Field Service Manual
for
Vulcan Air/Steam Onshore Hammers

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Bulletin 168G
3 April, 1999

US$50.00
UK£25.00
J¥7000

GENERAL SAFETY INFORMATION

- Pile hammers should be operated only by well trained, experienced personnel.
- Operating personnel should review all instructions and safety manuals before using pile hammers.Copies of all pertinent manuals should be kept with the pile hammer.
- Everyone near or on the pile driving site should wear safety clothing, including hard hats, safety shoes, safety glasses, and hearing protection.
- If any operating abnormalities are observed, the hammer should be stopped immediately.
- All personnel should stay clear of the work area during operations.
- Air or steam hose connections must be properly secured. Never use an air hose to carry steam. If the hose fails during operation, the results could be extremely dangerous.
- Personnel should stay clear of the hammer until the ram is resting on the base.
- Fire extinguishers must be kept available at all times.
- All federal, state, and local safety and health regulations should be observed.
- For additional important safety information, see Section 4 of this manual.

ORDERING PARTS AND ASSEMBLIES

Refer to the parts list and drawing for the size of hammer involved. Locate the item on the drawing. The key (or number) next to the item is the number used in the parts list. Use the EXACT NAME given in the list and the EXACT PART NUMBER.

Part orders must contain the following:

A) SIZE and SERIAL NUMBER of the hammer.
B) PART NAME AND PART NUMBER of the item(s).
C) Quantity required.

WARRANTY

Vulcan Iron Works Inc. warrants these products to be in accordance with our published specifications or those specifications agreed to by Vulcan in writing at the time of the sale. Vulcan makes no other warranty, express or implied. **THE IMPLIED WARRANTIES OF MERCHANTABILITY AND OF FITNESS FOR ANY PARTICULAR PURPOSE ARE EXCLUDED FROM THIS WARRANTY.** Our obligation and liability under this warranty is expressly limited to repairing or replacing, at Vulcan's option, any product which fails to meet these specifications within 180 days from date of initial use, but not to exceed one year from date of delivery. This remedy is *exclusive* and Vulcan's obligation does not include any transportation charges or costs of installation or any liability from direct, indirect or consequential damage or delay. If requested by Vulcan, products or parts for which a warranty claim is made are to be returned transportation prepaid to Vulcan. Any improper use, operation beyond rated capacity as stated in the written specifications, substitution of parts not approved by Vulcan in writing, or any alteration or repair by anyone other than a duly authorized representative of Vulcan shall void this warranty.

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1.0 INTRODUCTION

The field service manual has been prepared to provide helpful and necessary instructions for the operation, and maintenance of your VULCAN pile hammers. The different sizes covered in this manual are No's 1, 505, 06, 306, 506, 08, 508, 010, 510, 012, 512, 320, 330, 520 and 530 Single Acting Hammers.

Unless specified, the procedures and instructions given are applicable to all sizes. When the instructions are different between the sizes, the beginning of the instruction will indicate which size(s) are covered by the information.

Read the information carefully, follow the instructions properly and your pile hammers should deliver many years of safe and dependable service. The instructions given herein are the result of careful correlation between factory and field experience, and cover the best methods for operation, maintenance, lubrication and overhaul of VULCAN hammers.

Care has been taken to avoid undue emphasis of minor details, but when minor items have been emphasized it is because experience has indicated the wisdom of giving these points special attention.

For safe operation and correct maintenance procedure, it is recommended that the instructions given herein be carefully followed. Service and repair, other than those covered in this manual, are not recommended to be attempted outside of the factory. The manufacturer advocates that major overhaul of a hammer be accomplished by an authorized representative of the VULCAN IRON WORKS INC. or shipped directly to the factory. IT IS IMPORTANT THAT NO UNNECESSARY OR UNAUTHORIZED SERVICE BE PERFORMED ON THE HAMMERS AS THIS TYPE OF SERVICE HAS, IN MOST CASES, BEEN FOUND TO BE DETRIMENTAL.

It has been the aim of the manufacturer to build a hammer to give maximum service with minimum attention other than proper lubrication and adjustments. The latest engineering knowledge and design has been combined with the best materials obtainable and finest workmanship possible to attain high quality products.

DETAILED OPERATION, MAINTENANCE AND LUBRICATION INSTRUCTIONS IN THIS MANUAL ARE VERY IMPORTANT, and you cannot expect good service from your hammer unless the instructions are followed carefully.

All of the instructions have been made as concise as possible and the few minutes required to read them can save down time and money in the future.

(Section 2.0 is reserved for future use.)

3.0 SPECIFICATIONS

3.1 Specifications for Three (3) Foot Stroke Hammers

English Units	*#1*	*06*	*08*	*010*	*012*	*320*	*330*
Operating Data							
Rated Striking Energy, ft-lbs	15,000	19,500	26,000	32,500	39,000	60,000	90,000
Blows per Minute, Normal Stroke, No Set	60	60	50	50	50	55	54
Normal Stroke, Inches	36	36	39	39	39	36	36
Rated Operating Pressure at Hammer, psi	80	100	83	105	125	102	150
Steam Consumption, lbs/hr	2,794	3,230	4,158	5,022	5,835	6,200	8,280
Required Boiler Horsepower	81	94	125	150	175	200	250
Air Consumption (Adiabatic), cfm	565	625	880	1002	1075	1432	1795
Required Air Compressor Size, cfm	600	750	900	1050	1200	1600	2000
Dimensional Data							
Bore, inches	13.5	13.5	16.5	16.5	16.5	21.75	21.75
Net Area of Piston, sq. in.	133.51	133.51	197.92	197.92	197.92	335.75	335.75
Length of Hammer (overall), in.	153	153	178	187	187	209.5	209.5
Distance Across Female Jaws, in.	20	20	26	26	26	37	37
Width of Female Jaws, in.	8.25	8.25	9.25	9.25	9.25	11.25	11.25
Largest Outside Diameter of Pile, in.	18	18	24	24	24	34	34
Size of Hose, in.	2	2	2.5	2.5	2.5	3	3
Weight Data							
Weight of Striking Parts, lbs.	5,000	6,500	8,000	10,000	12,000	20,000	30,000
Net Weight of Hammer, lbs.	9,700	11,200	16,750	18,750	20,750	43,500	53,500
Shipping Weight of Hammer, lbs.	10,100	12,100	17,500	19,500	21,500	44,900	55,000

SI Units							
Operating Data							
Rated Striking Energy, kJ	20.3	26.4	35.3	44.1	52.9	81.3	122.0
Blows per Minute, Normal Stroke, No Set	60	60	50	50	50	55	54
Normal Stroke, mm	914	914	991	991	991	914	914
Rated Operating Pressure at Hammer, bar	5.52	6.89	5.72	7.24	8.62	7.03	10.34
Steam Consumption, kg/hr	1,267	1,465	1,886	2,278	2,647	2,812	3,756
Required Boiler Horsepower	81	94	125	150	175	200	250
Air Consumption (Adiabatic), cu. m./min	16.0	17.7	24.9	28.4	30.4	40.5	50.8
Required Air Compressor Size, cu. m./min	17.0	21.2	25.5	29.7	34.0	45.3	56.6
Dimensional Data							
Bore, mm	343	343	419	419	419	552	552
Net Area of Piston, sq. cm.	861.4	861.4	1276.9	1276.9	1276.9	2166.1	2166.1
Length of Hammer (overall), m	3886	3886	4521	4750	4750	5321	5321
Distance Across Female Jaws, mm	508	508	660	660	660	940	940
Width of Female Jaws, mm	210	210	235	235	235	286	286
Largest Outside Diameter of Pile, mm	457	457	610	610	610	864	864
Size of Hose, mm	51	51	64	64	64	76	76
Weight Data							
Weight of Striking Parts, kg	2,268	2,948	3,629	4,536	5,443	9,072	13,608
Net Weight of Hammer, kg	4,400	5,080	7,598	8,505	9,412	19,731	24,267
Shipping Weight of Hammer, kg	4,581	5,488	7,938	8,845	9,752	20,366	24,948

3.2 Specifications for Five (5) Foot Stroke Hammers

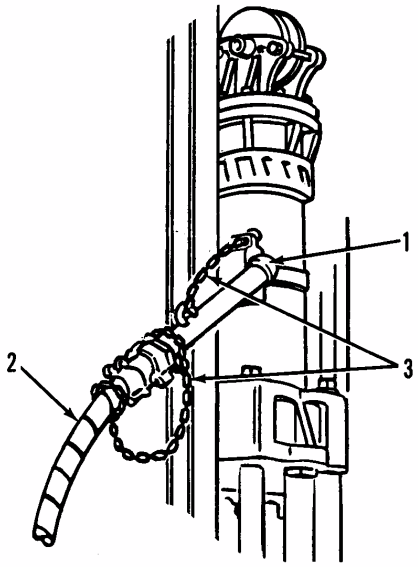
English Units	*505*	*506*	*508*	*510*	*512*	*520*	*530*
Operating Data							
Rated Striking Energy, ft-lbs	25,000	32,500	40,000	50,000	60,000	100,000	150,000
Blows per Minute, Normal Stroke, No Set	46	46	41	41	41	42	42
Normal Stroke, Inches	60	60	60	60	60	60	60
Rated Operating Pressure at Hammer, psi	100	120	65	83	100	102	150
Steam Consumption, lbs/hr	3,176	3,843	4,542	5,480	5,940	7,160	8,680
Required Boiler Horsepower	92	112	150	160	200	250	300
Air Consumption (Adiabatic), cfm	563	744	818	932	1094	1652	2076
Required Air Compressor Size, cfm	600	900	900	1050	1200	2000	2400
Dimensional Data							
Bore, inches	13.5	13.5	16.5	16.5	16.5	21.75	21.75
Net Area of Piston, sq. in.	133.51	133.51	197.92	197.92	197.92	335.75	335.75
Length of Hammer (overall), in.	209	209	221	221	221	258	258
Distance Across Female Jaws, in.	20	20	26	26	26	37	37
Width of Female Jaws, in.	8.25	8.25	9.25	9.25	9.25	11.25	11.25
Largest Outside Diameter of Pile, in.	18	18	24	24	24	34	34
Size of Hose, in.	2	2	2.5	2.5	2.5	3	3
Weight Data							
Weight of Striking Parts, lbs.	5,000	6,500	8,000	10,000	12,000	20,000	30,000
Net Weight of Hammer, lbs.	11,800	13,025	19,480	21,480	23,480	45,160	55,160
Shipping Weight of Hammer, lbs.	12,700	14,000	20,230	22,230	24,230	45,560	55,660

SI Units							
Operating Data							
Rated Striking Energy, kJ	33.9	44.1	54.2	67.8	81.3	135.6	203.4
Blows per Minute, Normal Stroke, No Set	46	46	41	41	41	42	42
Normal Stroke, mm	1524	1524	1524	1524	1524	1524	1524
Rated Operating Pressure at Hammer, bar	6.89	8.27	4.48	5.72	6.89	7.03	10.34
Steam Consumption, kg/hr	1,441	1,743	2,060	2,486	2,694	3,248	3,937
Required Boiler Horsepower	92	112	150	160	200	250	300
Air Consumption (Adiabatic), cu. m./min	15.9	21.1	23.2	26.4	31.0	46.8	58.8
Required Air Compressor Size, cu. m./min	17.0	25.5	25.5	29.7	34.0	56.6	68.0
Dimensional Data							
Bore, mm	343	343	419	419	419	552	552
Net Area of Piston, sq. cm.	861.4	861.4	1276.9	1276.9	1276.9	2166.1	2166.1
Length of Hammer (overall), m	5309	5309	5613	5613	5613	6553	6553
Distance Across Female Jaws, mm	508	508	660	660	660	940	940
Width of Female Jaws, mm	210	210	235	235	235	286	286
Largest Outside Diameter of Pile, mm	457	457	610	610	610	864	864
Size of Hose, mm	51	51	64	64	64	76	76
Weight Data							
Weight of Striking Parts, kg	2,268	2,948	3,629	4,536	5,443	9,072	13,608
Net Weight of Hammer, kg	5,352	5,908	8,836	9,743	10,650	20,484	25,020
Shipping Weight of Hammer, kg	5,761	6,350	9,176	10,083	10,991	20,666	25,247

4.0 OPERATION

4.1. Before Driving Begins

4.1.1 Hose Connections and Recommendations



1. Hammer Air Inlet
2. Air Line
3. Chain

Figure 4.1.1 Inlet Line Attachment

Before connecting steam or air hoses to line inlet, examine the exterior of the hose to be sure it is in good serviceable condition. Blow steam or air through the hose to ensure that no obstructions exist. Remove all protective tape from the openings in the hammer cylinder. If the openings were not covered, check the inside of the opening for cleanliness.

IMPORTANT

IF AIR OR STEAM LINES ARE NOT PROPERLY SECURED, OR IF THEY FAIL DURING OPERATION, THEY CAN BE EXTREMELY DANGEROUS! Never use manila or other fabric rope with pile driving equipment. (Refer to Section 4.5).

Steam will cause hoses to deteriorate more rapidly than air. Because of the heat and abrasion involved, use caution and protective gloves when handling hoses.

IMPORTANT

NEVER USE AIR HOSES TO CONVEY STEAM.

Air and steam lines should be connected to the hammer air inlet and then secured by a chain or piece of wire rope. The chain or wire rope should suspend the line in a manner which will relieve the weight of the hose at the coupling, and help eliminate the jarring motions which occur during operation (See Figure 4.1.1).

HOSE CONNECTIONS SHOULD NOT USE A NIPPLE EXCEEDING FOUR (4) INCHES (100 MM) IN LENGTH.

ADHERE TO ALL FEDERAL, STATE AND LOCAL SAFETY REGULATIONS AND PROCEDURES.

The overall length of air or steam hoses should be kept to an absolute minimum to insure correct operation. The longer the hoses, the greater the pressure losses in the hose.

Protect hoses from abrasion by wrapping or other means. All projecting surfaces on the leaders, should be covered to avoid catching or damaging hoses.

4.1.2 Set-Up and Starting Procedure

The simplest method of inserting the hammer in the leaders is to raise the leaders and lower them over the hammer. Flanges forming the jaws on the leaders should have ¼" (6 mm) sideways clearance from the sides of the hammer jaws.

A drain valve should be installed at the lowest point in the pipe so condensation can be drained from the hose and pipe.

After the hammer is positioned in the leaders and the air or steam lines are connected, check the entire installation.

Thoroughly warm a cold hammer by slowly letting air or steam into the cylinder. Allow the ram to strike a few soft blows. The slow starting and

warming will permit uniform casting expansion and reduce internal stresses.

4.2 During Operation

As the hammer drives the pile, there are a few things the operator(s) need to watch for.

First, it is important that the hammer produce the desired stroke. This can be either the full stroke or a reduced stroke selected using the Vari-Cycle (see Section 5.4.2). *This is the most important criterion in determining whether a hammer is operating properly or not;* other criterion, such as blow rate or the "rhythm" of the hammer, are simply not adequate.

Second, the operator must avoid pile runout. This takes place when the driving is very soft. Extensive hammer damage can take place if the hammer at full energy is allowed to drive the pile while it is running. This is because the pile is leaving the hammer faster than the hammer can follow, leading the ram to transfer all of the energy to the base and/or pipe cap. It is permissible to reduce pressure during runout to reduce the stroke temporarily until sufficient ground resistance is encountered.

Third, and the opposite of runout, the operator must avoid driving beyond the rated capacity of the hammer. For Vulcan onshore hammers, this means that the set of the pile must be more than 0.1" (2.54 mm) per blow, or 120 BPF. Any operation above this capacity will void the warranty. Cushion material must be kept fresh as well. Do not continue driving a pile when it is no longer moving as both damage to the pile and hammer will result.

Finally, the operator must take steps to avoid hammer racking due to excessive elastic compression of the pile. Although piles are made of "rigid" materials, such as wood, concrete, or steel, all of these are capable of and do experience elastic compression when they are struck on the end, especially if they are light cross-section piles. Such piles as long and light H-beam, pipe, and wood piles are especially prone to this, and also any type of piles when there is hard driving with most of the pile out of the ground. Again steps need to be taken to reduce the stroke of the hammer to avoid this problem.

4.3. Daily Inspection

The following items should be checked on the hammer assembly each day the hammer is in use and especially when the hammer has not been used and it is about ready to start driving:

1) Remove all protective tape or rags found in or over port openings of any kind in the cylinder. Should any of the port openings be found to be unprotected, check to be sure no foreign material has entered through the opening.
2) Check clearance between hammer and pipe cap jaws and the leader tracks, especially where the leader tracks have been bent. Hammer and cap must slide freely in the leaders. Make sure that the jaws and tracks are fully greased.
3) Check the columns and piston rods for nicks, burrs, and welding and burning slag.
4) Consult the Lubrication Section of the manual (See Section 5.1) for lubrication instructions. It is very important that the hammer be fully lubricated whenever operated.
5) Fill the steam line oiler, following the lubrication recommendations (See Section 5.1). Make sure the line oiler is properly operating and injecting lubricant into the steam line.
6) Fill the cushion pot on the driving accessory with cushion material and top plate (See Section 5.8).
7) Make sure the steam line and air hoses are completely clear of foreign matter before attaching these to the hammer, (See Section 4.1).
8) Secure the steam or air supply line to the hammer (See Section 4.1).
9) Check all fasteners for tightness (See Section 5.3.1.1).
10) Check all gaskets for breaks or leaks.
11) Check the tie cables for tightness. Check the general condition of all suspension and wrap cables.
12) Check ram keys for tightness (See Section 5.7.2). DO NOT OVERTIGHTEN THE RAM KEYS.

13) Check slide bar to make sure that it is secure (See Section 5.4.3).
14) Check drive cap-hammer base wire ropes to make sure that they are safe.

When the leaders are fully secured to the crane line, the hammer may be lifted onto the pile. For plumb pile, even though the hammer alignment must always be correct, the specific rotation of the hammer is not critical; however, with batter pile, the hammer should be positioned in such a way that the weight of the ram is evenly distributed on at least two (2) columns. Failure to do so may result in the one (1) column being galled and scored.

The hammer hoist line should be kept slack at all times while the pile is being driven so the full weight of the hammer rest squarely on the pile. A pile which is allowed to run ahead of the hammer will permit the hammer to drive on its own retaining members, damaging the hammer.

4.4 Special Conditions

4.4.1 Winter Weather Operation

During severe cold weather it may be necessary to preheat the cylinder and other lubricated parts with a torch. Warming will help thaw the oil and break the bond which would prevent the hammer from starting.

IMPORTANT

Keep heat away from nylon slide bars and cables.

Condensation will form in the cylinder and steam chest during cold weather. Sluggish performance will be noticeable until the condensate can drain out of the cylinder. Drainage is automatic.

To decrease the intensity of the hammer driving force, the steam or air pressure can be reduced during operation. Steam or air pressure reduction can be accomplished at the operator throttle valve, the air compressor, or steam boiler.

In sub-freezing weather the hammer must be preheated prior to operation. Pre-heating will prevent damage to the cylinder and valve by eliminating frozen condensation and possible thermal shock.

Drain any accumulated condensation from the lubricator at the end of each work shift, to avoid ice from plugging the oil suction line. It is also advisable to preheat the lubricator to assure immediate lubrication when the hammer is started.

