Technical Manual

ENGINEERING DATA

Design of Marion machines follows standards established by industry practices and procedures, material specifications and design/manufacturing disciplines developed by Marion. This section supplements the manual with additional information on maintenance practices and procedures. Some of this information may not apply to your specific machine.

BUSHINGS

There are several types of bushings used on Marion machines. Two most common are the bronze sleeve bushing and the flange bushing. The sleeve type mounts in a machined bearing boss opening with a light press fit. A flange bushing rests in an opening and is held in place with a minimum of (4) four dowels. Dowel material is softer than bushing materials to prevent scoring of shafting over the life of the bushing.

Bushing service life depends on several factors. Various environmental conditions, lubricant types & maintenance practices will result in various replacement frequencies. Table 1 gives specification tolerances for the full range of shaft diameters. When running clearance exceeds the value of these tolerances by a factor of (3) three, REPLACE THE BUSHING.

Bushing replacement requires disassembly of machinery shafting and gearing. Removal of bushings may require the use of an air chisel to slit the bushing for removal. Use extreme care to avoid cutting or scoring the bearing boss. Once the bushing is removed CLEAN bearing boss thoroughly of metal burrs and debris, grease, and dirt.

A clean new bushing can be easily installed in a bore if it is cooled in a bath of dry ice and alcohol. This will shrink the outside diameter of the bushing allowing it to drop or slide freely into the bearing boss bore.

An alternate method installs the bushing using a long threaded rod, steel plates and a hollow center jack. Assemble items as shown in Figure 1. Lightly coat bushing O.D. and boss I.D. with high quality anti-scoring, extreme pressure, pressing oil. Then PULL the bushing in place.

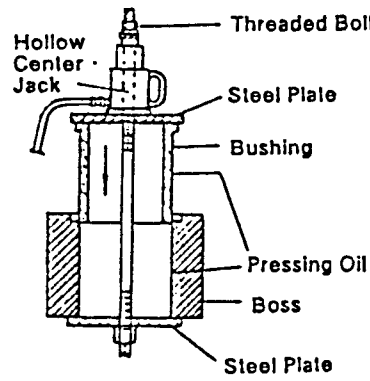


Figure 1
Bushing Installation

Required backlash for gears used on mining machines varies depending on value of diametral pitch. Table (2) gives assembled backlash values. These are measured in the plane of rotation.

NOTE: Plane of Rotating Backlash is the actual clearance measured with a dial indicator between teeth on an assembled gear set after rotating to the point of closest engagement.

Backlash shall be checked four (4) places at 90° on all gears. No reading less than the minimum value indicated in Table 2 is acceptable. Individual readings may exceed table maximums however the average of the four (4) readings shall remain within the chart range.

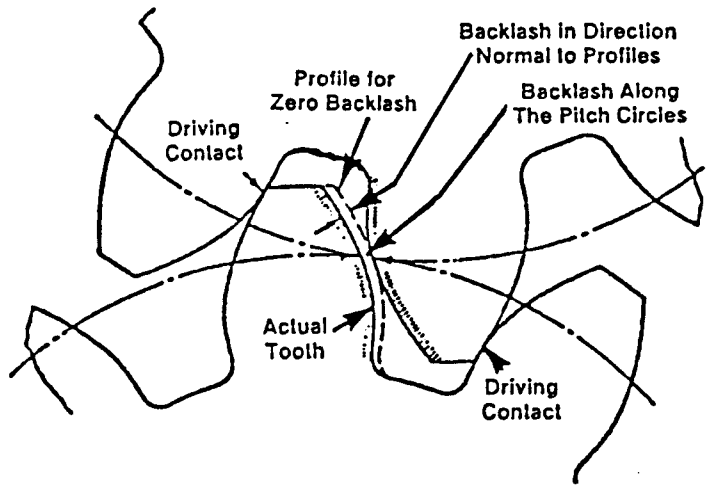
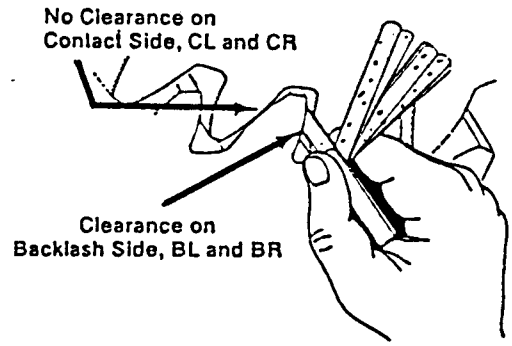


Figure 6

When measuring normal backlash with a feeler gauge, values in Table 2 must be adjusted per the following: multiply the value in the table by the cosine of the helix angle.

Helix Angle	Cosine
30°	.87
23°	.92
15°	.97

With pinion torqued firmly to gear CHECK the contact and backlash side of teeth at the mesh point. DRAW a feeler gauge between teeth as shown in sketch. ADJUST pedestal until obtaining a near zero feeler gauge reading at CL and CR, and a near equal backlash (within recommended range) at BL and BR. TAKE measurements at four points on the gear, 90 degrees apart.



Establish all backlash values with load on the gear.

TYPICAL ECCENTRIC CARTRIDGES

Fig. 10 is a typical eccentric cartridge that is utilized in Marion gear cases. Note the built-in eccentricity. Locate the centerline, to the case bore and the shaft bearing housing bore. It's the centerline through which the section is taken. This centerline contains Points "A" and "B". Point "A" represents the shaft end and Point "B" represents the end view of case bore centerline. These are the very same Points "A" and "B" of Fig. 8. Therefore if this eccentric cartridge is rotated about Point "B", Point "A" will move perpendicular to the centerline that contained Points "A" and "B" prior to any movement.

