

INSTALLATION OPERATING & SERVICING INSTRUCTIONS



**GSA SERIES
PUMPING
UNITS**

USS OILWELL
Division of United States Steel

Foreword

This manual is published as a guide for normal Installation, Operating and Servicing of your OILWELL equipment. Because of the many factors which contribute to the proper function or malfunction of this machinery and not having complete knowledge of each factor or combination of factors, we cannot detail all facets of these subjects. We must therefore confine the scope of this presentation and when situations encountered are not fully encompassed by complete, understandable instructions, these situations must be referred to the manufacturer.

Improvements in design, engineering, materials, production methods, etc., may necessitate changes in these products and result in inconsistencies between the contents of this publication and the physical equipment. We reserve the right to make these changes without incurring any liability or obligation beyond that stipulated in the purchase contract.

The dimensions and tolerances specified in this publication are those desirable for the most efficient operations of the equipment. When components become worn or when new parts are introduced into a worn unit, it may not be possible or economically feasible to reestablish such strict alignment and correct all dimensional deviations.

THE PICTURES, PHOTOGRAPHS, CHARTS, DIAGRAMS, DRAWINGS, VERBAL CONTENTS AND SPECIFICATIONS CONTAINED HEREIN ARE NOT TO BE CONSTRUED AS GIVING RISE TO ANY WARRANTY ON THE PART OF OILWELL. OILWELL MAKES NO WARRANTY, EITHER EXPRESS OR IMPLIED, BEYOND THAT STIPULATED IN THE PURCHASE CONTRACT.

CAUTION

Exercise safety in all performances, do not ignore any cautions, use only approved methods, materials and tools. Do not permit any function of questionable safety because accidents are caused by unsafe acts and unsafe conditions. SAFETY IS YOUR BUSINESS AND YOU ARE INVOLVED.

WARNING

Before performing any service function be certain that the unit is separated from its power source or that the power source is locked-out to prevent any form of energy from entering the equipment - this would include electrical or mechanical energy into or from the prime mover controls, monitoring devices, etc., as well as potential energy from structural imbalance, counterweights, crank angle, fluctuations in well loading, etc.

NOTICE

FAILURE TO OBSERVE THE WARNINGS AND NOTES OF CAUTION IN THIS PUBLICATION CAN RESULT IN PROPERTY DAMAGE, SERIOUS BODILY INJURY OR DEATH.

Introduction

It is suggested that the PARTS LIST, which accompanied the shipment of this machinery, be reviewed and maintained as a reference for detailed repair and replacement parts identification. The component identifications in this publication will be in general terminology and will not make reference to specific part numbers, size, material, etc.

The instructions outlined in this manual are intended to supplement the practices recommended by the American Petroleum Institute. Any instructions herein which are or may be in conflict with the instructions published by A.P.I. should be immediately called to the attention of the equipment manufacturer.

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Identification Of Pumping Units

There are more than 75 different sizes of beam type pumping units which are considered standard in our industry. These units have gear reducers with ratings ranging from 6,400 to 3,648,000 in-pounds of torque, the structures have capacities ranging from 2,100 to 47,000 pounds; the maximum stroke length of small units is approximately 16 inches and the stroke length of larger units can reach to 300 inches.

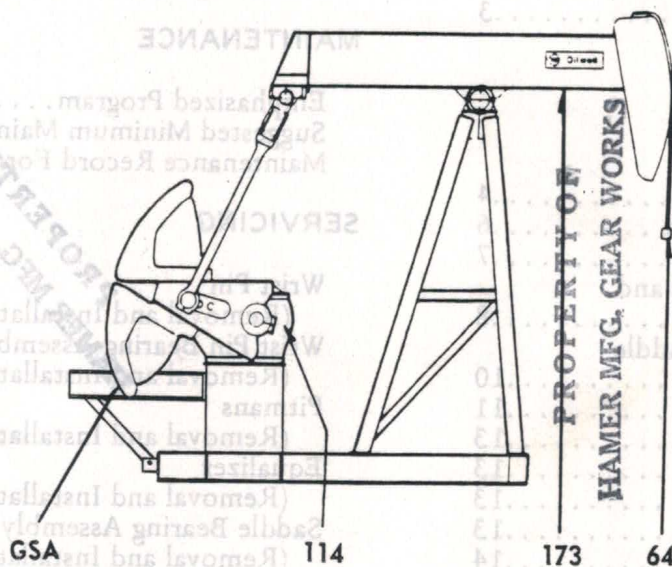
Three basic values are required to determine the "size" of a specific unit. There are:

GEAR REDUCER RATING

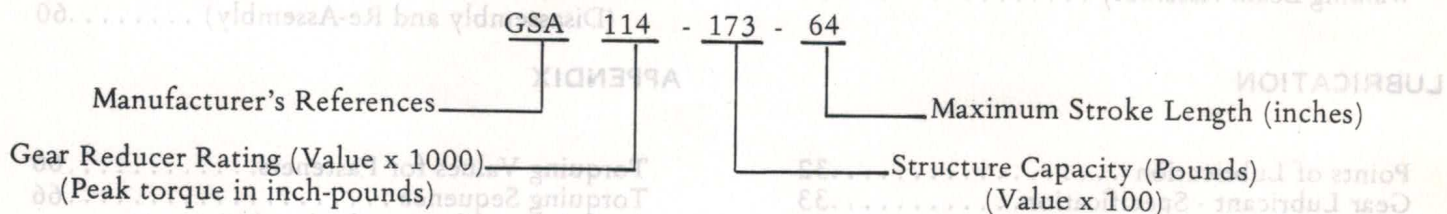
STRUCTURE CAPACITY

MAXIMUM STROKE LENGTH

These three values are stated in the "model number" assigned to each OILWELL unit. For example, an intermediate "size" unit having a "model number" GSA114-173-64 can be evaluated as follows:



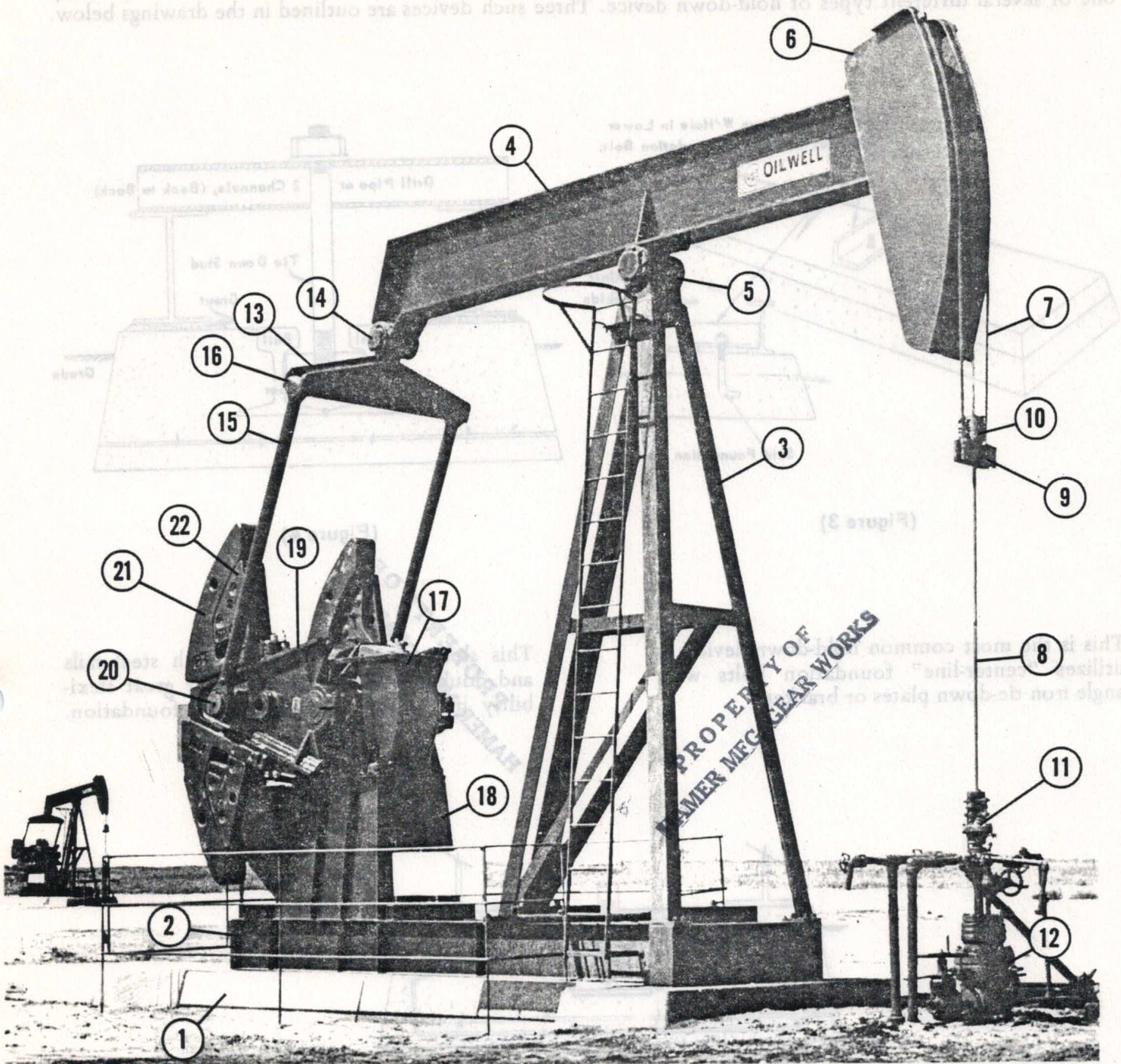
(Figure 1)



Therefore, the model GSA114-173-64 is a pumping unit having...

- 114,000 inch-pound gear rating (peak torque)
- 17,300 pound structure capacity
- 64 inch maximum stroke length

Component Identification



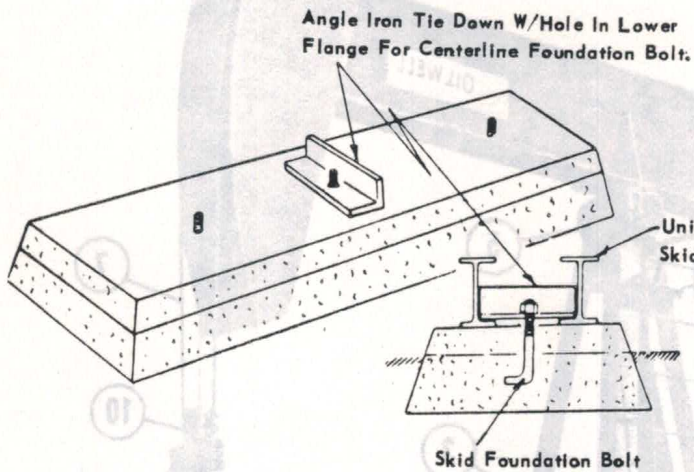
(Figure 2)

- | | |
|----------------------------------|---------------------------------------|
| (1) Foundation* | (12) Well Head* |
| (2) Base | (13) Equalizer |
| (3) Samson Post | (14) Equalizer Bearing |
| (4) Walking Beam | (15) Pitman(s) |
| (5) Trunnion & Saddle Bearing(s) | (16) Upper Pitman Bearing(s) |
| (6) Arc | (17) Gear Reducer |
| (7) Arc Cable | (18) Gear Reducer Base |
| (8) Polished Rod* | (19) Crank(s) |
| (9) Polished Rod Hanger | (20) Wrist Pin(s) |
| (10) Polished Rod Clamp* | (21) Crank Counterweight(s) |
| (11) Polished Rod Stuffing Box* | (22) Auxiliary Crank Counterweight(s) |

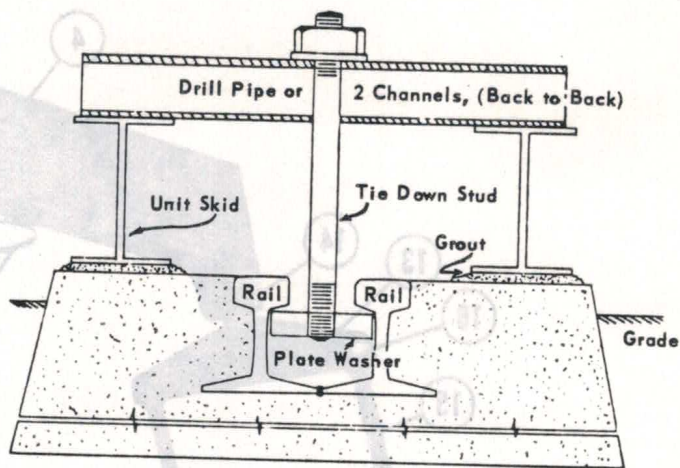
*Identified for reference purposes (not a component of a standard pumping unit).

Foundation

These pumping units are designed to be placed on a universal-type foundation and to be held in place by one of several different types of hold-down device. Three such devices are outlined in the drawings below.



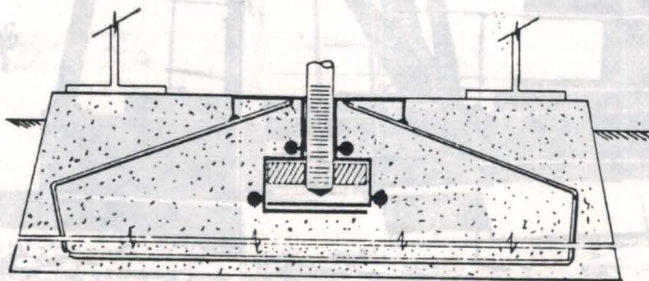
(Figure 3)



(Figure 4)

This is the most common hold-down device. It utilizes "center-line" foundation bolts with angle iron tie-down plates or brackets.

This slotted type hold-down, with steel rails and double-end bolts provides for great flexibility in locating the unit on the foundation.



(Figure 5)

This type of slotted hold-down has a narrow center slot and is reinforced with steel rods adjacent to the inverted "T" opening through the center of the block.

The universal-type foundation has the advantage of being able to secure most currently manufactured units (of reasonable design) without having to individually locate foundation bolts about the perimeter of the pumping unit base.

Foundation

Recommendations for the installation of pumping units are printed by the AMERICAN PETROLEUM INSTITUTE and the instructions herein are intended to only supplement those instructions where additional clarity may seem desirable or where emphasis may lend additional importance to a particular point or action.

1. The recommendation for and the preparation of the foundation is not the responsibility of the pumping unit manufacturer.

In the absence of owner/operator design details and preparation instructions, such can generally be obtained from local contractors specializing in these installations.

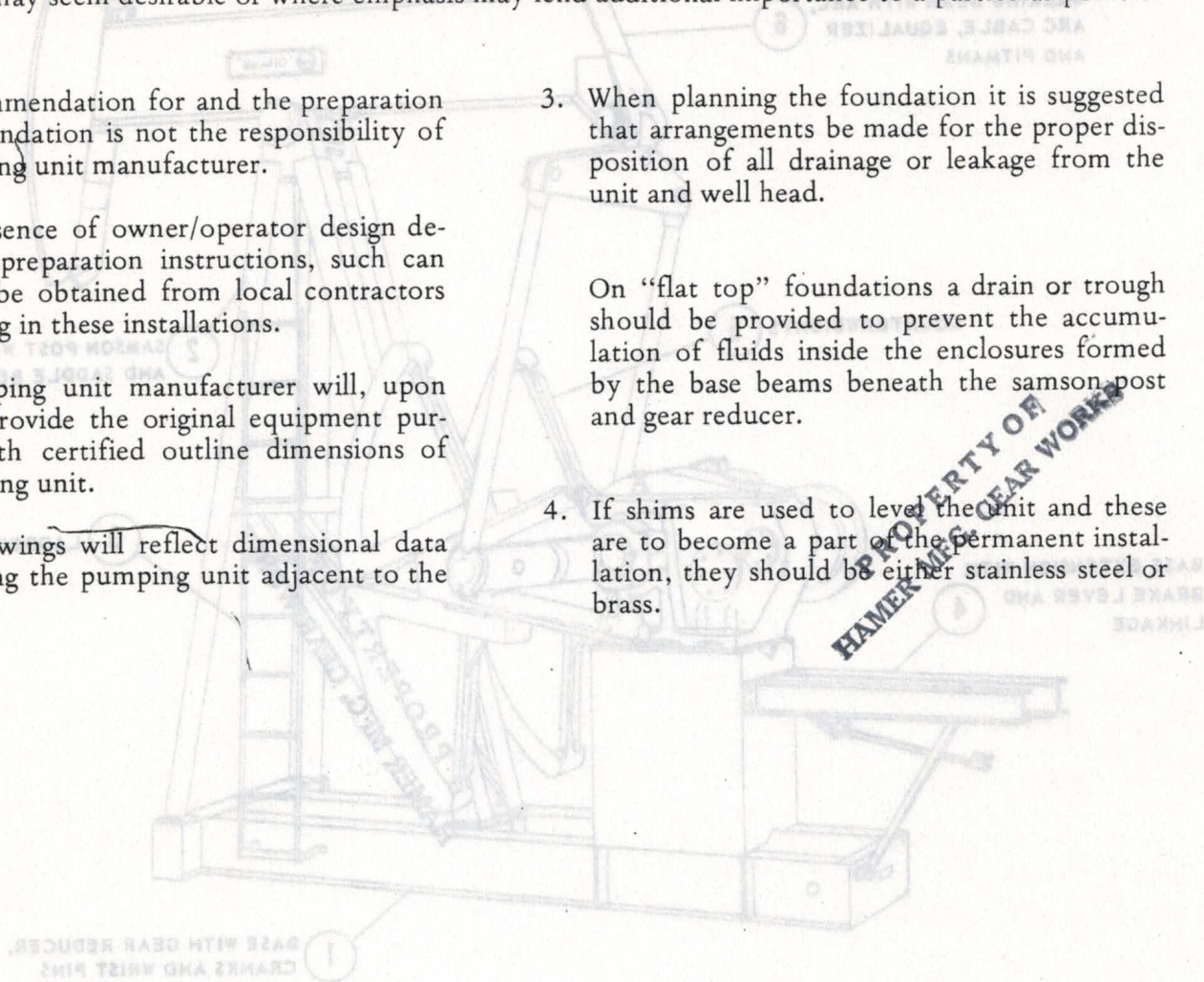
2. The pumping unit manufacturer will, upon request, provide the original equipment purchaser with certified outline dimensions of the pumping unit.

These drawings will reflect dimensional data for locating the pumping unit adjacent to the well head.

3. When planning the foundation it is suggested that arrangements be made for the proper disposition of all drainage or leakage from the unit and well head.

On "flat top" foundations a drain or trough should be provided to prevent the accumulation of fluids inside the enclosures formed by the base beams beneath the samson post and gear reducer.

4. If shims are used to level the unit and these are to become a part of the permanent installation, they should be either stainless steel or brass.

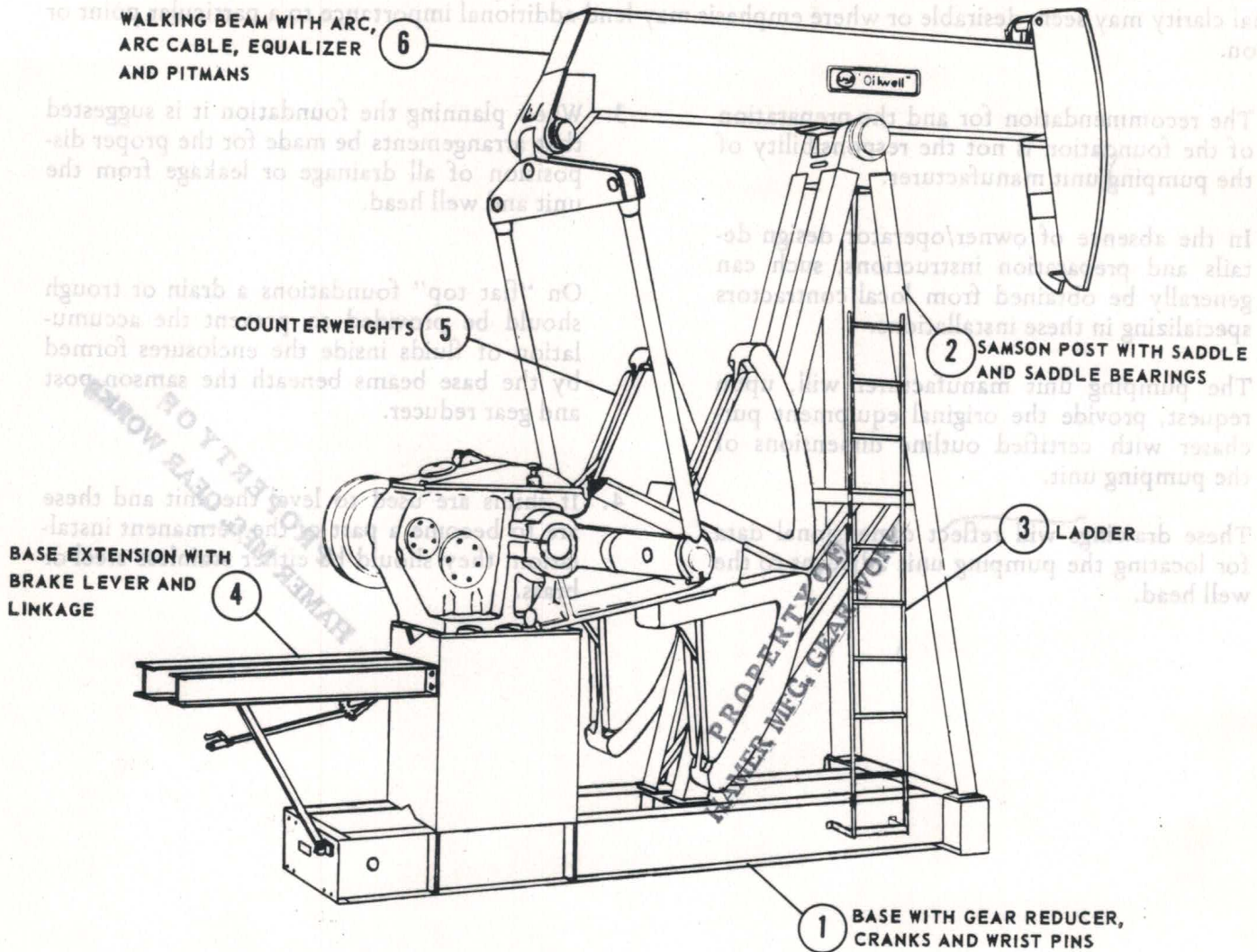


(Figure 8)

The proper installation of the pumping unit is important to the service life of the equipment. High stress levels may be imposed on the component by improper alignment and/or angular installation of the base on the foundation. This generally results in early equipment failure and loss of production. Failure to maintain the unit securely on the foundation to prevent movement during operations can have the same results.

Because of transportation regulations, unsafe handling methods and massiveness of the larger structures, the pumping units are shipped as sub-assemblies and component elements. The instructions contained in this publication will direct the assembly at the point of installation.

Installation



(Figure 6)

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Because of transportation regulations, unsafe handling methods and massiveness of the larger structures, the pumping units are shipped as sub-assemblies and component elements. The instructions continuing in this publication will direct the assembly at the point of installation.

Installation

INSTALLATION (Continued)

Personnel protection and environmental protection must be given foremost consideration when planning the installation. Safety guards are mandatory. Hand rails, supports, tie-downs, shields, deck plating, safety loops, etc., must be considered in your program. Avoid all environmental contamination. Where contamination cannot be avoided it must be controlled to the levels prescribed by regulatory authorities or agencies. Make it a safe, compatible installation.

Preparing For Installation

1. The assembly of the pumping unit will be made from the components listed on the opposite page plus the following:

- a. Prime mover
- b. Drive sheave
- c. V-belts
- d. Sheave/belt guard
- e. Counterweight guards
- f. Polished rod clamp/s

The above items are not a part of a standard pumping unit per se. They are generally secured as individual items and should be placed on location before commencing the assembly.

2. In addition to the above the following should be immediately available:

- a. Overhead crane
- b. Safety ladder
- c. Load chains
- d. Mechanics tools
- e. Sledge hammer
- f. Grease gun
- g. Grease*
- h. Gear lubricant*
- i. Carpenters level
- j. Two straight edges (boards)
- k. Chalk line
- l. Plumb bob
- m. Shim stock

3. If the installation is the type which includes grouting beneath the pumping unit base then this material should also be immediately available. In this instance wedges will be required to support the unit above the foundation.

Cement finishing tools, water, etc., should be on location.

4. There are many incidental items which are helpful during installation; among these are wire thread brushes, a good quality anti-seize compound for the threaded screw type fasteners, cleaning materials, etc.

WARNING

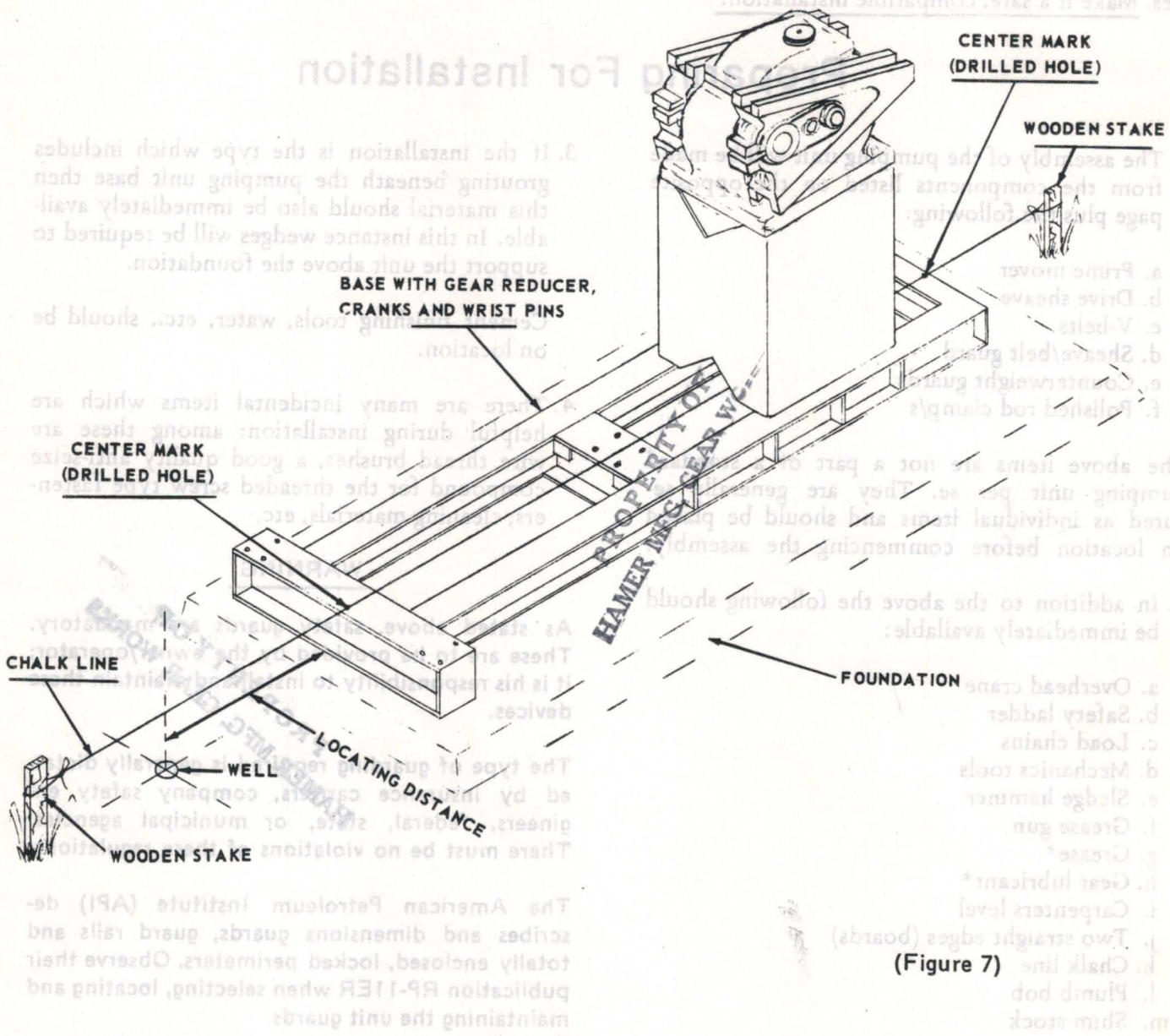
As stated above, safety guards are mandatory. These are to be provided by the owner/operator; it is his responsibility to install and maintain these devices.

The type of guarding required is generally dictated by insurance carriers, company safety engineers, federal, state, or municipal agencies. There must be no violations of these regulations.

The American Petroleum Institute (API) describes and dimensions guards, guard rails and totally enclosed, locked perimeters. Observe their publication RP-11ER when selecting, locating and maintaining the unit guards.

*Refer to lubricant specifications contained in this manual.

INSTALLATION (Continued)



Placing the base on the foundation and aligning it with the centerline of the well is the first order of assembly. The top of the foundation must be level, especially if the base is to be placed directly on this surface. If grouting is to be used the wedges which elevate the base must be adjusted to level the base.

INSTALLATION (Continued)

BASE WITH GEAR REDUCER, CRANKS AND WRIST PINS

1. The foundation must be free of all debris, concrete forms and other obstructions which could interfere with the placement of the base assembly on the foundation and aligning it with the well head.

2. Review the dimensional outline drawing for the specific unit involved; determine the distance from the centerline of the arc cable to the front of the unit base adjacent to the well head, this is the approximate distance from the centerline of the well head to the front of the unit base.

Measure from the centerline of the well head across the top of the foundation and mark the above distance on the top of the foundation. This will be the locating point for the front of the unit base.

3. Hoist the base assembly above the foundation; lower it to a point of near contact, align it visually with the longitudinal centerline of the foundation, locate the front of the base directly above the "locating point" (see above paragraph) and lower it carefully to the foundation.

Do not remove the hoisting lines at this time.

4. If the wooden stakes which located the longitudinal centerline of the foundation were removed, replace them (if the well has tubing extending from the tubing hanger this will suffice for one stake but it will be necessary to replace the one most remote to the well head).

Extend a chalk line between the stakes or from the tubing to the remote stake. The chalk line should be in a position of close proximity to the top of the base beams.

It should not touch the beams.

The chalk line should be looped or tied at the anchor points in such a fashion that it will be "self-centering" and will not be extended from the "side" of the anchor.

5. With the chalk line stretched tightly between the anchors, with only a slight amount of clearance between it and the top of the base beams, check alignment of the base.

The required alignment is for the center marks (small drilled holes), one at the front of the base and one at the rear of the base, to be directly centered beneath the chalk line. Also, the front of the base is to be at the "locating point" marked on the foundation (instructions were outlined in the foregoing).

6. If the installation requires grouting between the base and the foundation, elevate the chalk line at the anchors and elevate the base to a height equal to the thickness of the required grouting. Install wedges between the foundation and the base.