Insulate any hard piping to minimize air volume losses due to cold temperature.

4.4.2 Hammer Icing and Valve Flutter

One phenomenon frequently associated with cold weather operation is valve flutter, which is usually attributed to hammer icing in compressed air. Valve flutter is not exclusively associated with winter, however; if the temperature and humidity are right, hammer icing can take place in hot weather as well as cold. To avoid icing, several remedies exist:

1) A heater can be installed in the air compressor to heat air enough to eliminate ice formations.
2) The lubrication oil in the air line oiler can be diluted with 50 percent mixture of ethylene glycol and oil. There are other commercially available products, such as Kilfrost, that can be used to reduce icing.
3) A de-icing unit can be installed in the air line between the lubricator and the hammer. One such unit is the Tanner De-Icer Tank. This unit atomizes an anti-icing chemical into the airstream to prevent hammer icing. Tanner gas equipment is available from Tanner Systems, Inc., Sauk Rapids, MN 56379.

Strange as it may sound, "icing" is not always caused by ice. The same results can be obtained by using motor oil in the line oiler (see Section 5.1). This produces a gooey slime that can break the friction necessary for stable valve operation.

4.5 Safety

4.5.1 Basics

Today's Vulcan Pile Hammer is the product of over one hundred years of engineering and manufacturing experience. Every component of the machine has been designed for maximum

reliability and is fabricated from the most suitable materials available. Although we feel this machine has earned a reputation within the construction industry for both reliability and safety, we also feel that it is our duty to convey to you potential hazards associated with its use.

This section presents a discussion of each of the general types of hazards which must be considered for the successful use of the Vulcan Pile Hammer. Although considerable effort has been made to identify situations which may involve risk to personnel or property and to suggest how these risks may be avoided, nothing will substitute for good maintenance and well trained operators.

4.5.2 Operating Techniques

The pile hammer should be used only by well trained and experienced personnel. Before using the hammer all instruction and safety manuals should be thoroughly reviewed by all operating and maintenance personnel. These references are an invaluable source of information and should be retained by the owner for future study and to train new employees. Copies of these manuals should be kept with the hammer at the construction site for ready access. Additional copies are available from Vulcan.

Safe use of the pile hammer, as with any machine, is dependent upon the skill, knowledge and concern of those who maintain and use it. Because of the wide variety of environments and applications in which this machine may be used, a comprehensive description of detailed rigging and operating techniques within this book is not possible. (Specific requirements should be addressed to Vulcan's engineering department in Chattanooga, Tennessee.)

For reasons mentioned elsewhere, no one should be any closer to the hammer during driving than is absolutely essential. All workmen should wear safety clothing including hard hats, safety shoes, safety glasses and hearing protection.

Before, and periodically during usage, a complete inspection should be performed on the hammer and all associated equipment to insure operational integrity. The associated equipment includes items such as the compressor and/or boiler, hoses and hose couplings, leaders, support and lifting equipment and all rigging, etc. On the hammer, particular attention should be given to sheaves, pins, retaining bolts, hose couplings, the valve mechanism, all keys, ram point, pile cap, and the lifting points. Supervisors should be certain that all inspection and maintenance is properly done.

During the driving operation and whenever the hammer is moved, constant supervision and inspection should be provided. If abnormalities are observed, driving should be stopped immediately. One example would be that of the loss of one or more ram keys. If both keys are missing, then the ram would obviously no longer be connected to the piston. Without the ram to slow the acceleration of the piston on the up stroke, the piston may impact into the cylinder head with catastrophic effects. Another dangerous situation would be to continue hammer operation without a piling seated in the pile cap. In this event, the entire force of the falling ram could be absorbed by the hammer's columns, base and pile cap. Few such strokes could be sustained without severe damage to the hammer. Obviously, such destruction would be hazardous to anyone in the vicinity. Also, the cylinder head lifting points (sheave, axle, pins, keys and nuts) should be continuously checked for worn, loose or missing parts. Damaged or missing components of this assembly could cause hammer to disconnect from rigging and fall.

The effects of unregulated steam or air pressure may also create a risk. As noted elsewhere, failure of any of the hose couplings, while under pressure, could be very dangerous. In addition, operation at pressures either higher or lower than specified design should be avoided since structural damage to the hammer or inefficient operation may result. Obviously, all air or steam supply hoses must be properly sized to avoid undue flow restrictions.

Damage to the pile, pile cap, ram point and piston can occur if the alignment of the hammer and the pile is not correct. That is, the central axis of the hammer should be in alignment with the central axis of the pile and the pile end should be

square and uniform. If the error in alignment is great, the hammer will receive an unbalanced structural loading which could result in either a fatigue failure in the hammer or a significant shortening of its useful life. Obviously, this type of condition could be both expensive and dangerous, but can be avoided with reasonable care.

A common pile driving criterion is to drive until a certain number of blows per foot of pile insertion is achieved. This measure is based on the amount of energy delivered with each stroke of the ram. In a single acting hammer, the energy is dependent upon the falling weight and stroke length. Since falling weight is constant, only changes in stroke length can affect the energy delivered. Therefore, if a variable stroke hammer is used, it should be noted that the blow count taken is compared to the proper stroke energy, i.e., the blow count criterion will vary with the stroke length used. The supervisor should correlate the blow count criterion and the stroke length. Otherwise, pile and/or hammer damage, added expense, or inadequate pile installation could result. It should also be noted that significant deviations in pressure delivered to the hammer from the recommended pressure may affect the actual operating stroke length and thus influence the energy in each blow of the hammer.

Since the pile hammer is such an extremely powerful machine, it is conceivable that even with normal operation, surroundings at the driving site could be damaged. Operators should take every precaution to see that exhaust from the hammer and vibration of the earth are not a threat to the area surrounding the driving site. Failure to do so could be unsafe and possibly lead to expensive property damage.

As an additional precautionary measure, a pre-pile driving survey could be made.

Given the respect it deserves, the pile hammer should provide years of safe service. However, the ultimate safety and reliability of the hammer rest in the hands of the user.

4.5.3 Falling Objects and Projectiles

The pile hammer is a relatively large and heavy machine which is normally used in a suspended position. Consequently, gravity can propel the hammer or any of its parts downward with great force. Therefore, every effort should be made to see that neither the machine or any of the hammer's component parts are permitted to fall.

Supporting and lifting tackle should be of sufficient capacity to safely lift the weight of the hammer and to withstand the vibration of its operation. (See gross weight label on machine.) Likewise, all rigging should be heavy enough to handle the load safely and the entire system should be thoroughly inspected to insure its integrity before it is used. Refer to relevant standards such as A.N.S.I. B-305; O.S.H.A. 1926.251 and 1926.251; P.S.C.A.#1; C.A.G.I #1.

Since the hammer may be suspended well above the work level, all personnel should remain clear of the area. Barricades could be set up around the area for additional safety. Even an object such as a stone, bolt, or scrap may adhere to the hammer when laid down and if dropped from the hammer's suspended height could cause harm. In addition to remaining clear of the area, steps should be taken to prevent any parts from dropping into the system. Such things as bolts, nuts, keys, fasteners, wedges and couplings should be tightened and checked before each use and after each drive during use. Good maintenance cannot be overemphasized in promoting the safe and efficient use of the hammer.

In addition to free falling objects, it is possible that projectiles can be thrown out during operation. Any foreign material in the lubricant, supply hose or cylinder may be ejected through the exhaust at high velocity. Personnel should therefore remain clear of the exhaust to avoid this risk as well as to avoid being burned by the exhaust steam or air.

If the air or steam lines are either not properly secured by chain or heavy rope, or if they fail in use they can become extremely dangerous. To reduce the risk of this occurring, all couplings should be checked before use and all hoses must

be secured to the hammer just below the couplings. Refer to O.S.H.A. Standards 1926.603 (a) (9) (10). This will prevent the hose from whipping wildly over a great distance if the coupling should fail.

The ram point, pile cap, and pile cap cables take a lot of punishment during driving. With use, fragments of metal may be broken or spalled off and ejected with the speed of a bullet. The risk can be reduced by repairing or replacing worn ram parts, pile caps and pile cap cables, assuring that the pile is squarely cut, seating the pile in the cap properly while driving, assuring that the hammer is driving squarely, and using the appropriate pile cap. After each drive, a visual inspection of the ram point,pile cap and pile cap cables should be made, staying well clear of the hammer when in use.

4.5.4 Pressure and Wear Failures

Although unlikely to occur under normal operating conditions, hose failure can cause substantial injuries to personnel and property since the steam or air pressure used is typically over 100 PSI. This line pressure, when distributed over a few square inches of area, generates a tremendous force which will cause an unsecured broken hose to whip in a violent unpredictable way. Since such a condition could produce a substantial injury, precautions must be taken to see that this does not occur.

The air/steam supply hose should be secured to the hammer by heavy chain or wire rope of adequate strength (refer to O.S.H.A. Standards 1926.251), attached to the anchor point on the hammer with a shackle. Inspection of these connections should be made at the beginning of each shift and after the driving of each pile.

Another critical point of the hammer is its valve mechanism and as such, requires regular inspection and maintenance. With normal functioning, air or steam is admitted to the cylinder and released in alternating cycles. After release, the ram falls and impacts with the pile cap. If steam or air is not permitted to enter the cylinder freely or if it is not relieved, there is a possibility that a major structural problem could occur.

The valve mechanism could be jammed by foreign material or it could be broken through misuse or improper handling. However, regular inspection, cleaning and lubrication will reduce the likelihood of trouble. Nevertheless, special attention should be given to the slide bar and wedges, the valve, and the actuating levers at each opportunity. At all times, personnel should stay clear of the hammer until the ram is resting on the base.

Complete inspection and maintenance should be performed at the beginning of each shift and/or after the hammer has been inoperative for over an hour. Cylinder head nuts, the head itself, the cylinder and columns should be given attention. All keys wear and loosen with use and should therefore be checked and secured after each drive. Since they are heavy, a key could be dangerous if it should be dislodged and fall from the hammer. In addition, if both ram keys should be lost during use, the ram would not be secured to the piston and without the inertia and weight of the ram to retain it, the piston could be driven through the cylinder head. Therefore, key condition is obviously very important for safe operation and should be carefully maintained.

Because of wear that occurs during prolonged use, the ram point, pile cap or pile cap cables may fragment from metal fatigue. This fragmentation will be accelerated by improper use, such as by misalignment of the hammer axis with the pile and by using a pile cap of inappropriate size. The fragments may be violently ejected during driving and could be a threat to personnel safety. Therefore, the ram point, pile cap and pile cap cables should be checked after each drive and if excessive spalling or cracking is found, should be repaired or replaced. It is essential that the axis of the hammer be closely aligned with the axis of the pile and that the pile cap should be matched to the size of the pile being used. All personnel should remain well clear of the hammer during use, reducing the risk of being struck if fragmentation should occur.

4.5.5 Exposed Mechanical Hazards

Probably the most obvious danger in working around the pile hammer is that of its exposed mechanical parts. Crushing, pinching or shearing can occur if workmen contact moving or movable parts of the hammer. Even the small parts of the hammer are heavy and can cause serious injury if they shift position. Workmen should remain well clear of the exhaust, valve mechanism and slide bar, columns, supporting rig, the ram, pile cap, and the ram point during the operation of the hammer. These areas should be avoided at all times. Failure to do so may result in serious injury or death. If it becomes necessary to work on the hammer, it should be cooled after use, the ram should be blocked, residual air or steam in the cylinder and steam or air lines should be relieved, after having been shut off. Steam or air pressure lines should be disconnected and the hammer should be in a secured position.

4.5.6 High Temperature Hazards

Although the pile hammer is constructed of non-flammable materials, the high temperature generated during use can pose a threat to the user if caution is not used. The types of hazards that may be produced are, first, the combustion of materials associated with the use of the hammer and, second, burns from contacting the heated parts of the machine. During use, the hammer will get hot as a result of the tremendous energy that is expended with the expansion of steam or air in the cylinder and with each blow of the ram. Although it is unlikely, it is possible that the heat will be sufficient to ignite some lubricants that may be used on or around the hammer. Information regarding the combustibility of the lubricants can be found either on the container or can be obtained from the manufacturer. Keeping the machine reasonably clean and avoiding the build-up of dirt that could absorb oil and grease will reduce the risk of fire.

Cushion material, having been subjected to impact of the ram does experience very high temperatures. There is little chance of most materials actually flaming during use if they are the ones recommended by Vulcan and used in the recommended manner. However, when the material is removed and has access to open air, some materials may burn or come in contact with another material that will burn. Therefore, used cushion material should be stored or disposed of in a place and in such a way that it will not create a risk as a source or transmitter of fire.

During use, for reasons previously mentioned, the hammer can become hot and this heat can be retained for a long while after use. Consequently, during or just after the use of equipment, workmen should exercise caution when in the vicinity of the hammer to avoid being burned by contact with hot metal parts.

When steam is being used, special caution should be used. High pressure steam is extremely dangerous if not treated with respect. Also, condensed steam may drip off the hoses or the hammer and could cause serious burns.

Since there is some chance of fire, an approved type fire extinguisher should be kept on hand at all times and a burn treatment kit should be kept with first aid materials. Being alert and aware of the hazards is a good defense against them.

4.5.7 Air Contamination

When working in the vicinity of an operating pile hammer, some consideration should be given to the possibility of air contamination.

Almost without exception, the exhaust of a hammer will contain contaminants. The most common of these are traces of lubricant emitted in the form of oil droplets or vapor. Two hazards are associated with this emission. First, the contaminant may be harmful to the respiratory system and second, it may cause damage to material that it contacts if the contamination is very great. Consequently, one should not get into the exhaust stream, and steps should be taken to avoid letting the exhaust spray get onto surrounding buildings, vehicles, etc.

Since the exhaust is merely the release of air or steam that is used to drive the hammer, any contaminants associated with the generating of compressed air or steam and transporting it to the hammer may be present in the exhaust. This system should be checked,maintained,and cleaned to prevent such contamination. The

system includes the air compressor or steam boiler and the hoses running to the hammer.

Possibly the least likely source of air contamination is the cushion material that is used beneath the ram point. Because of the tremendous energy that must be transmitted by this material, it tends to fragment, decompose and sometimes burn. For most materials, this should not be a significant problem, but there are exceptions. One material that is commonly used by cushion manufacturers contains asbestos. When the material decomposes in use, the asbestos fibers are free to become airborne. If the asbestos fibers are inhaled, permanent lung damage known as asbestosis may occur. The material should be inspected and if there is any suspicion that the asbestos or the fibers are becoming airborne, an approved filter mask should be worn by all workmen in proximity of the material. WARNING: Use in "confined spaces" may be hazardous to health. Refer to O.S.H.A. Standards 1910.1000, Air Contaminants, and 1910.134, Respiratory Protection.

For each cushion material, lubricant, or other fluid used, the health hazards should be identified by the user and appropriate precautions should be taken. If the hazards are not readily identifiable, the user should consult with the manufacturer of the material or with a certified Industrial Hygienist.

4.5.8 Hearing Damage

There are two primary types of noise which are produced by any pile hammer. The first is impact noise produced by the ram striking the pile. The second type of noise is produced by the operating steam or air as it is exhausted from the cylinder. In both cases, depending upon hammer size, it is possible to produce noise levels which are potentially damaging to the auditory mechanism in the ear.

At present, there are not too many practical ways to reduce these noise levels. In the case of impact noise, cushion material can be used to reduce the noise levels as well as modify the impulse duration as required by soil type and piling composition. The exhaust noise can also be reduced through the use of an exhaust muffler. However, if it is impractical to muffle the exhaust, there are other alternatives which will provide construction personnel with adequate hearing protection. Because sound intensity decreases rapidly as the distance from the hammer increases, simply keep all personnel as far from the hammer as is practical. Obviously, there are many other safety reasons why no one should be near the hammer when it is in use. However, if personnel cannot be stationed far enough from the hammer to adequately reduce the noise, earmuffs or earplugs should be used. If there is concern about the noise level at any job site, it is advisable to use a sound level meter to establish what abatement procedure is needed. It is obvious that the user must give more attention to the noise problem as ever more stringent environmental safety restrictions are imposed by government authorities. Refer to O.S.H.A. Standards 1910.95 and 1926.52, Occupational Noise.

4.5.9 Shipping Precautions

The foremost source of difficulty in shipping or moving the pile hammer is its size and weight. Whether the hammer is laid on a platform, vehicle, or a vessel, it should be determined that its support is adequate and that the hammer is well secured. Likewise, the hammer should be lifted only by equipment of sufficient capacity and all rigging should be thoroughly inspected beforehand. Before lifting, check gross weight label, located on machine. If any tilting, vibration or accelerative loading is anticipated, such as on a vessel or vehicle, the hammer should be secured in position. This can be more easily done with the aid of a shipping skid which can be supplied by Vulcan. Of course, it is essential that the ropes, chains or fasteners used for securing the hammer be sized adequately to withstand the load. If the hammer will be subjected to any tilting, vibration or accelerative loading, it is necessary to block the ram in order to prevent the ram from sliding and impacting without a piling to absorb the shock. A sliding ram can transmit a large impulse or shock to the securing devices that hold the hammer in place which may cause the hammer to break free and thus pose a threat to the safety of the crew, transporting vehicle or vessel. At all times, when not in use, secure the ram at the lower extremity of its travel and shim or brace it in place

with wood or steel blocks and wedges. If a Vulcan designed shipping skid is used, it will provide proper support areas and a secure relationship between ram, base and piston.

Another consideration is that the carrier, whether vessel or vehicle, must be of sufficient capacity to handle the load and that the carrier should observe the operating limitations of the vessel or vehicle with that load (more than one flatbed trailer has been collapsed from improper loading of a hammer). Always refer to the gross weight label on the machine before attempting to move, load or transport.

If it is expected that the shipment will take an extended period of time, the same precautions should be taken as for storage.

These include inspection, lubrication, rust proofing and sheltering of the hammer. After shipment and before being placed in operation, a thorough inspection should again be performed to assure that no shipping damage was done and that the hammer is in operable condition. This will preclude the possibility of placing a damaged or defective hammer into use and thereby creating a hazardous situation.

4.5.10 Storage Precautions

If the pile hammer is to be stored or out of service for an extended period of time, certain precautions should be taken to prevent damage to the hammer and risk to personnel.

A storage or resting place should be selected which will adequately support the weight of the hammer. The site should be level, firm, and a protected area. Keep the hammer off the ground. This can be done by using the original shipping skid or resting the hammer on two 8" x 8" wood beams. In addition, because of the hammer's great weight it should be secured to preclude damage from unexpected movement. The ram should be properly blocked in the down position. This is accomplished by using a 4" x 4" timber wedged between the cylinder and the ram and securing the timber to a column with banding iron. The 4" x 4"'s should be used on diagonally opposite columns.

After its use, a thorough inspection should be performed. If any defects are found, they can be repaired during the storage period, thus preventing malfunction, danger or on the job downtime.

Before storage, a complete lubrication and rust proofing should be done in order to protect the hammer from the elements and subsequent corrosion. Lubricating oil should be flushed through the hammer. For further protection, a cover of canvas or plastic can be used to provide shelter, and thus reduce the effects of exposure to the environment. All openings in the hammer (exhaust or relief ports, steam or air inlets, etc.) should be plugged or taped closed. These will aid in preventing all kinds of foreign matter from entering the hammer; however, make sure you remove these from the hammer before operation.