After the two reference centerlines are selected for the gear case (review the section on orientation and Fig. 9) the eccentrics are installed with the centerline of the eccentric (that is common to Points "A" and "B") in-line with the reference centerline. These are factory set with very sensitive optical equipment.

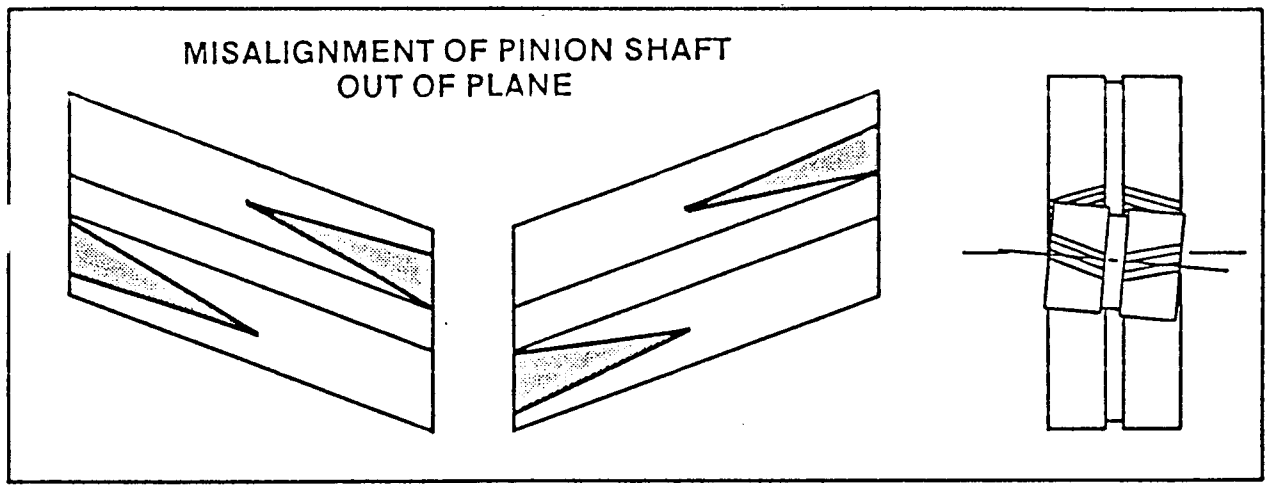
Fig. 11 shows the cross-sections of both eccentrics as they are installed relative to the reference centerlines. Notice that the centerline containing Points "A" and "B" and the reference centerlines are in line.

It is entirely possible to determine the direction of shaft end movement (when the eccentric is rotated) by locating any one of several tell-tale signs. First, Fig. 10 shows a partial keyway on the bottom of the outside flange which indicates that the eccentric cartridge centerline contacting this partial keyway contains Points "A" and "B" and that Point "B" is closest to the keyways. Therefore if the cartridge is rotated clockwise the shaft end will move to the right as indicated in Fig. 10. Counterclockwise rotation produces movement in the opposite direction.

Another indicator is the "thick" and "thin" portions of the cartridge. The centerline containing Points "A" and "B" of the cartridge runs from "thin" to "thick" portions. The "thick" portion reveals the same information as the partial keyway. This "thick" portion can be located by looking inside the case through the inspection openings.

Note:

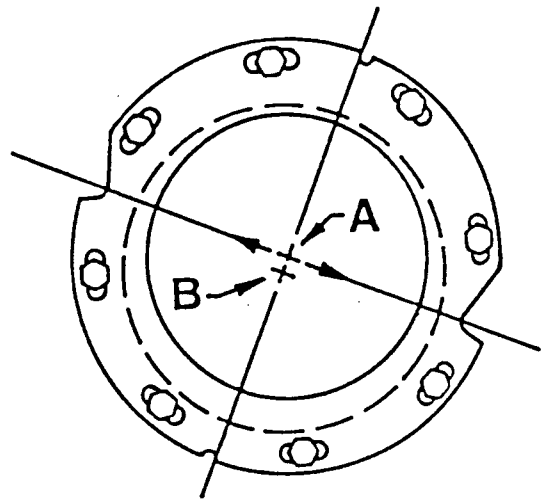
Figures 12 and 13 are shown on the next page. They point out two additional locations for the partial keyway. The partial keyway location for a given cartridge depends on the machine model and/or function. However, the partial keyway has the same meaning regardless of its location.