Use a carpenters level on top of the beams, both axis, to be certain that the wedges are properly placed; adjust the wedges if necessary.

With the base assembly on the wedges, align the base with the foundation as outlined in the foregoing.

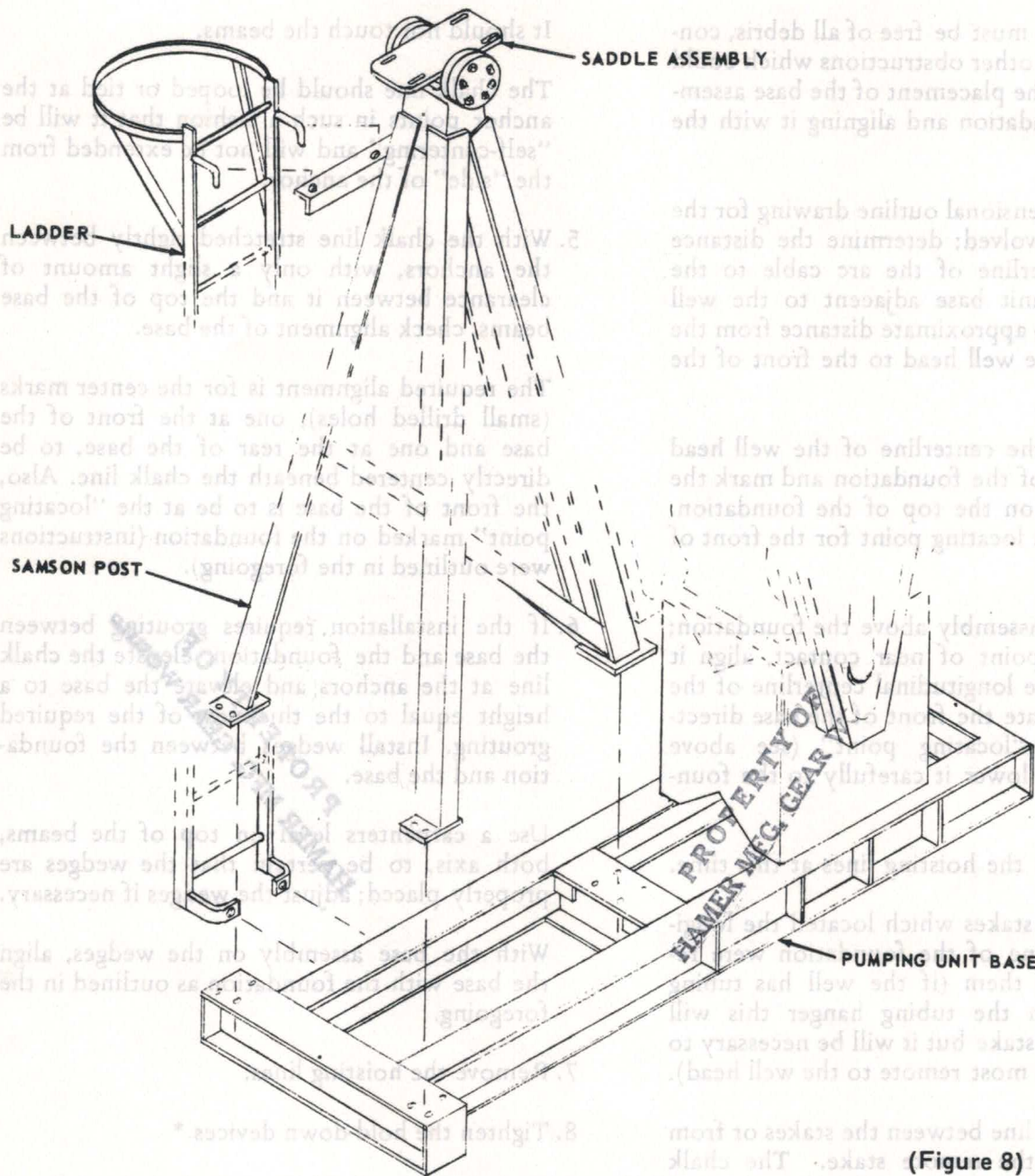
7. Remove the hoisting lines.

8. Tighten the hold-down devices.*

9. Remove the end of the chalk line from the remote stake and place it at the well head.

*Torquing values will be found in the APPENDIX of this publication.

BASE WITH GEAR REDUCER, CRANKS AND WRIST PINS



(Figure 8)

Mounting the samson post with saddle and saddle bearings on the pumping unit base. The ladder is also installed during this phase of assembly.

SAMSON POST WITH SADDLE AND SADDLE BEARINGS

1. Hoist the samson post and saddle assembly, with saddle in topmost position, above the pumping unit base and carefully lower it to a point of near contact with the base.

Align the drilled holes in the plates which form the feet of the samson post with the holes in the top of the base beams.

Lower the samson post assembly to the pumping unit base. Install the capscrews, lock washers and nuts* provided for this purpose.

2. Extend the chalk line across the top of the pumping unit base (instructions outlined in foregoing section of this manual).
3. Attach a plumb bob to a line which has been placed through the centering hole at the top of the samson post.

If the base of the pumping unit is level and the samson post is properly mounted, the point of the plumb bob will become stationary directly above the chalk line extended across the pumping unit base.

4. If the plumb bob does not point directly to the chalk line, adjustments must be

made to correct this alignment.

Misalignment is generally caused by the foundation which, being unlevel, causes the pumping unit base to be unlevel.

Release the tension on the hold-down devices and observe the position of the plumb bob.

Insert shims between the foundation and the lower flange on the base beams (or adjust the wedges if these have been inserted for grouting purposes). When this shimming action has achieved the proper alignment of the plumb bob with the chalk line, tighten* the hold-down devices.

Use a carpenters level to be certain that the shims have been properly placed and that the base is level on the longitudinal plane.

NOTE: It may be necessary to repeat the above action several times before proper alignment is achieved and the unit, with the hold-down devices secured, is level.

5. The hoisting lines, chalk line and the plumb bob with its line can all be removed.

LADDER

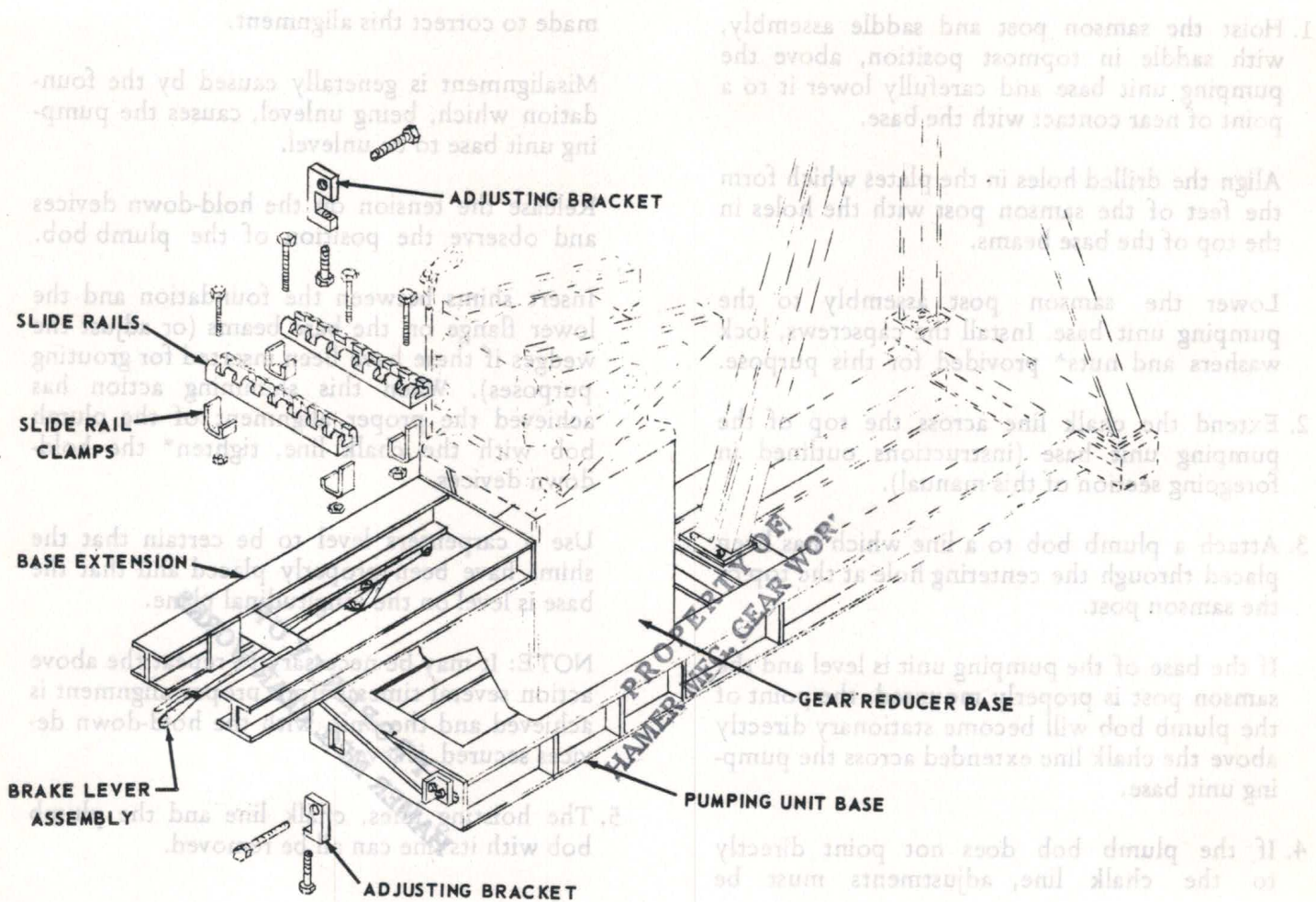
1. The ladder can be installed at any time after the samson post has been secured.
2. Hoist the ladder into position and place the hooks at the top of the ladder in the holes drilled in the angle iron brace at the top

of the samson post.

3. Install the capscrews, plate washers, lock washers and nuts* in the braces at the bottom of the ladder.
4. Remove the hoisting lines.

*Torquing values will be found in the APPENDIX of this publication.

SAMSON POST WITH SADDLE AND SADDLE BEARINGS



LADDER

(Figure 9)

The base extension, prime mover and drive should next be installed.

A means to rotate the cranks will be necessary in the continuing assembly of the pumping unit.

INSTALLATION (Continued)

BASE EXTENSION, BRAKE LEVER ASSEMBLY, PRIME MOVER AND DRIVE

BASE EXTENSION AND BRAKE LEVER ASSEMBLY

1. The base extension (electric motor base) extends from the rear of the gear reducer base and in addition to providing for support of the prime mover and adjustment for the v-belt drive, it is the anchor for the brake lever assembly.
2. Install the brace bracket/s, bolt/s, plate washer/s, lock washer/s and nut/s on the pumping unit base. Do not fully torque the fastener/s at this time.
3. Hoist the base extension to its point of assembly with the gear reducer base, align the holes in the base end plate with the holes in the gear reducer base; install the bolts, lock washers and nuts.*
4. Install the angle brace extending from the base

extension to the brace bracket on the pumping unit base. Install the fasteners but do not tighten these at this time.

Place a carpenter's level on the top of the base extension; it should be level, if not, loosen the fasteners holding the base extension to the gear reducer base, adjust the base extension until it is level and apply full torque* to all of the involved fasteners.

5. Attach the brake lever assembly to the base extension. Tighten* the nuts on the bolts with lock washers underneath the nuts.

Instructions for the assembly of the brake and brake linkage appear subsequently in this publication.

PRIME MOVER

1. Place the slide rails on the base extension; install the slide rail clamps and fasteners but do not tighten at this time.
2. Install the prime mover as directed by its manufacturer.
3. When the prime mover is installed the fasteners

which hold it to the slide rails should be fully tightened.*

4. The adjusting brackets should not be installed until the v-belts have been placed on the sheaves and the prime mover has been moved to its proximity of operations.

DRIVE

1. Install the drive sheave on the prime mover.** Be guided by the sheave manufacturer's instructions for this action.
2. Place the v-belts on the sheaves and position the prime mover for proper alignment and belt tension. The v-belt manufacturer's instructions must govern this installation.
3. When the above has been accomplished, tighten* the fasteners in the slide rail clamps.

4. Install the adjusting brackets on the base extension. These are to be placed on the outer edges of the wide face beams; one between the prime mover and gear reducer, adjacent to the v-belts and the other diagonally opposite on the beam remote to the v-belts. Locking nuts* are provided for both the retaining set screws and adjusting set screws.

5. Install the belt guard.

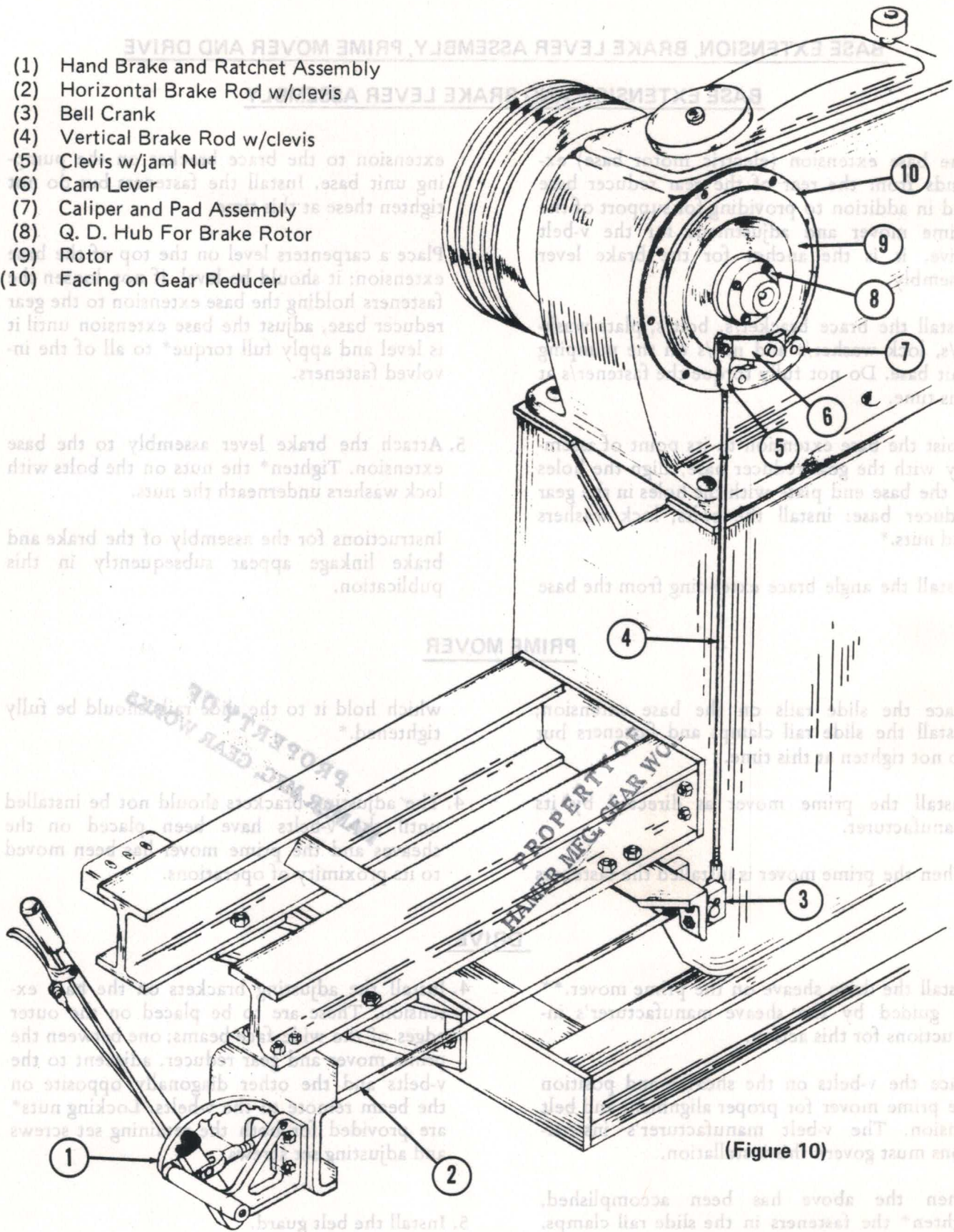
CAUTION: DO NOT ENERGIZE THE PRIME MOVER - REFER TO "LUBRICATION" AND "PLACING IN OPERATION" WHICH APPEAR SUBSEQUENTLY IN THIS PUBLICATION.

*Torquing values will be found in the APPENDIX of this publication.

**Inspect the belt guard: Some guards are of a design which requires the "belt guard back-plate" to be installed before the motor sheave and belts are installed.

INSTALLATION (Continued)

- (1) Hand Brake and Ratchet Assembly
- (2) Horizontal Brake Rod w/clevis
- (3) Bell Crank
- (4) Vertical Brake Rod w/clevis
- (5) Clevis w/jam Nut
- (6) Cam Lever
- (7) Caliper and Pad Assembly
- (8) Q. D. Hub For Brake Rotor
- (9) Rotor
- (10) Facing on Gear Reducer



(Figure 10)

The disc type brake is adjusted only at the Caliper and Pad Assembly. The hand lever and brake rods, when properly installed, place the cam lever of the caliper assembly in operating position with the caliper plungers retracted.

BRAKE ASSEMBLY

DISC TYPE BRAKE

1. Check the rotor hub, the caliper and pad assembly and the bell crank to be certain that the fasteners are properly torqued.*
2. Install the hand lever assembly and tighten* the fasteners in the mounting bracket. Move the hand lever forward (release position).
3. Install jam nuts on the horizontal and vertical brake rods.

Install clevises on one end of the horizontal brake rod and on one end of the vertical brake rod. Engage approximately 3/4-inch of threads with each clevis.

4. Install the free end of the horizontal brake rod in the clevis on the hand lever (engage approximately 3/4-inch of threads).

Place the clevis on the other end of the horizontal brake rod on the inboard (inside) arm of the bell crank. Install the clevis pin and cotter pin.

5. Install the free end of the vertical brake rod in the clevis on the cam lever of the caliper and pad assembly. Engage approximately 3/4-inch of threads).

Place the clevis on the other end of the vertical brake rod on the outboard (outside) arm of the bell crank. Install the clevis pin and cotter pin.

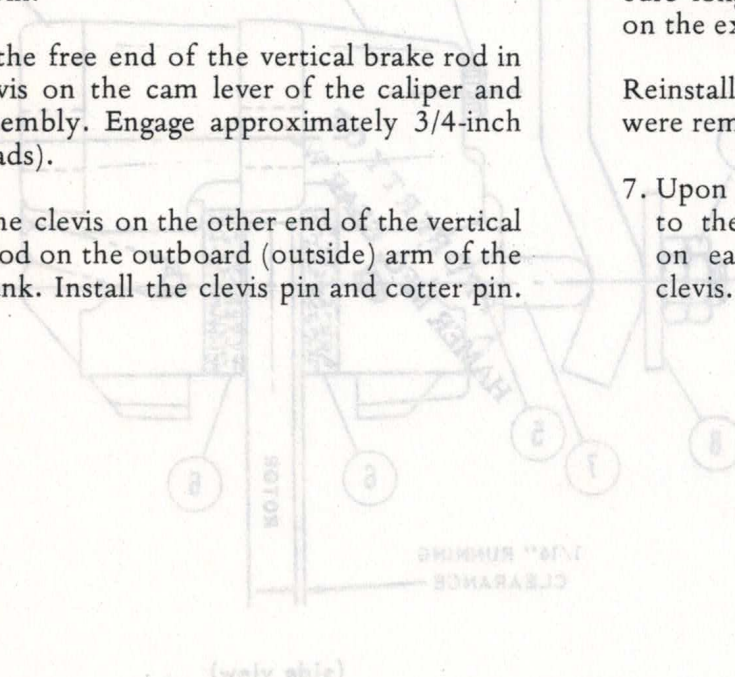
6. NOTICE: The foregoing installation should leave the clevis end of the cam lever of the caliper and pad assembly 90-degrees from a plain intersecting the centerline of the two plungers. This is the "off" position with the plungers retracted.

If the cam lever is not in the "off" position, remove the cotter pin and clevis pin from the bottom clevis on the vertical brake rod. Hold the cam lever in the "off" position; rotate the vertical brake rod in the upper clevis and rotate the clevis on the bottom of the brake rod until the hole through the yoke of the lower clevis is in alignment with the hole in the outside arm of the bell crank.

CAUTION: Retain at least 5/8-inch of rod thread in each clevis (both horizontal and vertical brake rods). If there is less than 5/8-inch engagement in the vertical rod assembly, adjust the horizontal brake rod by freeing its clevis at the bell crank. In extreme instances it may be necessary to secure longer brake rods or machine more threads on the existing brake rods.

Reinstall the clevis pins and cotter pins that were removed for this adjustment.

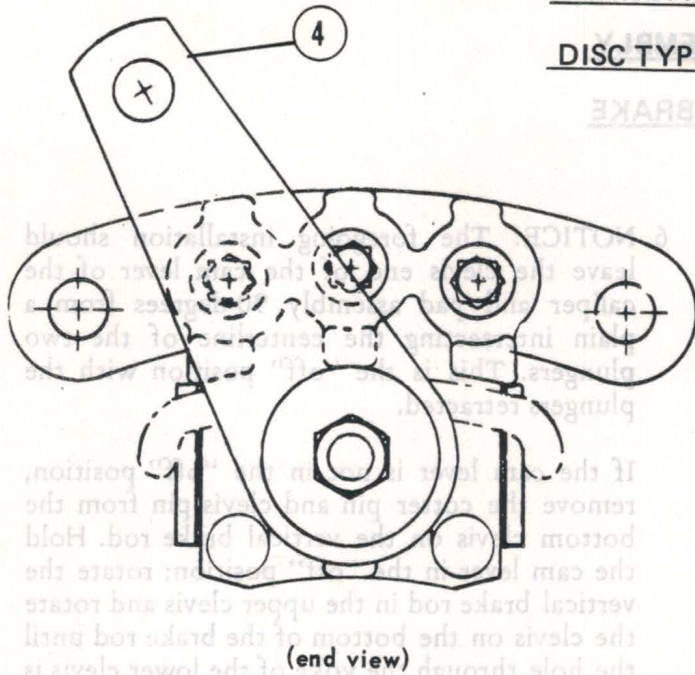
7. Upon completion of any and all adjustments to the brake rods, make certain the jam nut on each rod is locked against its respective clevis.



*Torquing values for fasteners will be found in the APPENDIX of this publication.

BRAKE ASSEMBLY

DISC TYPE BRAKE

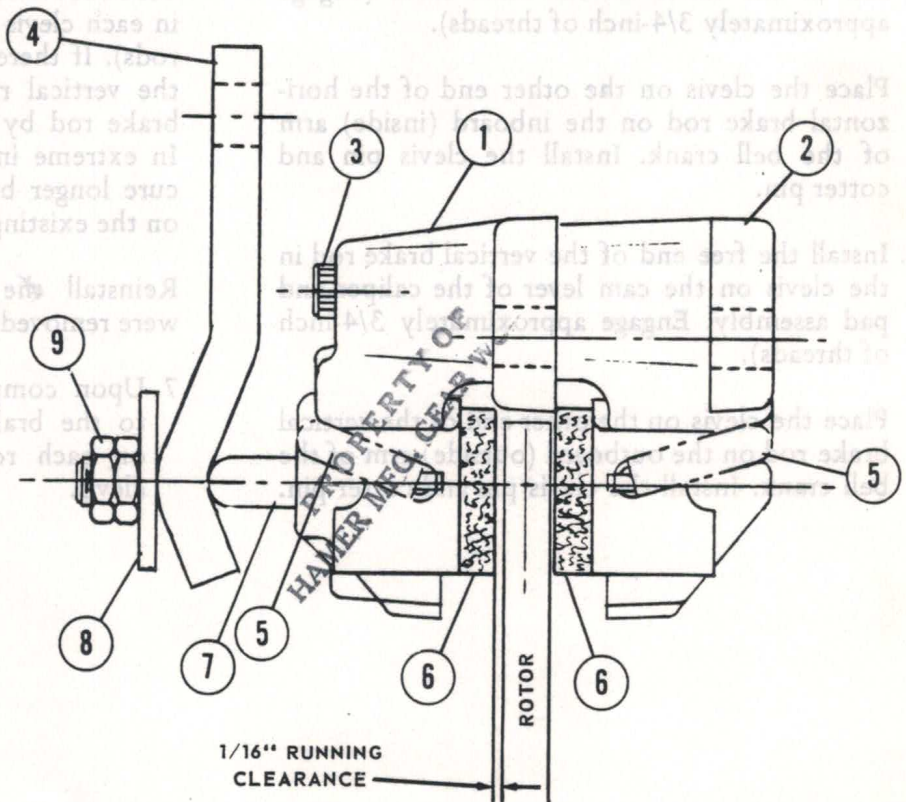


CALIPER AND PAD ASSEMBLY

(Figure 11)

1. Check the rotor, the caliper and pad assembly and the bell crank to be certain that the fasteners are properly torqued.
2. Install the hand lever assembly and tighten the fasteners in the mounting bracket. Move the hand lever forward (release position).
3. Install jam nuts on the horizontal and vertical brake rods.
4. Install the free end of the horizontal brake rod and on one end of the vertical brake rod. Engage approximately 3/4-inch of threads with each clevis.

- (1) Inner Body
- (2) Outer Body
- (3) Bolt
- (4) Cam Lever
- (5) S. S. Spring
- (6) Pad Assembly
- (7) Plunger
- (8) Washer
- (9) 1/2" Jam Nut



(side view)

The caliper and pad assembly is mounted on the side of the gear case, beneath the high speed shaft. A standard Q.D. sheave hub is keyed to the high speed shaft and the rotor is mounted on this hub.

DISC TYPE BRAKES

SUGGESTED MINIMUM MAINTENANCE

Many operators, because of improper maintenance or the absence of a maintenance program, often neglect the brakes on their pumping units. This can be dangerous and can be damaging to the equipment. Remove the guards and inspect the brake assembly completely at monthly intervals, test the brake each time it is inspected, make adjustments if they are necessary, use a dry lubricant on the clevis pins, hand lever pin, ratchet assembly, etc. Keep the rotor and brake pads free of lubricant and foreign material. Replace brake pads that are excessively worn or carbon glazed. Keep the rotor secured properly to its hub, replace the rotor if it is excessively worn or cracked. Keep guards securely in place and in colder climates additional protection may be desirable to protect the brake from ice. At all times the brake assembly must be capable of locking all elements against rotation with the crank counterweights at their angle of maximum gravitational force and without any polished rod load on the unit. Keep all fasteners tight* and provide additional maintenance as required by operators policies.

BRAKE ADJUSTMENT

NEW BRAKES

1. With brake rods installed as outlined on the previous page and the hand lever in the forward (released) position proceed to adjust the claiپر assembly.
2. Move the caliper and pad assembly outward from the gear reducer (the mounting arrangement provides for this horizontal movement).

With the inside brake pad against the inside of the rotor, check the clearance between the outside brake pad and the outside of the rotor. This clearance should be 1/16-inch.

3. If the clearance is more or less than 1/16"

inch, rotate the jam nut against the washer and cam lever to obtain this clearance.

4. Pull the hand lever outward to "set" the brake. Release the hand lever and observe the movement of the caliper and pad assembly, the rotor should now be in the center of the two pads. In some instances it may be necessary to reposition the rotor on the shaft to keep it free of contact with the pads when the brake is released.
5. Replace all guards and test the brake as outlined above in suggested maintenance.

BRAKE ADJUSTMENT

WORN BRAKES

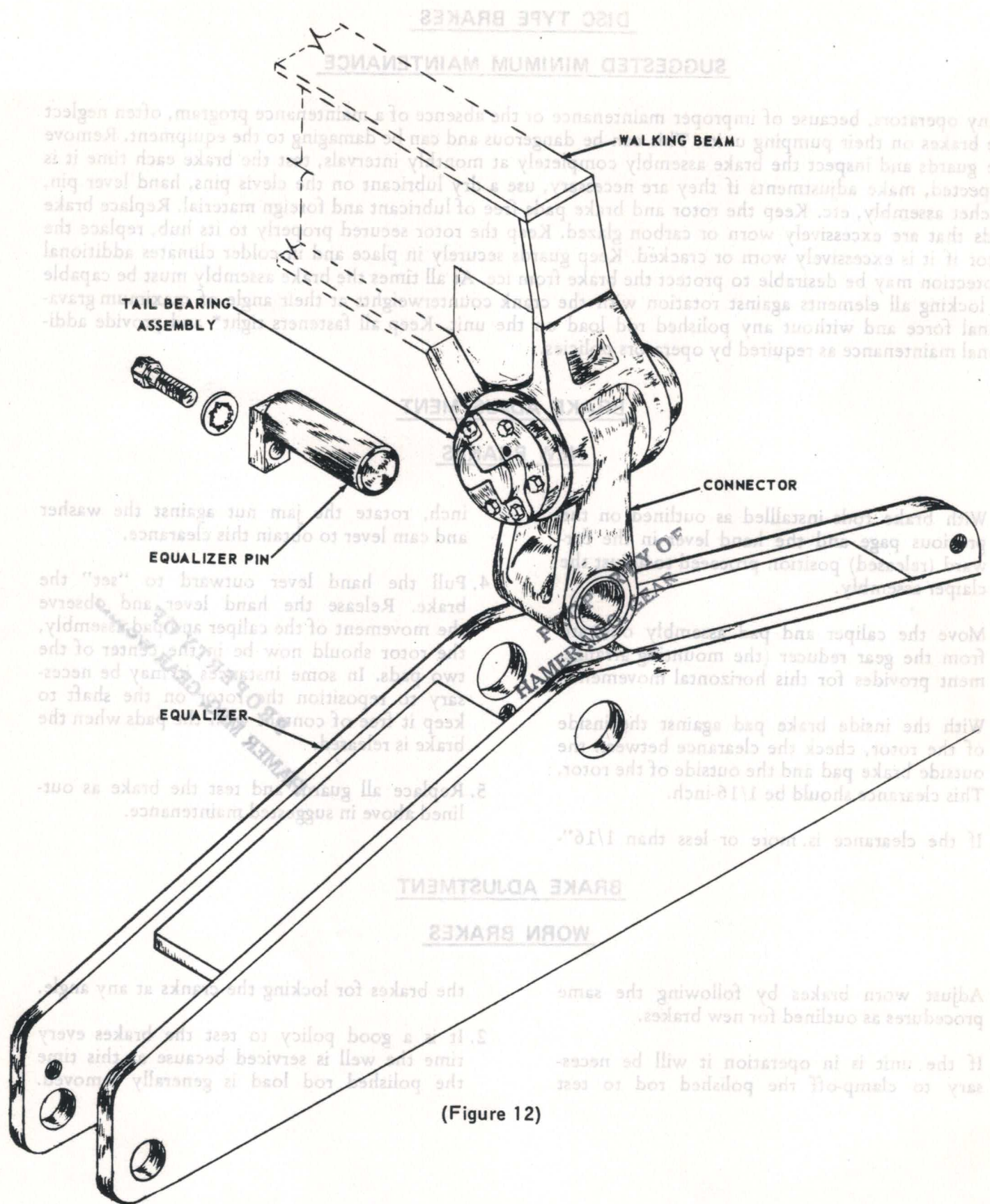
1. Adjust worn brakes by following the same procedures as outlined for new brakes.