When the storage period has ended and it is time to put the machine back into service, another thorough inspection, cleaning and lubrication will assure that the hammer is ready for service.

By taking these few precautions, the life of the hammer can be extended, its efficiency can be maintained, and its safety greatly enhanced. Detailed instructions on preparation for storage including inspection procedures and lubrication requirements are given in the Field Service Manual, supplied with each hammer by Vulcan.

4.5.11 Maintenance and Repairs

Repairs by anyone other than Vulcan Iron Works Inc. or its authorized representatives or use of replacements parts other than Vulcan Iron Works Inc. parts will void all warranties covering the hammer.

By closely following this Manual, many years of reliable operation will be possible. However, the manufacturer will not be responsible for improper maintenances or use not in accord with recommendations given here.

5.0. MAINTENANCE

5.1. Lubrication

Probably the most important aspect of hammer maintenance is proper lubrication. The recommended lubricants are given below. The letters for each part correspond to those in Figure 5.1. The proper state of the hammer should be checked *daily* (See Section 4.3).

It is important to keep your Vulcan hammer properly lubricated to insure the maximum possible hammer life and driving performance.

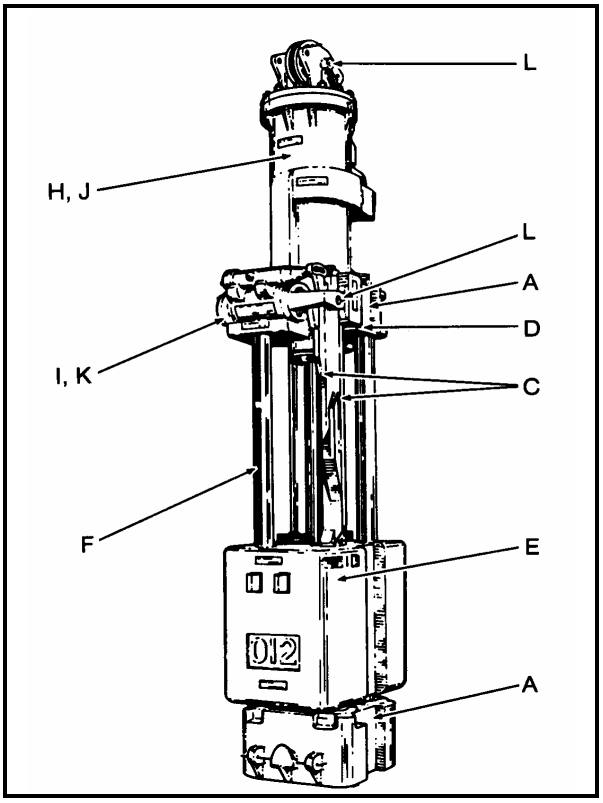


Figure 5.1.1 Lubrication Chart

5.1.1 Exposed Wear Surfaces (except columns) (A-D)

These include the following areas:

A) Cylinder and Base Jaws.

B) Trip Faces.

C) Slide Bar.

D) Slide Bar Dovetail.

These surfaces require an NLGI EP2 Grease with an oil viscosity @ 212°F (100°C) of 70-100 SUS (13-20 cSt) and a flash point of 450°F (235°C). The grease should have one of four thickeners: 1)Lithium 12 Hydroxy-Stearate, 2)Lithium Complex, 3)Calcium Complex, or 4)Polyurea. It should also have MoS_2 anti-wear and anti-rust additives.

5.1.2 Columns (E & F)

Usually these can be lubricated with the same grease as used in Section 5.1.1; however, since this is a very demanding application, and greases vary widely, another alternative to this is a heavy open gear lubricant with MoS_2 anti-wear additive such as TS Moly TS-201 or equivalent. This should be applied directly to the exposed columns.

5.1.3 Relief Ports and Line Oiler

Lubrication of the cylinder is *very* important for long hammer life and efficient hammer operation. Failure to do so can score the cylinder wall, destroy the piston, rings, and packing, and greatly reduce the efficiency of the hammer.

Most of the oil for the cylinder should be injected in to the steam or air line using a line oiler. This oiler should be capable of providing a *continuous* stream of oil into the flowing steam or air. Intermittent, hand-operated force feed lubricators are not suitable for the task. The oil in the line oilers should be checked every four (4) hours.

IMPORTANT

It is absolutely forbidden **to use motor oil of any kind in this application. Doing so can result in insufficient lubrication of the cylinder wall and/or valve flutter!**

In addition to the line oiler, oil should be poured daily into the relief ports of the hammer. This enhances the lubrication of the upper reaches of the cylinder.

5.1.3.1 Steam Operation (G & H)

For steam operation, it is recommended that the lubricant to be introduced into the steam should be a high-grade, AGMA 8 Steam Cylinder Oil with at least a ten percent (10%) tallow or lard oil content. The oil should have a viscosity @ 212 °F (100°C) of 160-190 SUS (34-41 cSt), and a flash point of 550°F (290°C).

5.1.3.2 Air Operation (I & J)

For air operation, it is recommended that a high quality AGMA 1 Air Compressor Oil be used for internal lubrication of the hammer. The oil should have a viscosity @ 212 °F (100°C) of 40-50 SUS (4.25-7.5 cSt), and a flash point of 400°F (200°C).

IMPORTANT

Air compressor oil should *never* be used with steam, nor steam oil with air.

5.1.4 Outboard (K) and Open Steam Chest (L) Bearings

An AGMA 5EP gear oil should be applied here. The oil should have a viscosity @ 212 °F (100°C) of 80-105 SUS (15-21.5 cSt), and a flash point of 400°F (200°C).

5.2 Threaded Fasteners

5.2.1 Fastener Torque

Many places in this manual refer to keeping things tight. But how tight is tight? Improper fastener torque and tightness can be ruinous to the smooth operation of any equipment and Vulcan air/steam impact hammers are no exception.

Below is a table of the recommended torque values of all of the fasteners used in the hammers. When tightening fasteners, a torque wrench or other accurate method of tightening should be employed.

To determine the torque you should perform the following procedure:

1) Determine the size and thread configuration of the bolt or stud. For the size, measure the outside diameter of the threads; for the thread configuration, count the number of threads per inch.
2) Determine the material of the bolt or stud. Vulcan supplies bolts in one of two material configurations; SAE Grade 8 or Bowmalloy. For hexagonal fasteners, Grade 8 have a small radial ridge at each corner of the hex; Bowmalloy fasteners have sixteen such ridges. Studs are generally Grade 8.

Once you have done all this, make sure the fastener is *clean* and apply an anti-seize compound such as Bowman Anti-Seize to the threads. Install using a torque wrench to the torque values shown in Table 5.2.1.

These torque values must be used with the following guidelines:

1) All torque values shown are for turning the NUT while holding the head of the bolt with wrench. If the application demands tightening by the bolt head, increase the value shown by 20% (multiply by 1.20). This will allow for the natural torsional twist of the bolt shank.
2) All torque values are calculated based on using Bowman Anti-Seize Compound to the threads before assembly.
3) For fasteners tightening into wood or rubber– specifically hose clamp blocks or suspension springs– simply firm tightening is necessary to secure these. As the rubber or wood compresses, though, it is necessary to check them very frequently for loosening.

IMPORTANT

***Never* use a torque wrench on the stuffing box studs. This is an adjustable connection and at no time requires anything other than a wrench adjustment.**

More information about this important subject– and the Anti-Seize compound– can be obtained from

Bowman Distribution
Barnes Group, Inc.
General Offices
850 East 72nd Street
Cleveland, OH, 44103
(216) 391-7200

Table 5.2.1 Recommended Torque Values for Threaded Fasteners

DIAMETER, IN.	THREADS PER INCH	TORQUE, FT-LBS Grade 8	TORQUE, FT-LBS Bowmalloy
1/4	20	7	10
1/4	28	9	12
5/16	18	15	20
5/16	24	17	22
3/8	16	26	36
3/8	24	30	41
7/16	14	42	58
7/16	20	47	65
1/2	13	64	87
1/2	20	72	100
9/16	12	92	125
9/16	18	102	140
5/8	11	127	175
5/8	18	144	200
3/4	10	226	310
3/4	16	252	345
7/8	9	364	500
7/8	14	400	590
1	8	545	750
1	14	597	810
1 1/8	7	773	1050
1 1/8	12	866	1170
1 ¼	7	1090	1500
1 ¼	12	1207	1650
1 3/8	6	1430	1950
1 3/8	12	1627	2220
1 ½	6	1897	2600
1 ½	12	2134	2900

5.2.2 Stud Removal and Replacement

If broken or damaged studs are encountered during assembly or disassembly, the following procedures will aid in replacement.

1) A broken stud can be removed by applying a generous portion of penetrating oil around stud threads. Let it stand overnight if possible.
2) Drill a hole in the broken stud (See Figure 5.2.2.1). Refer to Table 5.2.2.1 for drill sizes.
3) Thread an Ezy-Out®, into the drilled hole, then back out the stud.

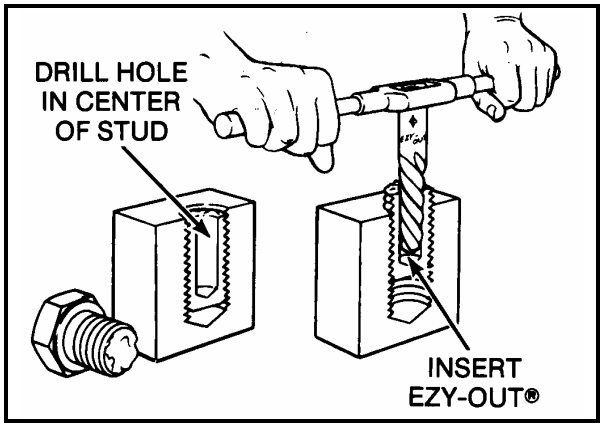


Figure 5.2.2.1 Stud Removal

Table 5.2.2.1 Drill Sizes

Ezy-Out®, No.	Drill Size, in.	Stud or Screw **Size, in.**
5	**17/64"**	**9/16"-3/4"**
6	**13/32"**	**¾"-1"**
7	**17/32"**	**1"-1 3/8"**
8	**13/16"**	**1 3/8"-1 ¾"**
9	**1 1/16"**	**1 ¾"-2 1/8"**
10	**1 5/16"**	**2 1/8"-2 ½"**
11	**1 9/16"**	**2 ½"-3"**
12	**1 15/16"**	**3"-3 ½"**

Stud installation requires certain precautions.

1) All Vulcan studs have an unthreaded portion between the threaded ends (See Figure 5.2.2.2). DO NOT use a pipe wrench to install the stud. Thread damage is possible and the pipe wrench marks or notches will create stress riser points in the stud.

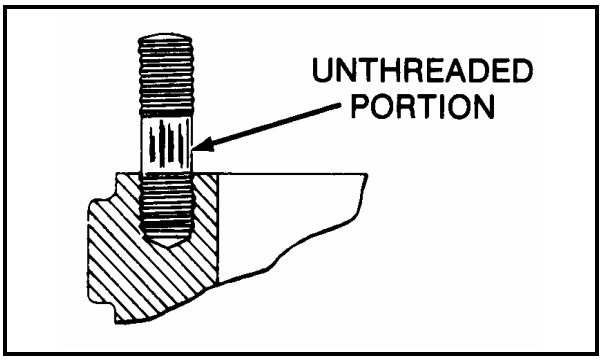


Figure 5.2.2.2 Vulcan Stud

2) Install studs by threading a jam nut on the stud. Place a flat washer over the jam nut. Thread a full nut on top of the washer (See Figure 5.2.2.3). The washer prevents the nuts from turning and an impact wrench or hand wrench can be used to install the stud.

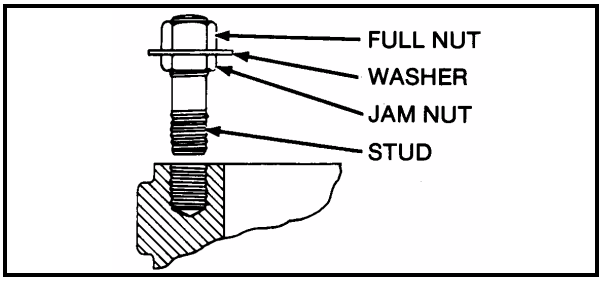


Figure 5.2.2.3 Stud Installation

3) Use care *not* to insert the stud into the thread until it bottoms out. If the stud does bottom out, the stress will be incorrect and failure will be accelerated.

5.3. Cylinder

Refer to the exploded views in the parts section for visual reference.

5.3.1 Cylinder Head Removal

CAUTION

BE SURE ALL STEAM OR AIR LINES HAVE BEEN DISCONNECTED BEFORE ANY REPAIR OR MAINTENANCE WORK BEGINS.

The cylinder head is fastened by a combination of nuts, bolts and studs. To remove the head:

1) Remove the nuts and jam nuts from the studs.
2) Remove the nuts, and bolts.
3) Lift the cylinder head off the studs.
4) Remove the oil gasket. Be sure no gasket material remains on the bottom of the cylinder head or top of the cylinder.
5) Disassemble the cylinder head by removing the cross cylinder head bolts.
6) Remove the cotter pins from the sheave pin and drive the sheave pin out.
7) The head sheave bushing should not be removed unless it needs replacement. If the head sheave needs replacement, a new bushing is included with the new sheave. Replace the head sheave when a) wear in the grooving exceeds 1/16" (1.6mm), b) the cable pattern is visible in the sheaves, or c) when the sheaves are loose, indicating a worn bushing.
8) Clean and inspect all items. Replace damaged items. Always use a new gasket for reassembly.

NOTE

If the sheave pin needs to be replaced, insert the new sheave pin with the cotter key in the existing hole until the key is firmly against the wall of the cylinder head. Then locate and drill a cotter key hole in the sheave pin. Make the hole the same size as the existing hole and locate it so that both sheave keys are firmly against the walls of the cylinder head.

5.3.2 Cylinder Replacement

1) Lay the hammer down with the slide bar facing up.
2) Remove the cylinder head and gasket.
3) Remove the slide bar keys, key block, key block seat and the slide bar.
4) Remove the gland bushing, packing and junk ring.
5) Install eye bolts in the threaded holes provided in the piston head.
6) Stand the hammer in the vertical position.
7) Remove the ram keys.
8) Raise the piston until the split bushing clears the ram.
9) Remove the split bushing, key ring and gland.

10) Remove the piston and rod.
11) Remove the cable nuts and washers.
12) Lift the cylinder off the columns.
13) Clean and inspect all items. Replace damaged or worn parts.

NOTE

When installing new packing gland, do not attempt to tighten the gland to the point of sealing steam or air leakage. A little air or steam escaping through the packing is acceptable. The oil mixed with the air or steam will lubricate the packing and piston rod.

5.3.3 Bushing Replacement

Bronze bushings are used in the head sheaves and both steam chest heads. When replacement is required follow the procedures listed below.

1) All bronze bushings are press fit. Due to manufacturing variations, bushings are supplied oversized. The fit of the bushing is obtained by turning the O.D.
2) Mount the bushing in a four (4) jaw chuck, indicating the I.D. for true position. Support the free end with a live center. Alternate method would be to use an arbor between centers.
3) Machine the bushing O.D. to give the proper press fit.
4) After machining, clean the bushing and remove cuttings.
5) Make sure bore receiving the bushing is clean, dry and free of burrs. Press the bushing into the bore without using a lubricant.

5.4 Valve and Steam Chest

5.4.1 Valve Liner Installation or Change

When installing a new valve mechanism the following steps should be observed:

1) With the valve liner in the cylinder and the blind steam chest head removed, place the valve stem and valve into the valve chest with the square end towards the open end of the valve chest. Rotate the valve and stem until the match marks on both valve and liner are together as shown in Figure 5.4.1.1. (The actual orientation of the valve may vary from the one depicted in the figure). Once this is done, the valve stem is backed away and the trips are installed, first the fixed and then the movable. The valve and stem is then reinserted to the outboard bearing bracket bushing and the movable trips connected to the Vari-Cycle (see Section 5.4.2). The trips should then be as shown in figure 5.4.1.2.

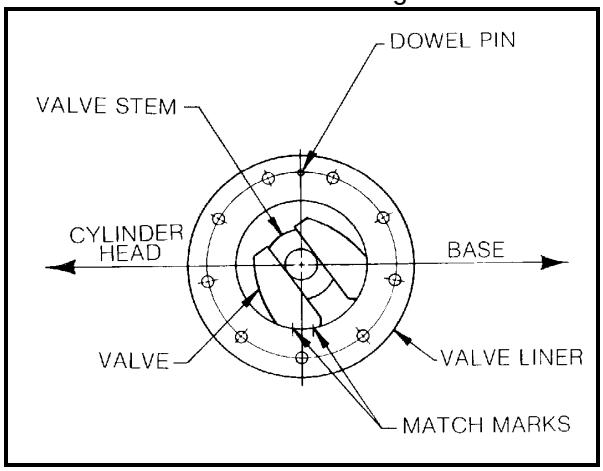


Figure 5.4.1.1 Valve Setting Diagram

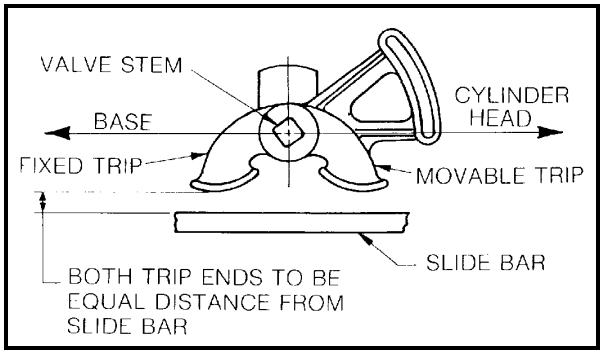


Figure 5.4.1.2 Trip Setting Diagram

2) Replace the blind steam chest head, gasket, studs, and nuts. Check all bearings for proper lubrication.

NOTE

Setting the valve properly is essential to insure maximum efficiency.

When replacing the liner it is very important to rotate the liner to the correct angular position. This is accomplished by the dowel pin

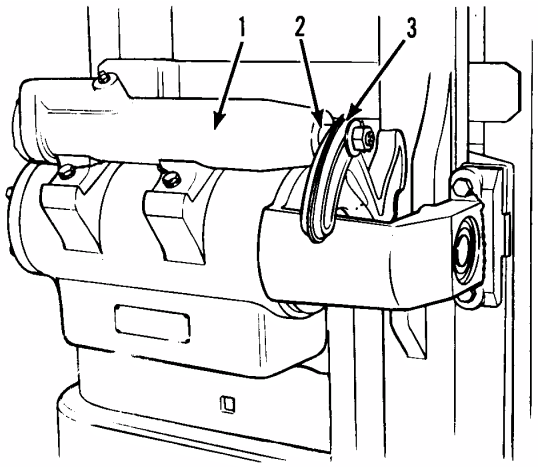
arrangement shown in Figure 5.4.1.1. The dowel pin holes in both cylinder and liner should be aligned with each other and the dowel pin driven through both.

Should the cylinder require replacing, a new liner is required with the factory set angular position.