CORRECTIVE ADJUSTMENT

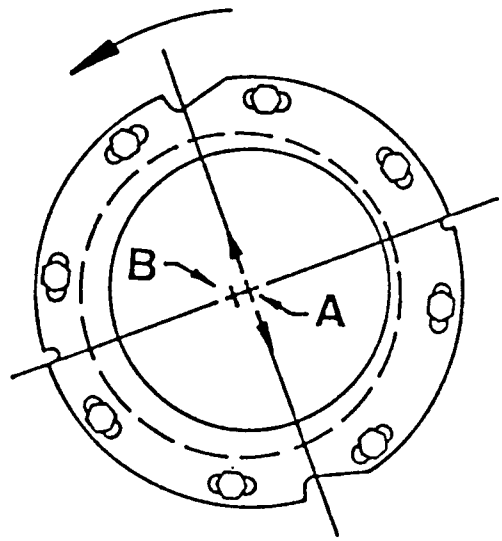
VIEW A-A

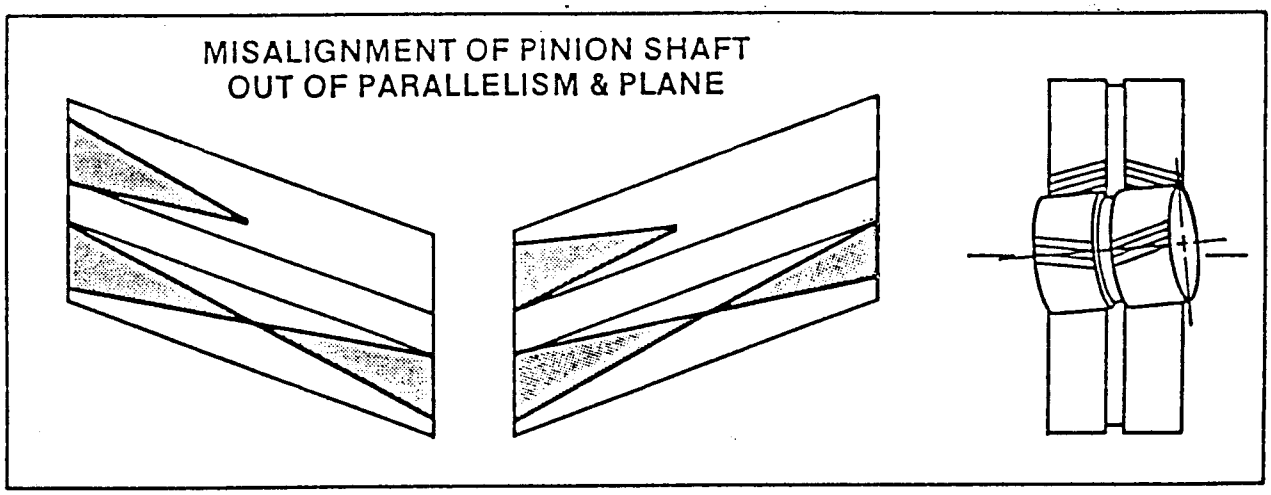
NO ADJUSTMENT REQUIRED.



VIEW B-B

ADJUST ECCENTRIC IN COUNTER CLOCKWISE DIRECTION.

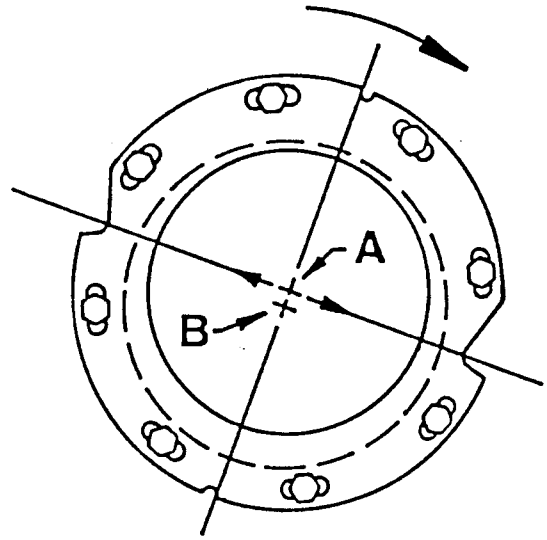




CORRECTIVE ADJUSTMENT

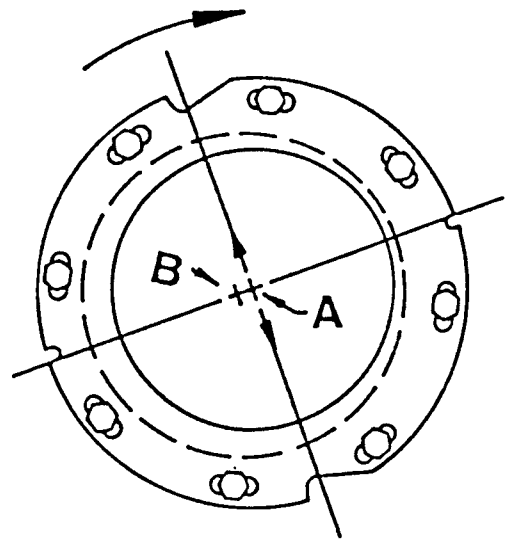
VIEW A-A

ADJUST ECCENTRIC IN
CLOCKWISE DIRECTION.



VIEW B-B

ADJUST ECCENTRIC IN
CLOCKWISE DIRECTION.



Drastic loss in rope diameter and lay lengthening.

Outer wire abrasion.

Broken wires.

Corroded wires.

Marks indicating mechanical abuse, distortion or crushing.

Inspect rope sheaves often. Check sheaves and drums for proper alignment.

Do not allow wear at rope sheave groove. An old rope wears a groove to a reduced radius. This groove crushes or deforms a newly installed rope.

Avoid sheave groove or drum lagging from assuming rope lay shape. Alternate right and left hand lays, if needed. Keep sheaves and drum free of rough spots, nicks and burrs. Never use cracked or chipped sheave.

Maximum rope life and the best service evolves from extreme care in handling and installation. This is important. Working a new rope at reduced loads gives the rope lay time to acquire a permanent set. Slow acceleration and deceleration of load and eliminating sudden actions are good habits to develop. Avoid over-stressing a rope by jerking or catching a heavy, falling load.

Lubrication remains the most important item in rope care. All rope is lubed when manufactured. Generally thin and filmy, this lube eases the manufacture rather than preserve the rope. This film drys rapidly or dissipates thru surrounding conditions.

Lubricate every rope at installation and keep coated thru continued service. Lubricant serves to reduce internal friction wear and the outer wire wear against sheave or drum. Lube protects rope from weather and corrosive air, too.

Marion recommends a light, penetrating type lubricant (WRL) containing anti-rust and corrosion agents and anti-wear additives. This lube saturates rope interior thus reducing internal friction providing a protective outer coating.

The rope lubricant selected may be an asphaltic type containing volatile solvent or diluent which allows strand and core penetration. This lube type works well for operations in highly abrasive material or water submersion.

One method of rope lubrication utilizes an automatic system that provides a drip fixture above sheaves on boom point, gantry, and fairlead.

All machined surfaces or machinery in the vicinity of the repair should be protected from spatter from welding and air carbon arc gouging sparks. Silicon blankets or steel plates can be used to protect machinery or machined parts.