If the unit is in operation it will be necessary to clamp-off the polished rod to test

the brakes for locking the cranks at any angle.

2. It is a good policy to test the brakes every time the well is serviced because at this time the polished rod load is generally removed.

*Torquing values for fasteners will be found in the APPENDIX of this publication.

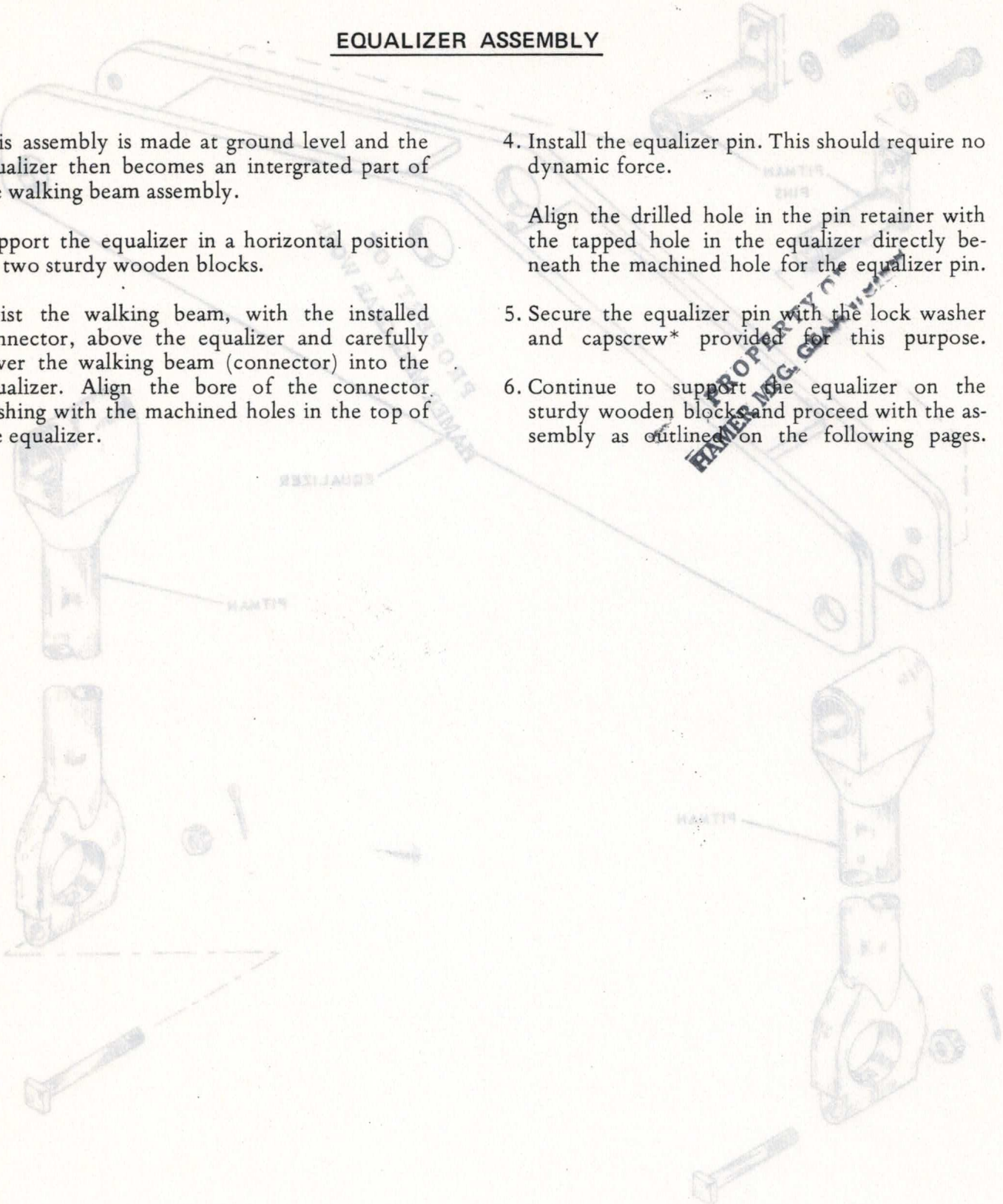


(Figure 12)

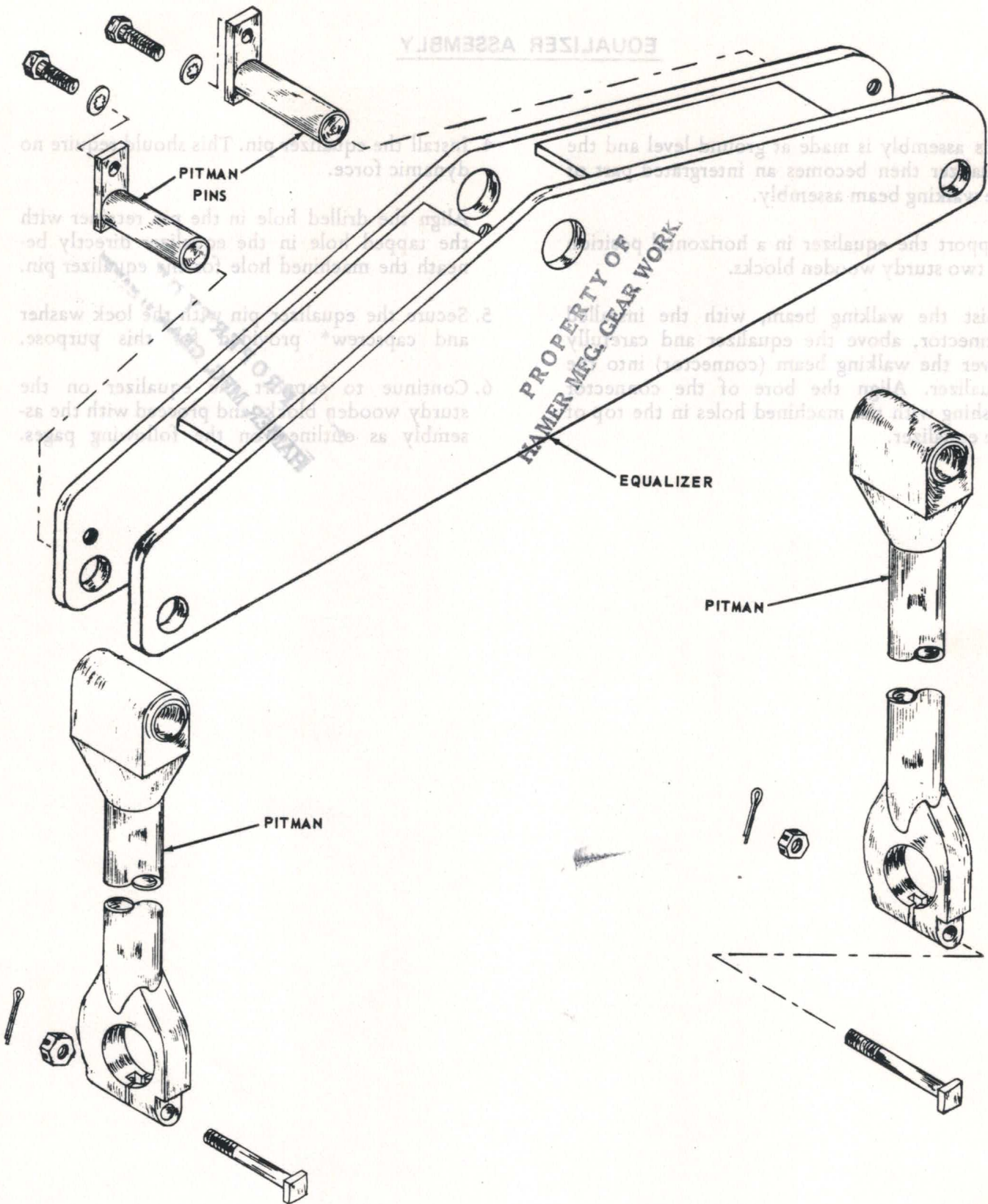
Attaching the equalizer to the walking beam. The connector is assembled on the walking beam prior to the shipment of the unit.

EQUALIZER ASSEMBLY

1. This assembly is made at ground level and the equalizer then becomes an intergrated part of the walking beam assembly.
2. Support the equalizer in a horizontal position on two sturdy wooden blocks.
3. Hoist the walking beam, with the installed connector, above the equalizer and carefully lower the walking beam (connector) into the equalizer. Align the bore of the connector, bushing with the machined holes in the top of the equalizer.
4. Install the equalizer pin. This should require no dynamic force.
Align the drilled hole in the pin retainer with the tapped hole in the equalizer directly beneath the machined hole for the equalizer pin.
5. Secure the equalizer pin with the lock washer and capscrew* provided for this purpose.
6. Continue to support the equalizer on the sturdy wooden blocks and proceed with the assembly as outlined on the following pages.



*Torquing values for fasteners will be found in the APPENDIX of this publication.



(Figure 13)

Installing the pitmans on the equalizer.

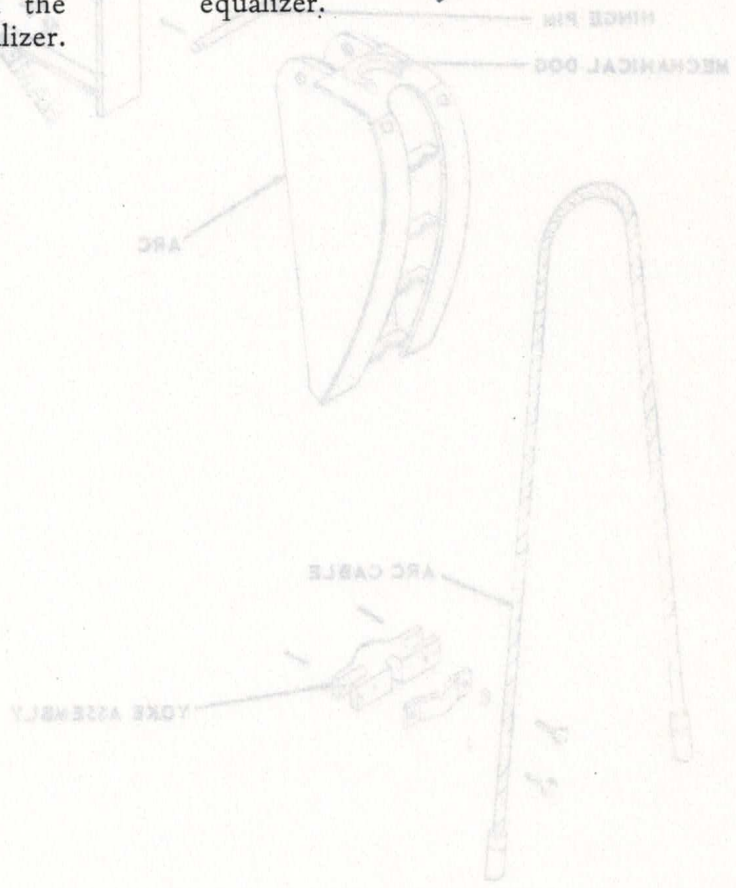
PITMAN/EQUALIZER ASSEMBLY

1. With the walking beam assembled to the equalizer and the equalizer safely supported on two sturdy wooden blocks, the pitmans can now join the assembly.
2. Move one of the pitmans to the proximity of the equalizer; place the upper pitman housing with its installed bushing adjacent to one end of the equalizer and align the longitudinal axis of the pitman with the longitudinal axis of the equalizer.
3. Elevate the upper pitman housing and align the bore of the pitman pin bushing with the machined holes in the end of the equalizer.

4. Install one of the pitman pins with the drilled hole in the retainer aligned with the threaded hole in the equalizer.

The installation of the pitman pins should require no dynamic force.

5. Secure the installation of the pitman pin with the lock washer and capscrew* provided for that purpose.
6. Observe the foregoing instructions to install the other pitman on the opposite end of the equalizer.



(Figure 14)

Installation of the arc, arc cable and yoke on the walking beam.

*Torquing values for fasteners will be found in the APPENDIX of this publication.

PITMAN/EQUALIZER ASSEMBLY

4. Install one of the pitman pins with the drilled hole in the retainer aligned with the threaded hole in the equalizer.

The installation of the pitman pins should require no dynamic force.

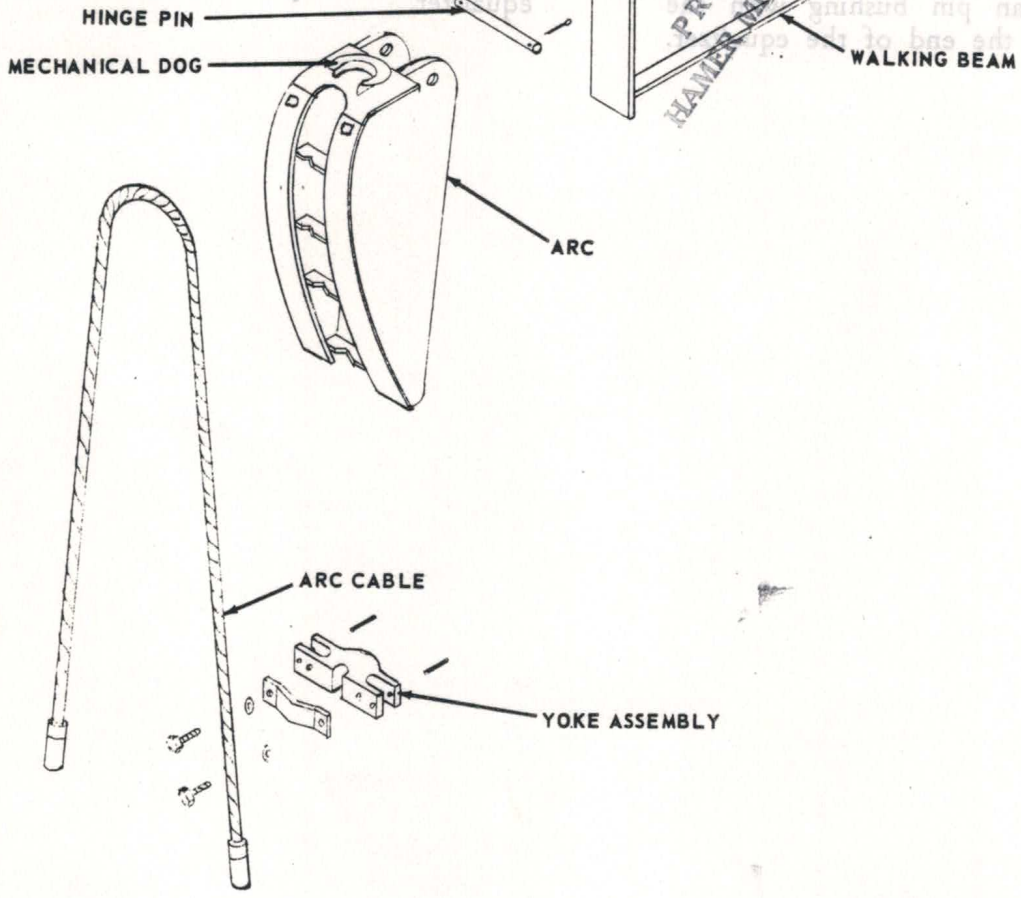
5. Secure the installation of the pitman pin with the lock washer and cap screw provided for that purpose.

6. Observe the foregoing instructions to install the other pitman the opposite end of the equalizer.

1. With the walking beam assembled to the equalizer and the equalizer safely supported on two sturdy wooden blocks, the pitman can now join the assembly.

2. Move one of the pitman pins to the proximity of the equalizer; place the upper pitman housing with its installed bushing adjacent to one end of the equalizer and align the longitudinal axis of the pitman with the longitudinal axis of the equalizer.

3. Elevate the upper pitman housing until the bore of the pitman pin bushing is aligned with the machined holes in the end of the equalizer.



(Figure 14)

Installation of the arc, arc cable and yoke on the walking beam.

*Torque values for fasteners will be found in the APPENDIX of this publication.

ARC, ARC CABLE AND YOKE

1. Elevate the end of the walking beam opposite the installed equalizer and pitman assemblies. Support the beam on sturdy wooden blocks.
2. Hoist the arc into position, align the drilled holes in the top of the arc with the holes in the mounting bracket on top of the walking beam, install the hinge pin and secure the hinge pin with the cotter pins provided for that purpose.

Release the hoisting line.

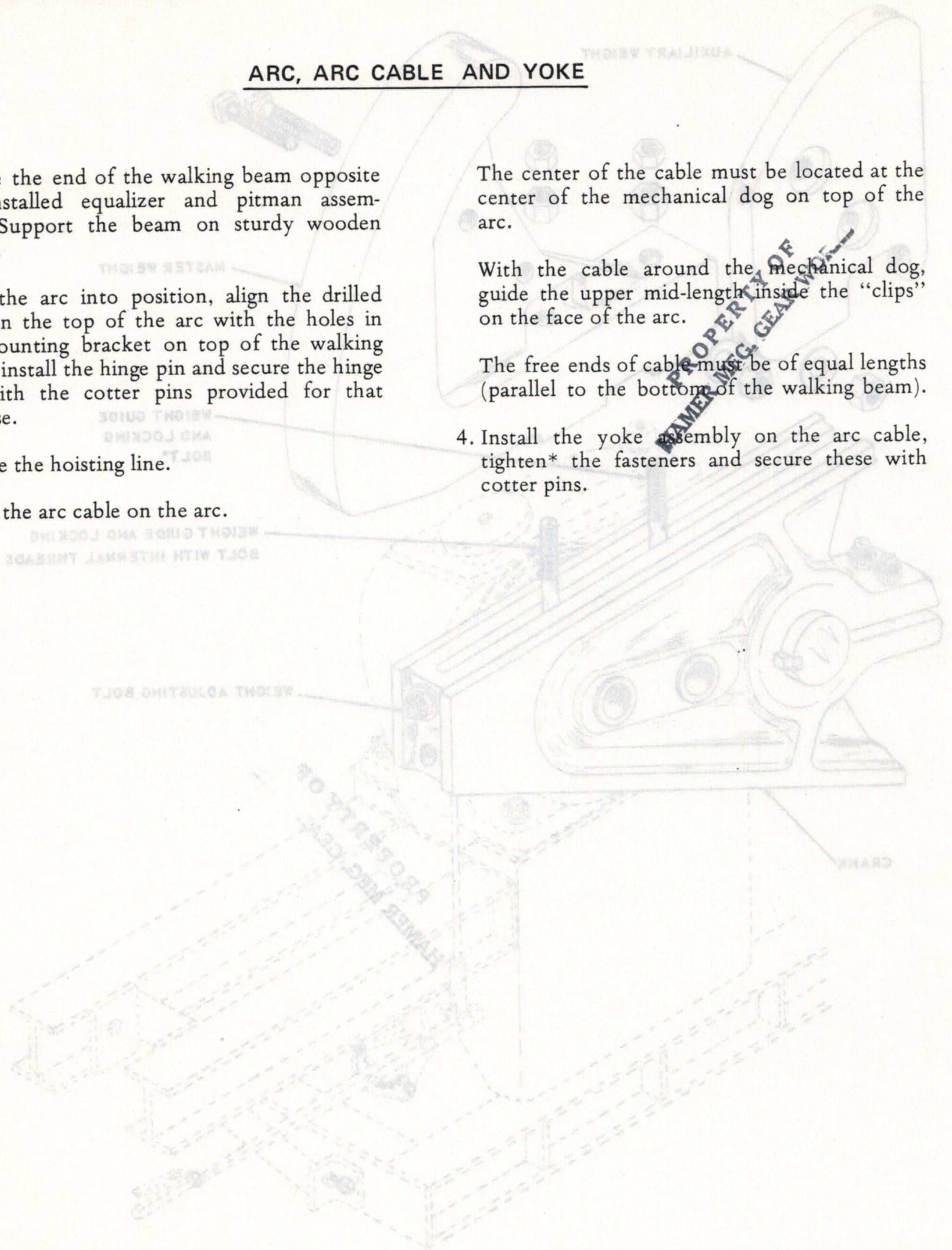
3. Install the arc cable on the arc.

The center of the cable must be located at the center of the mechanical dog on top of the arc.

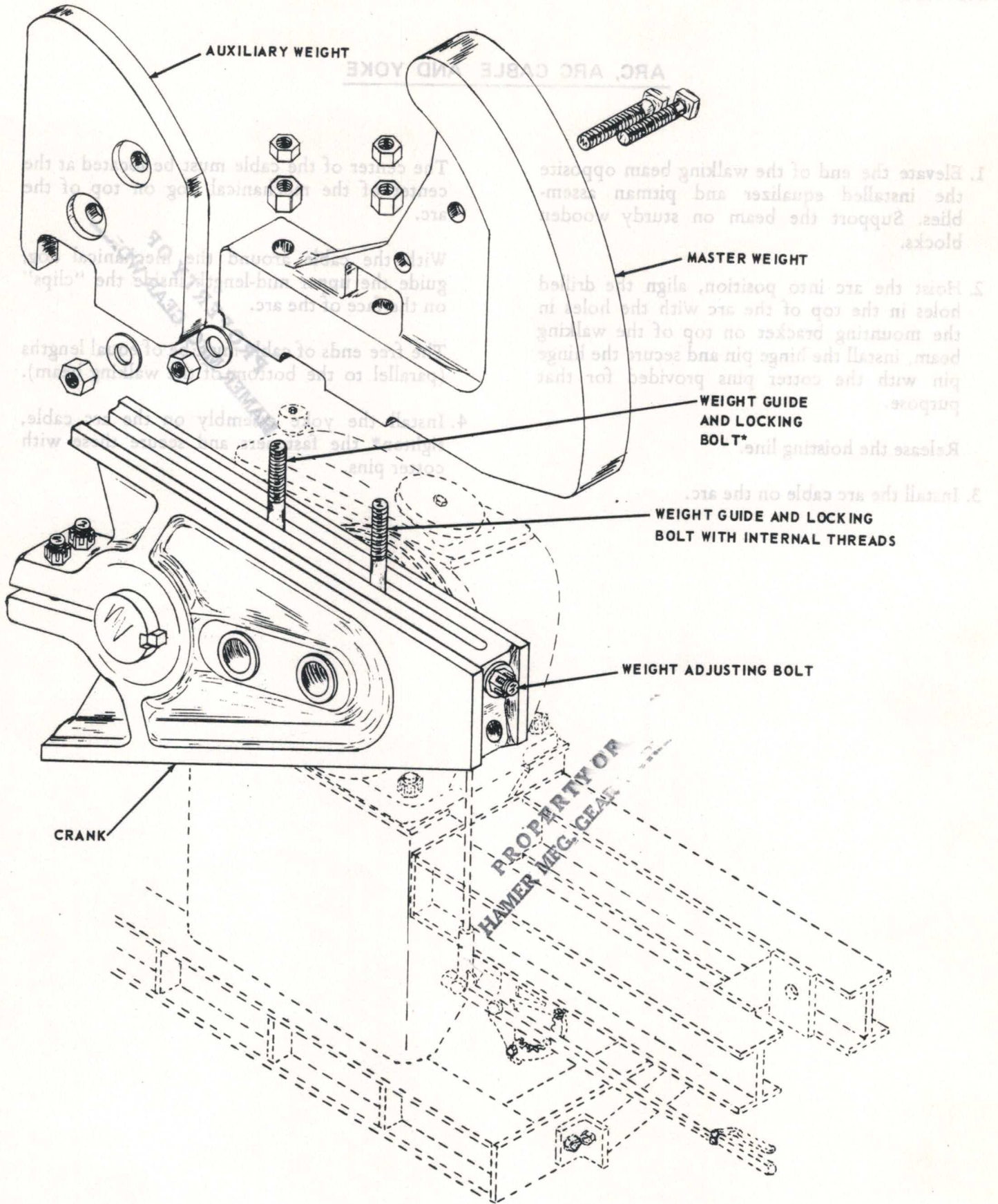
With the cable around the mechanical dog, guide the upper mid-length inside the "clips" on the face of the arc.

The free ends of cable must be of equal lengths (parallel to the bottom of the walking beam).

4. Install the yoke assembly on the arc cable, tighten* the fasteners and secure these with cotter pins.



*Torquing values for fasteners will be found in the APPENDIX of this publication.



(Figure 15)

Installation of counterweights on pumping unit crank.

*The quantity of weight guide and locking bolts increases on larger units.

COUNTERWEIGHT INSTALLATION

1. When the pumping unit was selected calculations should have been made to determine the counterbalance effect required for this specific application.

When the required counterbalance effect is known it can be applied to counterbalance effect charts prepared for the OILWELL pumping units; the charts will indicate:

- a. The size of counterweights
- b. Quantity of counterweights
- c. Location of counterweights

The size of the counterweights and the quantities of each should appear on the purchase request and should be indicated on the bill-of-lading which accompanied the shipment of the pumping unit.

The location of the counterweights on the cranks, if not immediately available, can be determined by the manufacturer's representative using the counterbalance effect charts in the OILWELL Pumping Unit Selection and Application Manual and the counterbalance effect calculations of the client.

The position of the counterweights on the cranks can, of course, be determined by "trial and error" after the unit has been placed in operation. This generally is a needless delay in the installation of the pumping unit.

2. Under certain conditions a pumping unit can be operated without counterweights because the cranks provide some counterbalance effect, however, this would be an exceptional application of equipment and the unit would probably be "over-sized" or would be grossly out of balance.
3. It is recommended that an equal mass of counterweight be applied to each side of both cranks and that each mass be located equal distance from the center of the crankshaft.

Should it be necessary to install only two auxiliary weights; place them on opposite sides of the gear reducer, one on a "leading" master weight and the other on a "trailing" master weight.

If six auxiliary weights are required, two of them should be placed as suggested in the foregoing paragraph.

4. To install the master weights secure a hoisting line to the end of one of the cranks and elevate the end of the crank until the surface on one side, which mates with the master weight, is in a horizontal position. Do not use the prime mover to position the crank/s unless the gear reducer has been lubricated.

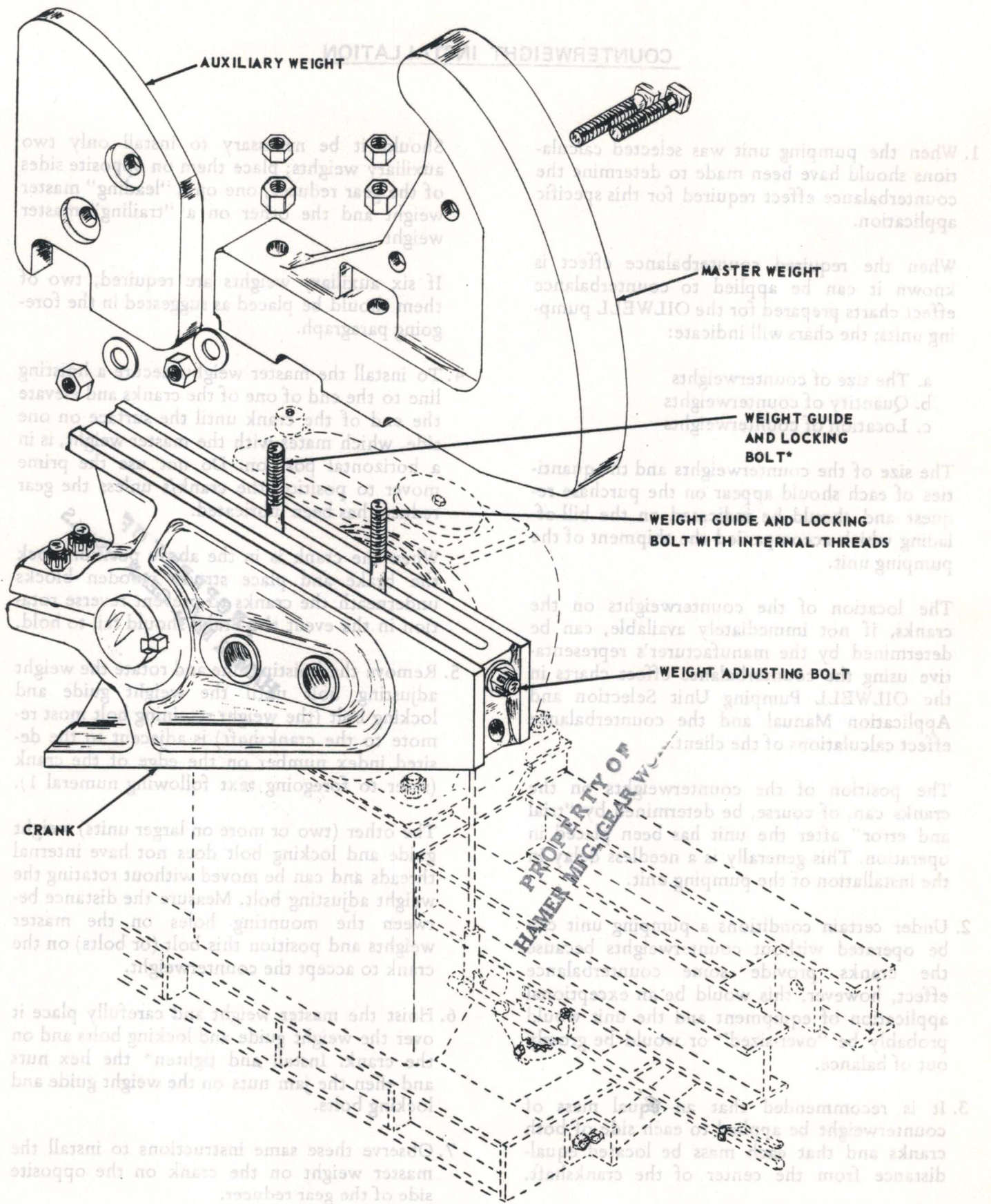
When the crank is in the above position, lock the brake and place sturdy wooden blocks underneath the cranks to prevent reverse rotation in the event the brake should fail to hold.

5. Remove the hoisting line and rotate the weight adjusting bolt until the weight guide and locking bolt (the weight retaining bolt most remote to the crankshaft) is adjacent to the desired index number on the edge of the crank (refer to foregoing text following numeral 1).

The other (two or more on larger units) weight guide and locking bolt does not have internal threads and can be moved without rotating the weight adjusting bolt. Measure the distance between the mounting holes on the master weights and position this bolt (or bolts) on the crank to accept the counterweight.