5.4.2 Stroke Adjustment for Single Acting Hammers

5.4.2.1 Vari-Cycle

The Vari-Cycle is a mechanical accessory that can be installed on the hammer to allow the operator to attain different levels of rated energy from the hammer. Consult the factory to determine if this option can be installed on your hammer. Most hammers built after 1980 have the Vari-Cycle installed at the factory.



1. Vari-Cycle Cylinder
2. Piston Rod
3. Movable Trip

Figure 5.4.2.1.1 Vari-Cycle Mounting

To add the Vari-Cycle:

2) Remove the blind head, the valve, valve stem, trip, dovetail insert, slide bar and trip spacer bushing.
3) Install a three wedge slide bar, fixed trip, movable trip, valve, valve stem and the outboard bearing bracket (if not already on hammer).
4) Remove the four hex-head bolts from the main cylinder pads and bolt on the Vari-Cycle cylinder using the capscrews furnished. Bolt the movable trip to the Vari-Cycle piston rod (See Figure 5.4.2.1).
5) Attach air or steam hose as shown in Figure 5.4.2.2. Hoses are not provided. Although the diagram shows certain hose sizes, there is some flexibility in the sizes which will work.

Air supplied to the trip shifting cylinder head will push the trip out into the short stroke position. Air supplied to the trip shifting cylinder will pull the trip back to the long stroke position.

NOTE

Vulcan does not supply the valve or hose.

Two energy levels are selected, generally, full and one-half rated energy. Any combination of energy pairs are available, from full rated to one-third rated energy.

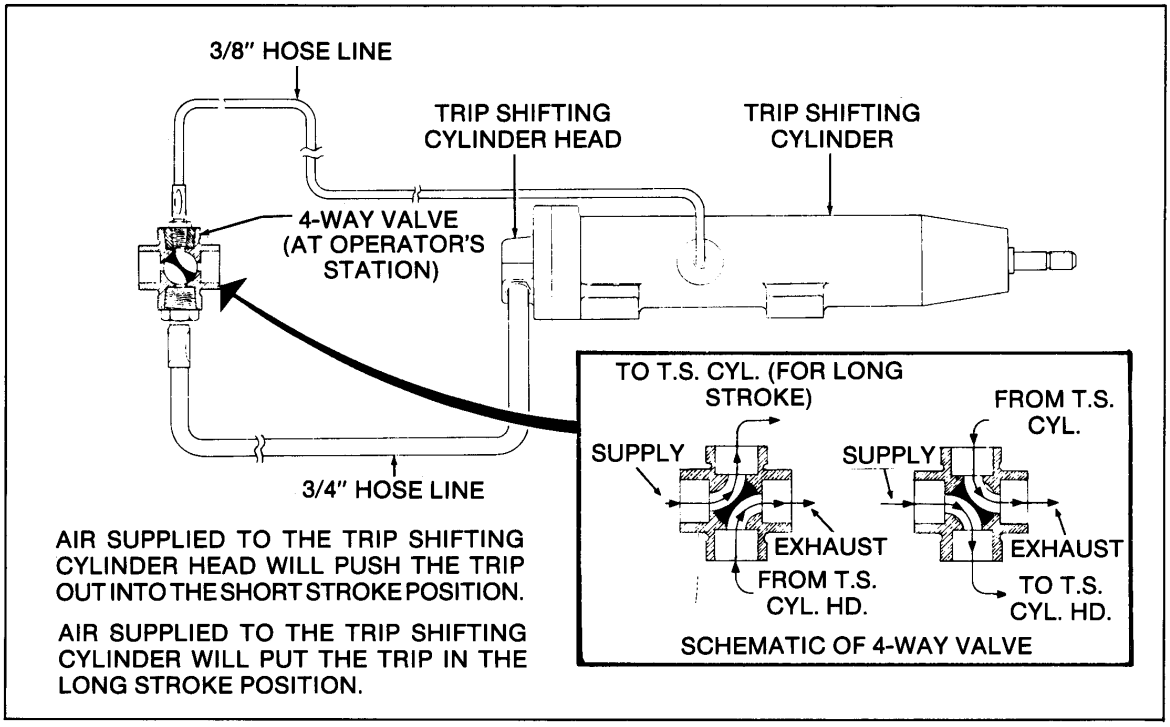


Figure 5.4.2.1.2 Vari-Cycle Piping Schematic

5.4.2.2 Outboard Bearing Bracket

Vulcan Pile Hammers equipped with the Vari-Cycle require an outboard bearing bracket on the open steam chest head. The bracket functions as a guard to protect the slide bar from damage and as an outboard bearing for the extended valve stem (See Figure 5.4.2.1.1).

The bracket must be installed with the outboard bearing directly in line with the open steam chest head bushing. Shims are required, under the bracket foot, to obtain the correct alignment. Shim thickness requirements are stamped on the cylinder on either side of the tongue and groove bracket joint. Do not deviate from the shim sizes specified on the cylinder casting.

A new outboard bracket must be installed whenever the cylinder is replaced.

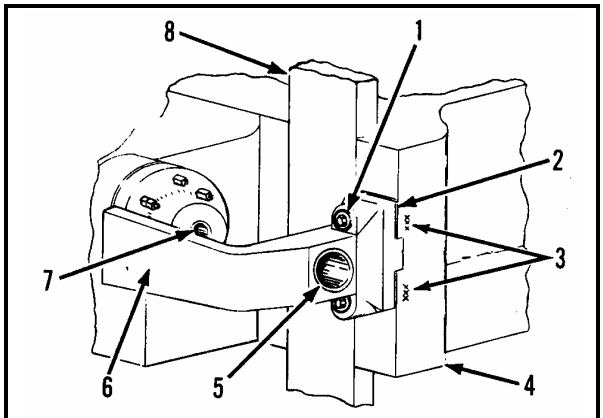
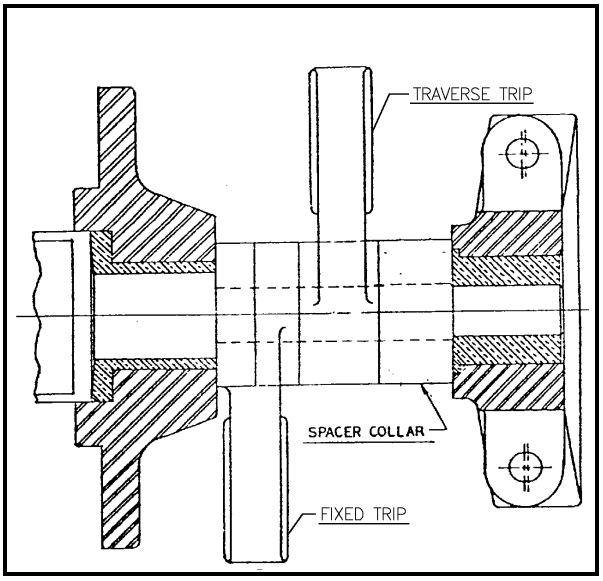


Figure 5.4.2.2.1 Outboard Bracket

5.4.2.3 Traverse Trip

The traverse trip is an alternative method of using the three wedge Vari-Cycle slide bar with a simpler but more economical mechanism of

changing the wedge used in the hammer upstroke. For sizes 505 and 506, the traverse trip is the preferred method of achieving less than full stroke.



5.4.2.3.1 Traverse Trip, Full Stroke Position

Looking at Figure 5.4.2.3.1, the valve mechanism has a fixed and traverse trip that can slide along the valve stem and on the face of the slide bar. The trips are prevented from sliding during operation by insertion of a spacer collar. For full stroke operation, the spacer collar and traverse trip should be positioned as shown in Figure 5.4.2.3.1.

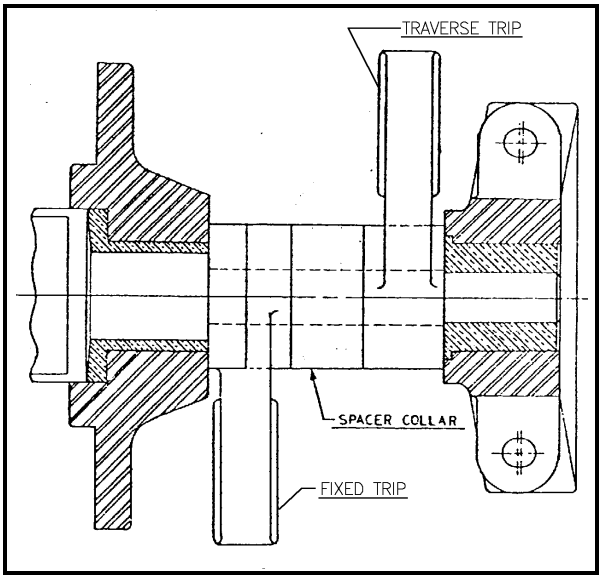


Figure 5.4.2.3.2 Traverse Trip, Short Stroke Position

For short stroke operation, the traverse trip and spacer collar should be reversed from the full stroke position, as shown in Figure 5.4.2.3.2.

To change from one stroke position to another, remove the blind steam chest head and pull the valve stem out just far enough to remove the spacer and traverse trip. Reinsert valve stem with traverse trip and spacer in the desired order.

5.4.3 Slide Bars

Slide bars and/or trips should be replaced if there is more than 1/8" (3mm) wear in either, or when either is bent or broken.

5.4.3.1 Installation

1) Remove the ram pipe plug.
2) Remove old babbitt by melting with a torch.

CAUTION

Babbitt contains lead! Use with caution. Lead has been shown to have the following potential side effects:

Low levels

- **Headache**
- **Joint and muscle pain**
- **Abdominal cramping**

High levels

- **Anemia**
- **Kidney disease**
- **Damage to nervous system**

Very High Levels

- **Seizures - coma - death**
- **May be reproductive hazard**

3) Position slide bar, the slide bar end block, slide bar key block seat and slide bar key block (See Figure 5.4.3.1.1).

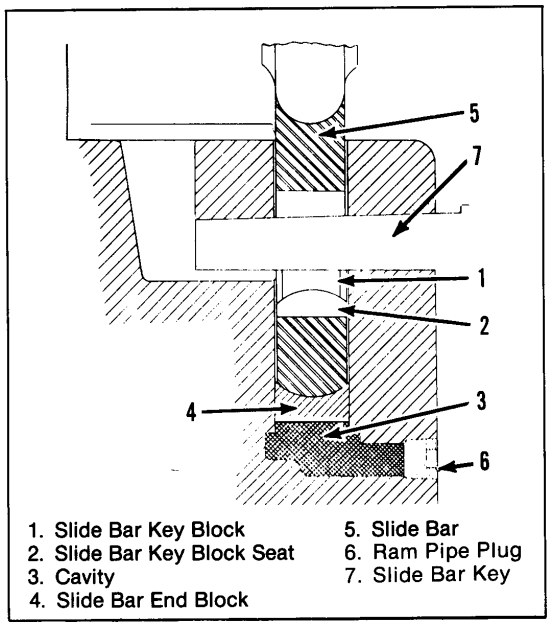


Figure 5.4.3.1.1 Slide Bar Pocket Assembly

4) Pour molten babbitt into the cavity until the babbitt is ¾" (19mm) from top of opening. Use only medium hard babbitt metal Glyco B or equivalent. DO NOT use pure lead.
5) After the babbitt has solidified, install the ram pipe plug.

NOTE

Some hammers have a solid slide bar pocket end in place of a babbitt hole. In this case, simply perform step (3) and install and tighten the slide bar key.

5.4.3.2. Adjustment

After the slide bar is installed, the slide bar key and key block should be checked to be sure they are tight.

If the slide bar key is loose, shims can be added beneath the slide bar end block.

Check the slide bar position by placing a straightedge across the machined boss of the ram (See Figure 5.4.3.2.1).

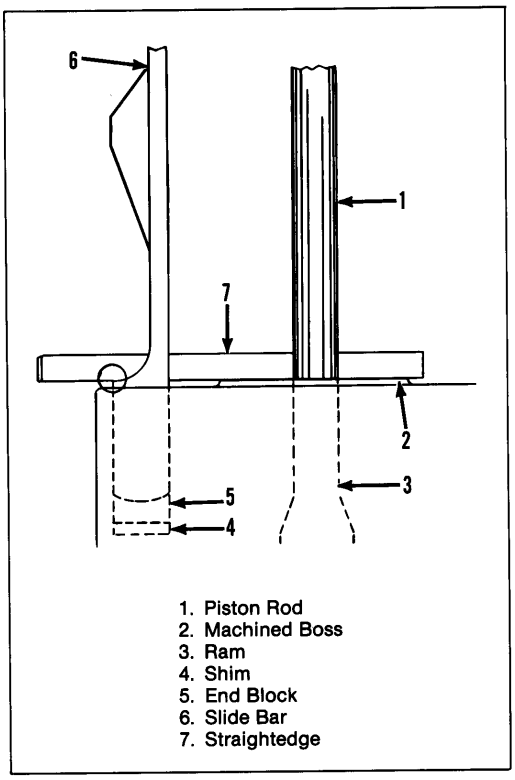


Figure 5.4.3.2.1 Slide Bar Adjustment

The bottom of the straightedge should be even with the edge of the slide bar as shown in the circled area on Figure 5.4.3.2.1.

Determine the thickness of shims to be added. Remove the slide bar and end block, and insert the shims under the slide block. Install the slide bar and slide bar key.

5.5 Cable Column Adjustment

1) Lay the hammer on its side.
2) Bend back and flatten the turned up side of the lock washer after heating (See Figure 5.5.1).

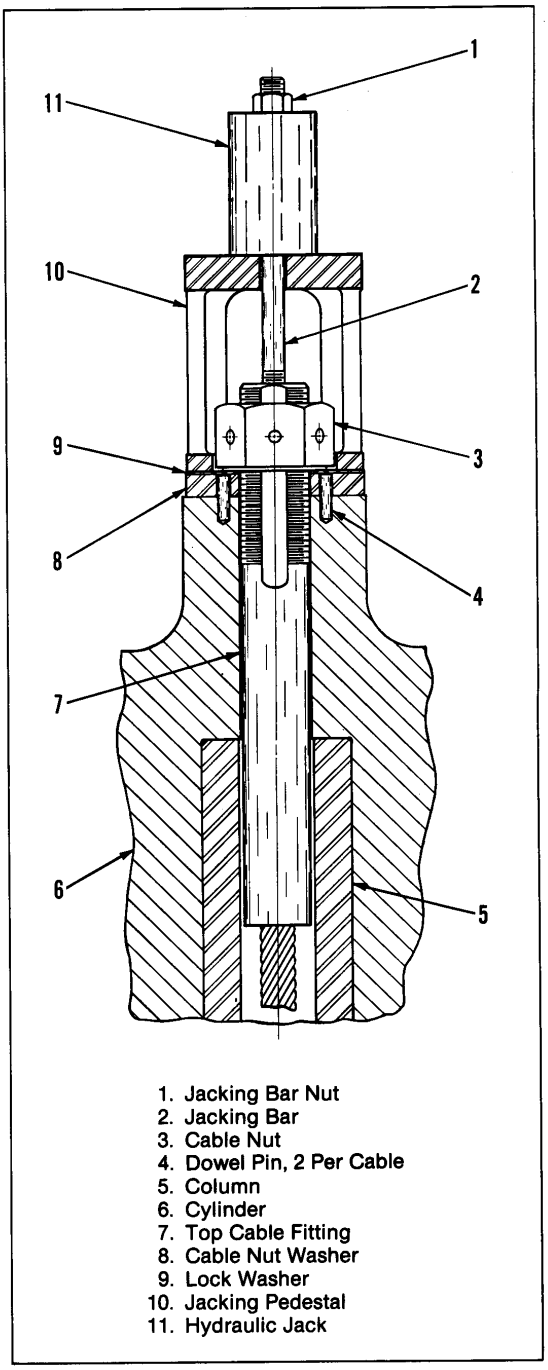


Figure 5.1.1 Cable Assembly

3) Screw jacking bar into top cable fitting.
4) Place Jacking pedestal over cable nut.
5) Place jack over jacking bar and screw on jacking bar nut.
6) Jack each cable to 40 U.S. Tons (355 kN). Alternate across corners.

CAUTION

Make sure that all personnel are clear of the Jack and Pedestal before applying pressure to the jack! This is to prevent injury in event of missile reaction.

7) Tighten nut using a ½" (13mm) diameter rod
8) After jacking is complete, heat lock washer tab with torch and bend against flat on cable nut.
9) Remove jacking bar nut, jack, pedestal and jacking bar.
10) Repeat steps 1 through 9 on remaining cables.

5.6 Side Channels (Cylinder and Base) Replacement

1) Use a drill to remove the countersunk head of the channel rivet studs. Make sure that the threads on the cylinder and base are undamaged.
2) Slide the channel toward the cylinder head end of the hammer and remove the channel.
3) Remove the remaining portion of the rivet studs by drilling a hole in the center of the stud. Insert a backing out tool (Ezy-Out®,) and remove the studs.
4) Install the channel by sliding it into the jaws on the hammer. Align the holes in the channel with the stud holes in the cylinder.
5) Insert the channel rivet studs. Torch cut the studs ¾" (19mm) above the channel surface.
6) Heat the exposed portion of the rivet stud with a torch and hot rivet each stud flush with the channel web surface. It may be necessary to hold the channel in place with capscrews while riveting.
7) Heat the two ears which extend beyond the base and cylinder walls and bend them flat against the cylinder or base.

5.7 Ram and Striking Parts

5.7.1 Piston Ring Gaps and Bore Specifications

All Vulcan onshore hammers use a single piece piston and rod with two piston rings. Gap specifications for these are given in Table 5.7.1.1.

This should be checked whenever new piston rings are installed or old ones reinstalled.

Table 5.7.1.1 Piston Ring Gap Specifications

Cylinder Bore	Maximum Gap	Minimum Gap
English Units (Inches)		
13.500	.081	.061
16.500	.099	.077
19.000	.114	.090
21.750	.126	.102
SI Units (mm)		
342.90	2.05	1.55
419.10	2.51	1.96
482.60	2.90	1.96
552.45	3.20	2.59

Table 5.7.1.2 Bore Specifications for Oversize Rings

New Cylinder Bore Diameter	Minimum Oversize Diameter	Maximum Oversize Diameter
English Units (Inches)		
13.500	13.594	13.688
16.500	16.594	16.688
19.000	19.094	19.188
21.750	21.844	21.938
SI Units (mm)		
342.90	345.28	347.66
419.10	421.28	423.66
482.60	484.98	487.36
552.45	554.83	557.21

If the gap on standard piston rings is too large because the bore is larger than the minimum oversize diameter, then standard oversize piston rings can be fitted to the hammer. For hammer with a bore larger than the maximum oversize diameter, a new cylinder is required. These dimensions are given in Table 5.7.1.2.