Attach the welding ground directly to the part that is being repaired. Do not allow welding current to go through bearings. Welding current could arc the bearings and shorten the bearing life.

If the crack opens up during the operation of the machine, the part should be realigned. This can be done many times right on the machine. The part should be brought into as close an alignment as possible and braced, clamped or tack welded to maintain the alignment.

When removing cracks or defects, a "V" groove should be made with a 30°-45° included angle and tapered at the ends. This allows for proper fusion, good slag removal, and access to the groove. The groove should be free of any gouges or notches and cleaned of any slag or carbon.

If a defect or crack is 8 inches (200mm) or less in length, begin removing the defective material by starting at least 1/2 inch (12.5mm) beyond each end of the crack and remove metal by working toward the center.

If the defect or crack is 8 inches (200mm) to 12 inches (300mm) in length, begin removing the material by starting 1/2 inch (12.5mm) beyond the crack and removing material to about half the distance of the crack. Repair weld this much of the defect and cascade the middle end of the weld. Finish removing the second half of the defect and complete the weld repair.

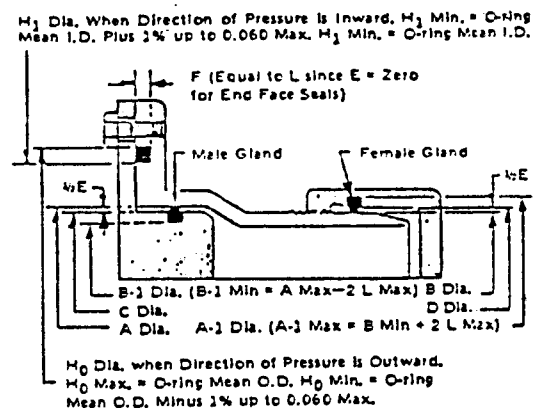
When the defect or crack is over 12 inches (300mm) in length, the crack should be divided into three sections. The weld metal can be used to help pull the part in to a closer fit-up because of weld shrinkage. This should be considered when deciding whether to start removing metal and repair welding at the two ends 1/3 of the crack or starting at the center 1/3 of the repair. Repairing a section at a time will help keep alignment and distortion to a minimum along with any required support braces. Again cascade the ends of welds so the next weld segment will blend in with the former weld. The back step method is another way to help control distortion. A worn out part should be checked for any spalled metal. This may be removed by grinding or machining.

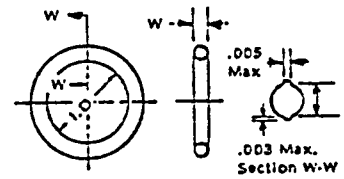
Before starting to weld repair the part, check the "V" groove or worn part with magnetic particle or dye penetrant inspection to ensure all cracks have been removed.

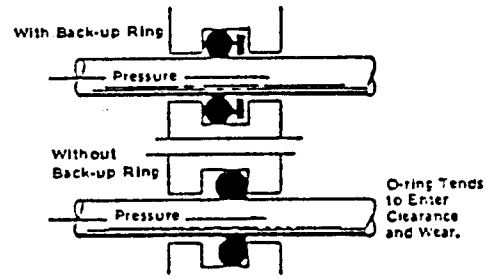
Preheating of the part before preparing it for a weld repair is essential to reduce the thermal stress. It is good practice to preheat prior to cutting or gouging to at least one-half the temperature that will be used for the repair welding operation.

Static seal use is generally simple. Three common types are shown at right.

When pressure exceeds 1500 psi, the backup ring is used. In static face seals, backup rings may not be needed.







MOST O-RING PROBLEMS return to three factors:

1. Size: Using incorrect size causes ineffective or totally destroyed function.

2. Compatibility: O-ring material must be compatible with the chemical, thermal and mechanical surroundings.

3. Installation: Improper handling during assembly causes a great deal of grief.

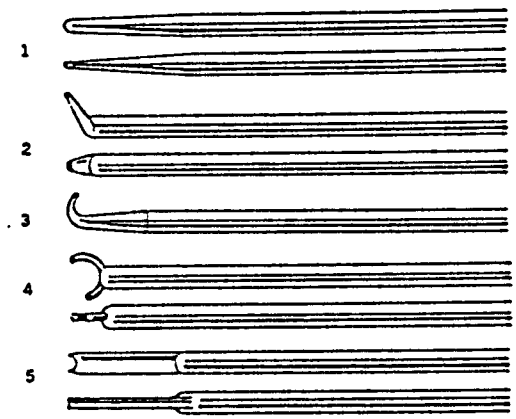
Size cannot be picked out by color code. Exact replacements are found ONLY by part number. DO NOT ATTEMPT matching size by feeling and comparing the new with the old. One other detail here: Do not open package until O-ring is needed for installation. This prevents mixing, rolling on floor, dropping in sewer; among other disasters.

POOR INSTALLATION may begin with the removal of the old seal.

Some points on removal:

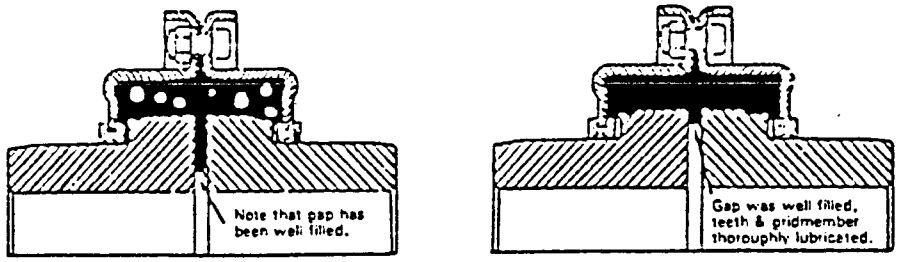
Removal involves parts with close tolerance surface finishes.

