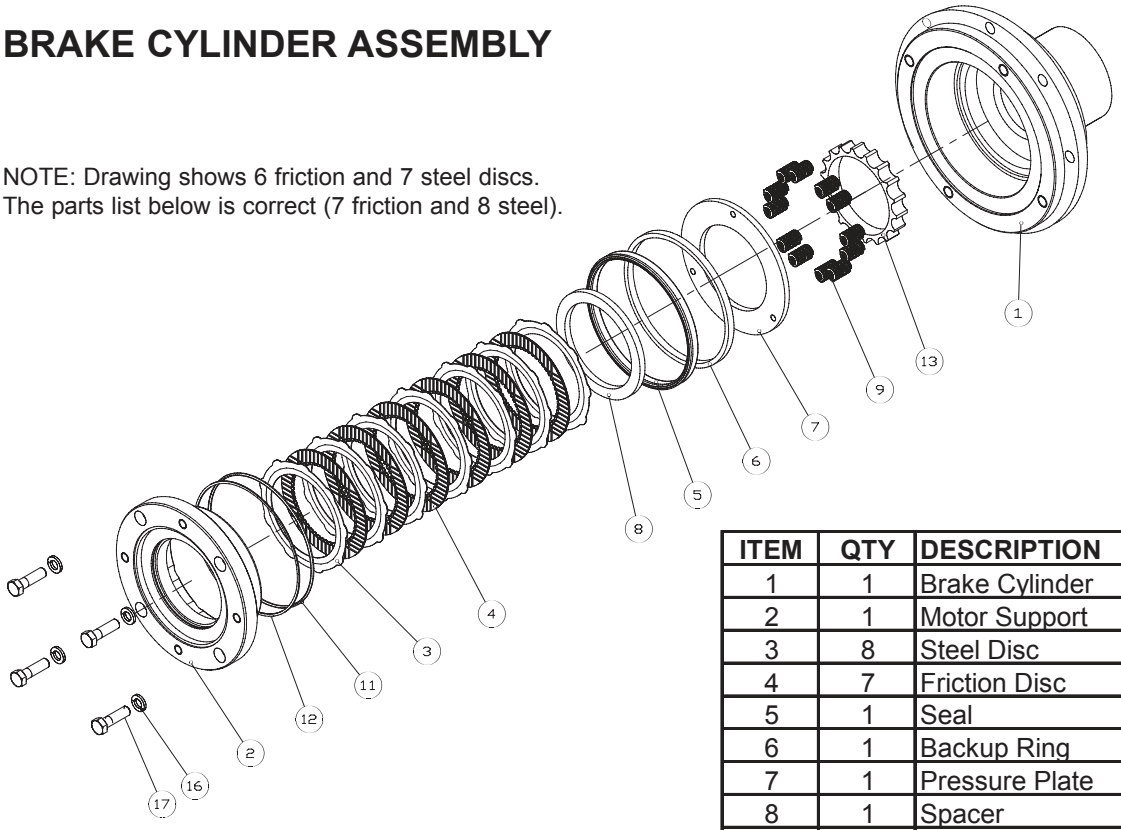
SPRAG CLUTCH ASSEMBLY



ITEM	QTY	DESCRIPTION
49	1	Outer Brake Race
50	1	Inner Brake Race
51	2	Sprag Bearing
52	2	Thrust Bearing
53	2	Retaining Ring
54	1	Sprag Clutch
55	1	Retaining Ring

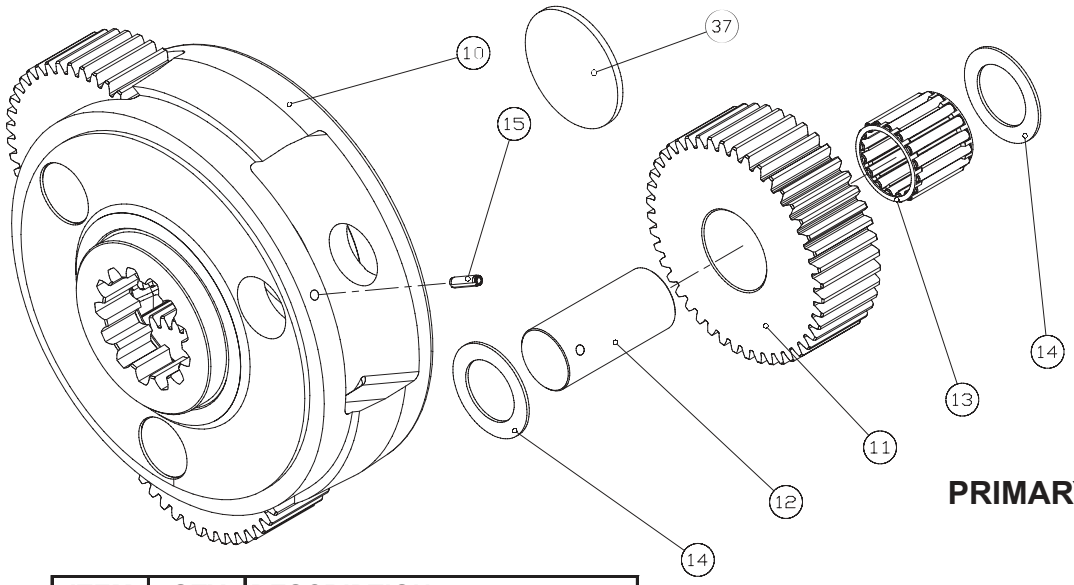
BRAKE CYLINDER ASSEMBLY

NOTE: Drawing shows 6 friction and 7 steel discs.
The parts list below is correct (7 friction and 8 steel).