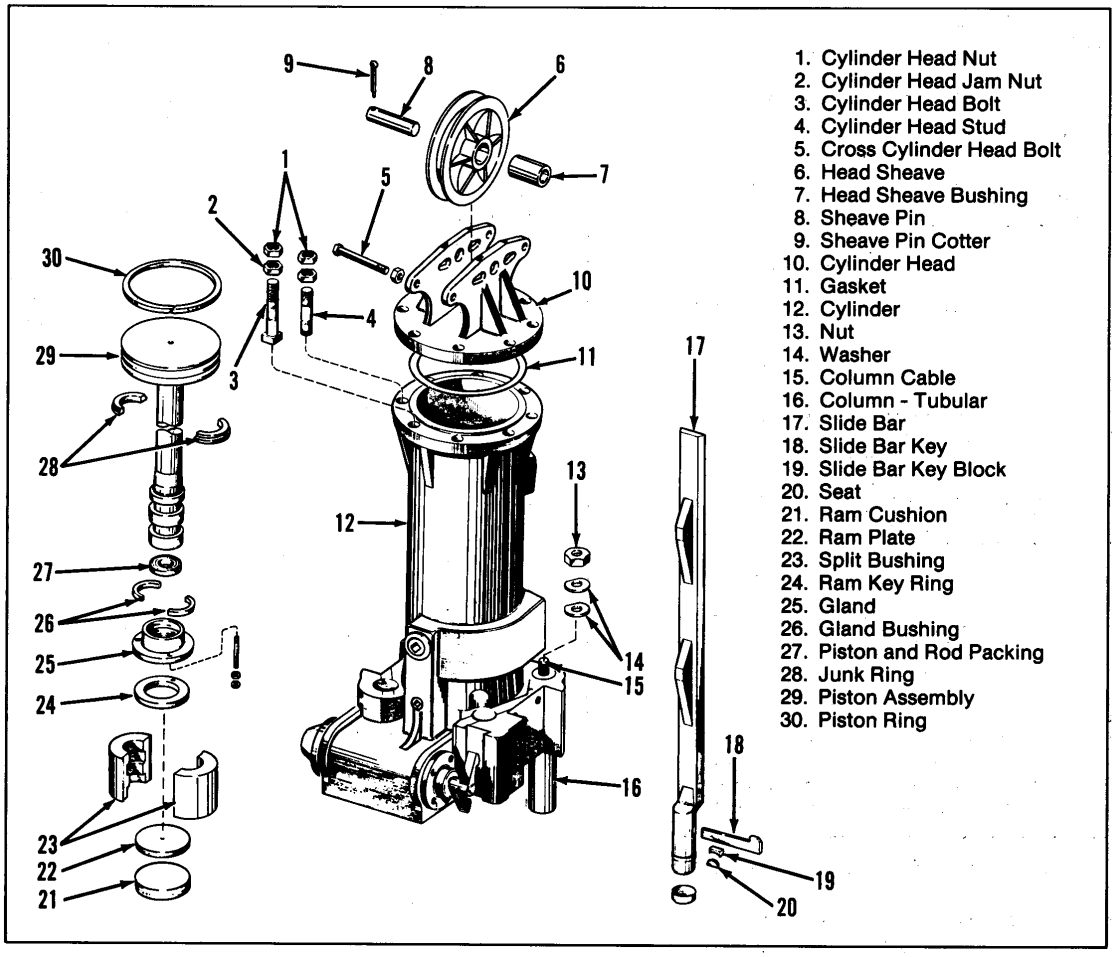


Figure 5.7.2.1 Cylinder Assembly

5.7.2 Removal of Piston and Rod

1) Place the hammer in a vertical position. See Figure 5.7.2.1.
2) Remove the cylinder head, gland and bushing.
3) Remove the piston rod packing and junk ring.
4) Remove the ram keys and ram key ring.
5) Remove the split bushing and pull out the piston and rod.
6) Inspect all the items, and replace or repair worn parts.

5.7.3 Installation of Piston and Rod

1) Install new piston rings. Check the ring gap using the dimensions shown in Table 5.7.1.1. If this is excessive, check the bore dimensions given in Table 5.7.1.2. If the gap is between the two oversize bore dimensions, install standard oversize rings. If the bore is greater than the maximum oversize diameter, replace with a new cylinder.
2) Insert new piston and rod. Complete reassembly by using reverse disassembly procedures.
3) Insert the small end of the piston rod into the ram. The split bushing configuration varies according to size.

For Sizes 1, 505, 06, 306, 506, 08, 010, 012, 508, 510 and 512: Assemble the piston and rod with the end projecting beyond the split bushing and resting on the ram plate (See Figure 5.7.3.1). The dimension "A" for the various hammers is 1/8" (3.2mm) for the sizes 1, 505, 06, 306, and 506 hammers and ¼" (6.4mm) for the sizes 08, 010, 012, 508, 510, 512.

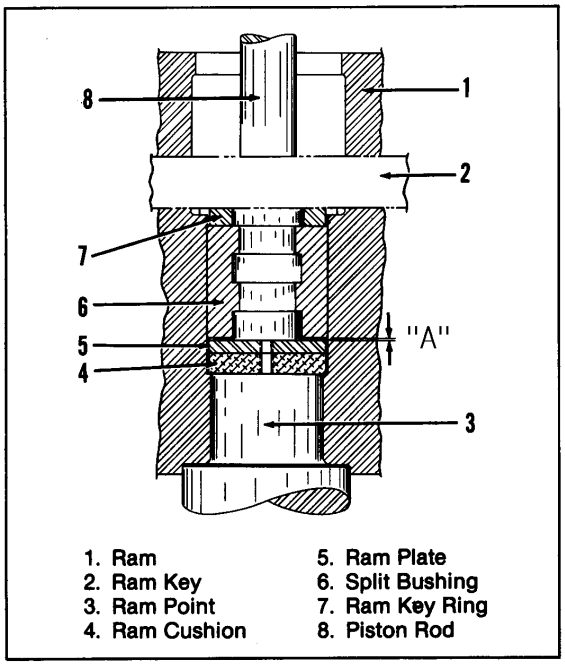


Figure 5.7.3.1 Ram and Point Assembly

All other sizes: Prior to reassembly the ram keys, determine the distance between the split bushing seat and the top of the ram cushion. The distance between the split bushing and the ram cushion should be from .010-.015" (0.25-0.38mm) larger than the thickness of the flange at the lower end of the piston rod. (See Figure 5.7.3.2). To attain the correct distance a steel shim can be inserted under the ram cushion. If necessary, the ram cushion may be turned on a lathe to reduce the thickness. Install eyebolts in the large end of the piston and install the piston and rod assembly. With the ram keys installed securely, the flanged end of the piston rod must be able to move laterally inside the ram when the split bushing is clamped against its seat or shoulder.

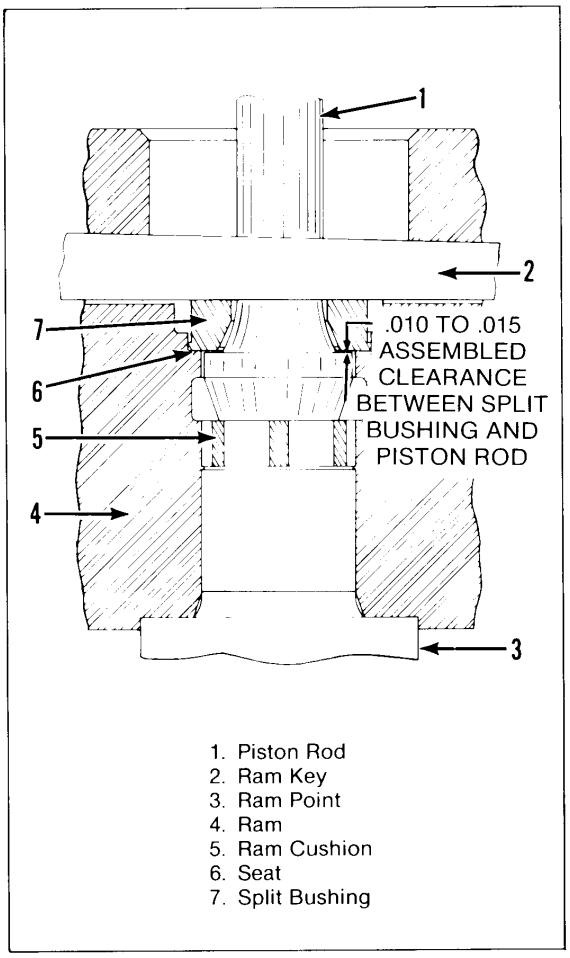


Figure 5.7.3.2 Ram and Point Assembly

5.7.4 Ram Keys

Ram keys are supplied at a length longer than necessary. After the piston and rod have been installed, drive the ram keys tight. Cut off any excess material that will interfere with hammer operation.

RAM KEYS SHOULD NOT BE DRIVEN TOO TIGHTLY. If the key is seated properly it will appear like No. 1 in Figure 5.7.4.1. When the ram key is too tight it will bend and a gap will widen as shown in No. 2 of the same figure.

Under certain conditions and on machines with many hours of use, the ram keys may periodically loosen. DO NOT weld the ram keys to the ram.

There is another way to tighten ram keys on Sizes 1, 505, 06, 306, 506, 08, 508, 010, 510, 012 and 512. On those sizes alone, shims can be

added between the ram plate and ram cushion to take up excessive clearance (See Figure 5.7.3.1).

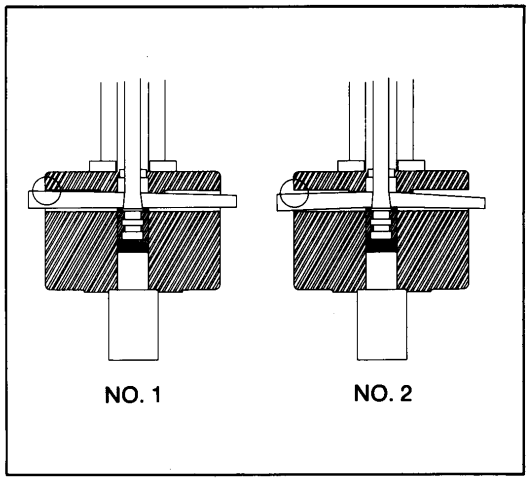


Figure 5.7.4.1 Ram Key Assembly

5.7.5 Slide Bar Gripper Installation (Sizes 020, 320, 520, 030, 330, and 530)

Refer to Figure 5.7.5.1 for illustration.

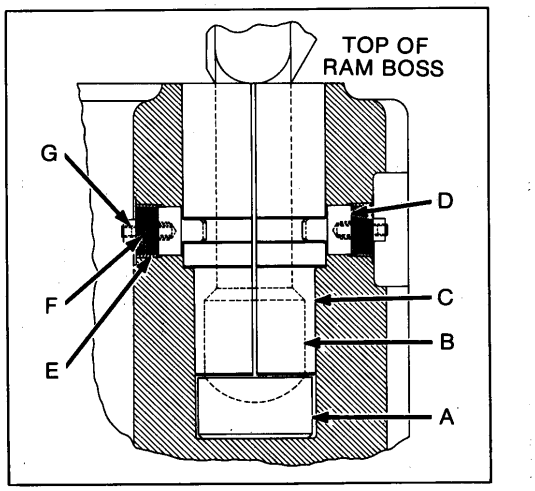


Figure 5.4.5.1 Slide Bar Gripper

1) Install end block in ram (A) and slide bar (B) in gripper ©.
2) Install gripper © in ram.
3) Install gripper retaining wedges (D) as shown.
4) Install retaining plugs (E) and tighten.
5) Install set screws (F) in retaining plugs (E) and tighten set screws. This causes the wedge to tighten against slots in gripper, securing the gripper in place.
6) Install locking set screws (G) as shown.

To disassemble, simply reverse the procedure. There is a tapped hole in the retaining wedges for removal.

5.7.6 Column Bore Wear and Ram Point Replacement

If there is more than 1/8" (3mm) of wear in the column bores, there is a risk of breaking the piston rod. Although bushings can be installed, we recommend that you consult the factory on such a repair.

For broken ram point replacement on any size, one should consult Vulcan Iron Works Inc. or authorized representative for procedure and assistance.

5.8 DRIVING ACCESSORIES

The pipe cap is loaded with cushion material as shown in Figure 5.8.1 if it has a standard pot and 5.8.2 if it is fitted with a capblock follower. If the latter is used, in addition to the cabling procedure described in Section 4.1, the hammer must be cabled to the follower and the follower to the pipe cap. *Do not use rusted or scrap cable for this application!*

Whenever the cushion pot ring is cracked or broken it must be replaced with a repair ring. Consult the factory for this procedure.

Care must be taken when welding adapters of any kind onto pipe caps, since these are for the most part alloy steel castings and require special welding procedures and care.

WARNING

Welding of any kind on hammers should be avoided and, if necessary, only performed with factory authorized procedures.

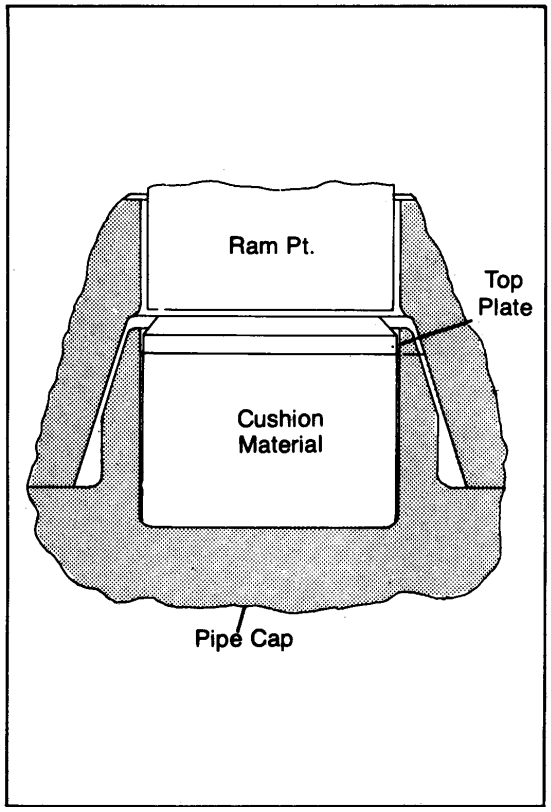


Figure 5.8.1 Integral Ring Cushion Pot

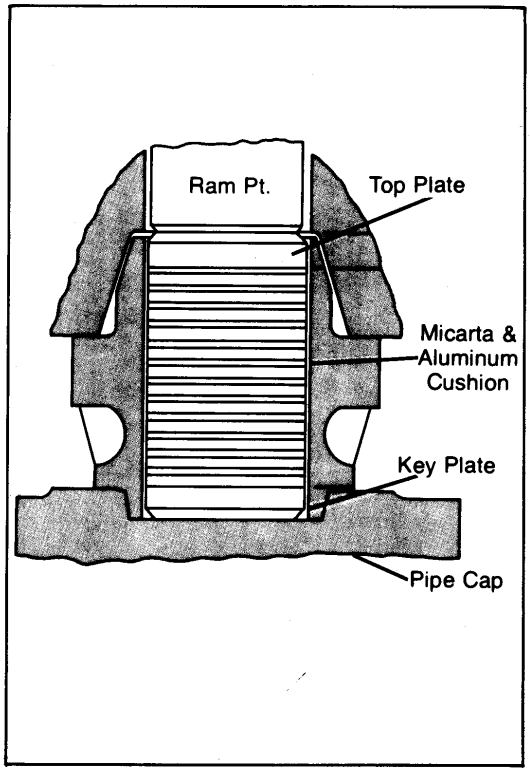


Figure 5.8.2 Capblock Follower

6.0 TROUBLESHOOTING

HAMMER RUNS TOO SLOW

CAUSE	REMEDY
Air or steam pressure too low.	Check pressure at compressor. Due to line loss, the pressure at compressor should be greater than the manufacturers required pressure at the hammer. Use air needle gauge to check air hose pressure at the hammer.
Air supply line too long or not proper size.	Use specified line size or larger. Supply line from the compressor to the hammer should be only as long as necessary. Eliminate as many bends and elbows in the air or steam line as possible.
Air supply line restricted in some manner.	Try new hose. Check throttle valve to see that it opens properly. Eliminate all hose kinks and as many elbows and bends as possible in the supply line. Check for any other kind of restrictions or blockages in the line.
Lack of lubrication.	Check oil level in line lubricator and see that lubricator is functioning properly. Check hammer columns for burrs and lubricate columns properly. Check for proper lubrication oil.
Worn or broken piston rings or scored cylinder wall. Check this by allowing enough air to enter the cylinder to hold the ram in about a half-raised position and note whether excessive air is escaping out of exhaust ports at top of cylinder.	Replace piston rings. Be sure rings have required gap. Machine scores from cylinder wall.
Piston rod packing too tight.	Loosen packing gland nuts until they are just hand tight against the packing gland. Lock the two nuts against each other to keep them in place. A small amount of steam leakage from the packing gland is not objectionable.
Leakage or using air for other purposes while hammer is running.	Stop leaks and other waste of air while hammer is operating.
Badly worn slide bar wedges or trip.	Replace slide bar or trip.
Loose cables caused by loose nuts or broken washers.	Replace the broken nuts or washers and retighten cables equally according to our specifications.

HAMMER RUNS TOO FAST

CAUSE	REMEDY
Excessive air pressure on hard driving indicated by bouncing of hammer on up-stroke.	Slow down by partially closing the throttle valve.
Ram not making full stroke.	Check for bent or twisted valve stem. Check valve setting.

EXCESSIVE SLIDE BAR BREAKAGE

CAUSE	REMEDY
Slide Bar Key loose.	Check slide bar key and key seat for proper fit. Key must be kept tight at all times.
Tie cables loose or unequally tensioned.	Tighten tie cables to prescribed tension.
Worn dovetail.	Replace dovetail insert.

HAMMER CHANGES SPEEDS WHILE OPERATING

CAUSE	REMEDY
Air Compressor not large enough.	Use larger size air compressor. Do not use air for other purposes while hammer is operating.
Loose or torn hose lining.	Replace with new hose.
Intermittent lubrication caused by defective line lubricator.	Replace lubricator.
Loose slide bar.	Replace slide bar, slide bar key, or gripper.
Icing.	In your air line oiler, dilute your lubricating oil with an equal amount of ethylene glycol.
Pile Rebound	This is a normal occurrence in pile driving. Make sure compressor operator maintains desired stroke.

HAMMER LEAKS STEAM AT MAIN EXHAUST PORT CONSTANTLY

CAUSE	REMEDY
Valve not seating properly.	Check to see if valve is broken or scored. Replace with new valve.
Scored or broken steam chest liner.	Replace steam chest liner.

HAMMER LEAKS STEAM EXCESSIVELY FROM EXHAUST PORTS AT TOP OF CYLINDER ON UPSTROKE

CAUSE	REMEDY
Worn or broken piston rings.	Replace piston rings.
Scored cylinder wall.	Machine scores out of cylinder wall.

RAM HANGS AND HAMMER STOPS OPERATING

CAUSE	REMEDY
Loose or unequally tensioned cables.	Retension cables to specified tension.
Rust or burrs on columns.	Dress columns to smooth finish.
Piston rings too large and seized up in cylinder.	Check ring dimensions and see that they have sufficient gap.
Piston packing too tight.	Loosen packing gland nuts until they are just hand tight against packing gland. Lock the two nuts against each other to keep them in place.
Icing	In your air line oiler, dilute your lubricating oil with an equal amount of ethylene glycol.
Insufficient lubricant	Check column or air/steam line lubricant.

CABLE BREAKING

CAUSE	REMEDY
Pile running out from under hammer causing ram to strike base.	Shut down hammer at throttle valve.
Unequal tensioning causing one cable to do all of the work.	Keep cables tensioned equally according to our specifications.
Insufficient cushion material allowing ram to strike base.	Top of top plate should not be lower than 3" (76mm) below top of cushion pot.