In critical surface areas; scratches, abrasions, dents, and other surface mars cause faulty seals. This results in component failure.



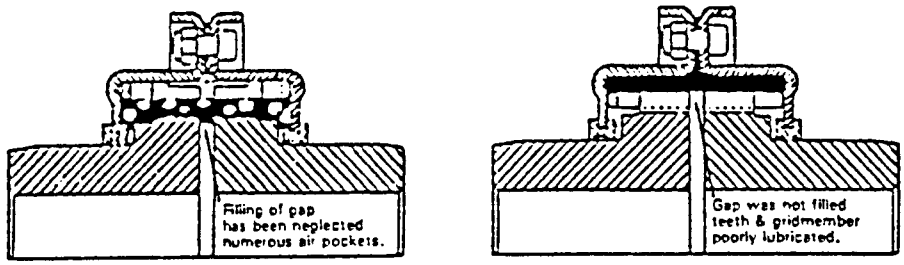
Typical O-ring installation tools

The lubricant in the gap acts as a reservoir. Centrifugal force causes it to flow from the gap into the voids and completely lubricate the coupling.



IMPROPERLY FILLED – Note the large number of air pockets and the absence of lubricant in the gap and at the inside diameter of the cover.

Centrifugal force throws the grease outward leaving the rubbing surfaces unprotected, thus causing excessive wear.



MOTOR–GENERATOR
KEYLESS COUPLINGS (Draglines Only)

ASSEMBLY

Assembly of Keyless Couplings requires heating coupling uniformly in an oven (DO NOT unevenly heat with a torch) to a temperature of 392 degrees F. or 200 degrees C., and shrinking onto a cylindrical shaft extension with no key or keyway. The amount of interference fit sufficiently gives adequate driving torque with adequate safety factor, using no key.

When reinstalling a removed coupling half, locate it in the original axial and angular position. Generally, axial position is when the hub end is flush with the shaft end. Space the pressure hole in the shaft as far as possible from the pull-off holes. Check the face of a solid coupling and insure it is perpendicular to the shaft. Check the periphery of the coupling and insure it is concentric with the shaft. If necessary, true up these surfaces. Perform these checking and truing operations with shaft accurately aligned in a lathe.

REMOVAL

Removal of Keyless Coupling uses hydraulic pressure applied to the circumference of groove C in shaft extension S. (See sketch on following pages for cutaway of section for removal). When this pressure exceeds initial radial stress, due to interference fit, coupling hub H expands a small amount and allows oil to seep into the fit in both directions from groove C. Although the distance from groove C to coupling face A is less than distance to face B, the end effect at corner maintains hydraulic pressure until entire bore length expands and oil appears at face B.

Upon reaching this condition (3 or 4 minutes after applying pressure) the coupling floats on a high pressure oil film and may be removed with a hand puller and wrench. When coupling face B uncovers groove C, oil pressure is instantly lost. The coupling now pulls harder to shaft end. However, this area is small enough that finishing with same wrench and puller adding a little more force does the job.

Protect the shaft center from damage with a small brass or copper shim under puller driving point.

WARNING: DO NOT USE ORDINARY PIPE FITTINGS. PRESSURES INVOLVED WELL ABOVE RUPTURING STRENGTH OF ORDINARY PIPE AND FITTINGS.

Use threaded holes near shaft for pulling coupling. Distortion of coupling is possible when pulling near the outer rim.

LUBRICATION SPECIFICATIONS

SPECIFICATION—GREASES

CODE OR SYMBOL NO.	ASTM or TEST	MPG	RGL	OGL TYPE B	OGL TYPE H
Penetration Worked 60X					
Summer, NLGI	D-217	2	semi-	1	—
Winter, NLGI		1	fluid	0	—
Penetration Worked 5000X, Max. Change	D-217	10%	—	—	—
Dropping Point, Min. ^{O}F.	D-566	350	—	325	—
Base Oil Viscosity @ 210^{O}F., Min.	D-446	75 SUS	140 SUS	200 SUF	200 SUF
Oxidation Stability Max. psi Drop - 100 hrs.	D-942	10	—	—	—
Water Resistance Max. Loss @ 100^{O}F.	D-1264	20%	—	10%	10%
Texture	Visual	Buttery	—	Adhesive	Tacky
EP Timken, Min. OK	—	35 lbs.	—	35 lbs.	35 lbs.

SPECIFICATIONS—OILS

CODE OR SYMBOL NO.		ASTM or TEST	OILS MO	OILS PO
Pour Point ^{O}F. Max.	- Summer	D-97	5	15
	Winter		0	15
Flash Point ^{O}F. Min.	- Summer	D-92	450	410
	Winter		420	410
Viscosity @ 100^{O}F. SUS		D-446	—	150 Min.

NAME OF PART	TYPE	NO. OF POINTS	LOCATION	LUB. SYM.	METHOD AND FREQUENCY
Drag Ropes	—	—	Spray on at Fairlead	WRL	Semi-Automatic 8 Hrs.
LUBRICATION OF HOIST, DRAG, PROPEL BRAKE (1 of 10)					
Lever Arm Pivot	Oilite	2	—	—	—
Brake Shoe Connection	Oilite	2	—	—	—
Spring Connection Assembly	Oilite	4	—	—	—
Tie Rod Anchor	Bushing	3	2 in End of Pin, 1 in Top of Lever Boss	MPG	Hand, 4-8 Hrs.
LUBRICATION OF FAIRLEAD AND TRI-STRUCTURE					
Top Fairlead Sheave	Anti-Friction	2	In End of Shaft	MPG	Automatic
Top Fairlead Swivel Journal	Bushing	2	In Side of Bearing Housing	MPG	Automatic
Bottom Fairlead Swivel Journal	Bushing	2	In Side of Bearing Housing	MPG	Automatic
Boom Raising Sheaves	Bushing	4	In End of Shaft	MPG	Hand, Before Use
Intermediate Support Ropes	Bushing	4	End of Pin	MPG	Automatic
Hoist Deflecting Sheaves	Bushing	2	End of Pin	MPG	Automatic
Boom Support Ropes	Bushing	6	End of Pin	MPG	Automatic
Rope Dampers	—	4	1, Each Damper	MPG	Hand, 6 Mo.