6. Hoist the master weight and carefully place it over the weight guide and locking bolts and on the crank. Install and tighten* the hex nuts and then the jam nuts on the weight guide and locking bolts.
7. Observe these same instructions to install the master weight on the crank on the opposite side of the gear reducer.

*Torquing values for fasteners will be found in the APPENDIX of this publication.



(Figure 16)

Installation of counterweights on pumping unit crank.

*The quantity of weight guide and locking bolts increases on larger units.

COUNTERWEIGHT INSTALLATION (Continued)

8. Attach a hoisting line to the crank, remove all slack from the line, release the brake, elevate the end of the crank and remove the wooden blocks from underneath the crank.

Slowly relax the hoisting line and allow the crank to rotate to a static position.

9. Reposition the hoisting line to rotate the crank until the other surface which mates with the master weights is in a horizontal position.

Lock the brake and place sturdy wooden blocks underneath the crank or installed master weights to prevent reverse rotation in the event the brake fails to hold.

10. Observe the foregoing instructions to install the other master weights.
11. Observe the foregoing instructions to allow the crank/s to rotate to a static position.
12. Remove the hoisting line.
13. Lock the brake.
14. The auxiliary weights can now be installed.

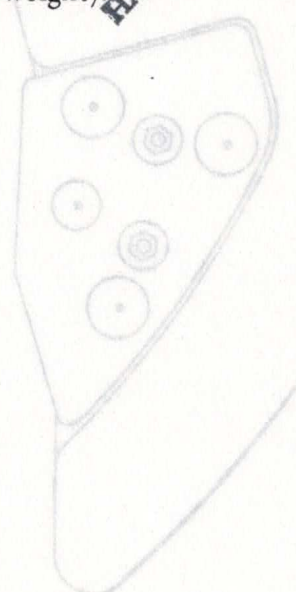
If two weights are to be installed, locate them in the outer "pockets" of one "leading" weight and one "trailing" weight on opposite sides of the gear reducer.

If four weights are to be installed, locate one in the outer "pocket" of each master weight.

If six weights are to be installed, locate four of them as outlined above and place the additional two in the inside "pockets." One each in a "leading" weight and "trailing" weight on opposite sides of the gear reducer.

If eight weights are to be installed, locate them, one each, in the outer "pockets" and inner "pockets" of the four master weights.

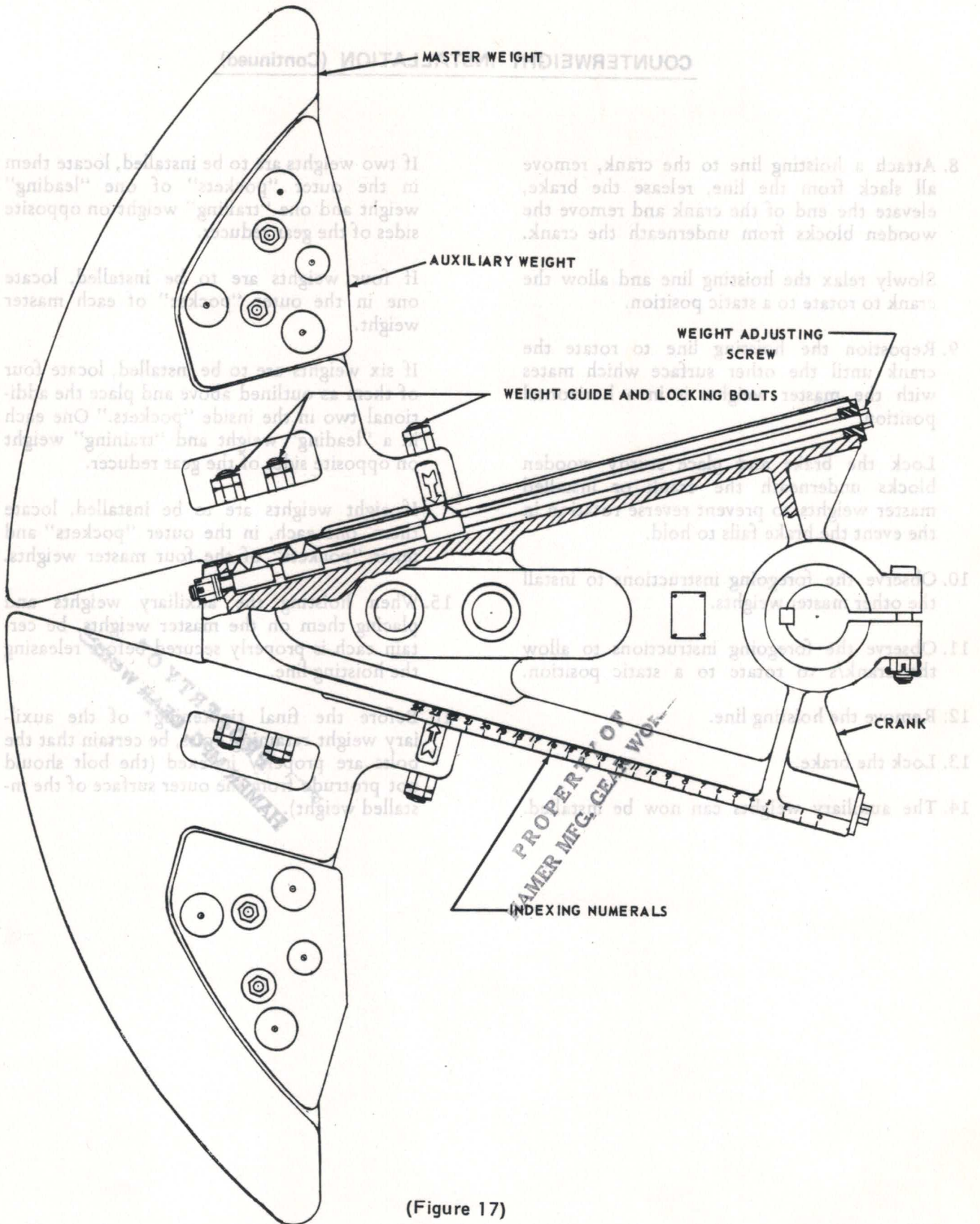
15. When hoisting the auxiliary weights and placing them on the master weights, be certain each is properly secured before releasing the hoisting line.
16. Before the final tightening* of the auxiliary weight retaining bolts, be certain that the bolts are properly indexed (the bolt should not protrude from the outer surface of the installed weight).



*Torquing values for fasteners will be found in the APPENDIX of this publication.

COUNTERWEIGHT ADJUSTMENT

INSTALLATION (Continued)



(Figure 17)

The design of the cranks and counterweights permits a wide range of adjustment with almost a limitless number of counterbalance effect values.

COUNTERWEIGHT ADJUSTMENT

Optimum counterbalance effect is achieved when the input horsepower required on the "up stroke" is equal to the input horsepower required on the "down stroke" with the unit subjected to operational loading. Dynagraph analysis of the pumping cycle is probably the most accurate means of determining counterweight adjustments; however, an ammeter may be used on electric motors to determine the power requirements during the pumping cycle and the counterweights adjusted to balance the power input on the "up stroke" with the power input on the "down stroke". A recording tachometer can be used for this purpose when a reciprocating engine is used as a prime mover.

The following is a guide for the adjustment of the installed counterweights.

1. De-energize the unit and lock the brake with the cranks in a horizontal position. Place sturdy wooden blocks beneath the lower counterweights to guard against gravitational rotation of the cranks should the brake fail to hold.
2. If the counterweights are to be moved outward from the crank shaft (to provide greater counterbalance effect) prepare to adjust the counterweight on the top side of the crank.

If the counterweights are to be moved inward toward the crank shaft (to provide for less counterbalance effect) prepare to adjust the counterweight on the bottom side of the crank.

Both of the crank counterweights can be adjusted with the crank in this position; however, it requires less force to move a counterweight down a decline of approximately 15-degrees than it does to move it up an incline of the same angle.

3. Loosen but do not remove the jam nuts and retaining nuts on the weight guide and locking bolts on the counterweight which is to be adjusted.

Place a heavy duty socket on the head of the weight adjusting screw and with a ratchet drive rotate the screw to move the counterweight to the desired position (five revolutions of the screw will move the weight one-inch).

Tighten* the nuts on the weight guide and locking bolts and secure these with the jam nuts.

4. Be guided by the foregoing instructions to adjust the counterweight of corresponding location on the opposite side of the gear reducer.**

5. Remove the wooden blocks from beneath the counterweights, release the brake and rotate the crank 180-degrees (horizontally opposite from previous position).

Lock the brake and replace the wooden blocks.

6. Observe the foregoing instructions to adjust the two counterweights which were not previously repositioned.

7. Be certain the weight guide and locking bolts are properly secured and remove the wooden blocks.

The unit is now ready to be returned to service.

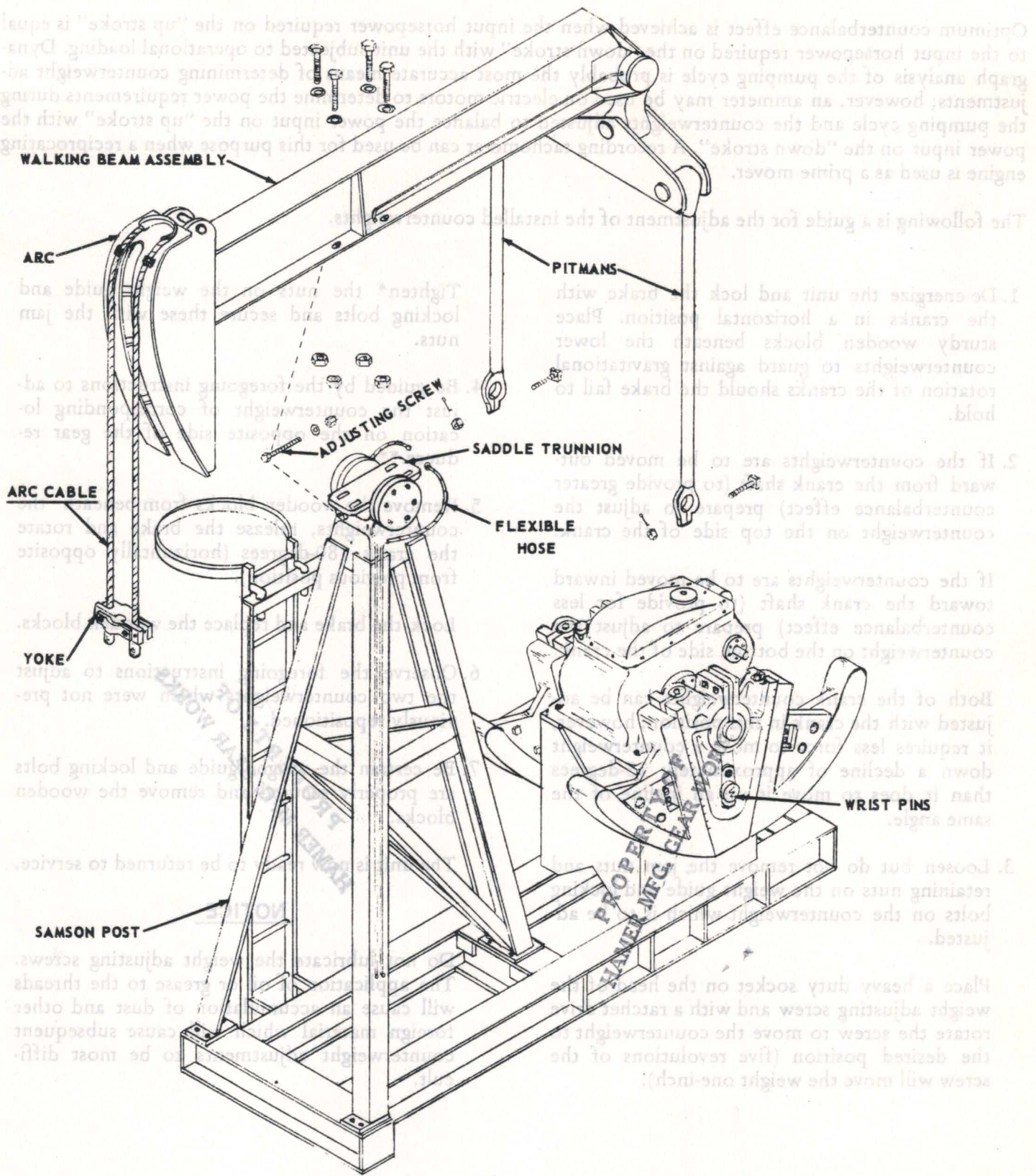
NOTICE

Do not lubricate the weight adjusting screws. The application of oil or grease to the threads will cause an accumulation of dust and other foreign material which will cause subsequent counterweight adjustments to be most difficult.

*Torquing values for fasteners will be found in the APPENDIX of this publication.

**All weights must be equal-distance from the center of the crankshaft. There are positioning "arrows" on the master weights and indexing numbers on the cranks to facilitate adjustment.

COUNTERWEIGHT ADJUSTMENT



(Figure 18)

Mounting the walking beam assembly on the samson post, attaching the pitmans and aligning the walking beam (arc) with the well head.

WALKING BEAM WITH ARC, ARC CABLE, EQUALIZER AND PITMANS

1. The walking beam, having been assembled with the arc, arc cable, equalizer and pitmans, is ready to be mounted on the samson post.

Using choker type slings attached to a hoisting line (or hoisting lines as required to safely support the working load), elevate the walking beam assembly a few inches to determine if it can be lifted in a balanced position that is parallel to the pumping unit base and with the "eyes" in the lower part of the pitmans on a horizontal axis.

If the slings are not at the balance points, lower the assembly to the support blocks and adjust the slings. Repeat the foregoing until "balanced" lifting is assured.

2. Carefully hoist the assembly to a position immediately above the samson post. CAUTION: The pitmans must be restrained during the hoisting operation to prevent them from being damaged and to position them on each side of the gear reducer (attach tailing ropes).
3. Lower the assembly to a point of near contact with the saddle "trunnion" on top of the samson post. Align the drilled holes in the bottom of the walking beam flange with the slotted holes in the trunnion. Install the fasteners but do not tighten the nuts.

Move the walking beam assembly toward the well head as far as is permitted by the slots in the trunnion.

4. Install the walking beam adjusting screw. This is placed through the drilled hole in the lug welded to the bottom of the walking beam, fitted with a lock washer and nut then threaded into the tapped hole in the lower front edge of the trunnion. Do not tighten the screw at this time.
5. Lower the walking beam assembly to a position of full contact with the trunnion and tighten* the fasteners. DO NOT RELAX THE HOISTING LINE.
6. Install the high pressure flexible hoses on both

sides of the walking beam. These are a part of the lubrication lines which extend from the legs of the samson post to the tail bearing assemblies.

7. Use the tailing ropes to pull the pitman "eyes" away from their suspended position above the counterbalance cranks.

Slowly unreel the hoisting line/s to lower the equalizer end of the walking beam until the "eyes" of the pitmans are in alignment with the wrist pins installed in the counterbalance cranks.

Relax the tailing ropes, rotate the wrist pin bearing housings to index with the "eyes" of the pitmans (grease fitting at the top and bolt channel at the bottom) and slip the "eyes" of the pitmans onto the wrist pin bearing housings.

Install the pitman bolts, tight* the nuts and install the cotter pins.

8. Remove the tailing ropes, hoisting line/s and slings.
9. Align the walking beam (arc) with the polished rod or tubing. A chalk line or similar line with plumb bob attached is required for this procedure.

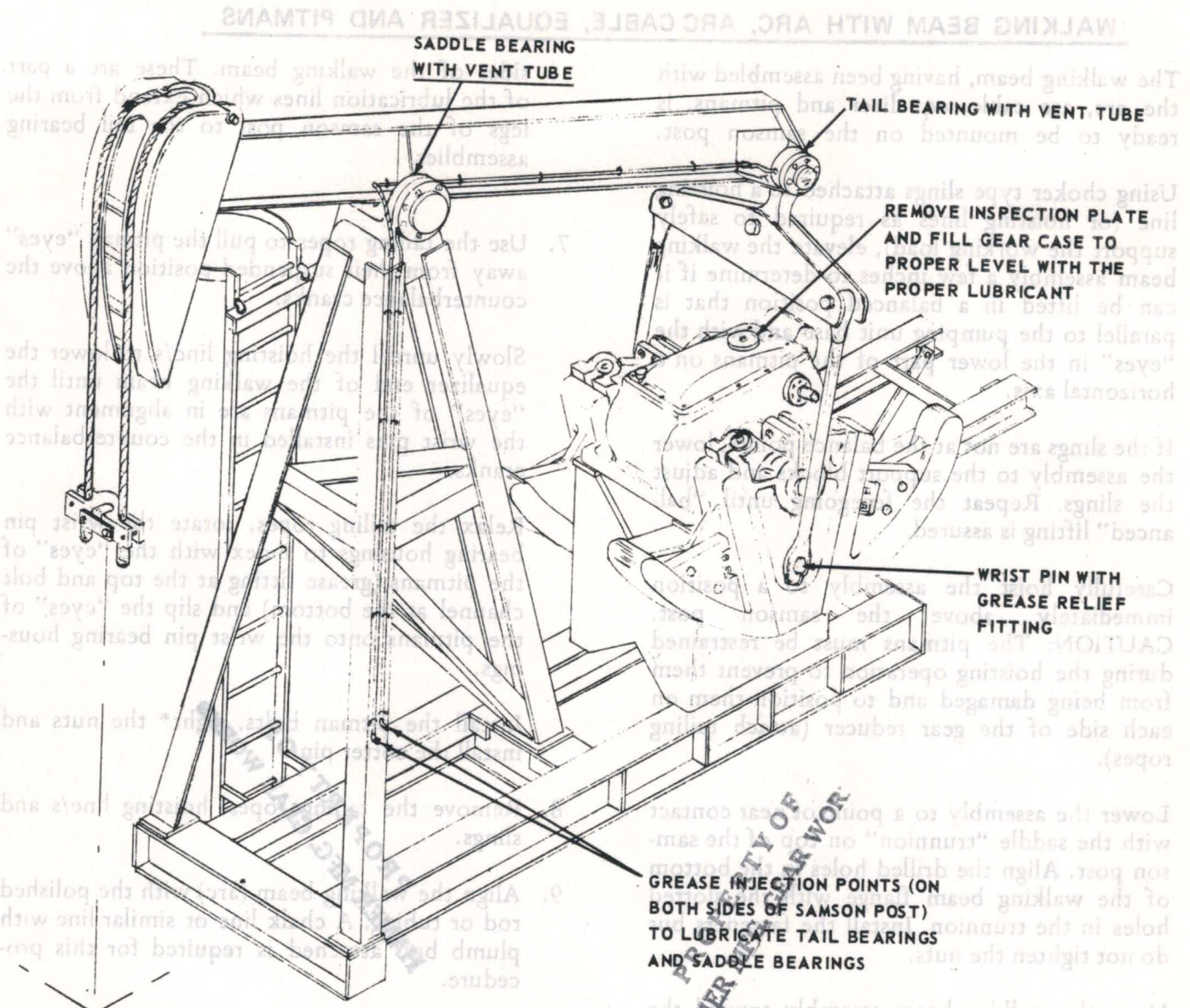
Suspend the plumb bob from the center of the arc (the arc is center-marked for this purpose) and note the location of the plumb bob in relation to the top of the polished rod or the center of the tubing. Previous instructions required the alignment of the pumping unit base and the well head; the plumb bob should point to this axis and a short distance beyond the intersecting axis at the polished rod or tubing. Adjust the walking beam (refer to paragraphs 3 and 4) to center the plumb bob above the polished rod or tubing.

10. Tighten* the walking beam/trunnion fasteners and the nut on the adjusting screw.
11. Remove the plumb bob.

*Torquing values for fasteners will be found in the APPENDIX of this publication.

LUBRICATION

INSTALLATION (Continued)



(Figure 19)

When filling the gear case direct some of the lubricant into the troughs adjacent to the bearing locations inside the gear case.

When injecting grease be certain that the grease fittings are clean and the relief fittings and/or vent tubes are open. Restricted relief can cause excessive pressures and damage grease seals. After the initial filling of the grease reservoirs only a small amount of lubricant should be required to maintain the reservoir. Grease should be added until some small amount is discharged from the relief fitting or vent tube.

When changing the lubricant in the gear reducer, completely drain the gear case, flush with mineral oil or non-detergent motor oil and refill with recommended lubricant. If the used lubricant is more than mildly contaminated remove the gear case cover and thoroughly clean the interior of the case, the troughs, passage-ways, etc., then flush and refill.

LUBRICATION

GEAR LUBRICANT

The loading and operating conditions of these units dictate that an EXTREME PRESSURE, HEAVY DUTY, INDUSTRIAL GEAR LUBRICANT should be introduced into the lubrication system and distributed to the moving parts. This lubricant must qualify under AGMA (American Gear Manufacturers Association) specification 250.03 (May 1972) and have a Timken Load Arm Test with the results being O. K., at not less than 60 pounds (27.2 kg). The pour point of the selected lubricant should be 15° F., (-9° C.) below the starting ambient temperature.

SEMI-SOLID LUBRICANT

The general recommendation is for NLGI GRADE 2 LITHIUM BASE, EXTREME PRESSURE, HIGH TEMPERATURE GREASE having a dropping point of not less than 350° F., when subjected to A.S.T.M. test method D-566. In cold environments it may be necessary to use grade 000, 00, 0 or 1 for proper lubrication. Secure recommendations from lubricant manufacturers.

OPERATING TEMPERATURE

In certain areas it is desirable to have a "summer lubricant" and a "winter lubricant". A lubricant which is suitable when the average ambient temperature is above 15° F., will not provide proper lubrication when the season changes and operations continue with a temperature of -30° F., and a wind velocity of 40 miles-per-hour resulting in a chill index of -101° F.

VISCOSITY RECOMMENDATIONS

AMBIENT TEMPERATURE

(deg. F.)	(deg. C.)
0 to +40	-17.8 to +4.0
-20 to +45	-28.9 to +4.9
+15 to +60	+9.4 to +15.6
+50 to +125	+10.0 to +33.9

LUBRICANT

Automatic Transmission Fluid
 AGMA No. 3-EP
 AGMA No. 4-EP
 AGMA No. 5-EP

Gearcase - Capacity & Minimum Speeds

<u>Reduction Gear</u>			<u>† Minimum rpm for Adequate Lubrication</u>	
<u>A.P.I. Size</u>	<u>Model No.</u>	<u>Capacity U. S. Gals.</u>	<u>Clockwise Rotation*</u>	<u>Counter Clockwise Rotation*</u>
80	D-80B	11	3½	6¼
114	D-114B	12	3½	7
160	D-160A	20	3	6
228	D-228A	28	4½	7½
320	D-320B	23	2½	6½
456	D-456	38	2	4

*Viewing with the low speed shaft on right hand side and with well head to the right.

†NOTE: These minimum lubricating speeds were obtained by using SAE 50 motor oil at room temperature.

SERVICE PERIODS

Change lubricant in gear reducer every six-months. If the lubricant is contaminated, change it immediately - do not wait until the end of the service period. Foreign material in the lubricant causes rapid gear wear and the destruction of bearings.

Lubricate the saddle and tail bearings once each month. Lubricate the wrist pin bearings once a year. NOTE: If the seals are leaking, the bearings must be lubricated more frequently until seals are replaced.

(Rev. 9.8.77)

PLACING THE UNIT IN OPERATION

It is assumed at this point that the unit has been properly installed, the foundation has "cured", the unit is level, aligned with well head, etc. Be certain of the foregoing and the following before energizing the prime mover or attaching the yoke to the polished rod. Check (✓) each point before placing the unit in operation.

- () Remove all tools, chains, slings, etc., from the unit.
- () V-belt drive must be properly aligned, tensioned and secured.
- () Clean the interior of the gear case - remove any/all foreign material.
- () Gear Reducer must be filled to operating level with proper lubricant.
- () Wrist pins, tail bearings and saddle bearings must be properly lubricated.**
- () Brake must be operable for full release and locking.
- () All fasteners must be properly secured.*
- () There must be no interference with crank/counterweight rotation.
- () The guard for belts and sheaves must be in proper place and secured.
- () The guards for crank/counterweights must be in proper place and secured.
- ()
- ()

With the above having been satisfied the yoke can be attached to the polished rod and the unit placed in operation by observing the following:

1. Lock the brake.
2. Remove the retaining plate from the front of the yoke and place the yoke on the polished rod. Replace* the retaining plate. CAUTION: The ends of the arc cable must be even - the yoke must be level.
3. With the rod spacing having been previously determined, elevate the polished rod to the top of the pump stroke. Install two polished rod clamps on the polished rod immediately above the yoke. There should be no space between the clamps and between the clamps and the yoke. Tighten* the clamps.
4. Carefully lower the rod string until the weight of the rods is transferred from the rod elevator to the polished rod yoke.

Remove the rod elevator.
5. Remove the polished rod clamp (if such was installed) from the polished rod immediately above the stuffing box.
6. Lubricate the polished rod stuffing box.
7. Initial operation should be for one revolution of the cranks and several intermittent periods of operation consisting of approximately five

revolutions each. This is to be sure that everything is in proper working order, the gear reducer is lubricating properly, the bottom hole pump is correctly spaced, etc. To accomplish this, observe the following:

Release the brake.

For electric motor prime movers, push the "start" button on the control panel. If the unit is heavily counterweighted or if a normal torque motor is installed, push the "stop" button after one-second of energy flow; allow the cranks to "swing" backward as far as possible and when the cranks reverse their direction of travel, again push the "start" button. It may take more than one application of this sequence starting to move the crank/counterweights past top-dead-center; however, by taking advantage of the available kinetic energy less electro/mechanical energy will be required for the initial revolution and less torque will be required at the crankshaft.

When a reciprocating engine is used for the prime mover the engagement and disengagement of the clutch, in the same sequence as the operations of the "start" and "stop" buttons, will have the same effect as far as the initial revolution is concerned.

*Torquing values for fasteners will be found in the APPENDIX of this publication.

**Separate the grease lines at the saddle and tail bearings and fill lines with grease and reconnect. Grease should then be added until a small amount of grease is discharged from the relief fittings.

SUSTAINING OPERATIONS

When a pumping unit is first placed in operation it generally is not fully loaded and not properly counterbalanced. As the fluid level rises inside the tubing (or casing when casing pumps are used) the polished rod load increases and the counterbalance attains its maximum effectiveness. The required counterbalance effect is usually precalculated but because of unknown well conditions it is seldom as precise or exacting as can be obtained under actual operating conditions. Also, as the weight of the fluid column increases, the sucker rods stretch and it is frequently necessary to respace the bottom-hole pump by repositioning the polished rod in the polished rod yoke or by adding/removing pony rods to/from the sucker rod string.

It is most advisable to attend the unit until the produced fluid is discharged into the flow line or storage vessels and during this interval be guided by the following: **CAUTION:** Always stop the unit and lock the brake before making any adjustments on the equipment. Always release the brake before starting the unit.

1. Remove the inspection plate from the top of the gear reducer to be certain of lubricant flow through the troughs to each bearing. Incorrect drive rotation, slow speed and high viscosity lubricant can cause improper lubrication.

Replace the inspection plate.
2. Check the temperature of each bearing in the gear reducer. The temperature should be not more than 25° F., above the ambient temperature.
3. Check the temperature of the saddle bearings, tail bearings and wrist pin bearings. The temperature of these bearings should not be of a degree which is uncomfortable when felt with the bare hands.
4. Restart the unit. Refer to instructions under the subject of "placing the unit in operation" which appears earlier in this manual.
5. When the well has "pumped up" or at any time during the operations, if it is found that the bottom hole pump is "pounding bottom" or "bumping up", have the well servicing crew make the required adjustments.
6. When the well has "pumped up" and it is found that more effective counterbalance is required, adjust the counterweights. Instructions for adjustments appear subsequently in this publication.
7. With the unit in operation, observe the "tracking" of the arc cable on the face of the arc. If the "tracking" is off-center or if the polished rod/yoke is forced from a true vertical axis during the stroke, it is probably the fault of a misaligned unit or "unlevel" installation. Make corrections as necessary.
8. With the unit in operation, observe the wrist pins in the cranks. If there is any movement (no matter how slight) it must be eliminated. Tightening procedures are outlined later in this publication.

MAINTENANCE

1. The requirement for a maintenance program cannot be over emphasized. This equipment represents a considerable investment and its function is necessary to your operations. Neglect is costly and will result in premature failures, early retirement of worn equipment and the junking of unusable machinery.
2. The installation of the maintenance program with positive execution will reward your operations economically by:
 - a. Reducing down time.
 - b. Reducing quantity of required repair and replacement parts.
 - c. Provide for longer periods of service free operations.
 - d. Extend the life of your equipment.
3. The maintenance program should be a separate assignment and not the responsibility of operating personnel.
4. The program should provide a schedule for a systematic inspection, lubrication, servicing, cleaning, etc. All observations and actions should be recorded and retained as a permanent record. Failure analysis should also be a part of this program.
5. The following page represents only a suggested MINIMUM requirement for maintenance of your pumping unit. It is designed for periodic inspection and adjustment; it does not preclude the necessity of immediate attention to items or elements which become maladjusted or worn, nor is it intended to remove the "common sense" factor which is so necessary in the operation of any mechanical equipment.
6. As indicated above, this is only a guide; other maintenance may be desirable and required to satisfy owner/operator programs and practices. No maintenance program can eliminate all mechanical failures; however, a good program will reduce the failure frequency and total failures. It also will include safety and environmental controls.