7.0 MAJOR OVERHAUL

Under average use the Vulcan pile hammer should be completely overhauled after every 400 to 500 hours of use.

Major overhaul should be accomplished by an authorized Vulcan Iron Works distributor. If the location of distributor is not known, contact

Vulcan Iron Works Inc.
P.O. Box 5402
2909 Riverside Drive
Chattanooga, TN 37406
(423) 698-1581
Toll Free (800) 742-6637
Telecopier (423) 698-1587

The necessary information will be supplied.

If any disassembly work is done on site, the hammer should be completely cleaned and then disassembled, all parts should be cleaned and carefully inspected. Using this manual, check all parts to see if there is any excessive wear or damage and to replace those parts which are no longer usable. The most important consideration in any overhauling procedure is the cleanliness of the work and environment. This is true in both disassembly and reassembly. AVOID DIRT, GRIT, WELDING SLAG, AND ALL FOREIGN MATTER, AND PROPERLY LUBRICATE AND SEAT THE PARTS AS THEY ARE REASSEMBLED.

After reassembly or overhaul, the hammer should be examined carefully and lubricated according to the lube information in this manual. Follow warming procedures prior to starting driving operations.

CAUTION

ALWAYS USE GENUINE VULCAN REPLACEMENT PARTS WHICH ARE AVAILABLE FROM DISTRIBUTORS OF VULCAN IRON WORKS INC.

8.0 STORAGE

When the hammer is placed in storage or will not be used for some time, cover the steam or air inlet, exhaust outlet and relief parts. Take precautions to prevent dirt from entering the steam chest and cylinder.

Protect the columns, piston and rod, and the slide bar by wrapping with cloth. Tie the cloth with wire and soak it with oil.

The hammer should be stored on its side and in a protected area. Keep the hammer off the ground and covered if possible.

Insert oil soaked rags into the exhaust port of the valve chest.

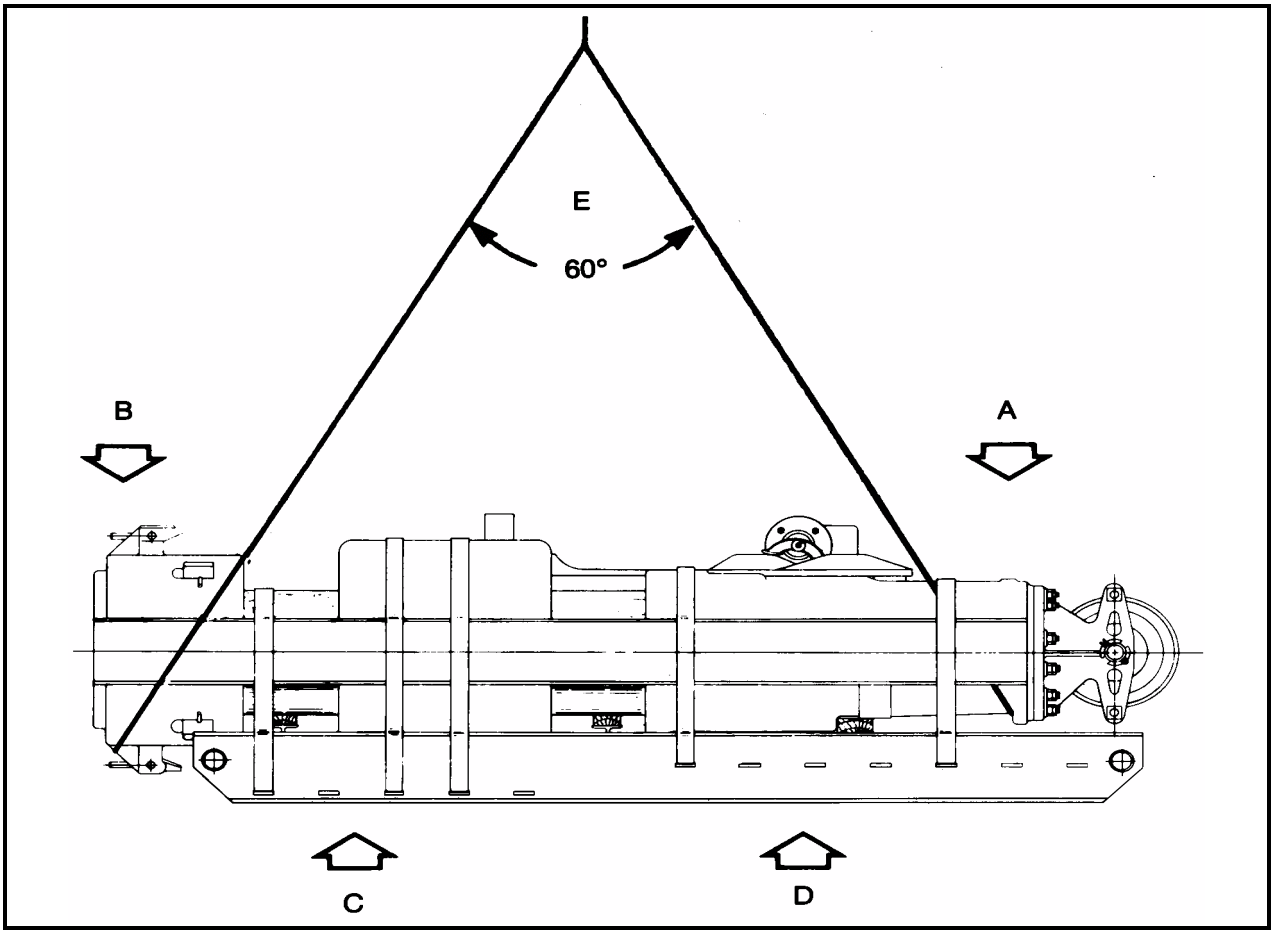
Pour a quart of oil in the air intake and seal the intake with waterproof tape.

On single acting hammers, pour a quart of oil into the exhaust port at the top of the cylinder. Seal the port with waterproof tape.

On differential acting hammers, insert oil soaked rags into the lower cylinder around the piston rod.

Refer to "Storage Precautions" in the Vulcan User's Guide.

9.0 SHIPPING



DO'S	DONT'S
Always secure lifting slings to the hammer, NOT TO THE SKID.	*Never* pull or drag the hammer with any line fastened to the skid.
Always attach slings to top of Cylinder (A) and Base (B) as shown.	*Never* attach slings to any of the four columns of the hammer.
Always secure sling behind channel, not over, if hammer has channels.	*Never* attach slings to ram point of hammer.
Always make sling angle (E) less than 60°.	*Never* attach slings to hammer at or near slide bar location.
Always check hammer weight to determine sling size.	*Never* attach sling to piston rod of hammer.
Always place forks at approximate locations C & D for fork truck handling.	*Never* place forks between hammer and skid.
Always secure the line to the hammer.	

10.0. PARTS LIST

10.1 General Notes

Refer to the parts drawing in this section of the manual that identifies the part or assembly with the key number and a line pointing to the part or assembly. Refer to the name of the part or assembly as given in this manual. Use this name and part number in ordering parts. PARTS ORDERS SHOULD INCLUDE THE FOLLOWING INFORMATION.

1) Size and Serial Number of the Hammer.
2) Part Number and Name. Do not use the key number.
3) Quantity required.
4) Specific Shipping Instructions.
5) Purchase order number, if any.

Concerning the serial numbers, beginning in the late 1960's Vulcan adopted a system of serial numbers that gave the year of the hammer's manufacture without having to consult the factory. All of this type of serial number is in the format of

XX-YYYY

where "XX" represents the year code in two letters; they translate into the last two digits of the year as follows:

Letter	Digit
A	1
B	2
C	3
D	4
E	5
F	6
G	7
H	8
I	9
J	0

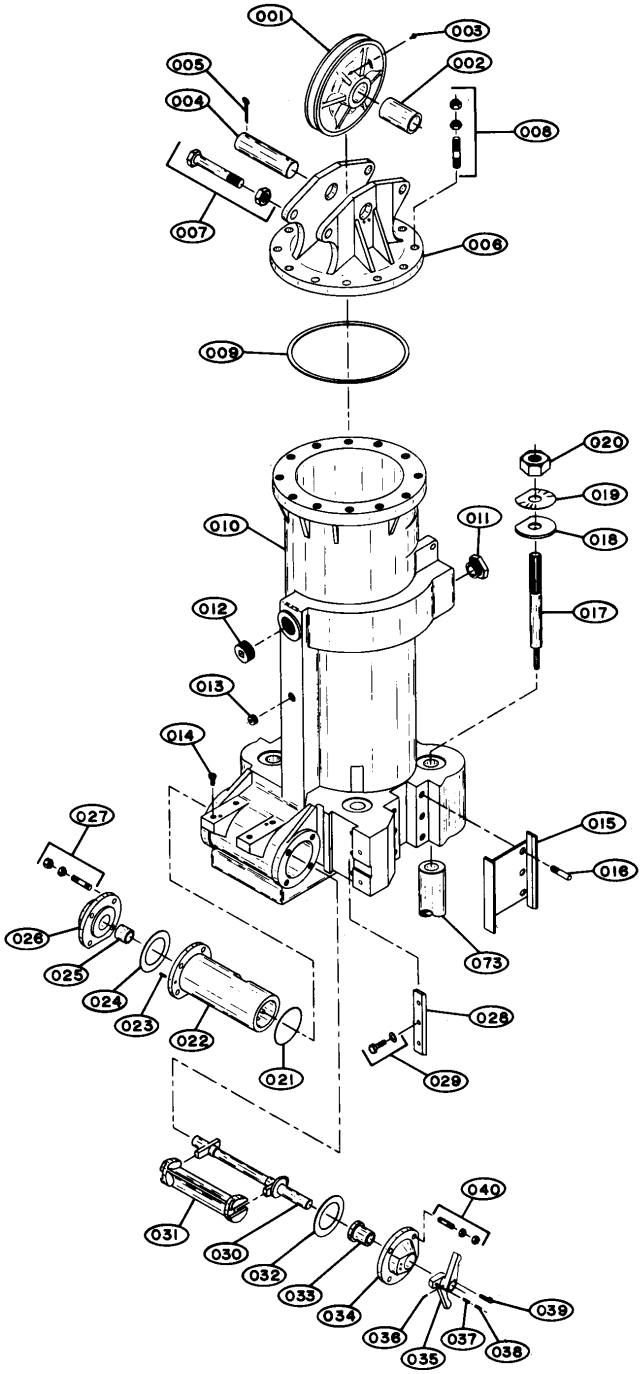
Thus, the serial number "GF" translates into "76", thus the hammer was made in 1976.

The "YYYY" is a sequential number assigned to the particular hammer.

For years of manufacture with strictly numerical serial numbers, please consult the factory.

10.2 Sizes #1, 06, 08, 010, 012, 505, 506, 508, 510, 512, 306

10.2.1 Exploded Views



10.2.2 Parts List for Hammers #1, 06, 08, 010, 012

Key	Description	#1	06	08	010	012
1	Head Sheave– Incl. Key 1,2,3	52V0911	53V0911	54V0910	55V0910	62V0910
2	Head Sheave Bushing	52V0136	53V0136	54V0138	55V0138	62V0138
3	Grease Fitting	52V0147	53V0147	54V0134	55V0134	62V0134
4	Sheave Pin	52V0137	53V0137	54V0139	55V0139	62V0139
5	Cotter Key - Sheave Pin	52V0140	53V0140	54V0142	55V0142	62V0142
6	Cylinder Head Complete - Incl. 1,2,3,4,5,6,7	52V0914	53V0914	54V0918	55V0922	62V0914
6	Cylinder Head - Sheave Type	52V0131	53V0131	54V0112	55V0112	62V0112
7	Cross Cylinder Head Bolt	52V0138	53V0138	54V0140	55V0140	62V0140
7	Cross Cylinder Head Bolt - Nut	52V0139	53V0139	54V0141	55V0141	62V0141
8	Cylinder Head Stud	52V0102	53V0102	54V0114	55V0114	62V0114
8	Cylinder Head Stud Nut - Jam	52V0103	53V0103	54V0150	55V0150	62V0150
8	Cylinder Head Stud Nut - Full	52V0104	53V0104	54V0151	55V0151	62V0151
9	Cylinder Head Gasket	52V0161	53V0161	54V0156	55V0156	62V0152
10	Cylinder Complete - Incl. Key 8,10-14,27-29, 40, 47	52V0900	53V0900	54V0914	55V0918	62V0900
10	Cylinder Only - Incl. Key 10,21,22,23	52V0901	53V0901	54V0915	55V0919	62V0901
11	Cylinder Pipe Bushing	52V0114	53V0114	54V0108	55V0108	62V0108
12	Cylinder Pipe Plug	52V0134	53V0134	54V0121	55V0121	62V0121
13	Cylinder Pipe Plug	52V0144	53V0144	54V0109	55V0109	62V0109
15	Stub Channels Complete - Incl. Key 15,16,75,78	52V0913	53V0913	54V0908	55V0908	62V0909
15	Stub Channel - Cylinder	52V0508	53V0508	54V0508	55V0508	62V0508
16	Channel Rivet Studs	52V0511	53V0511	54V0509	55V0509	62V0509
17	Cable Column W/End Fittings	52V0925	53V0925	54V0928	55V0928	62V0919
18	Cable Nut Washer	52V0525	53V0525	54V0528	55V0530	62V0514
19	Cable Lock Washer	52V0505	53V0505	54V0506	55V0506	62V0506
20	Cable Nut	52V0506	53V0506	54V0501	55V0501	62V0501
21	Cylinder Valve Liner O-Ring	52V0116	53V0116	54V0111	55V0111	62V0111
22	Cylinder Valve Liner	52V0115	53V0115	54V0110	55V0110	62V0110
23	Cylinder Valve Liner Dowel Pin	52V0117	53V0117	54V0135	55V0135	62V0135
24	Blind Steam Chest Head Gasket	52V0160	53V0160	54V0158	55V0158	62V0154
25	Blind Steam Chest Head Bushing	52V0124	53V0124	54V0125	55V0125	62V0125
26	Blind Steam Chest Head - Incl. Key 25	52V0903	53V0903	54V0902	55V0902	62V0903
27	Blind Steam Chest Head Stud	52V0108	53V0108	54V0102	55V0102	62V0102
27	Blind Steam Chest Head Stud Nut-Jam	52V0109	53V0109			
27	Blind Steam Chest Head Stud Nut-Full	52V0110	53V0110			
28	Dovetail Insert			54V0128	55V0128	62V0128
29	Dovetail Fastener Bolt			54V0129	55V0129	62V0129
29	Dovetail Insert Lockwasher			54V0130	55V0130	62V0130
30	Valve Stem	52V0126	53V0126	54V0127	55V0127	62V0127
31	Valve	52V0130	53V0130	54V0146	55V0146	62V0146
32	Open Steam Chest Head Gasket	52V0159	53V0159	54V0157	55V0157	62V0153
33	Open Steam Chest Head Bushing	52V0120	53V0120	54V0119	55V0119	62V0119
34	Open Steam Chest Head - Incl. Key 33	52V0902	53V0902	54V0901	55V0901	62V0902
35	Trip Complete - Incl. Key 35,36,37,38	52V0912	53V0912	54V0907	55V0907	62V0908
36	Trip Set Screw	52V0148	53V0148	54V0133	55V0133	62V0133
37	Ball Nose Spring Loaded Pin	52V0132	53V0132	54V0116	55V0116	62V0116
38	Ball Nose Set Screw	52V0133	53V0133	54V0117	55V0117	62V0117
39	Trip Key	52V0143	53V0143	54V0136	55V0136	62V0136
40	Open Steam Chest Head Stud	52V0105	53V0105	54V0101	55V0101	62V0101
40	Steam Chest Head Stud Nut-Jam	52V0106	53V0106	54V0103	55V0103	62V0103
40	Steam Chest Head Stud Nut-Full	52V0107	53V0107	54V0104	55V0104	62V0104
41	Piston and Rod Complete - Incl. Key 42,44	52V0904	53V0904	54V0903	55V0903	62V0904
41	Piston and Rod	52V0400	53V0400	54V0400	55V0400	62V0400
42	Piston Rings	52V0402	53V0402	54V0402	55V0402	62V0402
42	Piston Rings - Oversize	52V0403	53V0403	54V0403	55V0403	62V0403
43	Junk Ring	52V0129	53V0129	54V0145	55V0145	62V0145
44	Piston Rod Packing	52V0401	53V0401	54V0401	55V0401	62V0401
45	Gland Bushing	52V0128	53V0128	54V0144	55V0144	62V0144
46	Gland	52V0127	53V0127	54V0143	55V0143	62V0143
47	Stuffing Box Stud	52V0111	53V0111	54V0105	55V0105	62V0105
47	Stuffing Box Stud Nut-Jam	52V0112	53V0112	54V0106	55V0106	62V0106 5
47	Stuffing Box Stud Nut-Full	52V0113	53V0113	54V0107	55V0107	62V0107
48	Ram Key Ring	52V0221	53V0221	54V0222	55V0222	62V0222

Key	Description	#1	06	08	010	012
49	Split Bushing	52V0214	53V0214	54V0215	55V0215	62V0215
50	Ram Plug				55V0223	62V0223
51	Ram Plate	52V0222	53V0222	54V0223		
52	Ram Cushion	52V0215	53V0215	54V0216	55V0216	62V0216
53	Ram Complete-Incl. Key 54,55,56,57,59,64,65,67,68	52V0905	53V0905	54V0904	55V0904	62V0905
53	Ram Only (Include Babbitt)	52V0906	53V0906	54V0906	55V0906	62V0906
54	Upper Rubber Bumper	52V0224	53V0224	54V0217	55V0217	62V0217
55	Upper Bumper Stud	52V0216	53V0216	54V0218	55V0218	62V0218
56	Pin/Bumper Stud	52V0219	53V0219	54V0220	55V0220	62V0220
57	Washer/Bumper Stud	52V0218	53V0218	54V0219	55V0219	62V0219
58	Slide Bar Complete (Nylon) - Incl. Key 60	52V0909	53V0909	54V0911	55V0911	62V0911
58	Slide Bar Complete (Steel) - Incl. Key 60	52V0908	53V0908	54V0916	55V0916	62V0912
58	Upper Wedge	52V0206	53V0206	54V0207	55V0207	62V0207
58	Lower Wedge	52V0207	53V0207	54V0208	55V0208	62V0208
59	Slide Bar End Block	52V0213	53V0213	54V0214	55V0214	62V0214
60	Slide Bar Key Block Seat	52V0211	53V0211	54V0212	55V0212	62V0212
61	Slide Bar Key Block	52V0210	53V0210	54V0211	55V0211	62V0211
62	Ram Key	52V0204	53V0204	54V0205	55V0205	62V0205
63	Ram Key Pin	52V0205	53V0205	54V0206	55V0206	62V0206
64	Set Screw - Slide Bar Key	52V0202	53V0202	54V0203	55V0203	62V0203
65	Lock Nut - Jam - Setscrew	52V0203	53V0203	54V0204	55V0204	62V0204
66	Slide Bar Key	52V0212	53V0212	54V0213	55V0213	62V0213
67	Ram Pipe Plug	52V0223	53V0223	54V0202	55V0202	62V0202
68	Ram Point	52V0201	53V0201	54V0225	55V0225	62V0201
69	Lower Rubber Bumper	52V0307	53V0307	54V0305	55V0305	62V0305
70	Lower Bumper Stud	52V0304	53V0304	54V0304	55V0304	62V0304
71	Pin/Bumper Stud	52V0306	53V0306	54V0307	55V0307	62V0307
72	Washer/Bumper Stud	52V0305	53V0305	54V0306	55V0306	62V0306
73	Columns - Tubular	52V0303	53V0303	54V0303	55V0303	62V0303
74	Base Complete - Incl. Key 69,70,71,72,76,77	52V0907	53V0907	54V0905	55V0905	62V0907
74	Base (Cable)	52V0300	53V0300	54V0300	55V0300	62V0300
75	Stub Channel - Base	52V0515	53V0515	54V0513	55V0513	62V0513
76	Lock Bar	52V0301	53V0301	54V0301	55V0301	62V0301
77	Lock Bar Pin	52V0302	53V0302	54V0302	55V0302	62V0302