SECTION 3

COMPRESSED AIR SYSTEM AND COMPONENTS

The Marion air control is quite simple in operation. Reasonable care and maintenance ensures a long and trouble free life. Compressed air releases the hoist, drag, propel and swing brakes. It is piped to the auto-lube system also.

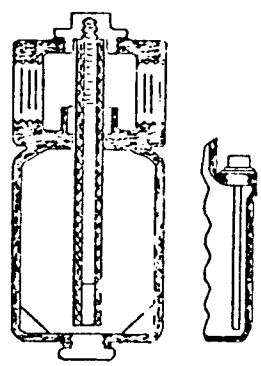
Air pressure provides a vital link in the safe operation of this machine. The operator MUST CONSTANTLY check the pressure gauge reading, located in operator cab. If at any time this pressure DROPS below 90 psi, SHUT DOWN and investigate the cause.

NEVER OPERATE THIS MACHINE WITHOUT FULL TANK PRESSURE.

Two **AIR COMPRESSORS,** located at rear of drag motors, are complete independent units. The left compressor operates propel, swing, hoist and drag brakes. The right compressor supplies air to the automatic lubrication system. Should a compressor fail, close compressor valve atop tank and open globe valve at cross over between the compressors. This valve is normally closed.

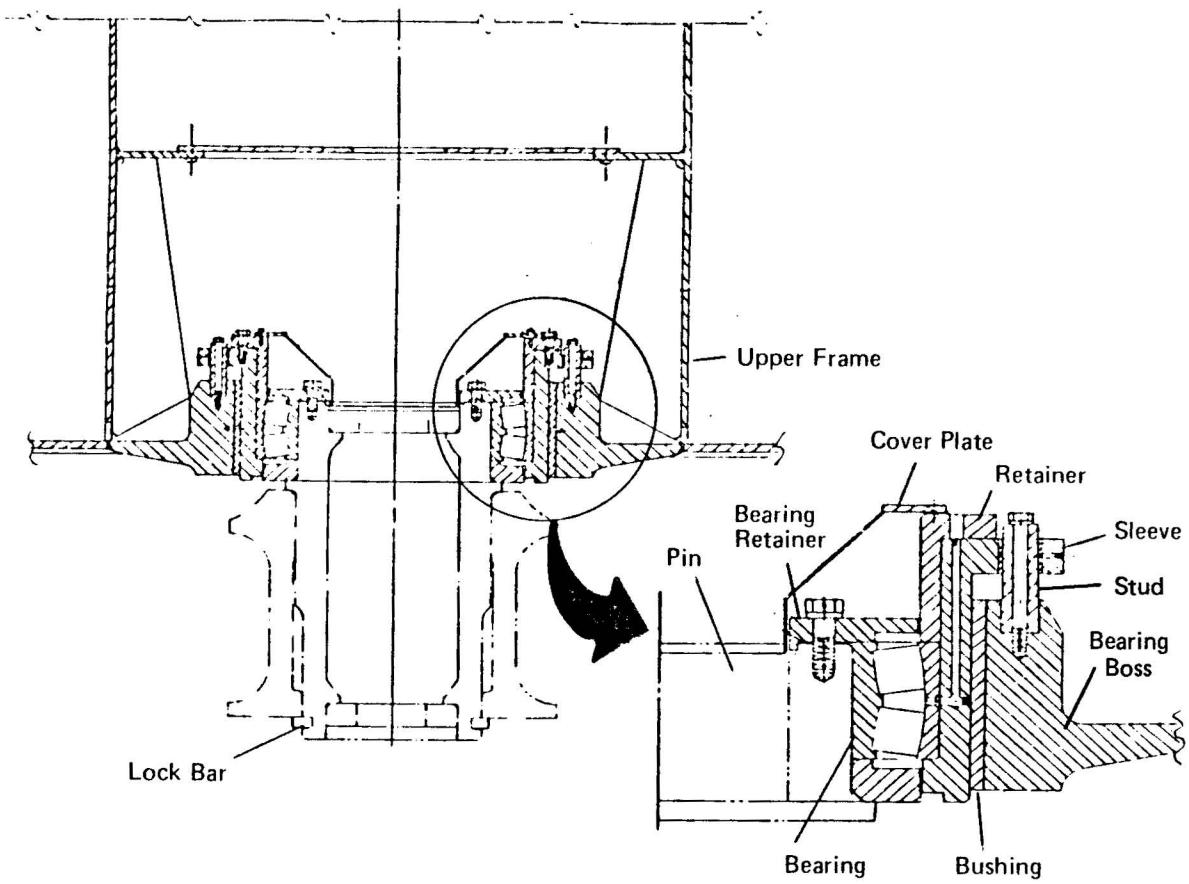
INSPECT the belt drive often. Maintain PROPER belt tension which permits no more than 5/8" deflection of a single strand. ADJUST by moving the electric motor on the base. CHECK crankcase oil level DAILY and keep at dipstick FULL mark. Every 500 operational hours, DRAIN and FLUSH the crankcase. Look in Lubrication Charts for the proper NON-DETERGENT oil to use. Clean the air cleaner once a week or daily if conditions require.

ANTI-FREEZER, installed in air line, prevents icing and freeze-up of air system in severe weather. Introduced alcohol vapor mixes with water vapor in entering air. A bottom alcohol chamber and a top vapor chamber separate the unit. A central rod fits to a plug in the top. This rod, covered with a wick, carries alcohol up into the vapor chamber where it evaporates into the air stream. This in-line unit is non-adjustable.