MAINTENANCE

MONTHLY

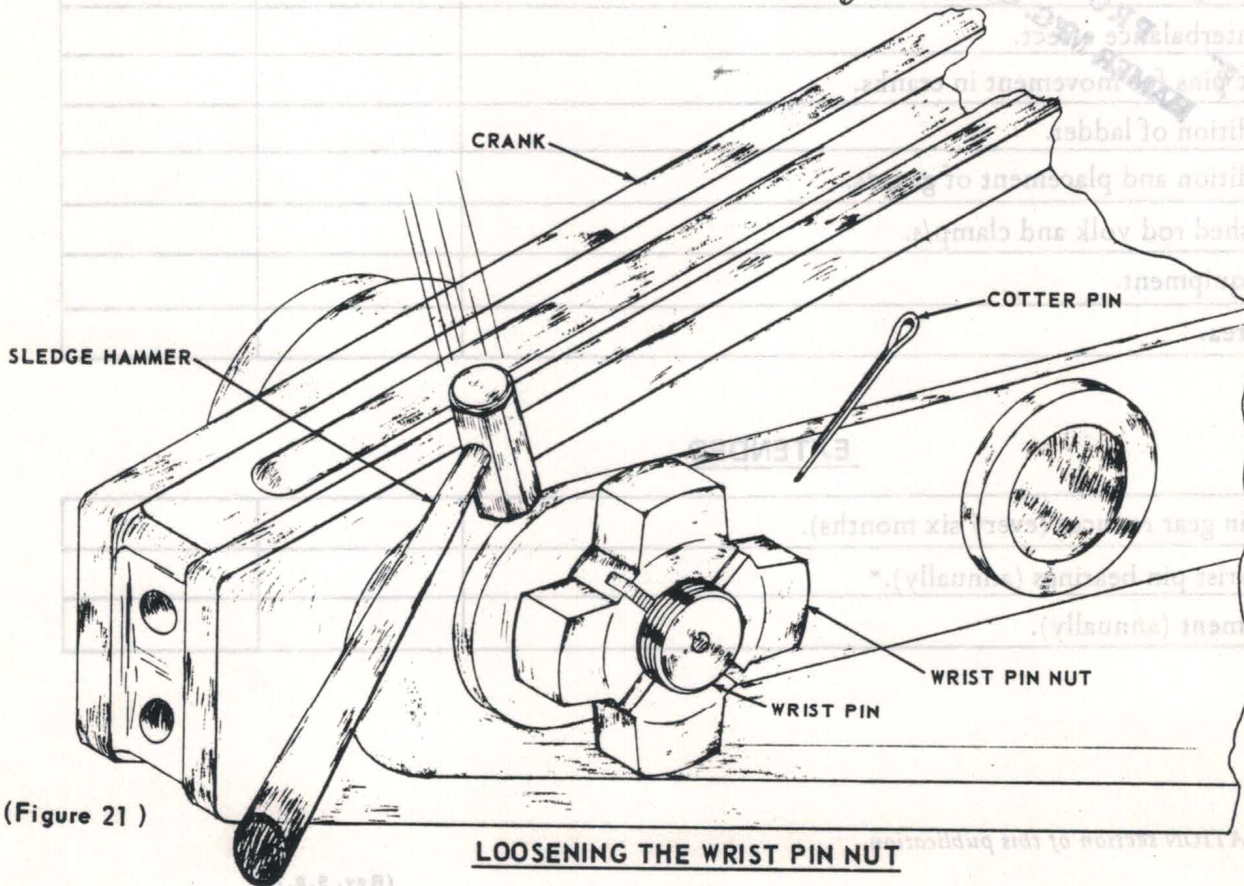
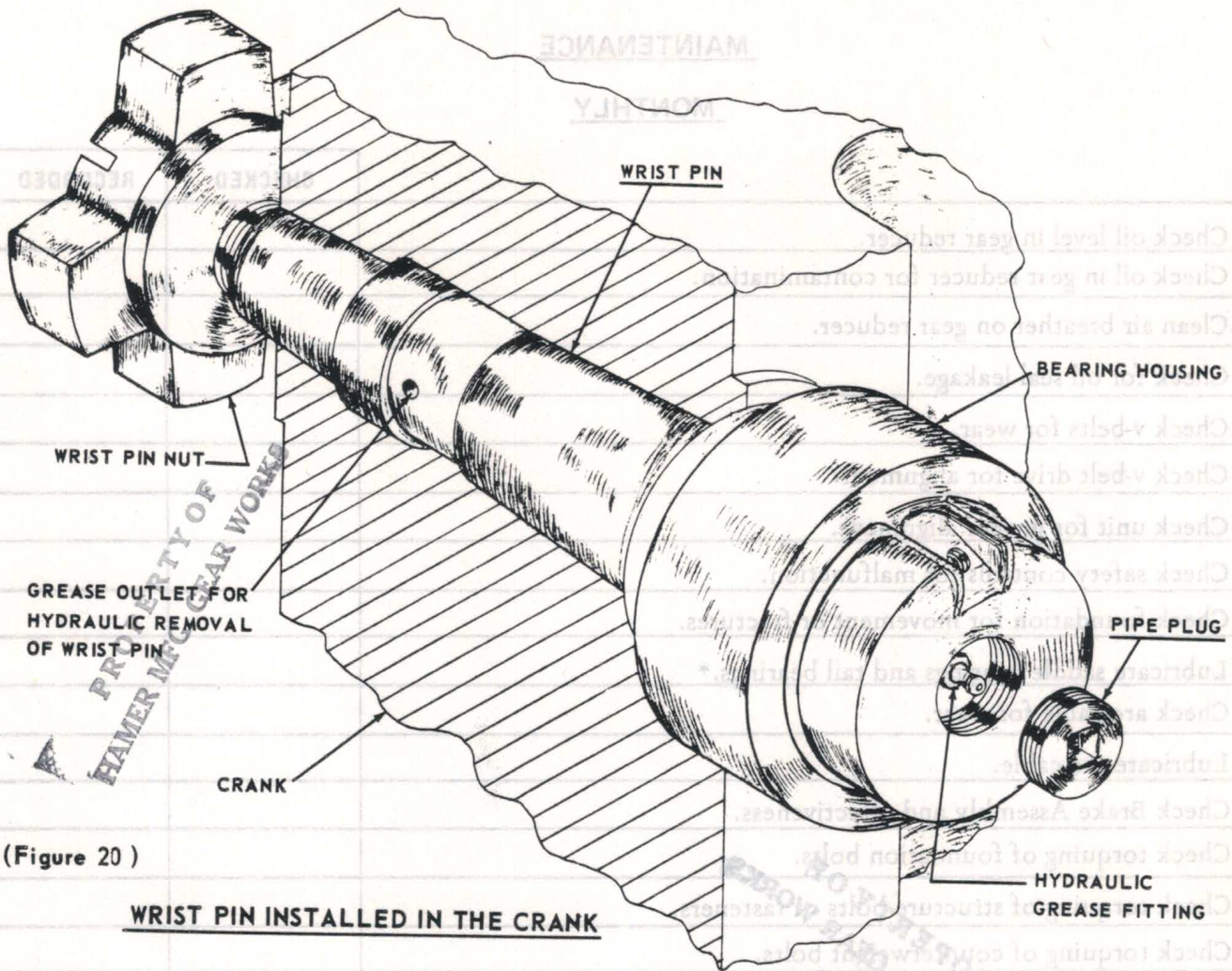
	CHECKED	RECORDED
1. Check oil level in gear reducer.		
2. Check oil in gear reducer for contamination.		
3. Clean air breather on gear reducer.		
4. Check for oil seal leakage.		
5. Check v-belts for wear.		
6. Check v-belt drive for alignment.		
7. Check unit for proper alignment.		
8. Check safety controls for malfunction.		
9. Check foundation for movement or fractures.		
10. Lubricate saddle bearings and tail bearings.*		
11. Check arc cable for wear.		
12. Lubricate arc cable.		
13. Check Brake Assembly and effectiveness.		
14. Check torquing of foundation bolts.		
15. Check torquing of structure bolts or fasteners.		
16. Check torquing of counterweight bolts.		
17. Check counterbalance effect.		
18. Check wrist pins for movement in cranks.		
19. Check condition of ladder.		
20. Check condition and placement of guards.		
21. Check polished rod yolk and clamp/s.		
22. Clean the equipment.		
23. Clean the area.		

EXTENDED

1. Change oil in gear reducer (every six months).		
2. Lubricate wrist pin bearings (annually).*		
3. Paint equipment (annually).		

*Refer to LUBRICATION section of this publication.

Wrist Pin Assembly



WRIST PIN ASSEMBLY

REMOVAL

1. Secure the unit and remove the clamp on the lower end of the pitman from the wrist pin housing.

Refer to PITMAN ASSEMBLY for specific instructions.

2. Remove the cotter pin from its installed position behind the wrist pin nut. Loosen the wrist pin nut approximately two revolutions.
3. Remove the pipe plug from the outer face of the wrist pin bearing housing. This will expose a hydraulic grease fitting in the end of the wrist pin.

Attach a high pressure grease gun to the grease fitting and inject grease into the fitting until the wrist pin is forced from its seated position in the crank.

CAUTION: The hydraulic force applied during the above action may cause the wrist pin to "pop" from its seated position; the wrist pin nut, which remains loose on the wrist pin, is to prevent the wrist pin from "jumping" completely out of the crank.

4. Remove the grease gun from the hydraulic fitting, remove the wrist pin nut and lift the wrist pin assembly from the crank.
5. Should the hydraulic force fail to loosen the wrist pin it can be "sledged" from the crank.

Relieve the hydraulic pressure, if previously applied. Remove the wrist pin nut and install a "drive nut" on the threaded end of the wrist pin. Again apply hydraulic pressure, as outlined above, then strike the drive nut with the sledge hammer to unseat the wrist pin assembly.

NOTE

Instructions relative to the removal and installation of the wrist pin bearing, housing, seal, etc., appear subsequently in this publication.

INSTALLATION

1. Use a non-toxic, non-explosive solvent to clean the tapered portion of the wrist pin and the tapered bore in the crank. These surfaces may be polished, if necessary, with fine grit emery cloth. If these are polished, be certain to remove all grit from the mating surfaces. Be sure that at time of final assembly these mating surfaces are dry and free of all foreign material, i.e., grit, dirt, rust, lint, oil, etc.

2. Place the wrist pin assembly in the crank and install the wrist pin nut. Rotate the nut until its face contacts the crank. Index the position of the nut with a paint stripe or other suitable marker - this marking should extend down the side of the nut and across the face of the crank.

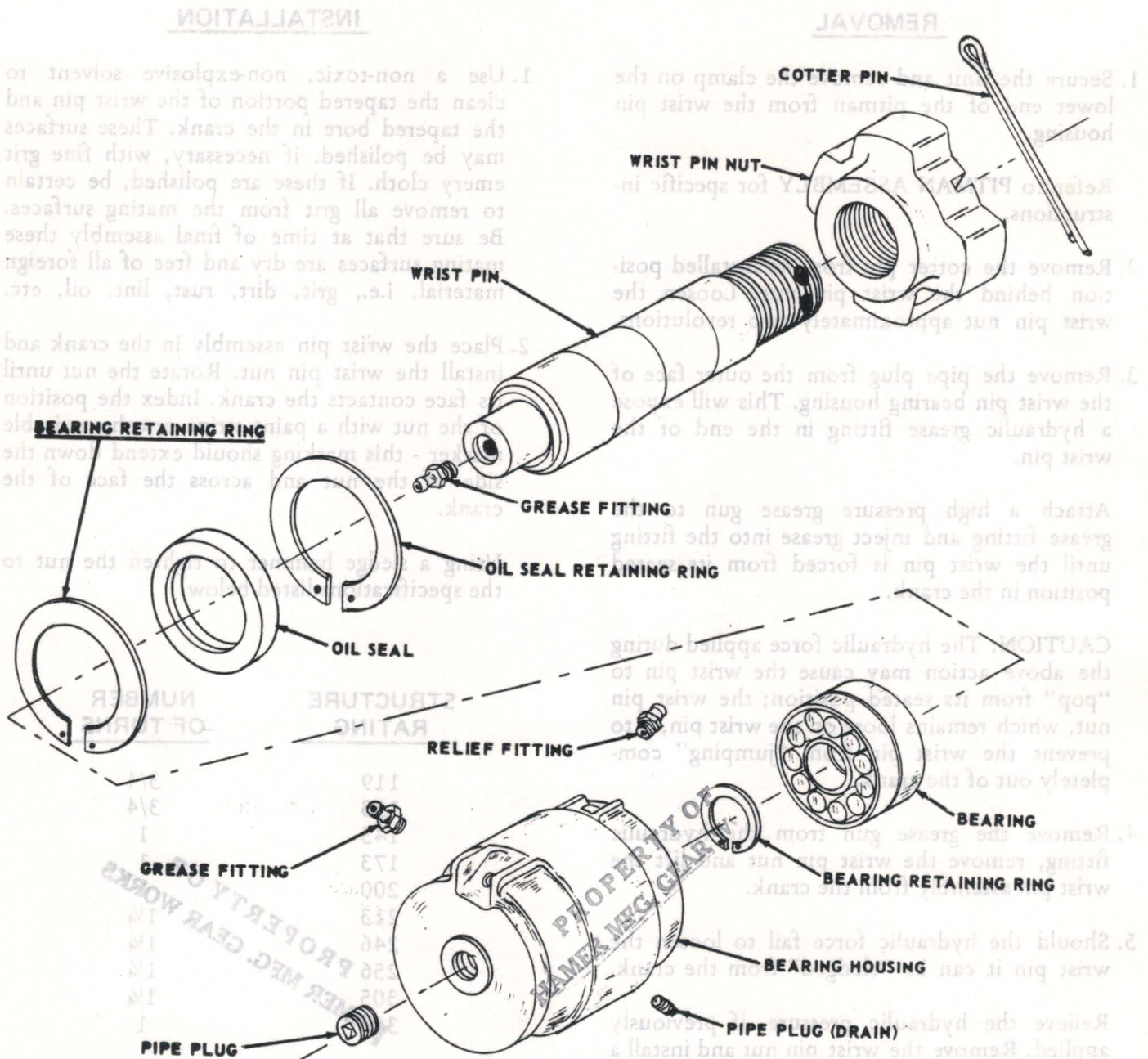
Using a sledge hammer to tighten the nut to the specifications listed below:

<u>STRUCTURE RATING</u>	<u>NUMBER OF TURNS</u>
119	3/4
133	3/4
143	1
173	1
200	1
213	1 1/4
246	1 1/4
256	1 1/4
305	1 1/4
368	1

Be certain that the tightness conforms with the above. Install the cotter pin.

3. Reinstall the pitman "refer to PITMAN ASSEMBLY for specific instructions."
4. Be certain that the wrist pin bearing is lubricated and then release the unit for service.

WRIST PIN ASSEMBLY



(Figure 22)

The wrist pin bearing is of the self-aligning spherical type and requires no adjustment. If there is looseness in the bearing it should be replaced. If replacement is necessary it is suggested that the wrist pin and bearing assembly be removed from the crank and transported to a machine shop where a bearing press, pin pliers and others tools are accessible.

WRIST PIN BEARING ASSEMBLY*

REMOVAL

1. With the wrist pin assembly removed from the crank, drain the lubricant from the bearing housing.
2. Remove the oil seal retaining ring and the oil seal. Note: After removing the retaining ring the oil seal can be "pumped" from the bearing housing by injecting grease into the housing. If this type of removal is anticipated, do not drain the lubricant from the bearing housing as instructed in the paragraph above. Drain the lubricant from the bearing housing after the oil seal is removed.
3. Remove the bearing retaining ring from the bearing housing. This is the ring which was installed adjacent to the oil seal.
4. Use a hydraulic press to remove the wrist pin with its installed bearing from the bearing housing.
5. Remove the bearing retaining ring from the small end of the wrist pin.

Remove the grease fitting from the end of the wrist pin.

Use a hydraulic press or bearing puller to remove the wrist pin bearing from the wrist pin.

INSTALLATION

1. Carefully clean and inspect all parts for flaws,

defects and wear. Replace all parts that are obviously defective and all that are of questionable quality.

2. Place the wrist pin bearing in a vat containing 15% soluble oil in water and heat until bearing is approximately 200° F.
3. Using wire hooks or tongs and asbestos gloves, remove the bearing from the heated oil/water solution and place it on the wrist pin. The bearing must be in full circumferential contact with the shoulder on the wrist pin and held in that position until it cools and grips the shaft.

Install the bearing retaining ring on the small end of the wrist pin.

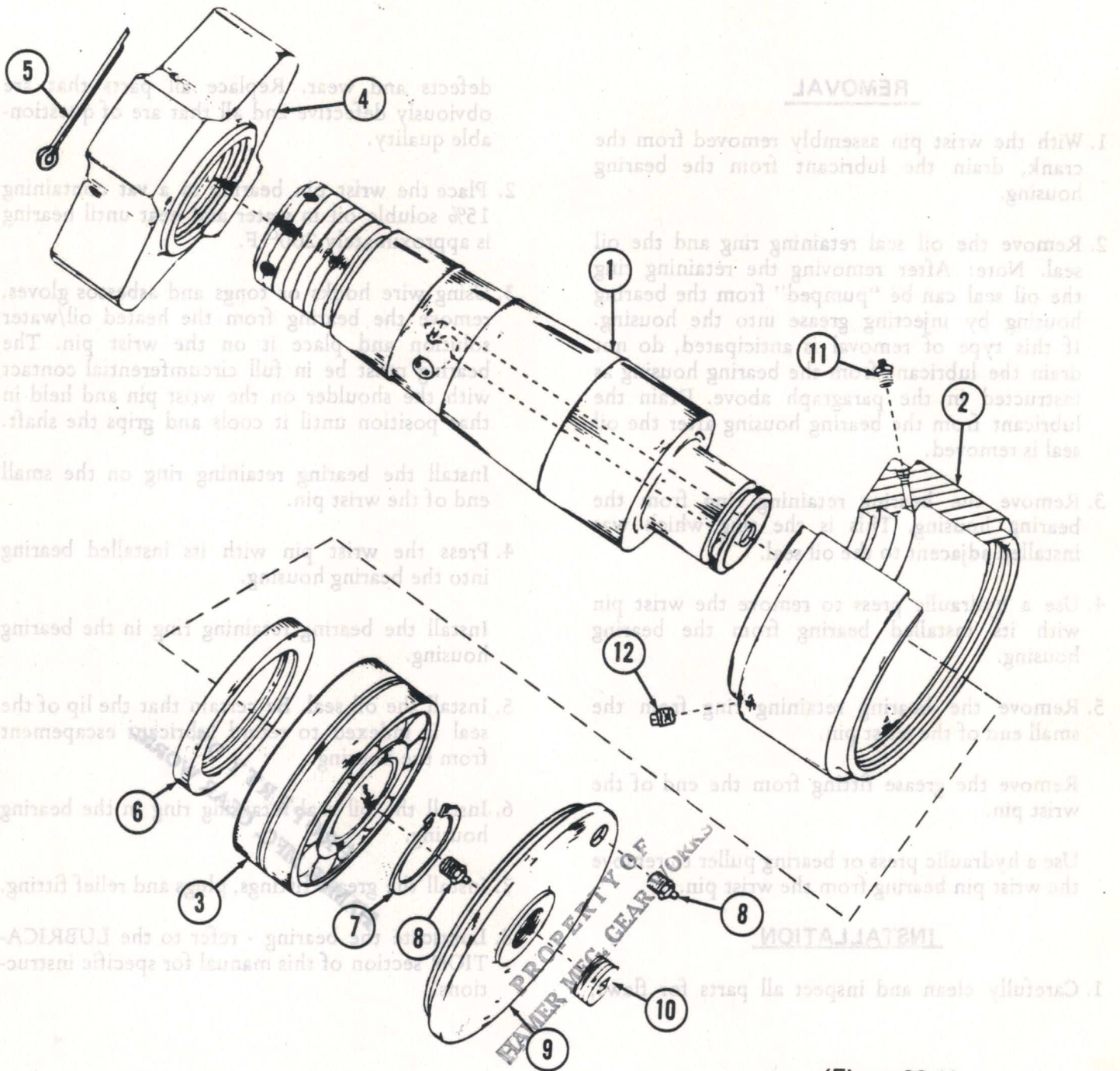
4. Press the wrist pin with its installed bearing into the bearing housing.

Install the bearing retaining ring in the bearing housing.

5. Install the oil seal. Be certain that the lip of the seal is indexed to retard lubricant escapement from the housing.
6. Install the oil seal retaining ring in the bearing housing.
7. Install the grease fittings, plugs and relief fitting.
8. Lubricate the bearing - refer to the LUBRICATION section of this manual for specific instructions.

**Refer to the next two pages for instructions directed to a different Wrist Pin Bearing Assembly that is currently installed on the GSA-456 Series of pumping units.*

Wrist Pin Bearing Assembly



(Figure 22-A)

- | | |
|---------------------|----------------------------|
| (1) Wrist Pin | (7) Snap Ring |
| (2) Bearing Housing | (8) Grease Fitting |
| (3) Bearing | (9) Bearing Housing Cap |
| (4) Wrist Pin Nut | (10) Pipe Plug |
| (5) Cotter Pin | (11) Grease Relief Fitting |
| (6) Oil Seal | (12) Pipe Plug |

The wrist pin bearing is of the self-aligning spherical type and requires no adjustment. If there is looseness in the bearing it should be replaced. If replacement is necessary it is suggested that the wrist pin and bearing assembly be removed from the crank and transported to a machine shop where a bearing press, pin pliers and other tools are accessible.

WRIST PIN BEARING ASSEMBLY
FOR THE GSA-456 SERIES OF PUMPING UNITS

REMOVAL

1. With the wrist pin assembly free of the crank, remove the plug and the grease pressure relief fitting from the bearing housing. Drain as much lubricant as possible from the bearing housing.
2. Support this assembly on wooden "V" blocks (the wrist pin nut, if reinstalled on the pin, can assist in the balance and support of the assembly). Remove the grease plug and the grease fitting from the bearing housing cap.
3. Place one end of a brass bar (about 1-inch diameter and about 8-inches long) against one of the lugs on the left hand side of the bearing housing cap. Elevate the free end of the bar to about 70-degrees from horizontal and strike the free end of the bar with a machinist's hammer. Repeated blows and progressing to other lugs on the cap will remove this threaded cap from the bearing housing.
4. Remove the snap ring (external type) from the small end of the wrist pin.

Remove the grease fitting from the bearing end of the wrist pin.

5. Place the wrist pin assembly (remove the wrist pin nut if it was reinstalled in paragraph No. 2 above) in a hydraulic press.

Place the nut end of the wrist pin through a perforated anvil with the ram of the press at the bearing end of the wrist pin. The hole in the anvil should be only 1/16" to 1/8" larger than the O. D. of the wrist pin at its largest diameter.

The ram of the press or the ram extension must be smaller in diameter than the I.D. of the bearing.

Be certain that the wrist pin will not fall when it is free of the bearing. Energize the press forcing the wrist pin out of the bearing.

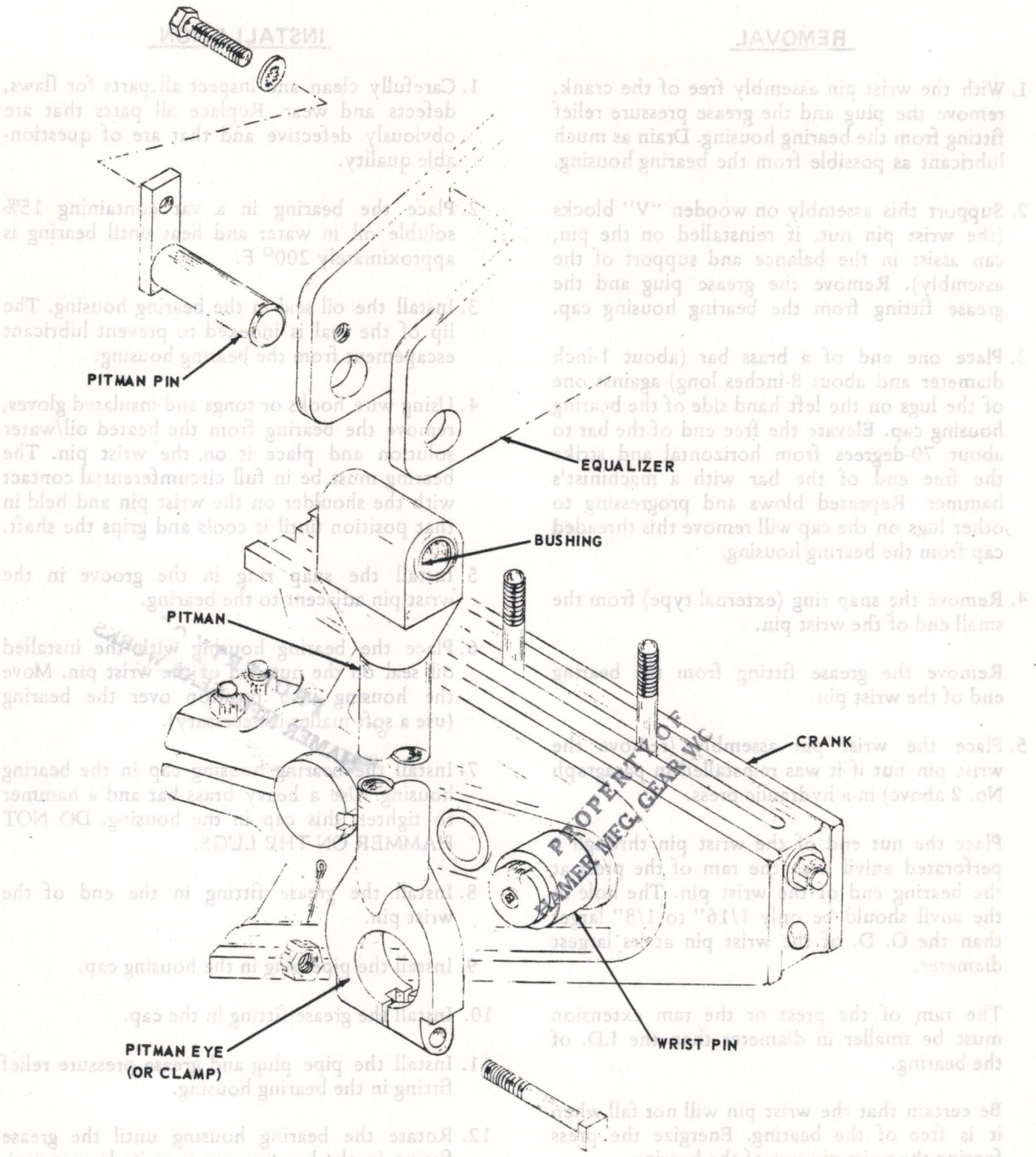
6. Use a brass bar and a hammer to remove the bearing and the oil seal from the bearing housing.

INSTALLATION

1. Carefully clean and inspect all parts for flaws, defects and wear. Replace all parts that are obviously defective and that are of questionable quality.
2. Place the bearing in a vat containing 15% soluble oil in water and heat until bearing is approximately 200° F.
3. Install the oil seal in the bearing housing. The lip of the seal is indexed to prevent lubricant escapement from the bearing housing.
4. Using wire hooks or tongs and insulated gloves, remove the bearing from the heated oil/water solution and place it on the wrist pin. The bearing must be in full circumferential contact with the shoulder on the wrist pin and held in that position until it cools and grips the shaft.
5. Install the snap ring in the groove in the wrist pin adjacent to the bearing.
6. Place the bearing housing with the installed oil seal on the nut end of the wrist pin. Move the housing into position over the bearing (use a soft mallet if necessary).
7. Install the bearing housing cap in the bearing housing. Use a heavy brass bar and a hammer to tighten this cap in the housing. **DO NOT HAMMER ON THE LUGS.**
8. Install the grease fitting in the end of the wrist pin.
9. Install the pipe plug in the housing cap.
10. Install the grease fitting in the cap.
11. Install the pipe plug and grease pressure relief fitting in the bearing housing.
12. Rotate the bearing housing until the grease fitting in the housing cap is in its lowest position. Inject grease through this fitting until a small quantity escapes from the grease relief fitting.

Pitmans

FOR THE GSA-458 SERIES OF PUMPING UNITS



(Figure 23)

When installing the "eyes" of the pitmans on the wrist pin bearing housings, rotate the bearing housings to place the grease fitting at the top and the bolt channel at the bottom. Altering the tension on the chains which secure the walking beam can aid in the alignment of the pitmans with the wrist pins.

REMOVAL

1. De-energize the unit and with the cranks in a horizontal position, lock the brake.

Place sturdy wooden blocks beneath the lower counterweights to guard against gravitational rotation of the cranks should the brake fail to hold.

2. Install two polished rod clamps on the polished rod immediately above the stuffing box. There should be no space between these clamps or between the clamps and the stuffing box. Tighten* the clamps.
3. Secure the walking beam in its horizontal position. Attach two heavy load chains to the arc end of the beam and extend each to the pumping unit base (frame). Be certain that the "hitch" on the beam and on the base cannot slide or move from its attached position. Use a safety load binder on each chain to remove slack and provide equal tension in each chain.
4. Remove the cotter pin, nut and bolt from the lower pitman eye (or clamp). Remove the lower end of the pitman from the wrist pin bearing housing. NOTE: It may be necessary to "open up" the eye of the pitman with a pinch bar or other tool and then use a pry bar between the crank and the pitman to assist in this removal.
5. Attach a hoisting line to the pitman, fashion the "hitch" to support the pitman in a vertical position, remove all slack from the hoisting line and then remove the upper pitman pin.
6. Use a hydraulic press to remove the bushing from the upper pitman housing.
7. Follow the instructions outlined above to remove the pitman from the opposite side of the gear reducer.

INSTALLATION

1. Carefully clean and inspect all parts for flaws, defects and wear. Replace all parts that are obviously defective and all that are of questionable quality.
2. Press the upper pitman bushing into the upper pitman housing.
3. Attach a hoisting line to the pitman, elevate the pitman in a vertical position with the bore of the bushing indexed to align with the machined holes in the end of the equalizer.
4. With the bore of the bushing aligned as instructed above, install the pitman pin.