10.2.2 Parts List for Hammers 505, 506, 508, 510, 512

Key	Description	505	506	508	510	512
1	Head Sheave– Incl. Key 1,2,3	45V0911	46V0911	48V0909	49V0909	12V0909
2	Head Sheave Bushing	45V0135	46V0135	48V0138	49V0138	12V0138
3	Grease Fitting	45V0146	46V0146	48V0136	49V0136	12V0136
4	Sheave Pin	45V0136	46V0136	48V0139	49V0139	12V0139
5	Cotter Key - Sheave Pin	45V0139	46V0139	48V0142	49V0142	12V0142
6	Cylinder Head Complete - Incl. 1,2,3,4,5,6,7	45V0910	46V0910	48V0912	49V0912	12V0912
6	Cylinder Head - Sheave Type	45V0130	46V0130	48V0112	49V0112	12V0112
7	Cross Cylinder Head Bolt	45V0140	46V0137	48V0140	49V0140	12V0140
7	Cross Cylinder Head Nut - Full	45V0141	46V0138	48V0141	49V0141	12V0141
8	Cylinder Head Stud	45V0101	46V0101	48V0114	49V0114	12V0114
8	Cylinder Head Stud Nut - Jam	45V0102	46V0102	48V0115	49V0115	12V0115
8	Cylinder Head Stud Nut - Full	45V0103	46V0103	48V0116	49V0116	12V0116
9	Cylinder Head Gasket	45V0117	46V0117	48V0113	49V0113	12V0113
10	Cylinder Complete - Incl. Key 8,10-14,27-29,40,47	45V0900	46V0900	48V0900	49V0900	12V0900
10	Cylinder Only - Incl. Key 10,21,22,23	45V0901	46V0901	48V0901	49V0901	12V0901
11	Cylinder Pipe Bushing	45V0113	46V0113	48V0108	49V0108	12V0108
12	Cylinder Pipe Plug	45V0133	46V0133	48V0109	49V0109	12V0109
13	Cylinder Pipe Plug	45V0143	46V0143	48V0121	49V0121	12V0121
15	Stub Channels Complete - Incl. Key 15,16,75,78	45V0913	46V0913	48V0908	49V0908	12V0908
15	Stub Channel - Cylinder	45V0507	46V0507	48V0507	49V0507	12V0507
16	Channel Rivet Studs	45V0509	46V0509	48V0508	49V0509	12V0508
17	Cable Column W/End Fittings		46V0914	48V0911	49V0914	12V0911
18	Cable Nut Washer Flat Lock	45V0503	46V0503	48V0504	49V0503	12V0504
19	Cable Lock Washer	45V0504	46V0504	48V0505	49V0504	12V0505
20	Cable Nut	45V0505	46V0505	48V0501	49V0505	12V0501
21	Cylinder Valve Liner O-Ring	45V0115	46V0115	48V0111	49V0111	12V0111
22	Cylinder Valve Liner	45V0114	46V0114	48V0110	49V0110	12V0110
23	Cylinder Valve Liner Dowel Pin	45V0116	46V0116	48V0135	49V0135	12V0135
24	Blind Steam Chest Head Gasket	45V0124	46V0124	48V0126	49V0126	12V0126
25	Blind Steam Chest Head Bushing	45V0123	46V0123	48V0125	49V0125	12V0125
26	Blind Steam Chest Head - Incl. Key 25	45V0903	46V0903	48V0903	49V0903	12V0903
27	Blind Steam Chest Head Stud	45V0107	46V0107	48V0102	49V0102	12V0102
27	Blind Steam Chest Head Stud Nut-Jam	45V0108	46V0108	48V0103	49V0103	12V0103
27	Blind Steam Chest Head Stud Nut-Full	45V0109	46V0109	48V0104	49V0104	12V0104
28	Dovetail Insert	45V0148	46V0148	48V0128	49V0128	12V0128
29	Dovetail Fastener Bolt	45V0149	46V0149	48V0129	49V0129	12V0129
29	Dovetail Insert Lockwasher	45V0150	46V0150	48V0130	49V0130	12V0130
30	Valve Stem	45V0125	46V0125	48V0127	49V0127	12V0127
31	Valve	45V0129	46V0129	48V0146	49V0146	12V0146
32	Open Steam Chest Head Gasket	45V0121	46V0121	48V0120	49V0120	12V0120
33	Open Steam Chest Head Bushing	45V0119	46V0119	48V0119	49V0119	12V0119
34	Open Steam Chest Head - Incl. Key 33	45V0902	46V0902	48V0902	49V0902	
35	Trip Complete - Incl. Key 35,36,37,38	45V0912	46V0912	48V0123	49V0123	12V0123
36	Trip Set Screw	45V0147	46V0147			
37	Ball Nose Spring Loaded Pin	45V0131	46V0131			
38	Ball Nose Set Screw	45V0132	46V0132			
39	Trip Key	45V0142	46V0142			
40	Open Steam Chest Head Stud	45V0104	46V0104	48V0101	49V0101	12V0101
40	Steam Chest Head Stud Nut-Jam	45V0105	46V0105	48V0103	49V0103	12V0103
40	Steam Chest Head Stud Nut-Full	45V0106	46V0106	48V0104	49V0104	12V0104
41	Piston and Rod Complete - Incl. Key 42,44	45V0904	46V0904	48V0904	49V0904	12V0904
41	Piston and Rod	45V0400	46V0400	48V0400	49V0400	12V0400
42	Piston Rings	45V0402	46V0402	48V0402	49V0402	12V0402
42	Piston Rings - Oversize	45V0403	46V0403	48V0403	49V0403	12V0403
43	Junk Ring	45V0128	46V0128	48V0145	49V0145	12V0145
44	Piston Rod Packing	45V0401	46V0401	48V0401	49V0401	12V0401
45	Gland Bushing	45V0127	46V0127	48V0144	49V0144	12V0144
46	Gland	45V0126	46V0126	48V0143	49V0143	12V0143
47	Stuffing Box Stud	45V0110	46V0110	48V0105	49V0105	12V0105
47	Stuffing Box Stud Nut-Jam	45V0111	46V0111	48V0106	49V0106	12V0106
47	Stuffing Box Stud Nut-Full	45V0112	46V0112	48V0107	49V0107	12V0107
48	Ram Key Ring	45V0220	46V0220	48V0222	49V0222	12V0222
49	Split Bushing	45V0214	46V0214	48V0215	49V0215	12V0215

Key	Description	505	506	508	510	512
50	Ram Plug		46V0221	48V0223	49V0223	12V0223
51	Ram Plate					
52	Ram Cushion	45V0215	46V0215	48V0216	49V0216	12V0216
53	Ram Complete-Incl. Key 54,55,56,57,59,64,65,67,68		46V0905	48V0905		12V0905
53	Ram Only (Include Babbitt)		46V0906	48V0906		12V0906
54	Upper Rubber Bumper	45V0223	46V0223	48V0217	49V0217	12V0217
55	Upper Bumper Stud	45V0216	46V0216	48V0218	49V0218	12V0218
56	Pin/Bumper Stud	45V0218	46V0218	48V0220	49V0220	12V0220
57	Washer/Bumper Stud	45V0217	46V0217	48V0219	49V0219	12V0219
58	Slide Bar Complete - Incl. Key 60	45V0909	46V0909	48V0916	49V0916	12V0910
58	Slide Bar - Steel - Incl. Key 60					12V0913
58	Upper Wedge	45V0206	46V0206			12V0207
58	Lower Wedge	45V0207	46V0207			12V0208
59	Slide Bar End Block	45V0213	46V0213	48V0214	49V0214	12V0214
60	Slide Bar Key Block Seat	45V0211	46V0211	48V0212	49V0212	12V0212
61	Slide Bar Key Block	45V0210	46V0210	48V0211	49V0211	12V0211
62	Ram Key	45V0204	46V0204	48V0205	49V0205	12V0205
63	Ram Key Pin	45V0205	46V0205	48V0206	49V0206	12V0206
64	Set Screw - Slide Bar Key	45V0202	46V0202	48V0203	49V0203	12V0203
65	Lock Nut - Jam - Setscrew	45V0203	46V0203	48V0204	49V0204	12V0204
66	Slide Bar Key	45V0212	46V0212	48V0213	49V0213	12V0213
67	Ram Pipe Plug	45V0222	46V0222	48V0202	49V0202	12V0202
68	Ram Point	45V0201	46V0201	48V0201	49V0201	12V0201
69	Lower Rubber Bumper	45V0307	46V0307	48V0305	49V0305	12V0305
70	Lower Bumper Stud	45V0304	46V0304	48V0304	49V0304	12V0304
71	Pin/Bumper Stud	45V0306	46V0306	48V0307	49V0307	12V0307
72	Washer/Bumper Stud	45V0305	46V0305	48V0306	49V0306	12V0306
73	Columns - Tubular		46V0303	48V0303	49V0303	12V0303
74	Base Complete - Incl. Key 69,70,71,72,76,77	45V0907	46V0907	48V0907	49V0907	12V0907
74	Base	45V0300	46V0300	48V0300	49V0300	12V0300
75	Stub Channel - Base	45V0508	46V0508	48V0509	49V0509	12V0509
76	Lock Bar	45V0301	46V0301	48V0301	49V0301	12V0301
77	Lock Bar Pin	45V0302	46V0302	48V0302	49V0302	12V0302

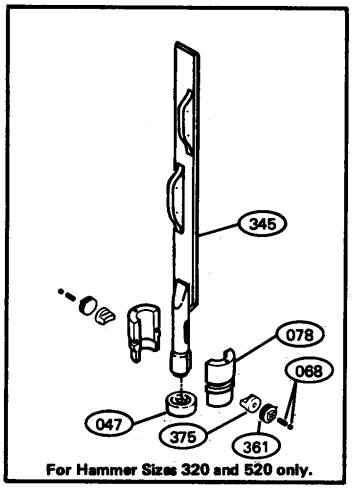
10.2.3 Parts List for Hammer 306

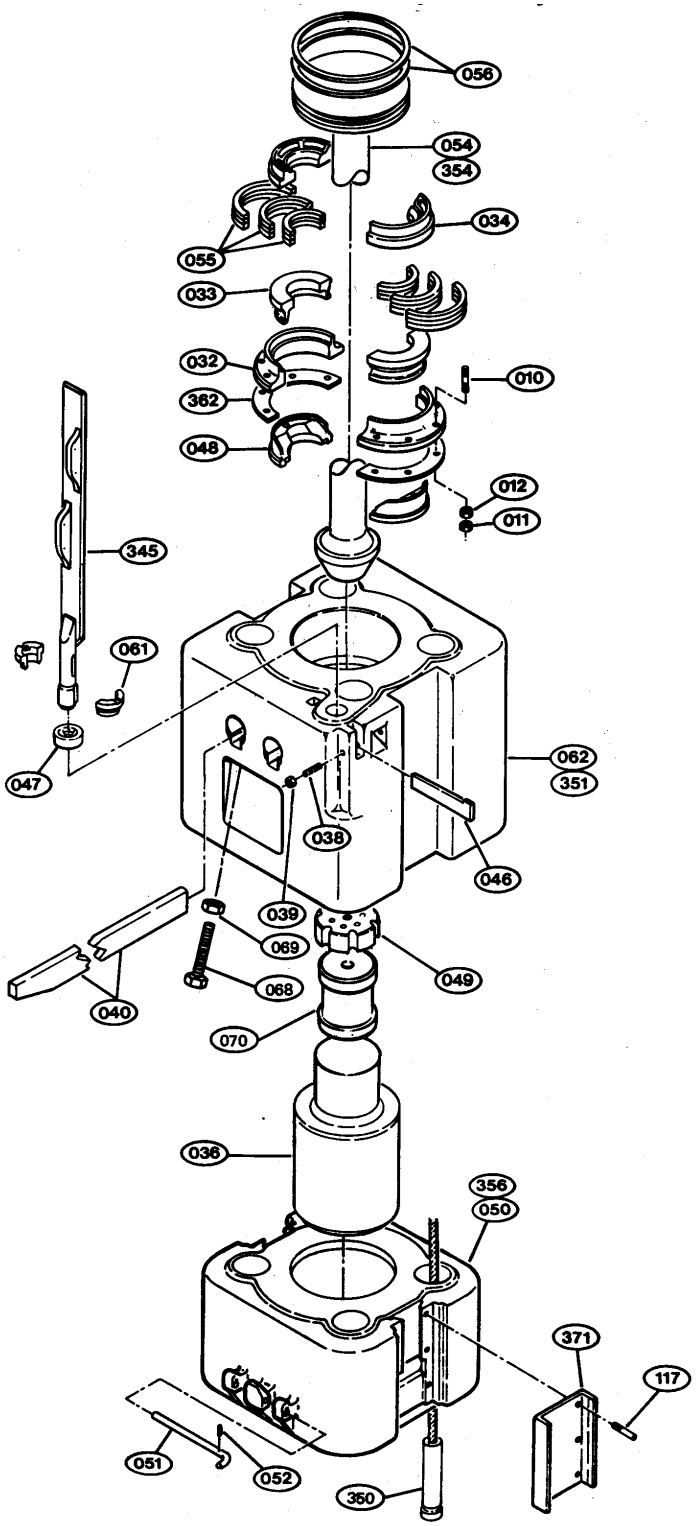
Key	Description	306
1	Head Sheave– Incl. Key 1,2,3	66V0911
2	Head Sheave Bushing	66V0135
3	Grease Fitting	66V0146
4	Sheave Pin	66V0136
5	Cotter Key - Sheave Pin	66V0139
6	Cylinder Head Complete - Incl. 1,2,3,4,5,6,7	66V0910
6	Cylinder Head - Sheave Type	66V0130
7	Cross Cylinder Head Bolt	66V0137
7	Cross Cylinder Head Bolt - Nut	66V0138
8	Cylinder Head Stud	66V0101
8	Cylinder Head Stud Nut - Jam	66V0102
8	Cylinder Head Stud Nut - Full	66V0103
9	Cylinder Head Gasket	66V0117
10	Cylinder Complete - Incl. Key 8,10-14,27-29,40,47	
10	Cylinder Only - Incl. Key 10,21,22,23	
11	Cylinder Pipe Bushing	66V0113
12	Cylinder Pipe Plug	66V0133
13	Cylinder Pipe Plug	66V0143
15	Stub Channels Complete - Incl. Key 15,16,75,78	66V0913
15	Stub Channel - Cylinder	66V0507
16	Channel Rivet Studs	66V0509
17	Cable Column W/End Fittings	
18	Cable Nut Washer Flat Lock	66V0503
19	Cable Lock Washer	66V0504
20	Cable Nut	66V0505
21	Cylinder Valve Liner O-Ring	66V0115
22	Cylinder Valve Liner	66V0114
23	Cylinder Valve Liner Dowel Pin	66V0116
24	Blind Steam Chest Head Gasket	66V0124
25	Blind Steam Chest Head Bushing	66V0123
26	Blind Steam Chest Head - Incl. Key 25	66V0903
27	Blind Steam Chest Head Stud	66V0107
27	Blind Steam Chest Head Stud Nut-Jam	66V0108
27	Blind Steam Chest Head Stud Nut-Full	66V0109
28	Dovetail Insert	66V0148
29	Dovetail Fastener Bolt	66V0149
29	Dovetail Insert Lockwasher	66V0150
30	Valve Stem	66V0125
31	Valve	66V0129
32	Open Steam Chest Head Gasket	66V0121
33	Open Steam Chest Head Bushing	66V0119
34	Open Steam Chest Head - Incl. Key 33	66V0902
35	Trip Complete - Incl. Key 35,36,37,38	66V0912
36	Trip Set Screw	66V0147
37	Ball Nose Spring Loaded Pin	66V0131
38	Socket Set Screw	66V0132
39	Trip Key	66V0142
40	Open Steam Chest Head Stud	66V0104
40	Steam Chest Head Stud Nut-Jam	66V0105
40	Steam Chest Head Stud Nut-Full	66V0106
41	Piston and Rod Complete - Incl. Key 42,44	
41	Piston and Rod	66V0400
42	Piston Rings	66V0402
42	Piston Rings - Oversize	66V0403
43	Junk Ring	66V0128
44	Piston Rod Packing	66V0401
45	Gland Bushing	66V0127
46	Gland	66V0126
47	Stuffing Box Stud	66V0110
47	Stuffing Box Stud Nut-Jam	66V0111
47	Stuffing Box Stud Nut-Full	66V0112
48	Ram Key Ring	66V0220
49	Split Bushing	66V0214

Key	Description	306
50	Ram Plug	66V0221
51	Ram Plate	
52	Ram Cushion	66V0215
53	Ram Complete-Incl. Key 54,55,56,57,59,64,65,67,68	
53	Ram Only (Include Babbitt)	
54	Upper Rubber Bumper	66V0223
55	Upper Bumper Stud	66V0216
56	Pin/Bumper Stud	66V0218
57	Washer/Bumper Stud	66V0217
58	Slide Bar Complete (Nylon)- Incl. Key 60	66V0909
58	Upper Wedge	66V0206
58	Lower Wedge	66V0207
59	Slide Bar End Block	66V0213
60	Slide Bar Key Block Seat	66V0211
61	Slide Bar Key Block	66V0210
62	Ram Key	66V0204
63	Ram Key Pin	66V0205
64	Set Screw - Slide Bar Key	66V0202
65	Lock Nut - Jam - Setscrew	66V0203
66	Slide Bar Key	66V0212
67	Ram Pipe Plug	66V0222
68	Ram Point	66V0201
69	Lower Rubber Bumper	66V0307
70	Lower Bumper Stud	66V0304
71	Pin/Bumper Stud	66V0306
72	Washer/Bumper Stud	66V0305
73	Columns - Tubular	66V0303
74	Base Complete - Incl. Key 69,70,71,72,76,77	66V0907
74	Base	66V0300
75	Stub Channel - Base	66V0508
76	Lock Bar	66V0301
77	Lock Bar Pin	66V0302