MAINTENANCE requires cleaning bowl and wick assembly with non-flammable solvent before freezing weather. Drain plug is in bottom. TURN OFF air compressor BEFORE checking or refilling. Vent the line pressure thru cut-out. Pressure not vented off escapes thru a small hole drilled in cap and vents out between cap and bowl. Due to this filler cap safety factor and to avoid over-

The **CENTER JOURNAL** pin holds the rotating frame and tub in concentric alignment at center of rotation.



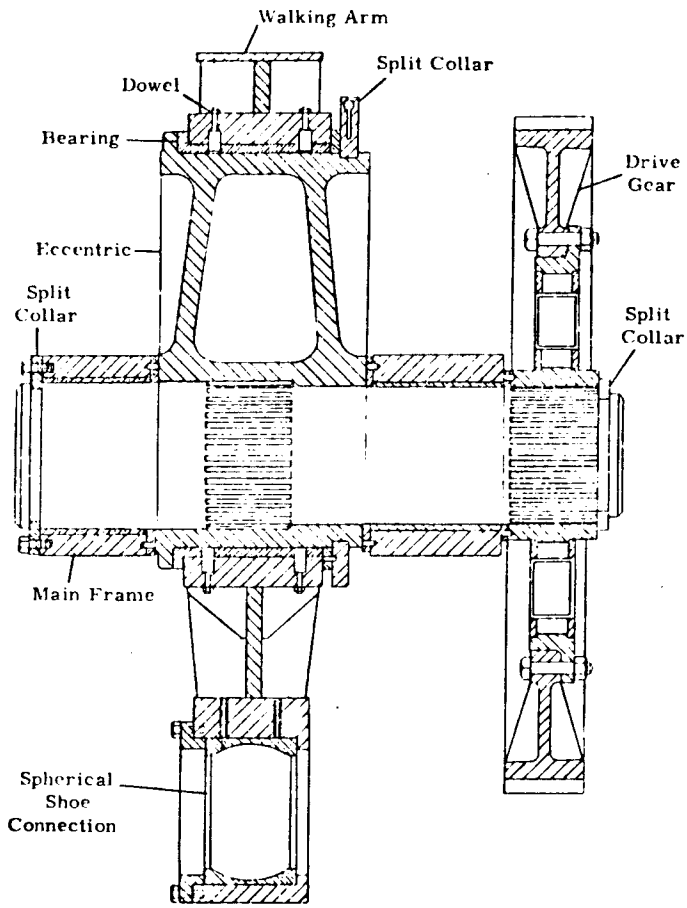
The pin is assembled and is secured by two lock bars in a heavy integral boss in the tub structure. The rotating frame turns around the pin on a large diameter spherical roller bearing. The bearing cone (inner race) is clamped against the lower labyrinth grease seal and a flange on the pin by a bearing retainer plate. Place shims under bearing plate so bearing is snug when retainer is down tight.

The spherical bearing cup is assembled in a flanged sleeve, that mounts in the rotating frame bearing boss. A retainer ring holds bearing cup in place.

The sleeve is prevented from turning by four vertical studs. When machine weight is resting evenly on all rollers maintain a clearance between BEARING BOSS and bottom of sleeve flange, to allow a complete revolution of rotating frame without binding, and also to allow vertical movement of rotating frame during walking cycle.

It is not necessary to disconnect incoming power at source to service or inspect center bearing as collector rings are isolated in an upper compartment. It will be necessary to disconnect and remove collector rings should bearing replacement be required.

The **MAIN PROPEL SHAFT** assembly consists of the main drive gear hub and gear and walking eccentric. The gear hub and walking eccentric is attached to the shaft with involute splines. The shaft is supported by two large diameter bronze bushings. The walking shaft is inserted thru the assembly from outside after the gear hub and eccentric has been blocked in place. The shaft is locked in place with two split collars.



The main drive gear is attached to the gear hub with drive fit bolts. See Section 1 for assembly.

Pack bearings and splines with MPG.

The **WALKING SHOE** is a one piece weldment. Manholes in the top plates and bulkhead are provided for shoe inspection.

The shoe attaches to the walking arm by a swivel and spherical bearing. The spherical bearing allows shoe to rotate about a longitudinal axis. The swivel shaft will slide within the ball to allow lateral shoe movement.

Only the drive gear is inside oil tight gear case. The pinion that turns main drum shaft gear is an open gear with suitable guard. A split oil seal on the shaft between gear and pinion is installed with lip turned toward drive gear. See Engineering Data Section for installation of grease seals.

DISASSEMBLE GEAR CASE by removing case cover hold down bolts, the cap screws from top half of bearing retainer plate at intermediate shaft and the motor extension shaft assembly. Loosen cap screws in bottom half of bearing retainer plate, about two turns. Remove split oil seal from intermediate shaft and remove pins from outboard bearing housing. Lift off case cover from over intermediate shafts. It may be necessary to drive a small wedge between case and cover to break seal.

Remove cap screws from lower half of bearing retainer plates. Use a sling around shaft, lift intermediate shaft assembly out of case. Lift assembly along a line perpendicular to surface of gear case and allow gear to turn out of engagement with main drive gear. Separate motor couplings and remove motor extension shaft assemblies from case.

Drain and clean gear case, flush out with light oil.

Reverse procedure to reassemble unit.

The **HOIST/DRAG LIMIT SWITCH** is installed as a convenience to the operator and IS NOT intended as fail-safe protection to the boom point and bucket rigging.