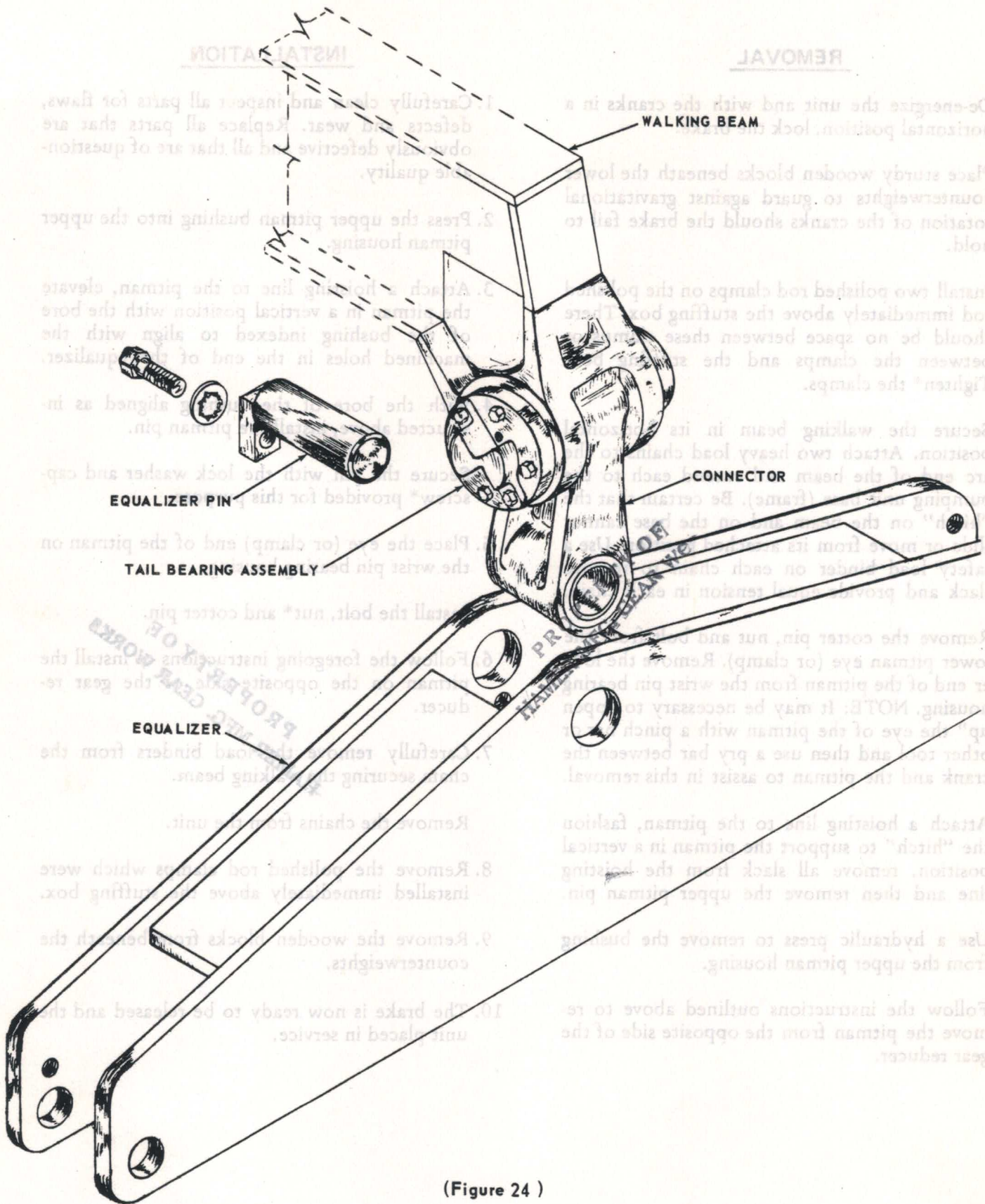
Secure the pin with the lock washer and cap-screw* provided for this purpose.
5. Place the eye (or clamp) end of the pitman on the wrist pin bearing housing.

Install the bolt, nut* and cotter pin.
6. Follow the foregoing instructions to install the pitman on the opposite side of the gear reducer.
7. Carefully remove the load binders from the chain securing the walking beam.

Remove the chains from the unit.
8. Remove the polished rod clamps which were installed immediately above the stuffing box.
9. Remove the wooden blocks from beneath the counterweights.
10. The brake is now ready to be released and the unit placed in service.

*Torquing values for fasteners will be found in the APPENDIX of this publication.

Equalizer



(Figure 24)

Be certain the sling is properly attached to the equalizer and that the equalizer is safely balanced during removal and installation procedures.

EQUALIZER

REMOVAL

1. Remove the pitmans. Refer to PITMANS for specific instructions.
2. Using a bridle type sling on a hoisting line, position the sling hooks to balance the equalizer and then tighten the hoisting line to support the weight of the equalizer.
3. Remove the equalizer pin. The equalizer is now free to be removed to the pre-selected area.

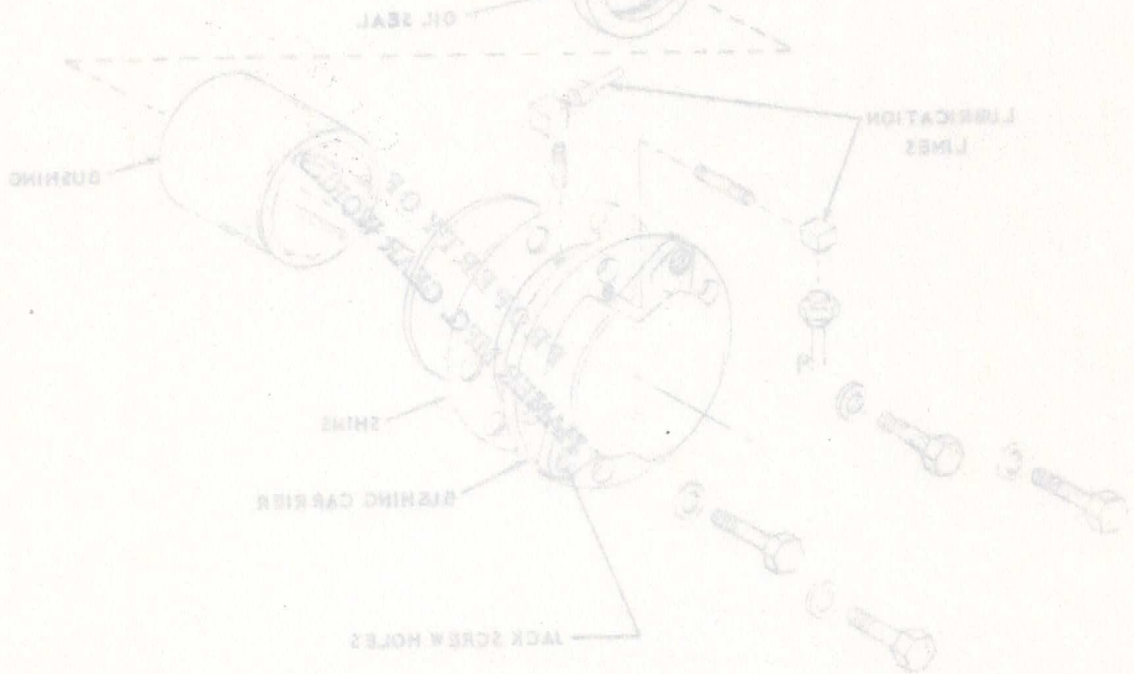
INSTALLATION

1. Carefully clean and inspect the equalizer and equalizer pin. If the pin is worn, it should be replaced (the connector bushing should also be replaced - see TAIL BEARING ASSEMBLY in

this publication for instructions relative to the replacement of the connector bushing).

If the equalizer pin and the pitman pins have been properly secured during operations there should be no wear on the equalizer; however, if it is worn or if there are any cracks in the equalizer it should be replaced.

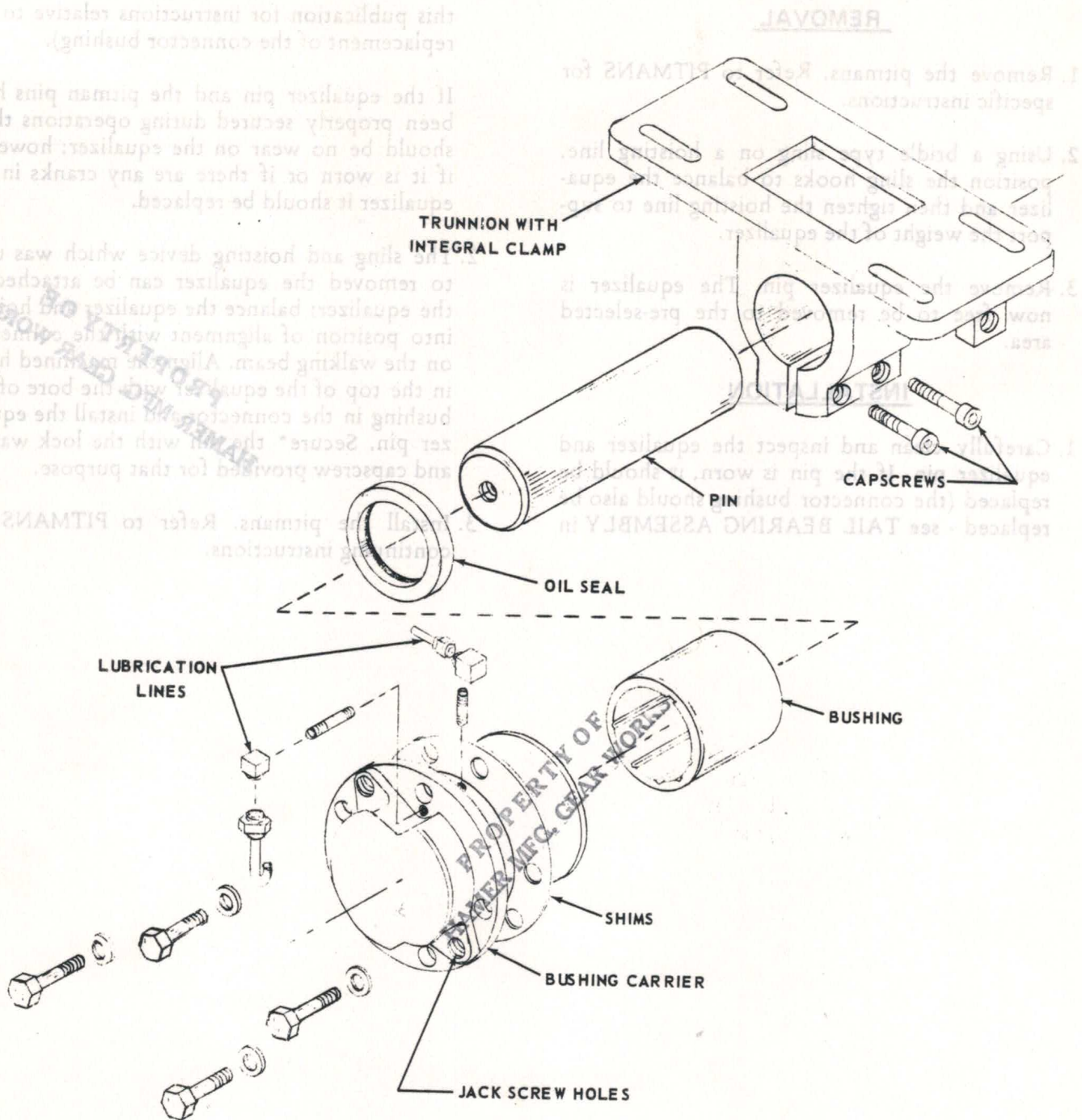
2. The sling and hoisting device which was used to removed the equalizer can be attached to the equalizer; balance the equalizer and hoist it into position of alignment with the connector on the walking beam. Align the machined holes in the top of the equalizer with the bore of the bushing in the connector and install the equalizer pin. Secure* the pin with the lock washer and capscrew provided for that purpose.
3. Install the pitmans. Refer to PITMANS for continuing instructions.



(Figure 22)

*Torquing values for fasteners will be found in the APPENDIX of this publication.

Saddle Bearing Assembly



(Figure 25)

The above reflects only one side of the saddle bearing assembly. Identical parts are located on the opposite side of the trunnion.

The bushing can tolerate approximately 1/16-inch of wear before the lubrication grooves are eliminated and improper lubrication results. Without proper lubrication the pin wear will be accelerated.

SADDLE BEARING ASSEMBLY

The saddle bearing is when the unit is in operation, heavily loaded and must be properly lubricated at all times. If it becomes necessary to replace the bushings, oil seals or pin, a hoisting device will be required to support the walking beam during the operations of removal and installation.

REMOVAL

1. De-energize the prime mover and when the cranks are at their lowest point of rotation, lock the brake.
2. Install two polished rod clamps on the polished rod immediately above the stuffing box to support the rod string. These clamps should be fully tightened.*
3. Remove the polished rod clamps above yoke.
4. Place a choker type sling on the walking beam adjacent to the arc. Attach the sling to the hoisting line and slightly elevate the walking beam to relieve the weight on the saddle bearing assembly.
5. Remove the lubrication lines from the bushing carriers and drain the lubricant.
6. Remove the capscrews from the bushing carriers and install jackscrews in the tapped holes in the bushing carriers.

Alternately and evenly tighten the jackscrews to pull the bushing carrier, bushing, oil seal and shims from their installed position.

7. Remove the oil seals from the bushing carriers and use a bearing puller to pull the bushings from the carriers.
8. The pin can now be removed from the trunnion. Remove the capscrews which clamp the pin in place and move the pin horizontally out of the clamp.

INSTALLATION

1. Carefully clean and inspect all parts for flaws, defects and wear. Replace all parts that are obviously defective and all that are of questionable quality.
2. Press the bushings into the bushing carriers. CAUTION: There is a chamfer on the O. D. of each bushing - this chamfer should lead the bushing into the carrier. Also, the lubrication grooves inside the bushing must be indexed to

be on the lower side of the saddle bearing pin when the bushing carriers are installed. The word "top" has been placed on each bushing to indicate the proper installation.

3. Install oil seals in the bushing carriers. Be certain that the lip of the seal is indexed to retard lubricant escapement from the carriers.
4. Install the pin in the saddle trunnion. The pin must extend an equal-distance on each side of the trunnion. NOTE: If a used pin is being installed it should be rotated 180° on its horizontal axis (from its previously installed position) to place the worn position of the pin in the vertical position.

Install* the capscrews in the trunnion clamp to secure the installed pin.

5. Suspend a plumb bob from the top of the arc.

Install the bushing carriers (less shims) and carefully, with half torque* on the capscrews, adjust these on alternate sides until the plumb bob is centered over the polished rod. Measure the gap (stand-off) between the flange on each bushing carrier and the bolting flange on the Samson Post. Select shims with a total thickness to fill each gap and then add .03125 (1/32-inch) of shims to each shim set. Install these shims and tighten* the capscrews.

6. Install the lubrication lines.
7. Remove the hoisting line and sling from the walking beam.

Reinstall the polished rod clamps on the polished rod above the yoke.*

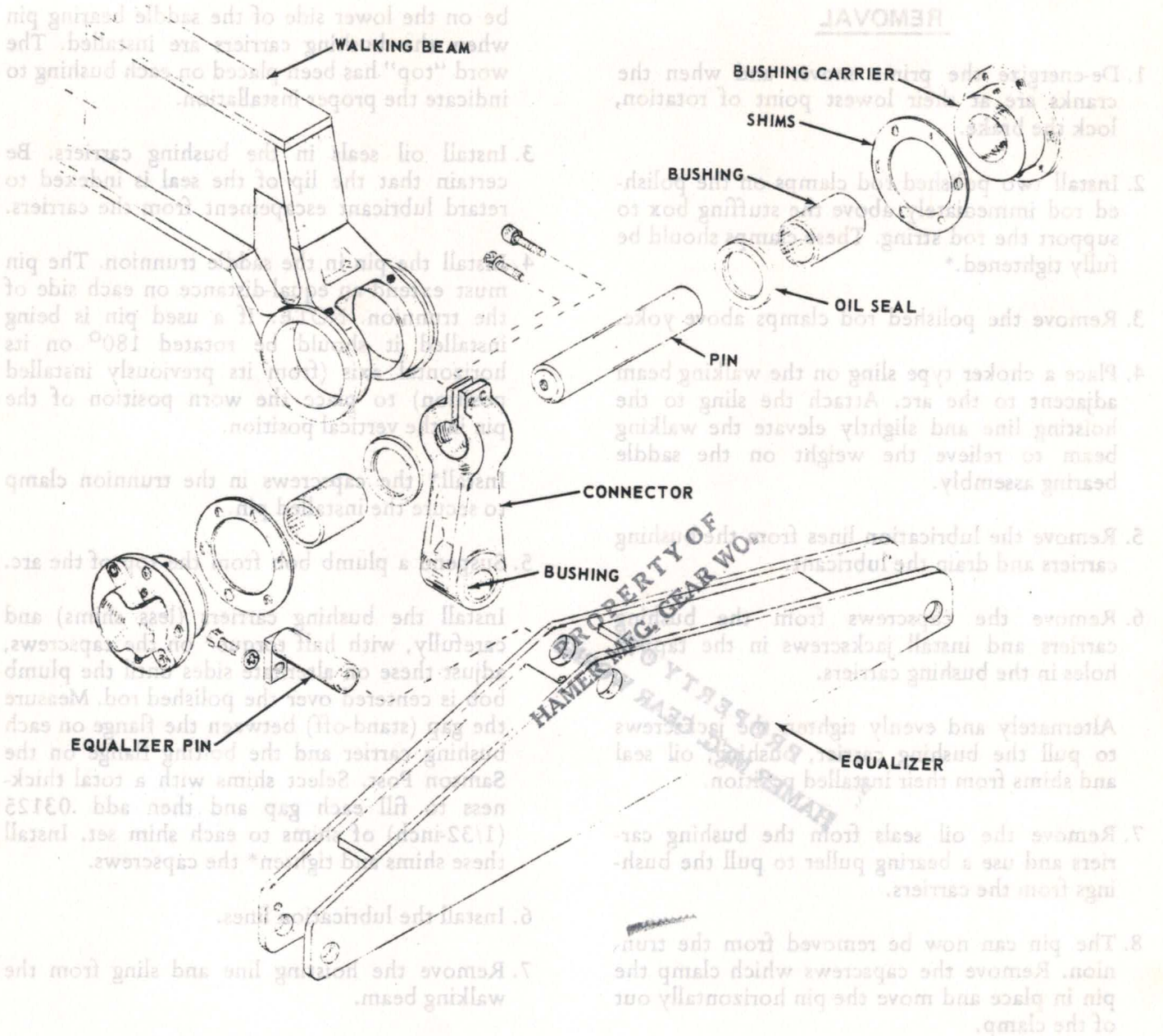
Remove the polished rod clamps which were placed on the polished rod at the top of the stuffing box.

8. Lubricate the saddle bearing. Refer to LUBRICATION in this publication for specific instructions.
9. Release the brake - the unit is now ready to be returned to service.

*Torquing values for fasteners will be found in the APPENDIX of this publication.

Tail Bearing Assembly

The saddle bearing is when the unit is in operation, heavily loaded and must be properly lubricated at all times. If it becomes necessary to replace the bushings, oil seals or pins, a hoisting device will be required to support the walking beam during the operations of removal and installation.



REMOVAL

1. De-energize the drive and lower the unit to its lowest point of rotation. Lock the unit in position.
2. Install the polished rod clamp above the yoke.
3. Remove the polished rod clamp above the yoke.
4. Place a choker type sling on the walking beam adjacent to the arc. Attach the sling to the hoisting line and slightly elevate the walking beam to relieve the weight on the saddle bearing assembly.
5. Remove the lubricating lines from the bushing carriers and drain the lubricant.
6. Remove the cap screws from the bushing carriers and install jackscrews in the lower bushing carrier holes in the bushing carriers. Alternately and evenly tighten the jackscrews to pull the bushing carrier, bushing, oil seal and shims from their installed position.
7. Remove the oil seals from the bushing carrier and use a bearing puller to pull the bushing from the carrier.
8. The pin can now be removed from the walking beam. Remove the cap screws which clamp the pin in place and move the pin horizontally out of the clamp.

INSTALLATION

1. Carefully clean and inspect all parts for flaws, defects and wear. Replace all parts that are obviously defective and all that are of questionable quality.
2. Press the bushings into the bushing carriers.
3. Lubricate the saddle bearing. Refer to LUBRICATION in this publication for specific instructions.

(Figure 26)

The tail bearing bushings should be replaced when they are worn approximately 1/16-inch. When the lubrication grooves in these bushings disappear lubrication is not properly distributed and the wear of the tail bearing pin is accelerated.

TAIL BEARING ASSEMBLY

REMOVAL

1. Remove the equalizer. Refer to EQUALIZER in this publication for specific instructions.
2. Rotate the connector to expose the clamping screws and remove these screws.
3. Remove the bushing carriers from each side of the walking beam. The bushings, shims and oil seals are generally removed with the carriers.

If necessary, install jack screws in the tapped holes in the carrier flange; alternately and evenly tighten these jack screws to pull the carriers from their installed position.

4. Remove the shims, oil seals and jack screws (if used as instructed above) from the bushing carriers.
5. Use a bearing puller to remove the bushings from the bushing carriers.
6. Support the connector and remove the tail bearing pin.

If the pin removal is restricted, use a pinch bar to open the clamp and relieve the clamping force on the pin.

7. Use a bearing press to remove the bushing from the connector.

INSTALLATION

1. Carefully clean and inspect all parts for flaws, defects and wear. Replace all parts that are obviously defective and all that are of questionable quality.
2. Use a bearing press to install the bushing in the connector.
3. Hoist the connector into position between the

tail bearing carriers and install the tail bearing pin.

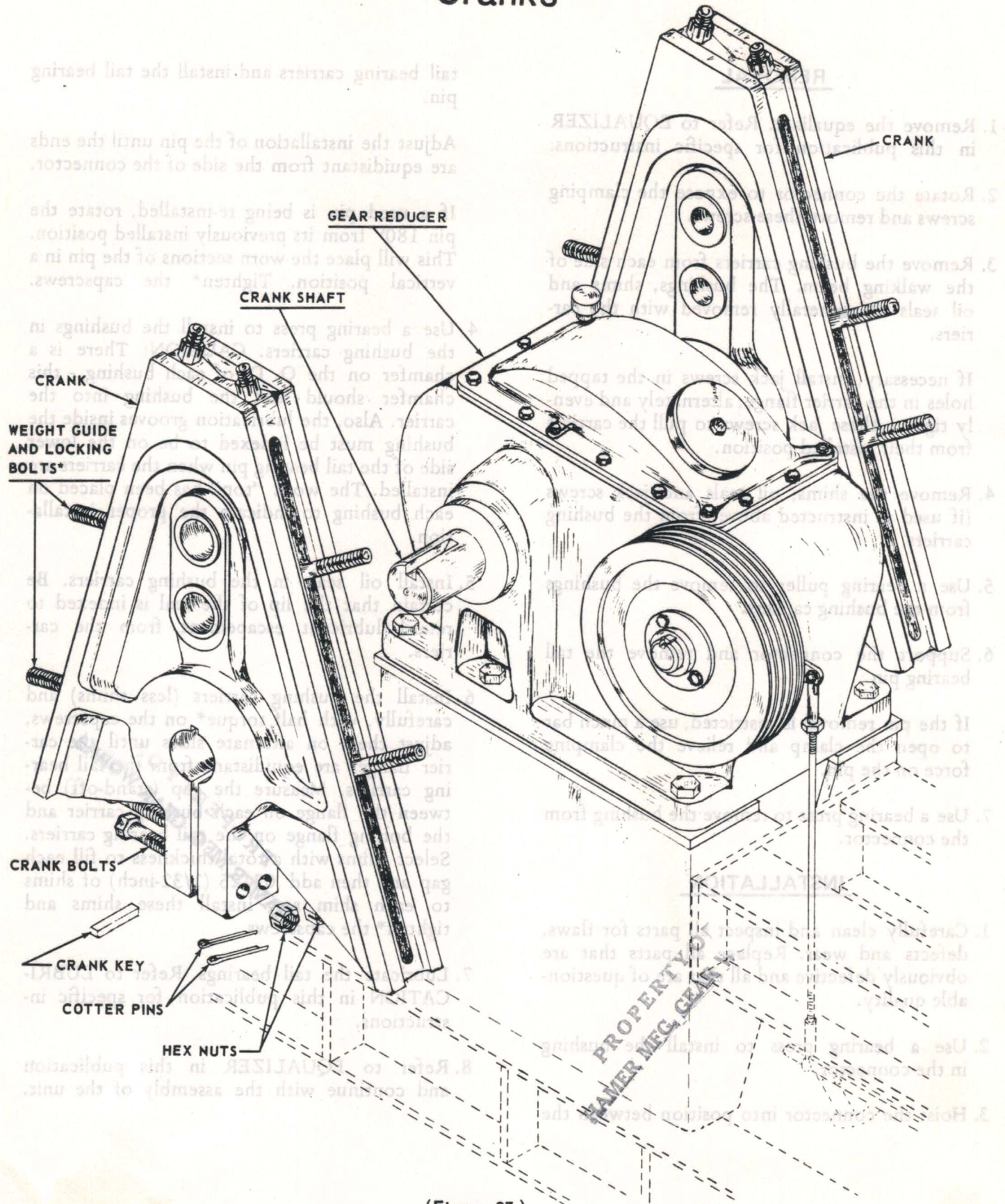
Adjust the installation of the pin until the ends are equidistant from the side of the connector.

If a used pin is being re-installed, rotate the pin 180° from its previously installed position. This will place the worn sections of the pin in a vertical position. Tighten* the capscrews.

4. Use a bearing press to install the bushings in the bushing carriers. CAUTION: There is a chamfer on the O. D. of each bushing - this chamfer should lead the bushing into the carrier. Also, the lubrication grooves inside the bushing must be indexed to be on the lower side of the tail bearing pin when the carriers are installed. The word "top" has been placed on each bushing to indicate the proper installation.
5. Install oil seals in the bushing carriers. Be certain that the lip of the seal is indexed to retard lubricant escapement from the carriers.
6. Install the bushing carriers (less shims) and carefully, with half torque* on the capscrews, adjust these on alternate sides until the carrier flanges are equidistant from the tail bearing carriers. Measure the gap (stand-off) between the flange on each bushing carrier and the bolting flange on the tail bearing carriers. Select shims with a total thickness to fill each gap and then add .03125 (1/32-inch) of shims to each shim set. Install these shims and tighten* the capscrews.
7. Lubricate the tail bearings. Refer to LUBRICATION in this publication for specific instructions.
8. Refer to EQUALIZER in this publication and continue with the assembly of the unit.

*Torquing values for fasteners will be found in the APPENDIX of this publication.

Cranks



(Figure 27)

The cranks are very heavy and require heavy duty hoisting equipment for their safe removal and installation.

*Quantities of weight guide and locking bolts increases on larger units.

CRANKS

REMOVAL

1. Secure the unit and remove the clamps on the lower end of the pitmans from the wrist pin housings.

Refer to PITMAN ASSEMBLY for specific instructions.

2. Lock the brake.
3. Remove the auxiliary counterweights.

Remove the master counterweights - one at a time by carefully supporting each segment and then removing the nuts from the counterweight guide and locking bolts.

4. Loosen the brake and attach a hoisting line to one of the cranks and elevate the end of the cranks to a vertical position.

Lock the brake.

5. Place a heavy steel bar (approximately the same diameter as the I. D. of the unused wrist pin hole in the crank).

Attach a bridle sling to each end of the heavy steel bar, adjacent to the crank. Tighten the hoisting line to support the crank.

6. Remove the cotter pins, hex nuts and bolts which clamp the crank to the crankshaft.
7. Drive two heavy duty mild steel wedges into the split clamp. These should be placed beneath the crank and driven upward toward the crankshaft.

This wedging action should release the crank from its grip on the crankshaft.

8. Slide the crank from the crankshaft and remove the crank key from the crankshaft.
9. Be guided by the foregoing instructions to remove the crank from the opposite side of the gear reducer.
10. Remove the wrist pin assembly from each crank. Refer to WRIST PIN ASSEMBLY in this publication for specific instructions.

INSTALLATION

1. Carefully clean the crankshaft extensions and the bore of the split clamp on the crank. Use a non-toxic, non-explosive solvent.

2. Install the wrist pin assemblies in the cranks. Refer to WRIST PIN ASSEMBLY in this publication for specific instructions.

3. Install the crank key.

Hoist the crank into position and slide it over the end of the crankshaft.

4. Before tightening the crank clamp it must be horizontally positioned on the crankshaft to cause a plumb line extended from the center of the upper pitman pin to be in the exact horizontal center of the wrist pin bearing housing. NOTE: The equalizer must be horizontally level and the upper pitman pins equidistant from the center line of the unit.

This adjustment is necessary to be certain that the pitmans operate on a true vertical axis.

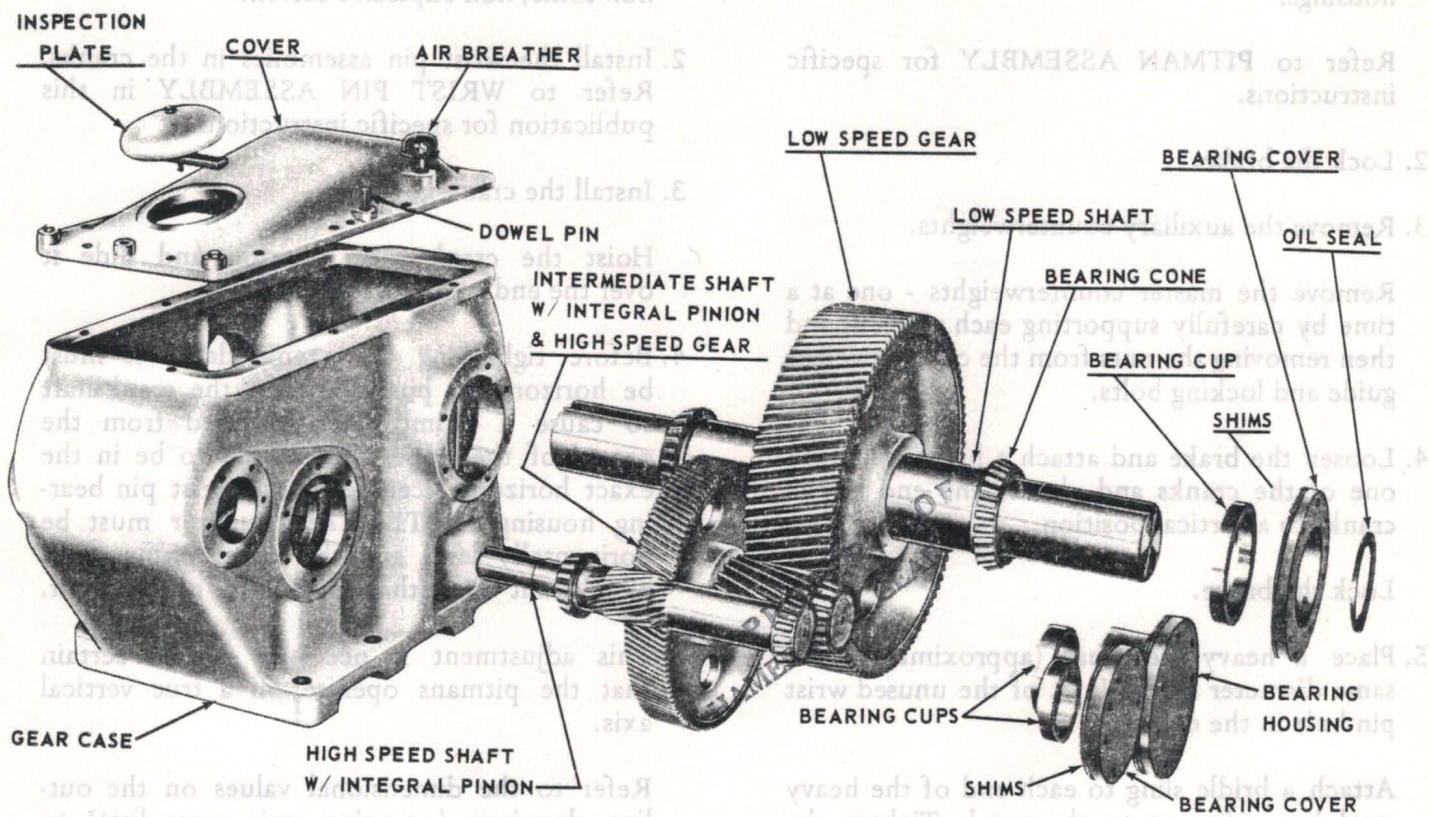
Refer to the dimensional values on the outline drawings (pumping unit parts lists) to verify the positioning of the cranks.