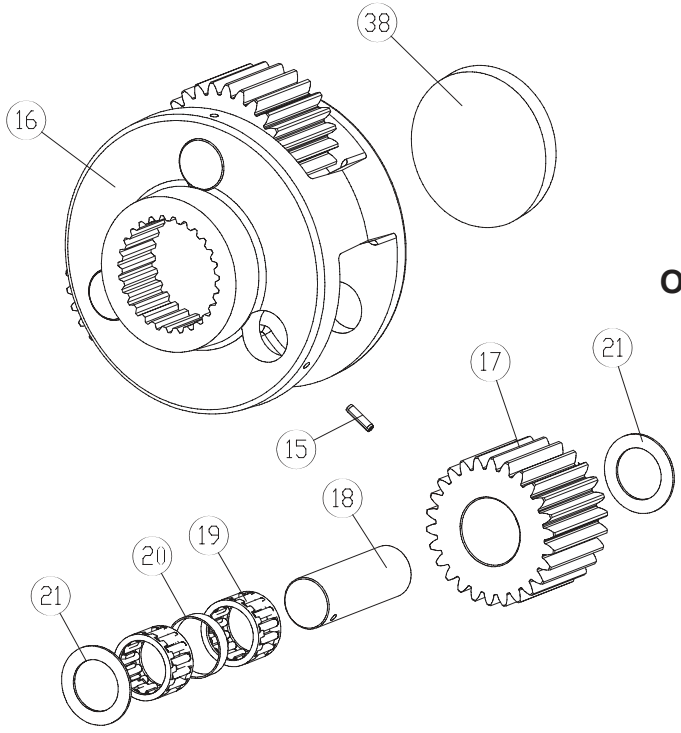
ITEM	QTY	DESCRIPTION
1	1	Brake Cylinder
2	1	Motor Support
3	8	Steel Disc
4	7	Friction Disc
5	1	Seal
6	1	Backup Ring
7	1	Pressure Plate
8	1	Spacer
9	12	Spring
11	1	O-Ring
12	1	Backup Ring
13	1	Spring Spacer
16	4	Lockwasher (1/2 Z)
17	4	Capscrew (1/2 - 13 X 2 G8 Z)

PLANET CARRIER ASSEMBLIES



PRIMARY

ITEM	QTY	DESCRIPTION
10	1	Primary Planet Carrier
11	3	Primary Planet Gear
12	3	Primary Planet Gear Shaft
13	3	Roller Bearing
14	6	Thrust Washer
15	3	Spirol Pin
37	1	Thrust Washer



OUTPUT

ITEM	QTY	DESCRIPTION
15	3	Spirol Pin
16	1	Output Planet Carrier
17	3	Output Planet Gear
18	3	Output Planet Gear Shaft
19	6	Roller Bearing
20	3	Bearing Spacer
21	6	Thrust Washer
38	1	Thrust Washer

METRIC CONVERSION TABLE

English to Metric			Metric to English		
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^2 (sq.in.)	X 645.15	= millimeters^2 (mm^2)	millimeters^2 (mm^2)	X 0.000155	= inches^2 (sq.in.)
feet^2 (sq.ft.)	X 0.0929	= meters^2 (m^2)	meters^2 (m^2)	X 10.764	= feet^2 (sq.ft.)
VOLUME					
inches^3 (cu.in.)	X 0.01639	= liters (l)	liters (l)	X 61.024	= inches^3 (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^3 (cu.in.)	X 16.39	= centimeters^3 (cc)	centimeters3 (cc)	X 0.06102	= inches^3 (cu.in.)
feet^3 (cu.ft.)	X 28.317	= liters (l)	liters (l)	X 0.03531	= feet^3 (cu.ft.)
feet^3 (cu.ft.)	X 0.02832	= meters^3 (m^3)	meters3 (m3)	X 35.315	= feet^3 (cu.ft.)
fluid ounce (fl.oz.)	X 29.57	= millileters (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^2)	kilograms/sq.cm. (kg/cm2)	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_2O (60°F)	X 0.2488	= kilopascals (kPa)	kilopascals (kPa)	X 4.0193	= inches H_2O (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 10^6	deci	(d)	= 0.1 or 10^{-1}
kilo	(k)	= 1,000 or 10^3	centi	(c)	= 0.01 or 10^{-2}
hecto	(h)	= 100 or 10^2	milli	(m)	= 0.001 or 10^{-3}
deka	(da)	= 10 or 10^1	micro	(μ)	= 0.000.001 or 10^{-6}