The limit switching consists of a series of cam operated micro-switches. The switch component is driven by a shaft coupled to the drum shaft thru a reduction gearbox. A right angle or in-line drive reduction may be used. Often a 24 to 1 ratio is used. Another style limit switch consists of a threaded rod coupled to the drum shaft. This rod drives a carrier cam, which actuates the micro-switches in the case.

In either style unit; the micro-switch wires connect to the control circuits for the purpose of:

First, causing a single stroke alarm to indicate the Dead End of rope drum on pay-out or when the bucket with rigging approaches the boom point sheave.

Second, cause hoist power field to reverse; thereby creating a braking force to halt the drum rotation and set the brake.

The adjustment of the cams or the position of the micro-switches in the case is determined by the needed dumping height, line pull, and hoist speed. Optimum settings depend upon the working conditions of each application.

CAUTION: THE TORSION BAR MUST BE INSTALLED IN A NO STRESS CONDITION. DO NOT BEND, TWIST OR STRETCH.

Install torsion bar center support bearing in similar manner. The center support bearing must not place any bending stress on the torsion bar.

INSTALLATION OF CLASS "C" BOLTS – Class "C" bolts are identified by six (6) radial marks on bolt head. Bolted surfaces must be clean and free of scale, rust, paint and burrs. Use Class "C" flat washers under Class "C" nuts. DO NOT use spring lock washers. Install all bolts to be used in the assembly and draw nuts to SNUG FIT. Snug fit is described, "tight as can be turned with hand tools." Mark position of nut on bolt. Hold head of bolt and advance nut one half turn. Use impact wrench or hand wrench and a heavy hammer. The bolt tension will prevent nut from loosening.

ANTI-TIGHT-LINE LIMIT SWITCH is installed as a convenience to the operator. IT IS NOT INTENDED AS FAIL-SAFE PROTECTION.

Without this device serious damage to boom could result. For example: as bucket is hoisted from the digging face and the drag ropes are not payed out or too much tension is held on drag, the bucket will be pulled up near the boom. The hoist ropes will strike the boom lacing at the deep section (center of boom), and the bucket can strike the boom also. Likewise, if the bucket is hoisted to boom point with to much tension on drag ropes, the drag ropes can strike the boom lacing at the apex.

Two tight-line units are installed on the machine. One switch located near boom apex and the other is located near boom point. The switches will de-energize hoist and drag power whenever hoist, drag rope or bucket approaches boom underside.

The arrangement consists of a 1/4 inch wire rope drawn taut across underside of boom. When the hoist rope strikes the rope at boom point or the drag rope strikes the apex rope, the 1/4 inch rope deflection will actuate a micro switch connected to the hoist and drag motor control circuit. NOTE: Once motors are de-energized, the LE circuit MUST be re-established by manual control.

Each 1/4 inch wire rope forms a full loop attached to the lever operated micro switch, spring loaded, with adjustable turnbuckle.

Pressure of 10 pounds against taut line is required to actuate switch. Pressure of 50 pounds will cause spring to give way. The spring and 1/4 inch wire rope are expendable items and spare replacement must be kept available.

4. Run newly ground brushes under light loads for a short while. This allows the surface to set, or wear itself in, better before heavy loads are put on. When a commutator has been used for some time, it should have a chocolate color. It is preferable to install a complete set of brushes at a time, rather than replace them singly.

COMMUTATORS–

It is important that the electrician inspect commutator surfaces at frequent intervals to be sure surface faults are detected in the early stages. Faults can be corrected then with little expense or loss of time. Such surface faults as bar burning, high or low bars, high mica and flat spots tend to become more serious with time and often at an accelerating rate. Unless corrected when first observed, they may require a long shutdown with expensive repairs.

If excessive sparking or arcing has taken place for any length of time, the commutator will be burned or blackened.

To smooth the commutator, use a very fine sandpaper (2/0 or 3/0). Fold the paper around a wood block, shaped to the contour of the commutator. Hold it against the commutator with the motor or generator running at no-load. It is good practice, when sanding, to use a slow lateral movement of the block to avoid diagonal scratches.

If the commutator is only slightly blackened, it is best to use a piece of canvas wrapped around the wood block. Canvas leaves the surface clean and does not scratch the copper.

A good commutator surface must be highly polished and show a chocolate color. Too much sandpapering destorys this polished surface and results in increased brush wear. Use sandpaper as little as possible. In many cases, polishing commutators with canvas, as described above, will take care of blackening of commutators.

One of the principal objections to the use of sandpaper for cleaning commutators is that it rarely leaves the bars properly ground. On an unslotted commutator, particularly when mica is high, sandpaper has a tendency to flatten the center of the bars.

If a commutator becomes so badly pitted or rough that sandpaper or canvas cannot clean it or take out the bad spots, use a hand stone.

Sanding removes some roughness, but cannot be depended upon to remove large flat spots. While it may appear to eliminate them, the effect is merely to broaden the spot, so it is no longer apparent, due to the flexibility of the paper. A commutator stone is recommended in preference to sandpaper when any amount of smoothing is to be done. The stone presents a rigid contact surfaxe and can be more firmly held in place while grinding.

Previously discussed was the importance of starting tests at the right point. This is the logical one that checks the most components at one time. With failure in one motion, first check stall current. With correct stall current, assume master switch, control equipment and generator okay and trouble probably exists in motor.

With stall current incorrect, check generator field and then master switch. Suspecting the D.C. excitation system, check voltage on BOTH sides of fuses and then proceed to indicated direction. If A.C. system is suspect, start at any point where three phase 220 or 400 volt supply is measured. If D.C. and A.C. voltmeter exist on machine, check time.

In conclusion, a good trouble shooter attack plan includes:

Adequate preparation including:

Understanding the system and components
Availability of wiring diagrams and test data
Quality test equipment designed for job

Preliminary investigation to determine effect of fault

Estimation of probable cause

Testing for determining faulty part

Correction of failure

Preventative maintenance