5. If wedges were driven into the split clamp, CAREFULLY remove the wedges.
6. Install the crank bolts, tighten* the nuts and install the cotter pins.
7. Be guided by the foregoing instructions to install the crank on the opposite side of the gear reducer.
8. Install the counterweights. Refer to COUNTERWEIGHT INSTALLATION in this publication for specific instructions.
9. Install the pitmans. For specific instructions, refer to PITMANS in this publication.

*Torquing values for fasteners will be found in the APPENDIX of this publication.

Gear Reducer

BEARING ADJUSTMENT



(Figure 28)

The above is a typical arrangement of a pumping unit gear reducer; however, most have a double extended high speed shaft, shaft guard and direct mounted bearings on the intermediate shaft. The parts list provided for each unit model will detail the components of the reducer and outline their arrangement in the gear case.

These are double reduction gear units with specific speed reduction ratios (refer to parts listing for the ratio of each gear reducer size). The gears and pinions (two each) are the single helical type. They are mounted or machined on three parallel shafts and are roller bearing supported.

The tapered roller, shim adjustable, bearings in the gear reducer can be adjusted with the gear reducer installed on the unit; however, the cranks, v-belts drive, gear reducer sheave and brake assembly must all be removed when making precise and exacting adjustments.

Gear Reducer

MODEL D80-B AND MODEL D320-B BEARING ADJUSTMENT

When in proper adjustment the bearings on the low speed shaft and the bearings on the intermediate shaft will be "pre-loaded"; the bearings on the high speed shaft will be "loose". The tolerances for these adjustments are listed below.

1. Remove the cranks from the low speed shaft of the gear reducer. Refer to CRANKS in this publication for specific instructions.
2. Remove the gear reducer sheave and the brake assembly from the high speed shaft.
3. Remove the gear case cover, the oil scrapers (if installed) may also be removed to provide additional excess to the gears.
4. Mount a dial indicator as close to the low speed gear as possible inside the housing at the top flange with the contact point on the top flange of the opposite side. This is to detect gear housing deflection when bearing adjustments are made.
5. Mount a second dial indicator on the top machined surface of the gear housing with the contact point on the rim face of the low speed gear.

Adjust both dial indicators to zero.

--LOW SPEED SHAFT BEARINGS--

6. Use a pry bar to move the low speed gear from side to side. Rotate the gear frequently to be sure bearing rollers are seated. Record the movement reflected by the dial indicator on the rim face of the low speed gear.

CAUTION: When applying force to the pry bar observe the dial indicator placed across the top of the gear case opening. There must be no deflection in the gear case when moving the low speed gear from side to side. Excessive force on the pry bar can cause damage to the gear or fracture of the gear case.

The total of the "plus" and "minus" readings of the indicator on the gear face represents the looseness of the bearings.

7. Remove the bearing retainer and remove a quantity of shims equal to the total looseness

of the bearings. This should result in zero end-play of the low speed shaft.

CAUTION: Observe the dial indicator placed across the opening in the gear case, there should be no deflection of the case when the bearing retainer capscrews are being fully torqued.

--INTERMEDIATE SHAFT BEARINGS--

8. Move the dial indicator from the rim face of low speed gear and place it inside the gear housing with the base on the inside housing wall and the contact point on the rim face of the high speed gear on the intermediate shaft.

Set dial indicator to zero.

9. Follow instructions outlined in paragraphs 6 and 7 above, moving the high speed gear, to obtain zero end-play in the intermediate shaft.

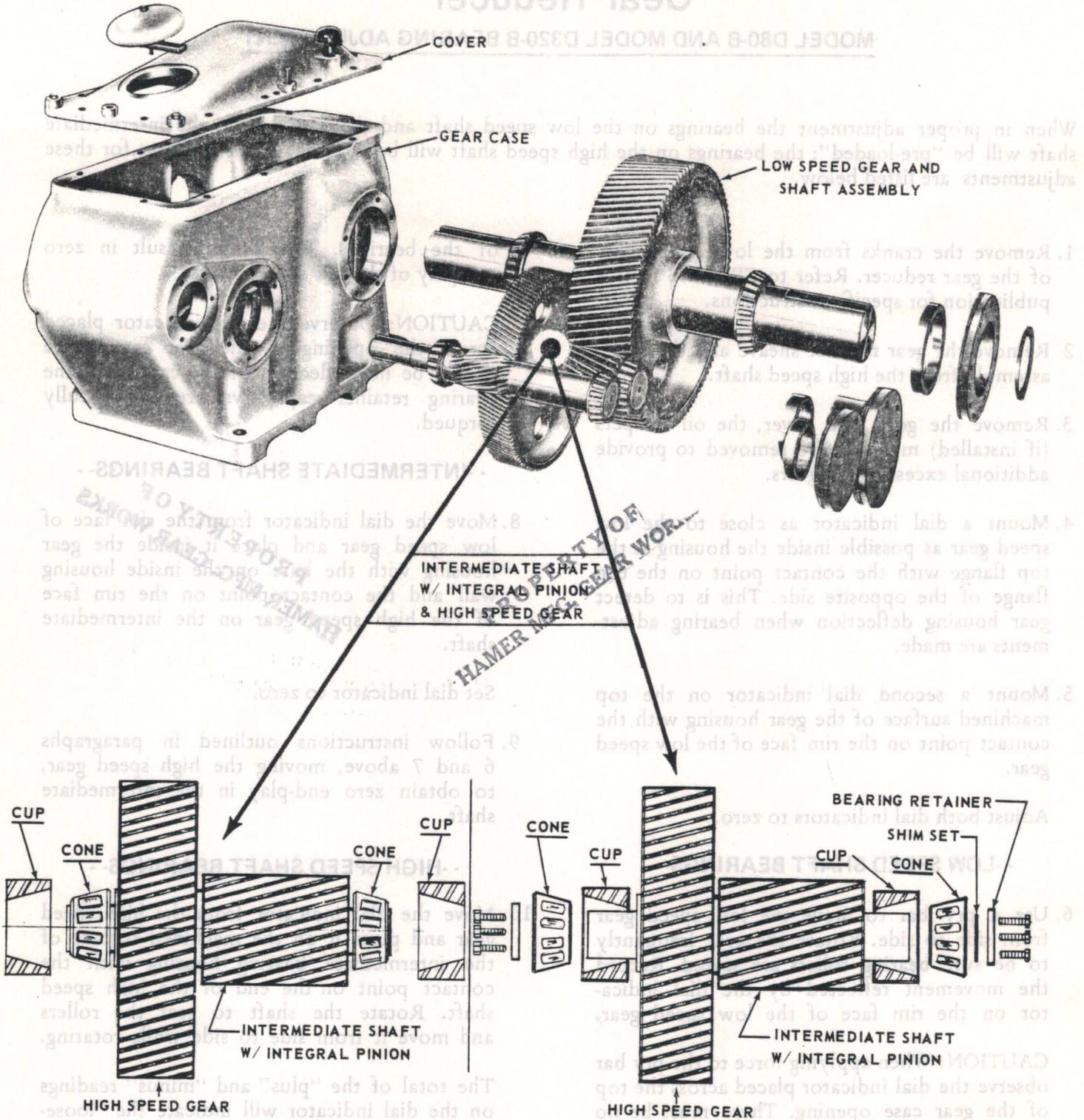
--HIGH SPEED SHAFT BEARINGS--

10. Move the dial indicator from the high speed gear and place it on the machined surface of the intermediate bearing housing with the contact point on the end of the high speed shaft. Rotate the shaft to seat the rollers and move it from side to side while rotating.

The total of the "plus" and "minus" readings on the dial indicator will indicate the "looseness" of the high speed bearings. Add or remove shims as required to obtain .001" to .003" high speed shaft end-play.

11. Install the gear case cover and dowel.
12. Pre-load intermediate bearings by removing .005" shim thickness.
Pre-load low speed bearings by removing .005" or .0075" shim thickness.

BEARING ADJUSTMENT (Continued)



(Figure 29)

**DIRECT BEARING MOUNTING
FOR D80-B and D320-B GEAR REDUCERS**

These gear reducers are assembled with the cups pressed into the bearing housings at each end of the intermediate shaft. The bearings are adjusted with the shims between the bearing housing and the gear case.

**INDIRECT BEARING MOUNTING
D114-B, D160-A, D228-A and D-456 GEAR REDUCERS**

These gear reducers are assembled with the bearing cups pressed into the gear case and the bearings are adjusted with the shims between the end of the shaft and the bearing retainer.

Gear Reducer

MODEL D114-B, D160-A, D228-A and D-456 BEARING ADJUSTMENT

When in proper adjustment the bearings on the low speed shaft will be "pre-loaded". The intermediate shaft will have zero end-play and the bearings on the high speed shaft will be "loose". The tolerances for the adjustments are listed below.

1. Remove the cranks from the low speed shaft of the gear reducer. Refer to CRANKS in this publication for specific instructions.
2. Remove the gear reducer sheave and the brake assembly from the high speed shaft.
3. Remove the gear case cover, the oil scrapers (if installed) may also be removed to provide additional access to the gears.
4. Mount a dial indicator as close to the low speed gear as possible inside the housing at the top flange with the contact point on the top flange of the opposite side. This is to detect gear housing deflection when bearing adjustments are made.
5. Mount a second dial indicator on the top machined surface with the contact point on the rim face of the low speed gear.

Adjust both dial indicators to zero.

- -LOW SPEED SHAFT BEARINGS- -

6. Use a pry bar to move the low speed gear from side to side. Rotate the gear frequently to be sure bearing rollers are seated. Record the movement reflected by the dial indicator on the rim face of the low speed gear.

CAUTION: When applying force to the pry bar, observe the dial indicator placed across the top of the gear case opening. There must be no deflection in the gear case when moving the low speed gear from side to side. Excessive force on the pry bar can cause damage to the gear or fracture of the gear case.

The total of the "plus" and "minus" reading of the indicator on the gear face represents the looseness of the bearings.

7. Remove the bearing retainer and remove a quantity of shims equal to the total looseness of the bearings. This should result in zero end-play of the low speed shaft.

CAUTION: Observe the dial indicator placed across the opening in the gear case, there should be no deflection of the case when the bearing retainer capscrews are being fully torqued.

- -INTERMEDIATE SHAFT BEARINGS- -

8. Move the dial indicator from the low speed gear and place its base on the inside wall of the gear housing adjacent to the high speed gear on the intermediate shaft. The contact point of the dial indicator is to be placed on the rim face to the high speed gear.

Set dial indicator to zero.

9. Move high speed gear from side to side while rotating the gear to be certain that the bearing rollers are seated.
10. Follow instructions in paragraphs 6 and 7 above, moving the high speed gear, to obtain zero end-play.

- -HIGH SPEED SHAFT BEARING- -

11. Move the dial indicator from the high speed gear and place it on the machined surface of the intermediate bearing housing with the contact point on the end of the high speed shaft. Rotate the shaft to seat the rollers and move it from side to side while rotating.

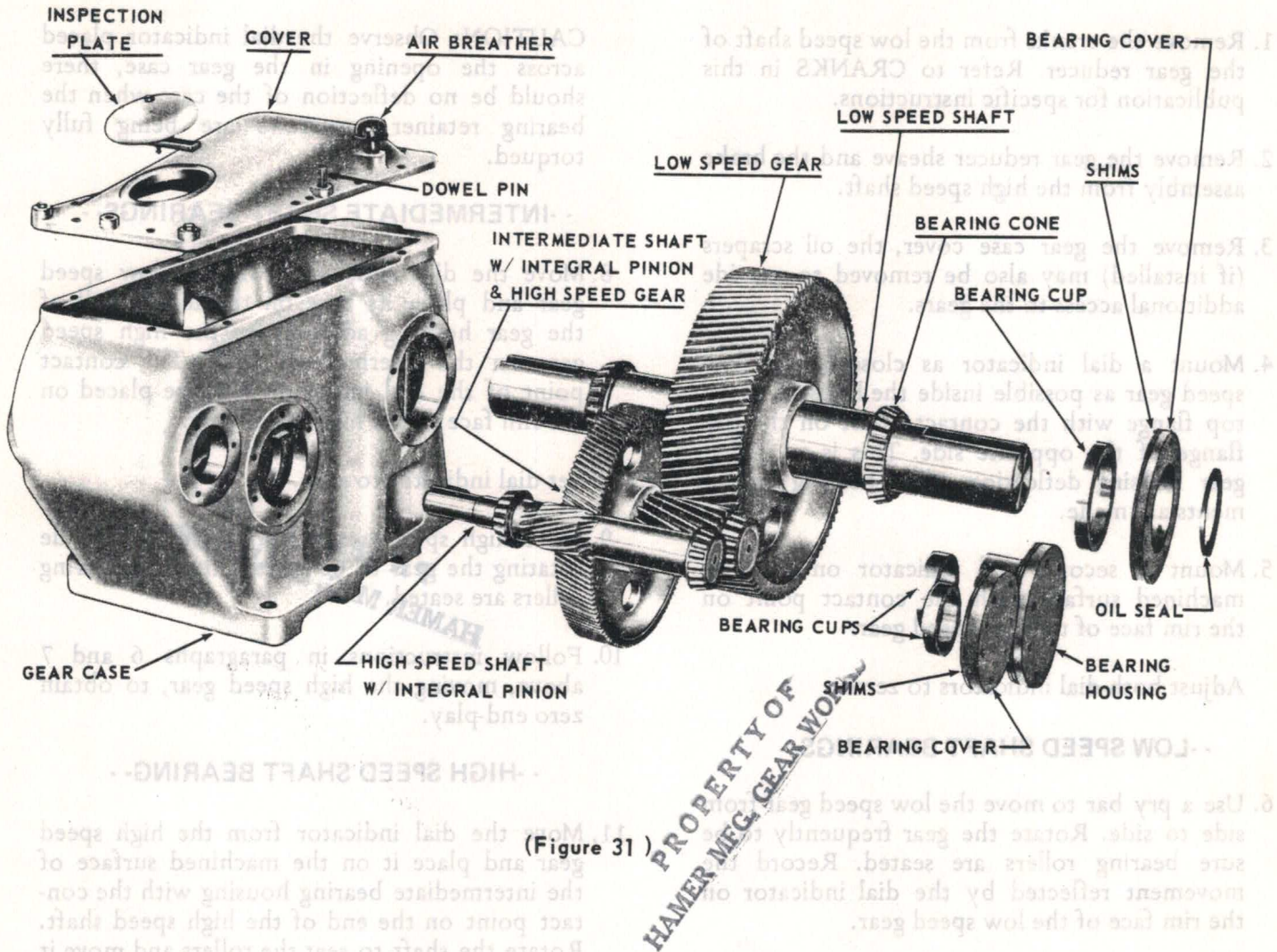
The total of the "plus" and "minus" readings on the dial indicator will indicate the "looseness" of the high speed bearings.

Add or remove shims as required to obtain .001" to .003" high speed shaft end-play. EXCEPTION, high speed shaft on Model D-456 gear reducer is to have .003" to .005" end-play.

12. Install gear case cover and dowel.
13. Pre-load low speed bearings by removing .005" to .0075" shim thickness.

Gear Reducer DISASSEMBLY

MODEL D14-B, D160-A, D228-A and D-458 BEARING ADJUSTMENT



(Figure 31)

The above is a typical arrangement of a pumping unit gear reducer; however, some may have a double extended high speed shaft, shaft guard and direct mounted bearings on the intermediate shaft. The parts list provided for each unit model will detail the components of the reducer and outline their arrangement in the gear case.

These are double reduction gear units with specific speed reduction ratios (refer to parts listing for the ratio of each gear reducer size). The gears and pinions (two each) are the single helical type. They are mounted or machined on three parallel shafts and are roller bearing supported.

The tapered roller, shim adjustable, bearings in the gear reducer can be adjusted with the gear reducer installed on the unit; however, dis-assembly and re-assembly operations can best be performed if the reducer is removed from the unit and transported to a machine shop where a large bearing press, overhead hoist, bearing pullers, etc., are immediately available.

GEAR REDUCER

DISASSEMBLY

1. Remove the cranks from the low speed shaft of the gear reducer. Refer to CRANKS in this publication for specific instructions.
2. Remove the v-belts from the gear reducer.
3. Disconnect the brake linkage by removing the upper clevis pin.
4. Drain the lubricant from the unit.
5. Remove the unit from its base or pedestal and transport it to a machine shop where a large bearing press, bearing pullers, etc., are available.
6. Remove the gear reducer sheave and brake assembly.
7. Remove the gear case cover (remove the oil scrapers and spacers*).
8. Remove the bearing covers, oil seals and shims from the low speed shaft.
9. Support the low speed gear and shaft assembly with an overhead hoist - this is to remove the weight from the bearings.

Remove the low speed bearing cup from the right hand side of the gear case (right hand and left hand is determined by standing at the high speed end of the gear reducer and looking toward the low speed end). A minimum of force from a hydraulic ram placed against the left hand end of the low speed shaft should move this cup from the case.

10. Use a bearing puller to remove the low speed bearing cone from the right hand end of the low speed shaft.
11. Place a tubular spacer on the right hand end of the low speed shaft. The shaft must be able to move freely inside the spacer; the spacer must extend through the bearing opening and butt against the hub of the low speed gear. The spacer must be of sufficient length to permit the shaft to be pressed into it approximately 18-inches.

Support this spacer and with the outside end placed against the anvil of the bearing press, press the shaft out of the gear and in-

to the spacer.

CAUTION: Do not anchor the gear case and use the inside vertical surface as a "back-up" for the gear during this removal operation - the case may be fractured.

When the largest diameter of the shaft has passed through the gear hub the shaft will be loose; however, the left hand bearing cone must be removed before the shaft can be pulled from the right hand side of the gear case.

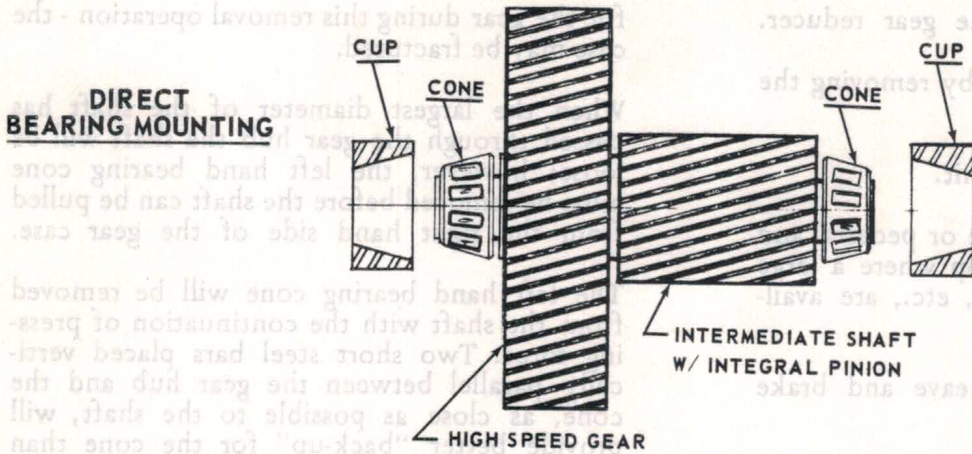
The left hand bearing cone will be removed from the shaft with the continuation of pressing force. Two short steel bars placed vertically parallel between the gear hub and the cone, as close as possible to the shaft, will provide better "back-up" for the cone than will the face of the gear hub.

When the bearing cone is relieved of its grip on the shaft, retract the hydraulic ram, remove the parallel bars and remove the bearing cone from the end of the shaft. Balance the shaft with a choker type sling attached to a hoisting line and pull it from the right hand side of the gear case.

12. Remove the low speed gear from the gear case and remove the gear key from the low speed shaft.
13. Use a bearing puller to remove the low speed bearing cup from the left hand side of the gear case.
14. To remove the high speed pinion with its integral shaft; support the shaft with an overhead hoist to remove the weight from the bearings, remove the bearing covers, oil seal/s and shims.
15. Remove the high speed bearing cup from the left hand side of the gear case. A minimum of force from a hydraulic ram placed against the right hand end of the high speed shaft should move this cup from the case.
16. Balance the shaft and pull it horizontally from the left hand side of the case.
17. Use a bearing puller to remove the bearing cones from the shaft and to remove the bearing cup from the right hand side of the gear case.

*All gear reducers are not equipped with oil scrapers - refer to parts drawings.

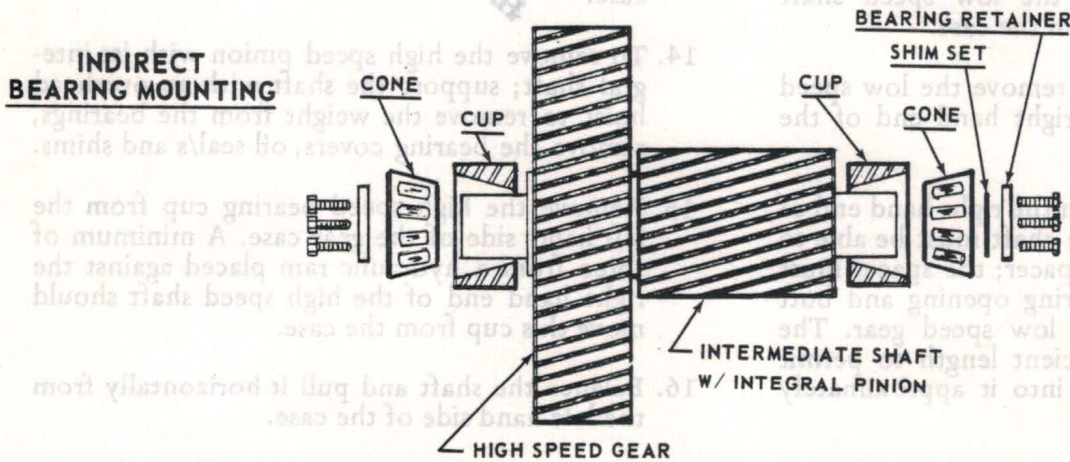
**D80-B and D320-B GEAR REDUCERS
INTERMEDIATE BEARING ARRANGEMENT**



(Figure 32)

These gear reducers are assembled with the cups pressed into the bearing housings at each end of the intermediate shaft. The bearing cones are placed on the intermediate shaft.

**D114-B, D160-A, D228-A and D-456 GEAR REDUCERS
INTERMEDIATE BEARING ARRANGEMENT**



(Figure 33)

These gear reducers are assembled with the bearing cups pressed into the gear case, the bearing cones are then placed on the intermediate shaft and secured with bearing retainers.

GEAR REDUCER - DISASSEMBLY (Continued)

D80-B and D320-B GEAR REDUCERS

- 18. Support the intermediate shaft assembly with an overhead hoist - this is to remove the weight from the bearings.
- 19. Remove the intermediate bearing housings, shims and bearing cups. Install jackscrews in the tapped holes in the flanges of the housings, tighten these screws alternately and evenly to withdraw the housings from the gear case.
- 20. Use a bearing puller to remove the bearing cones from the ends of the intermediate shaft.
- 21. The shaft assembly can now be moved horizontally to the left, the right hand end of the shaft elevated and in this position it can be hoisted from the gear case.
- 22. The shaft with its integral pinion can now be pressed from the high speed gear and the high speed gear key removed from the shaft.
- 23. Use a bearing puller to remove the bearing cups from the bearing housings.

D114-B, D160-A, D228-A and D456 GEAR REDUCERS

- 18A. Support the intermediate shaft assembly with an overhead hoist - this is to remove

the weight from the bearings.

- 19A. Remove the intermediate bearing covers and gaskets from the gear case.

Remove the bearing retainers and shims from the ends of the intermediate shaft.

- 20A. Introduce a slight force from a hydraulic ram to the right hand end of the intermediate shaft. CAUTION: The diameter of the ram must be less than the inside diameter of the bearing cone. This should force the shaft through the right hand bearing cone and simultaneously extend the left hand end of the shaft to a point outside the gear case where a bearing puller can be applied to pull the left hand bearing cone from the shaft.

Remove the right hand bearing cone from shaft.

- 21A. The shaft assembly can now be moved horizontally to the left, the right hand end of the shaft elevated and in this position it can be hoisted from the gear case.

- 22A. The shaft with its integral pinion can now be pressed from the high speed gear and the high speed gear key removed from the shaft.

- 23A. Use a bearing puller to remove the bearing cups from the gear case.

INDIRECT BEARING MOUNTING FOR D114-B, D160-A, D228-A and D456 GEAR REDUCERS

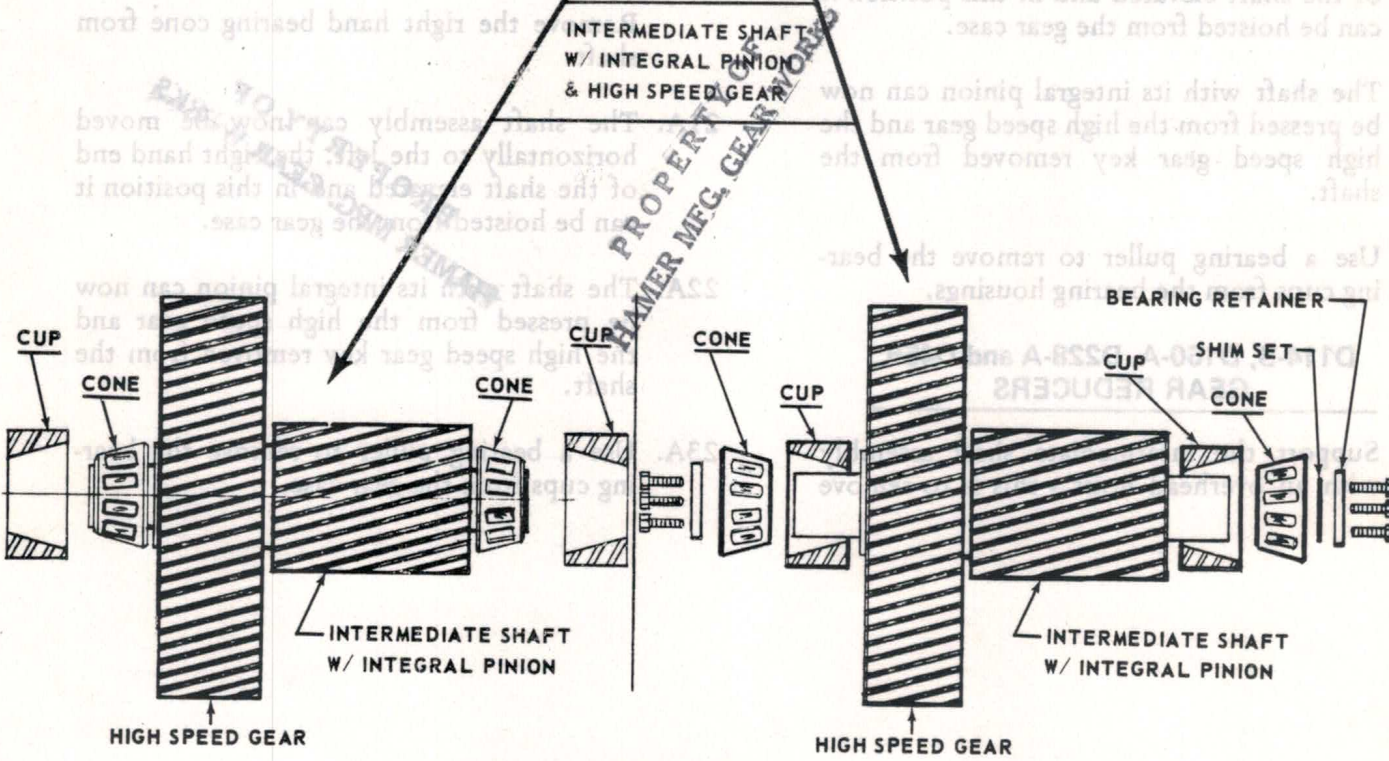
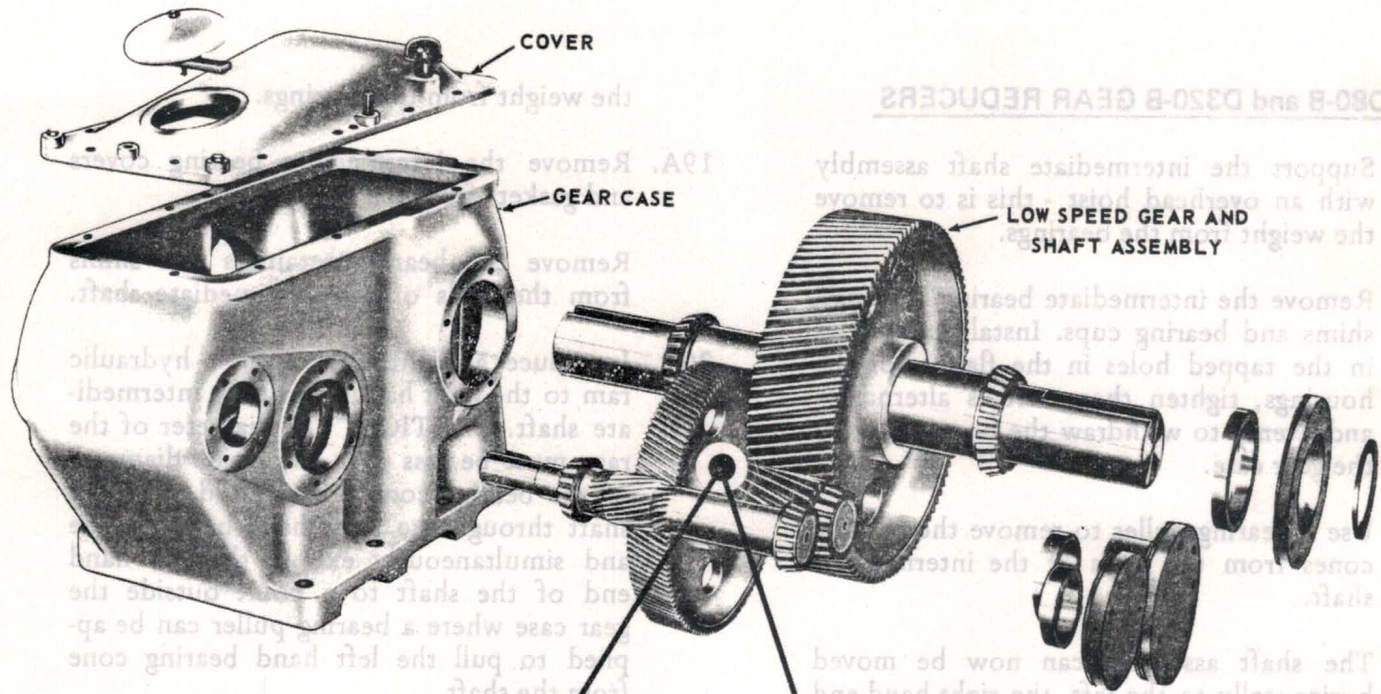
These gear reducers are assembled with the bearing cups pressed into the bearing housing and the bearings are adjusted with the shims between the end of the shaft and the bearing retainer.

DIRECT BEARING MOUNTING FOR D80-B and D320-B GEAR REDUCERS

These gear reducers are assembled with the cups pressed into the bearing housing at each end of the intermediate shaft. The bearings are adjusted with the shims between the bearing housing and the gear case.

Gear Reducer

RE-ASSEMBLY



(Figure 34)

DIRECT BEARING MOUNTING FOR D80-B and D320-B GEAR REDUCERS

These gear reducers are assembled with the cups pressed into the bearing housings at each end of the intermediate shaft. The bearings are adjusted with the shims between the bearing housing and the gear case.

INDIRECT BEARING MOUNTING FOR D114-B, D160-A, D228-A and D-456 GEAR REDUCERS

These gear reducers are assembled with the bearing cups pressed into the gear case and the bearings are adjusted with the shims between the end of the shaft and the bearing retainer.

GEAR REDUCER

RE-ASSEMBLY

1. Carefully clean and inspect all parts for flaws, defects and wear. Replace all parts that are obviously defective and all that are of questionable quality.
2. Place all of the bearing cones in a vat containing 15% soluble oil in water and heat until bearing cones are approximately 200° F.
3. Install the key for the high speed gear in the intermediate shaft.

Press the high speed gear on the intermediate shaft.

D80-B and D320-B GEAR REDUCERS

The continued instructions are applicable to the D80-B and D320-B gear reducers. Instructions pertinent to the assembly of the intermediate shaft in the D114-B, D160-A, D228-A and D456 gear reducers appear subsequently in this manual.

4. Press the cups for the intermediate bearings into the intermediate bearing housings.
5. Support the intermediate shaft with its integral pinion and installed high speed gear. Elevate the right hand end of the shaft assembly and lower the assembly into the gear case. Move the assembly into position with the high speed gear on the left hand side of the gear case and the ends of the shaft centered in the openings for the intermediate bearings.
6. Using wire hooks and asbestos gloves, remove the heated bearing cones from the oil/water solution and place these (large diameter inward) on the ends of the intermediate shaft. These must be in full circumferential metal-to-metal contact with the shoulder on the shaft and held in this position until they cool and grip the shaft.
7. Install a full set of shims on each bearing housing (refer to PARTS LISTS for details

of various shim sets).

Install the bearing housings on the gear case and apply half-torque to the capscrews.*

D114-B, D-160A, D-228A and D456 GEAR REDUCERS

The continuing instructions are applicable to the D114-B, D160-A, D-228A and D456 gear reducers. Instructions pertinent to the assembly of the intermediate shaft in the D80-B and D320-B gear reducers appeared earlier in this manual.

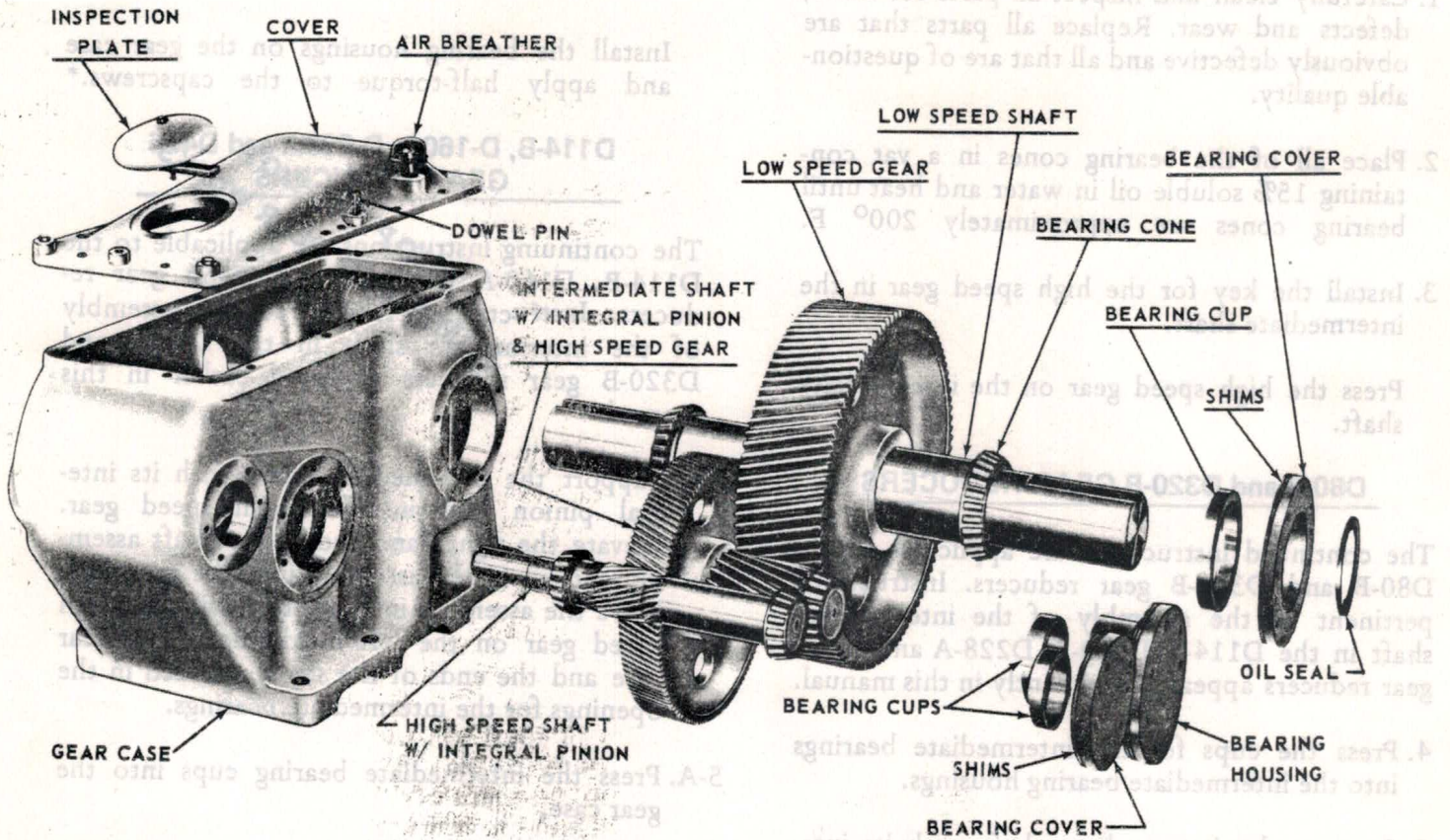
- 4-A. Support the intermediate shaft with its integral pinion and installed high speed gear. Elevate the right hand end of the shaft assembly and lower the assembly into the gear case. Move the assembly into position with the high speed gear on the left hand side of the gear case and the ends of the shaft centered in the openings for the intermediate bearings.
- 5-A. Press the intermediate bearing cups into the gear case.
- 6-A. Using wire hooks and asbestos gloves, remove the heated intermediate bearing cones from the oil/water solution and place these (large diameter outward) on the ends of the shaft. These must be in full circumferential metal-to-metal contact with the shoulder on the shaft and held in this position until they cool and grip the shaft.
- 7-A. Install a full set of shims on the right hand end of the shaft, (refer to PARTS LISTS for details of the various shim sets), install the bearing retainers (one on each end of the shaft) and apply half-torque to the capscrews.*

The bearing covers with their gaskets need not be installed until after the bearings have been adjusted (follow subsequent instructions) but must be installed prior to placing the unit in service.

*Torquing values for fasteners will be found in the APPENDIX of this publication.

GEAR REDUCER

RE-ASSEMBLY



(Figure 35)

As previously stated in this publication, the above is a typical arrangement of a pumping unit gear reducer; however, some may have a double extended high speed shaft, shaft guard and direct mounted bearings on the intermediate shaft. The parts list provided for each unit model will detail the components of the reducer and outline their arrangement in the gear case.

These instructions provide for the re-assembly of the gear reducer in a machine shop and while it is not specifically stated, it should be understood that when the re-assembly is completed and the bearings properly adjusted, the gear reducer must be returned to its original position on the pumping unit and securely fastened to its base or pedestal.

GEAR REDUCER - RE-ASSEMBLY (Continued)

8. Elevate the low speed gear with an overhead hoist and place it inside the gear case. The teeth on the gear must mesh with the installed intermediate pinion and the bore should be in alignment with the openings for the low speed bearings in the gear case.
9. Place the low speed bearing key in the low speed shaft. Balance the shaft on a sling line attached to an overhead hoist, move the end of the shaft through the bearing opening in the gear case and through the bore of the low speed gear to the point where the largest diameter of the shaft is immediately adjacent to the bore of the gear. Place a large tubular spacer over the end of the shaft (the end which was moved through the hub of the gear). The shaft must be able to move freely inside the spacer; the spacer must extend through the bearing opening and butt against the hub of the low speed gear. The spacer must be of sufficient length to permit the shaft to be pressed into it approximately 18-inches.

Support the spacer with the outside end placed against the anvil of a gearing press, align the keyway in the gear hub with the key installed in the low speed shaft and press the shaft into the gear. The gear must be in the exact center of the shaft.

10. Remove the sling line from the shaft, but continue to support the assembly with the hoist attached to the low speed gear. The tubular spacer should also be removed.
11. Using wire hooks and asbestos gloves, remove the heated low speed bearing cones from the oil/water solution and place one on each end of the low speed shaft (the large diameter of the cone must lead the cone onto the shaft). Hold these cones in full circumferential metal-to-metal contact against the shoulder on the shaft until they cool and grip the shaft.
12. Place the low speed bearing cups on the installed bearing cones.
13. Install a full set of shims on each of the bearing housings (refer to PARTS LISTS for shim sets) and apply half-torque to the retaining capscrew.*

CAUTION: When placing plastic shims on the bearing housings a special shim with a reduced diameter to fit within the bolt

circle must be placed adjacent to the flange of the bearing housing. This shim is to function as a gasket.

14. Install the oil seals in the bearing housings. The lip of the seals must be indexed to retard lubricant escapement from the gear case.
15. Support the high speed pinion with its integral shaft on wooden v-blocks.

Using wire hooks and asbestos gloves, remove the high speed bearing cones from the heated oil/water solution and place one each on the end of the high speed shaft (the large diameter of the cone must lead the cone onto the shaft). Hold these cones in full circumferential metal-to-metal contact against the shoulder on the shaft until they cool and grip the shaft.

16. Support the high speed shaft with a sling attached to an overhead hoist and move it carefully into position through one of the openings for the high speed bearings in the gear case. Continue to support the shaft with the teeth of the pinion meshed with the teeth on the high speed gear and ends of the shaft centered in the bearing openings in the gear case.
17. Place the high speed bearing cups on the installed high speed bearing cones.
18. Place a full set of shims on each of the bearing housings (refer to the PARTS LISTS for details of the various shim sets). Install the bearing housings with half-torque* on the retaining capscrews.

CAUTION: When placing plastic shims on the bearing housings a special shim with a reduced diameter to fit within the bolt circle must be placed adjacent to the flange of the bearing housing. This shim is to function as a gasket.

19. Install the oil seal/s in the bearing housings/s. The lip of the seal/s must be indexed to retard lubricant escapement from the gear case.
20. Adjust the gear reducer bearings and continue with the assembly by following the instructions outlined earlier in this publication under the subject of GEAR REDUCER BEARING ADJUSTMENT.

*Torquing values for fasteners will be found in the APPENDIX of this publication.

Appendix

TORQUING VALUES FOR FASTENERS*

The proper torquing of all bolts, studs, capscrews and nuts is IMPORTANT. Improper torquing will cause failure by fatigue or yield and result in serious damage.

1. Thoroughly clean all threads, internal and external, at the time of installation.
2. Lubricate the threads and the inside face of the head on the capscrew or bolt as well as the inside face of the nut, with a good quality anti-seize compound.
3. Be certain tightening progresses uniformly to prevent misalignment or damage to the components.
4. The following values are to be observed in the final tightening of the fasteners.

DIAMETER (INCHES)	THREADS PER INCH	TORQUE REQUIRED (LBS/FT)		
		GROUP 1	GROUP 2	GROUP 3
1/4	20	1.95	5.06	6.22
5/16	18	4.05	10.4	12.9
3/8	16	7.2	16.5	23.9
7/16	14	11.5	29.6	36.6
1/2	13	17.6	45.2	55.8
5/8	11	34.9	90.0	111.
3/4	10	62.	159.	196.
7/8	9	100.	236.	318.
1	8	150.	354.	477.
1-1/8	7	211.	475.	675.
1-1/4	7	300.	675.	955.
1-3/8	6		877.	1245.
1-1/2	6		1508.	2105.
1-3/4	5		2456.	3440.

MATERIAL AND SPECIFICATIONS

GROUP 1: Low carbon steel bolts, capscrews and studs. SAE grade 1 or ASTM A-307.



GROUP 2: Heat treated carbon steel bolts and capscrews. SAE grade 5 or ASTM A-325.

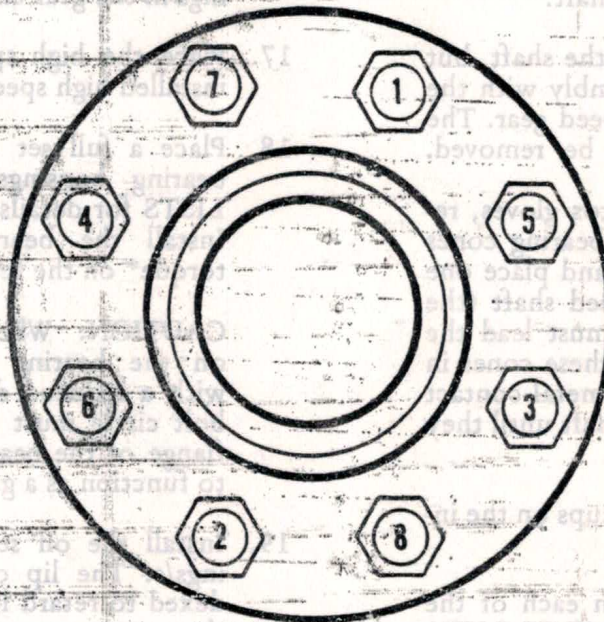


GROUP 3: Alloy steel studs. SAE grade 7 or ASTM A-193 (B-7).



*These torquing values are for lubricated threads (Dry threads require different torquing values).

TORQUING SEQUENCE



A pattern or sequence for the torquing of fasteners is necessary for the proper installation of many machinery components.

Bearing housings, flanges, covers, etc., retained with multiple fasteners, should have equal "stand-off" and clamping force in all areas.

The above sketch reflects the "cross over" pattern

for the torquing of the fasteners. It is suggested that all fasteners be installed "hand tight" and that the torquing be applied in two steps. First, apply half torque to fastener number 1, then number 2, then number 3, etc. When half torque has been applied to all the fasteners, apply full torque to fastener number 1, then number 2, etc., until all the fasteners have been fully torqued.

Appendix

WRENCH OPENING FOR HEX CAPSCREWS AND HEX NUTS*

NOMINAL SIZE OF SCREW OR NUT	WRENCH OPENING**	
	STD. HEX	HVY. HEX
1/4	7/16	1/2
5/16	1/2	9/16
3/8	9/16	11/16
7/16	5/8	3/4
1/2	3/4	7/8
9/16	13/16	15/16
5/8	15/16	1-1/16
3/4	1-1/8	1-1/4
7/8	1-5/16	1-7/16
1	1-1/2	1-5/8
1-1/8	1-11/16	1-13/16
1-1/4	1-7/8	2
1-3/8	2-1/16	2-3/16
1-1/2	2-1/4	2-3/8
1-5/8	2-7/16	2-9/16
1-3/4	2-5/8	2-3/4
1-7/8	2-13/16	2-15/16
2	3	3-1/8
2-1/4	3-3/8	3-1/2
2-1/2	3-3/4	3-7/8
2-3/4	4-1/8	4-1/4
3	4-1/2	4-5/8

*AMERICAN STANDARDS INDICATE THAT ALL HEX NUTS 1-5/8" NOMINAL SIZE AND LARGER WILL BE OF THE HEAVY SERIES.

**The wrench opening is the maximum width across the flats of the fastener plus an allowable tolerance ranging from .003" to .016" for the 1/4" to 3" nominal screw or nut sizes listed above.

Appendix

CAPACITY OF ROUND TANKS

U. S. Gallons in Round Tanks (For One Foot in Depth)

Diam. of Tanks Ft.—In.	No. U. S. Gals.	Cu. Ft. and Area in Sq. Ft.	Diam. of Tanks Ft.—In.	No. U. S. Gals.	Cu. Ft. and Area in Sq. Ft.	Diam. of Tanks Ft.—In.	No. U. S. Gals.	Cu. Ft. and Area in Sq. Ft.	Diam. of Tanks Ft.—In.	No. U. S. Gals.	Cu. Ft. and Area in Sq. Ft.
1 0	5.87	785	4 9	132.56	17.72	13 6	1070.80	143.14	23 3	3175.90	424.56
1 1	6.89	922	4 10	137.25	18.35	13 9	1110.80	148.49	23 6	3244.60	433.74
1 2	8	1,069	4 11	142.02	18.99	14	1151.50	153.94	23 9	3314	443.01
1 3	9.18	1,227	5	146.88	19.63	14 3	1193	159.48	24	3384.10	452.39
1 4	10.44	1,396	5 1	151.82	20.29	14 6	1235.30	165.13	24 3	3455	461.86
1 5	11.79	1,576	5 2	156.83	20.97	14 9	1278.20	170.87	24 6	3526.60	471.44
1 6	13.22	1,767	5 3	161.93	21.65	15	1321.90	176.71	24 9	3598.90	481.11
1 7	14.73	1,969	5 4	167.12	22.34	15 3	1366.40	182.65	25	3672	490.87
1 8	16.32	2,182	5 5	172.38	23.04	15 6	1411.50	188.69	25 3	3745.80	500.74
1 9	17.99	2,405	5 6	177.72	23.76	15 9	1457.40	194.83	25 6	3820.30	510.71
1 10	19.75	2,640	5 7	183.15	24.48	16	1504.10	201.06	25 9	3895.60	520.77
1 11	21.58	2,885	5 8	188.66	25.22	16 3	1551.40	207.39	26	3971.60	530.93
2	23.50	3,142	5 9	194.25	25.97	16 6	1599.50	213.82	26 3	4048.40	541.19
2 1	25.50	3,409	5 10	199.92	26.73	16 9	1648.40	220.35	26 6	4125.90	551.55
2 2	27.58	3,687	5 11	205.67	27.49	17	1697.90	226.98	26 9	4204.10	562
2 3	29.74	3,976	6	211.51	28.27	17 3	1748.20	233.71	27	4283	572.56
2 4	31.99	4,276	6 3	229.60	30.68	17 6	1799.30	240.53	27 3	4362.70	583.21
2 5	34.31	4,587	6 6	248.23	33.18	17 9	1851.10	247.45	27 6	4443.10	593.96
2 6	36.72	4,909	6 9	267.69	35.78	18	1903.60	254.47	27 9	4524.30	604.81
2 7	39.21	5,241	7	287.88	38.48	18 3	1956.80	261.59	28	4606.20	615.75
2 8	41.78	5,585	7 3	308.81	41.28	18 6	2010.80	268.80	28 3	4688.80	626.80
2 9	44.43	5,940	7 6	330.48	44.18	18 9	2066.50	276.12	28 6	4772.10	637.94
2 10	47.16	6,305	7 9	352.88	47.17	19	2120.90	283.53	28 9	4856.20	649.18
2 11	49.98	6,681	8	376.01	50.27	19 3	2177.10	291.04	29	4941	660.52
3	52.88	7,069	8 3	399.88	53.45	19 6	2234	298.65	29 3	5026.60	671.96
3 1	55.86	7,467	8 6	424.48	56.75	19 9	2291.70	306.35	29 6	5112.90	683.49
3 2	58.92	7,876	8 9	449.82	60.13	20	2350.10	314.16	29 9	5199.90	695.13
3 3	62.06	8,296	9	475.89	63.62	20 3	2409.20	322.06	30	5287.70	706.86
3 4	65.28	8,727	9 3	502.70	67.20	20 6	2469.10	330.06	30 3	5376.20	718.69
3 5	68.58	9,168	9 6	530.24	70.88	20 9	2529.60	338.16	30 6	5465.40	730.62
3 6	71.97	9,621	9 9	558.51	74.66	21	2591	346.36	30 9	5555.40	742.64
3 7	75.44	10,085	10	587.52	78.54	21 3	2653	354.66	31	5646.10	754.77
3 8	78.99	10,559	10 3	617.26	82.52	21 6	2718.80	363.05	31 3	5737.50	766.99
3 9	82.62	11,045	10 6	647.74	86.59	21 9	2779.30	371.54	31 6	5829.70	779.31
3 10	86.33	11,541	10 9	678.95	90.76	22	2843.60	380.13	31 9	5922.60	791.73
3 11	90.13	12,048	11	710.90	95.03	22 3	2908.60	388.82	32	6016.20	804.25
4	94	12,566	11 3	743.58	99.40	22 6	2974.30	397.61	32 3	6110.60	816.86
4 1	97.96	13,095	11 6	776.99	103.87	22 9	3040.80	406.49	32 6	6205.70	829.58
4 2	102	13,635	11 9	811.14	108.43	23	3108	415.48	32 9	6301.50	842.39
4 3	106.12	14,186	12	846.03	113.10						
4 4	110.32	14,748	12 3	881.65	117.86						
4 5	114.61	15,321	12 6	918	122.72						
4 6	118.97	15,90	12 9	955.09	127.68						
4 7	123.42	16,50	13	992.91	132.73						
4 8	127.95	17.10	13 3	1031.50	137.89						

1. Gallon equals 231 cubic inches.
 2. Gallons equal 1 barrel (petroleum measure).
 To find the capacity of tanks greater than the largest given in the table, look in the table for a Tank of one-half of the given size and multiply its capacity by 4, or one of one-third its size and multiply its capacity by 9, etc.

Appendix

CAPACITY OF SPHERICAL TANKS

Diameter (feet)	VOLUME OF SPHERE			Surface (sq. ft.)
	U. S. Barrels	U. S. Gallons	Cubic Feet	
1	0.09	3.89	0.52	3.14
2	0.75	31.34	4.19	12.57
3	5.04	105.77	14.14	28.27
4	8.25	250.67	33.51	50.27
5	11.66	489.60	65.45	78.54
6	20.	845.	113.1	113.1
7	32	1,346.	179.6	153.9
8	48.	2,005.	268.1	201.1
9	68.	2,858.	381.7	254.5
10	93.	3,920.	523.6	314.2
11	124.	5,139.	696.9	380.1
12	161.	6,770.	904.8	452.4
13	205.	8,603.	1,150.3	530.9
14	256.	10,750.	1,436.8	615.8
15	315.	13,218.	1,767.1	706.9
16	382.	16,046.	2,145.	804.
17	458.	19,240.	2,572.	907.
18	544.	22,846.	3,054.	1,017.
19	640.	26,863.	3,591.	1,134.
20	746.	31,336.	4,189.	1,257.
21	864.	36,273.	4,849.	1,385.
22	993.	41,704.	5,575.	1,520.
23	1,135.	47,659.	6,371.	1,662.
24	1,288.	54,144.	7,238.	1,810.
25	1,457.	61,198.	8,181.	1,963.
26	1,639.	68,844.	9,203.	2,124.
27	1,836.	77,095.	10,306.	2,290.
28	2,047.	85,981.	11,494.	2,463.
29	2,275.	95,527.	12,770.	2,642.
30	2,518.	105,753.	14,137.	2,827.
31	2,778.	116,689.	15,599.	3,019.
32	3,056.	128,344.	17,157.	3,217.
33	3,352.	140,762.	18,817.	3,431.

Diameter (feet)	VOLUME OF SPHERE			Surface (sq. ft.)
	U. S. Barrels	U. S. Gallons	Cubic Feet	
34	3,665	153,950	20,580	3,632
35	3,998	167,93	22,449	3,848
36	4,351	182,742	24,429	4,072
37	4,724	198,399	26,522	4,301
38	5,117	214,922	28,731	4,536
39	5,532	232,338	31,059	4,778
40	5,968	250,673	33,510	5,027
41	6,428	269,951	36,087	5,281
42	6,911	290,260	38,792	5,542
43	7,415	311,416	41,630	5,809
44	7,944	333,647	44,602	6,082
45	8,498	356,919	47,713	6,362
46	9,077	381,246	50,965	6,648
47	9,682	406,628	54,362	6,940
48	10,313	433,137	57,906	7,238
49	10,972	460,809	61,601	7,543
50	11,657	489,602	65,450	7,854
51	12,368	519,569	69,456	8,171
52	13,113	550,733	73,622	8,495
53	13,884	583,124	77,952	8,825
54	14,683	616,756	82,448	9,161
55	15,510	651,661	87,104	9,503
56	16,376	687,908	91,933	9,852
57	17,270	725,213	96,967	10,207
58	18,194	764,164	102,161	10,568
59	19,148	804,869	107,526	10,936
60	20,132	845,973	113,098	11,310
61	21,146	888,976	118,827	11,690
62	22,190	933,415	124,788	12,076
63	23,338	979,314	130,924	12,469
64	24,469	1,027,709	137,528	12,868
65	25,607	1,075,512	143,793	13,273
66	26,809	1,125,987	150,533	13,685

34.7	822.1	339.8	885.1	377.04	60.13	317.1
37.3	120.1	738.8	171.1	615.31	37.18	282.1
37.8	339.1	678.8	681.1	618.21	37.88	283.1
37.8	339.1	747.8	602.1	732.21	38.27	284.1
37.8	339.1	828.8	722.1	811.21	38.28	284.1
37.8	339.1	828.8	722.1	811.21	38.28	284.1
37.8	339.1	828.8	722.1	811.21	38.28	284.1
37.8	339.1	828.8	722.1	811.21	38.28	284.1
37.8	339.1	828.8	722.1	811.21	38.28	284.1
37.8	339.1	828.8	722.1	811.21	38.28	284.1

Appendix A

PIPE FILL TABLES

VOLUMETRIC CAPACITY OF A. P. I. TUBING (External Upset and Plain End)

OUTSIDE DIAMETER TUBING BODY IN.	NOMINAL WEIGHT LBS. PER FT. T AND C	INSIDE DIA. IN.	HEIGHT FILLED BY		HEIGHT TO DISPLACE	
			1 CU. FT.	1 BBL.	1 CU. FT.	1 BBL.
1.660	2.40	1.380	96.27	540.48	66.54	373.57
1.900	2.90	1.610	75.78	397.09	50.79	285.15
2-3/8	4.70	1.995	46.07	258.65	32.50	182.46
2-7/8	6.50	2.441	30.77	172.75	22.18	124.52
3-1/2	9.30	2.992	20.48	114.98	14.97	84.04
4	11.00	3.476	15.17	85.17	11.46	64.23
4-1/2	12.75	3.958	11.70	65.69	9.05	50.81

VOLUMETRIC CAPACITY OF A.P.I. CASING

O.D.	Wt.	I.D.	Height Filled by		Height to Displace	
			1 Cu. Ft.	1 Bbl.	1 Cu. Ft.	1 Bbl.
4 1/4	9.50	4.090	10.960	61.520	9.058	50.815
4 1/2	11.60	4.000	11.455	64.255	9.058	50.815
4 3/4	13.50	3.920	11.980	66.610	9.058	50.815
5	13.00	4.494	9.080	50.930	7.331	41.126
5	15.00	4.408	9.435	52.930	7.331	41.126
5 1/4	13.00	5.044	7.220	40.450	6.061	34.002
5 1/4	14.00	5.012	7.305	40.950	6.061	34.002
5 1/4	15.50	4.950	7.480	41.990	6.061	34.002
5 1/4	17.00	4.892	7.650	42.980	6.061	34.002
5 1/4	20.00	4.778	8.035	45.050	6.061	34.002
5 1/4	23.00	4.670	8.405	47.240	6.061	34.002
6	18.00	5.424	6.220	34.960	5.094	28.58
6	20.00	5.352	6.385	35.910	5.094	28.58
6 5/8	24.20	5.921	5.236	29.34	4.177	23.43
6 5/8	26.20	5.855	5.383	30.20	4.177	23.43
6 5/8	28.80	5.837	5.410	32.00	4.177	23.43
6 5/8	28.10	5.791	5.467	30.67	4.177	23.43
6 5/8	29.10	5.761	5.525	30.99	4.177	23.43
7	24.30	6.336	4.566	25.63	3.741	20.99
7	26.30	6.276	4.655	26.12	3.741	20.99
7	28.30	6.214	4.748	26.64	3.741	20.99
7	29.80	6.168	4.836	27.08	3.741	20.99
7	30.30	6.154	4.840	27.15	3.741	20.99
7	40.20	5.836	5.410	32.00	3.741	20.99
7 7/8	26.60	6.969	3.770	21.10	3.154	17.69
7 7/8	30.00	6.875	3.870	21.65	3.154	17.69
7 7/8	34.00	6.765	4.006	22.48	3.154	17.69
8 5/8	32.70	7.921	2.922	16.39	2.465	13.83
8 5/8	36.70	7.825	2.994	16.80	2.465	13.83
8 5/8	38.70	7.776	3.032	17.02	2.465	13.83
8 5/8	43.70	7.651	3.132	17.57	2.465	13.83
8 5/8	44.70	7.625	3.154	17.69	2.465	13.83
9	41.20	8.150	2.760	15.48	2.263	12.70
9	46.10	8.032	2.842	15.94	2.263	12.70
9	55.20	7.812	3.094	16.85	2.263	12.70
9 5/8	40.60	8.835	2.350	13.18	1.979	11.10
9 5/8	44.30	8.755	2.392	13.42	1.979	11.10
9 5/8	47.60	8.681	2.433	13.65	1.979	11.10
9 5/8	54.20	8.535	2.517	14.12	1.979	11.10
10 3/4	46.20	9.950	1.852	10.39	1.586	8.90
10 3/4	51.30	9.890	1.890	10.60	1.586	8.90
10 3/4	54.60	9.784	1.915	10.75	1.586	8.90
10 3/4	55.80	9.760	1.925	10.80	1.586	8.90
11 3/4	61.00	10.772	1.580	8.864	1.328	7.45
13 3/4	61.70	12.515	1.171	6.567	1.025	5.75
13 3/4	68.10	12.415	1.189	6.673	1.025	5.75
13 3/4	72.50	12.347	1.203	6.747	1.025	5.75
13 3/4	83.50	12.175	1.237	6.939	1.025	5.75
16	70.00	15.198	0.7938	4.453	0.7163	4.019
16	75.50	15.125	0.8014	4.496	0.7163	4.019
16	84.50	15.010	0.8138	4.565	0.7163	4.019