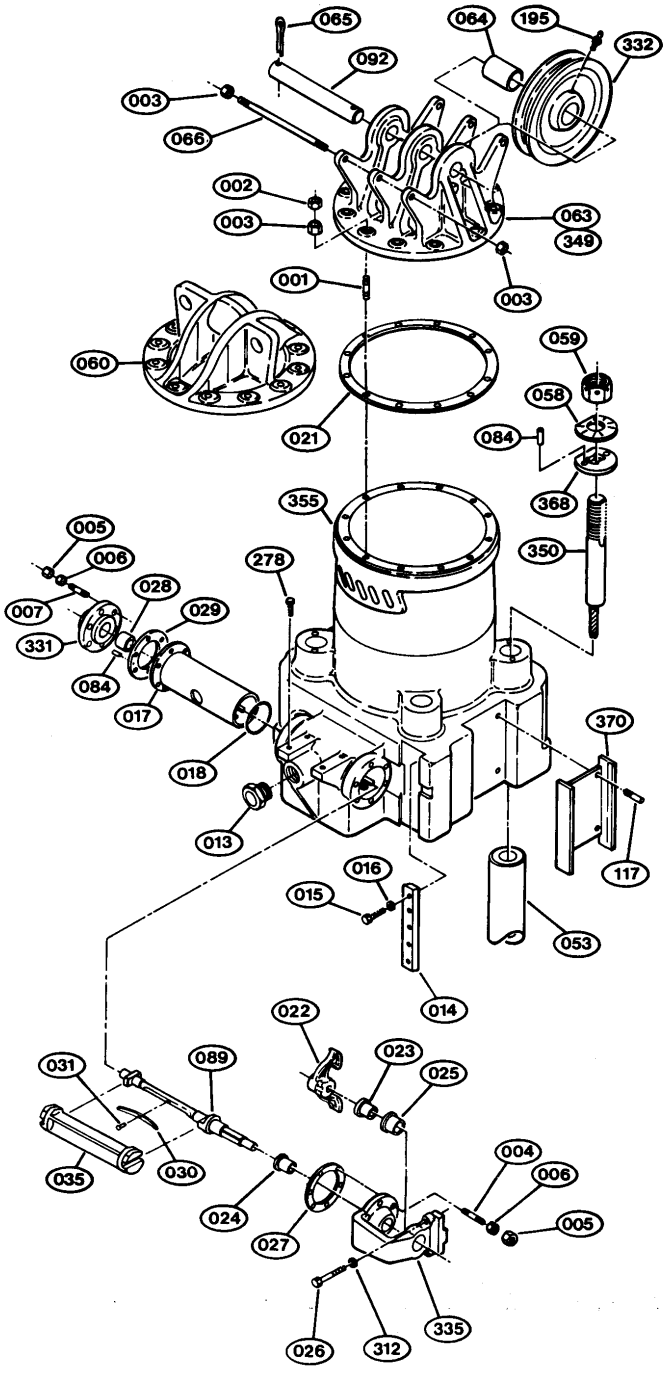
10.3 Hammer Sizes 330, 530, 320, 520

10.3.1 Exploded View





Hammer Size — 320, 330, 520, 530



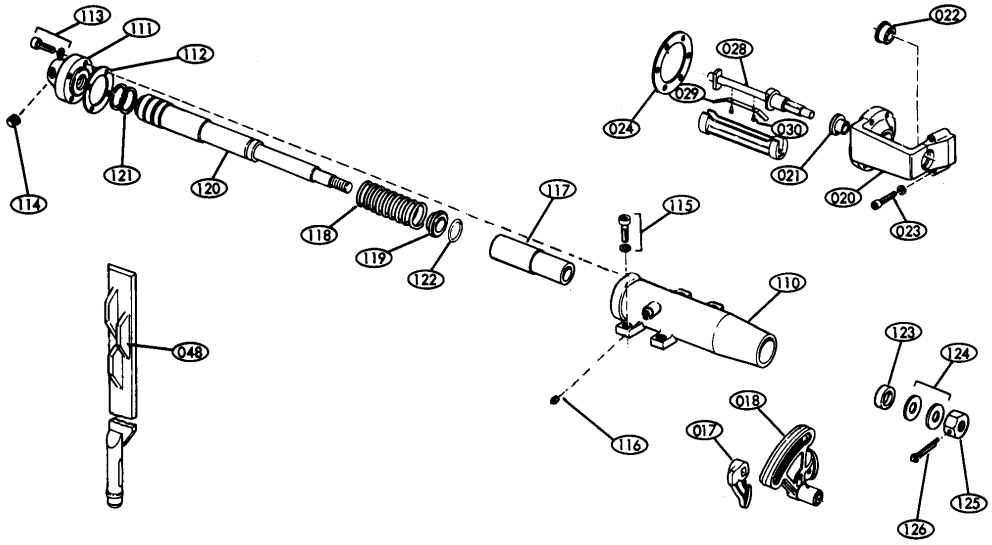
10.3.2 Parts List

Key	Description	330	530	320	520
1	Cylinder Head Stud	33V0101	38V0101	32V0101	34V0102
2	Cylinder Head Stud Nut - Jam	33V0102	38V0102	32V0102	34V0103
3	Cylinder Head Stud Nut - Full	33V0103	38V0103	32V0103	34V0104
3	Cross Cylinder Head Stud Nut - Full	33V0156	38V0156	32V0151	34V0152
4	Open Steam Chest Head Stud	33V0104	38V0104	32V0104	34V0105
5	Open Steam Chest Head Stud Nut - Jam	33V0105	38V0105	32V0105	34V0106
5	Blind Steam Chest Head Stud Nut - Jam	33V0108	38V0108	32V0108	34V0109
6	Open Steam Chest Head Stud Nut - Full	33V0106	38V0106	32V0106	34V0107
6	Blind Steam Chest Head Stud Nut - Full	33V0109	38V0109	32V0109	34V0110
7	Blind Steam Chest Head Stud	33V0107	38V0107	32V0107	34V0108
10	Stuffing Box Stud	33V0110	38V0110	32V0110	34V0111
11	Stuffing Box Stud Nut - Jam	33V0111	38V0111	32V0111	34V0112
12	Stuffing Box Stud Nut - Full	33V0112	38V0112	32V0112	34V0113
13	Cylinder Pipe Bushing	33V0113	38V0113	32V0113	34V0114
14	Dovetail Insert	33V0114	38V0114	32V0114	34V0115
15	Dovetail Insert Fastener Bolt	33V0115	38V0115	32V0115	34V0116
16	Dovetail Insert Fastener Bolt Lockwasher	33V0116	38V0116	32V0116	34V0117
17	Cylinder Valve Liner	33V0117	38V0117	32V0117	34V0118
18	Cylinder Valve Liner O-Ring Gasket	33V0118	38V0118	32V0118	34V0119
21	Cylinder Head Gasket	33V0122	38V0122	32V0121	34V0122
22	Trip	33V0123	38V0123	32V0122	34V0123
23	Open Steam Chest Head Outboard Bushing Spacer	33V0124	38V0124	32V0123	34V0124
24	Open Steam Chest Head Inboard Bushing	33V0125	38V0125	32V0124	34V0125
25	Open Steam Chest Head Outboard Bushing	33V0126	38V0126	32V0125	34V0126
26	Outboard Bearing Bracket Bolt	33V0127	38V0127	32V0126	34V0127
27	Open Steam Chest Head Gasket	33V0131	38V0131	32V0130	34V0131
28	Blind Steam Chest Head Bushing	33V0133	38V0133	32V0132	34V0133
29	Blind Steam Chest Head Gasket	33V0134	38V0134	32V0133	34V0134
30	Valve Spring	33V0135	38V0135	32V0134	34V0135
31	Valve Spring Rivet	33V0136	38V0136	32V0135	34V0136
32	Gland	33V0138	38V0138	32V0137	34V0138
33	Gland Bushing	33V0139	38V0139	32V0138	34V0139
34	Junk Ring	33V0140	38V0140	32V0139	34V0140
35	Valve	33V0141	38V0141	32V0140	34V0141
36	Ram Point	33V0201	38V0201	32V0201	34V0201
38	Slide Bar Key Set Screw		38V0203		34V0202
39	Set Screw Lock Nut - Jam		38V0204		34V0203
40	Ram Key	33V0202	38V0205	32V0202	34V0204
46	Slide Bar Key		38V0206		34V0209
47	Slide Bar End Block	33V0203	38V0207	32V0203	34V0210
48	Split Bushing	33V0209	38V0208	32V0209	34V0211
49	Ram Cushion	33V0210	38V0209	32V0210	34V0212
50	Base	33V0300	38V0300	32V0300	34V0300
51	Lock Bar	33V0301	38V0301	32V0301	34V0301
52	Lock Bar Pin	33V0302	38V0302	32V0302	34V0302
53	Columns	33V0303	38V0303	32V0303	34V0303
54	Piston and Rod	33V0400	38V0400	32V0400	34V0400
55	Piston Rod Packing	33V0401	38V0401	32V0401	34V0401
55	Piston Rod Packing	33V0402	38V0402	32V0402	34V0402
55	Piston Rod Packing	33V0403	38V0403	32V0403	34V0403
56	Piston Rings	33V0404	38V0404	32V0404	34V0404
56	Piston Rings - Oversize	33V0405	38V0405	32V0405	34V0405
58	Cable Nut Lockwasher	33V0505	38V0505	32V0505	34V0505
59	Cable Nut	33V0503	38V0503	32V0503	34V0503
60	Cylinder Head - Suspension	33V0148	38V0148	32V0145	34V0146
61	Slide Bar Key Block - Split		38V0213		34V0213
62	Ram	33V0200	38V0200	32V0200	34V0200
63	Cylinder Head - Sheave Type	33V0151	38V0151	32V0146	34V0147
64	Head Sheave Bushing	33V0153	38V0153	32V0148	34V0149
65	Sheave Pin Cotter	33V0157	38V0157	32V0152	34V0153
66	Cross Cylinder Head Stud	33V0155	38V0155	32V0150	34V0151
68	Ram Key Set Screw	33V0211	38V0210	32V0211	34V0205
68	Wedge Plug Set Screw	33V0207		32V0207	

Key	Description	330	530	320	520
68	Set Screw - Plug Set Screw	33V0208		32V0208	
69	Ram Key Set Screw Lock Nut - Jam	33V0212	38V0211	32V0212	34V0215
70	Ram Plug	33V0213	38V0212	32V0213	34V0216
78	Gripper	33V0204		32V0204	
84	Dowel Pin - Cylinder Valve Liner	33V0119	38V0119	32V0119	34V0120
84	Dowel Pin	33V0510	38V0510	32V0510	34V0510
89	Valve Stem	33V0137	38V0137	32V0136	34V0137
92	Sheave Pin	33V0154	38V0154	32V0149	34V0150
117	Stub Channel Rivet Stud	33V0509	38V0509	32V0509	34V0509
195	Grease Fitting	33V0146	38V0146	32V0154	34V0154
278	Cylinder Cap Screw	33V0142	38V0142	32V0141	34V0142
312	Open Steam Chest Head Bracket Washer	33V0128	38V0128	32V0127	34V0128
331	Blind Steam Chest Head	33V0132	38V0132	32V0131	34V0132
331	Blind Steam Chest Head Complete - Incl. Key 54,55,56	33V0903	38V0903	32V0903	34V0903
332	Head Sheave	33V0152	38V0152	32V0147	34V0148
332	Head Sheave - Incl. Key 64,195,332	33V0912	38V0912	32V0912	34V0913
335	Open Steam Chest Head Bracket	33V0130	38V0130	32V0129	34V0130
335	Open Steam Chest Head Bracket - Incl. Key 24,25,27	33V0902	38V0902	32V0902	34V0902
350	Cable Columns with End Fittings	33V0911	38V0911	32V0911	34V0912
350	Cable Columns Complete - Incl. Key 58,59,84	33V0906	38V0906	32V0906	34V0906
351	Ram Complete - Incl. Key 36,40,62,69	33V0905	38V0905	32V0905	34V0905
354	Piston and Rod Complete - Incl. Key 54,55,56,57,58	33V0904	38V0904	32V0904	34V0904
355	Cylinder - Cable Tie	33V0100	38V0100	32V0100	34V0101
355	Cylinder Only - Incl. Key 17,18,84	33V0901	38V0901	32V0901	34V0901
355	Cylinder Complete - Incl. Key 1-7,10-16	33V0900	38V0900	32V0900	34V0900
356	Base Complete - Incl. Key 51,52,54	33V0908	38V0908	32V0908	34V0909
361	Wedge Retaining Plug	33V0206		32V0206	
362	Split Washer	33V0158	38V0158	32V0153	34V0155
368	Cable Nut Washer	33V0504	38V0504	32V0504	34V0504
370	Cylinder Stub Channel	33V0506	38V0506	32V0506	34V0506
371	Base Stub Channel	33V0507	38V0507	32V0507	34V0507
374	Stub Channels Complete - Incl. Key 117,370,371	33V0913	38V0913	32V0913	34V0914
375	Gripper Retaining Wedge	33V0205		32V0205	

10.4 Vari-Cycle

10.4.1 Exploded View



10.4.2 Sizes 306, 08, 010, 012

Key	Description	306	08	010	012
17	Fixed Trip	66V0701	54V0701	55V0701	62V0701
18	Movable Trip	66V0700	54V0700	55V0700	62V0700
20	Open Steam Chest Head Bracket	66V0723	54V0723	55V0723	62V0723
20	Open Steam Chest Head Bracket Complete	66V0915	54V0925	55V0925	62V0917
21	Open Steam Chest Head Bracket Inboard Bushing	66V0724	54V0724	55V0724	62V0724
22	Open Steam Chest Head Bracket Outboard Bushing	66V0725	54V0725	55V0725	62V0725
23	Open Steam Chest Head Bracket Bolt	66V0726	54V0726	55V0726	62V0726
23	Open Steam Chest Head Bracket Bolt Washer	66V0727	54V0727	55V0727	62V0727
28	Valve Stem - Trip Shifting	66V0735	54V0731	55V0731	62V0731
29	Valve Spring				
30	Valve Spring Rivet				
48	Slide Bar - Nylon Complete		54V0927	55V0927	62V0918
110	Cylinder - Trip Shifting	66V0702	54V0702	55V0702	62V0702
111	Cylinder Head - Trip Shifter	66V0708	54V0708	55V0708	62V0708
112	Cylinder Head Gasket - Trip Shifter	66V0709	54V0709	55V0709	62V0709
113	Cylinder Head Cap Screw	66V0710	54V0710	55V0710	62V0710
113	Cylinder Head Cap Screw Washer	66V0711	54V0711	55V0711	62V0711
114	Cylinder Head Pipe Plug	66V0712	54V0712	55V0712	62V0712
115	Cylinder Bolt	66V0703	54V0703	55V0703	62V0703
115	Cylinder Bolt Washer	66V0704	54V0704	55V0704	62V0704
116	Cylinder Pipe Plug	66V0707	54V0707	55V0707	62V0707
117	Cylinder Sleeve - Trip Shifter	66V0720	54V0720	55V0720	62V0720
118	Compression Spring	66V0721	54V0721	55V0721	62V0721
119	Compression Spring Seat	66V0722	54V0722	55V0722	62V0722
120	Piston - Trip Shifting	66V0713	54V0713	55V0713	62V0713
121	Piston Rings	66V0714	54V0714	55V0714	62V0714
122	Piston Seal O-Ring	66V0715	54V0715	55V0715	62V0715
123	Piston Collar	66V0716	54V0716	55V0716	62V0716
124	Piston Washer	66V0717	54V0717	55V0717	62V0717
125	Piston Nut	66V0718	54V0718	55V0718	62V0718
126	Cotter Key for Piston Nut	66V0719	54V0719	55V0719	62V0719
110	Vari-Cycle Cylinder Complete	66V0916	54V0924	55V0924	62V0915

10.4.3 Sizes 505, 506, 508, 510, 512

Key	Description	505	506	508	510	512
17	Fixed Trip	45V0701	46V0701	48V0701	49V0701	12V0701
18	Movable Trip	45V0700	46V0700	48V0700	49V0700	12V0700
20	Open Steam Chest Head Bracket	45V0723	46V0723	48V0118	49V0118	12V0118
20	Open Steam Chest Head Bracket Complete	45V0915	46V0915	48V0902	49V0902	12V0902
21	Open Steam Chest Head Bracket Inboard Bushing	45V0724	46V0724	48V0119	49V0119	12V0119
22	Open Steam Chest Head Bracket Outboard Bushing	45V0725	46V0725	48V0122	49V0122	12V0122
23	Open Steam Chest Head Bracket Bolt	45V0726	46V0726	48V0133	49V0133	12V0133
23	Open Steam Chest Head Bracket Bolt Washer	45V0727	46V0727	48V0134	49V0134	12V0134
28	Valve Stem - Trip Shifting	45V0735	46V0125	48V0127	49V0127	12V0127
28	Valve Stem Complete					
28	Valve Stem Complete					
29	Valve Spring					
30	Valve Spring Rivet					
48	Slide Bar - Nylon Complete	45V0918	46V0918	48V0916	49V0916	12V0916
110	Cylinder - Trip Shifting	45V0702	46V0702	48V0702	49V0702	12V0702
110	Vari-Cycle Cylinder Complete	45V0916	46V0916	48V0914	49V0914	12V0914
111	Cylinder Head - Trip Shifter	45V0708	46V0708	48V0708	49V0708	12V0708
112	Cylinder Head Gasket - Trip Shifter	45V0709	46V0709	48V0709	49V0709	12V0709
113	Cylinder Head Cap Screw	45V0710	46V0710	48V0710	49V0710	12V0710
113	Cylinder Head Cap Screw Washer	45V0711	46V0711	48V0711	49V0711	12V0711
114	Cylinder Head Pipe Plug	45V0712	46V0712	48V0712	49V0712	12V0712
115	Cylinder Bolt	45V0703	46V0703	48V0703	49V0703	12V0703
115	Cylinder Bolt Washer	45V0704	46V0704	48V0704	49V0704	12V0704
116	Cylinder Pipe Plug	45V0707	46V0707	48V0707	49V0707	12V0707
117	Cylinder Sleeve - Trip Shifter	45V0720	46V0720	48V0720	49V0720	12V0720
118	Compression Spring	45V0721	46V0721	48V0721	49V0721	12V0721
119	Compression Spring Seat	45V0722	46V0722	48V0722	49V0722	12V0722
120	Piston - Trip Shifting	45V0713	46V0713	48V0713	49V0713	12V0713
121	Piston Rings	45V0714	46V0714	48V0714	49V0714	12V0714
122	Piston Seal O-Ring	45V0715	46V0715	48V0715	49V0715	12V0715
123	Piston Collar	45V0716	46V0716	48V0716	49V0716	12V0716
124	Piston Washer	45V0717	46V0717	48V0717	49V0717	12V0717
125	Piston Nut	45V0718	46V0718	48V0718	49V0718	12V0718
126	Cotter Key for Piston Nut	45V0719	46V0719	48V0719	49V0719	12V0719

10.4.4 Sizes 330, 530, 320, 520

Key	Description	330	530	320	520
17	Fixed Trip	33V0701	38V0701	32V0701	34V0701
18	Movable Trip	33V0700	38V0700	32V0700	34V0700
20	Open Steam Chest Head Bracket	33V0130	38V0130	32V0129	34V0130
20	Open Steam Chest Head Bracket Complete	33V0902	38V0902	32V0902	34V0902
21	Open Steam Chest Head Bracket Inboard Bushing	33V0125	38V0125	32V0124	34V0125
22	Open Steam Chest Head Bracket Outboard Bushing	33V0126	38V0126	32V0125	34V0126
23	Open Steam Chest Head Bracket Bolt	33V0127	38V0127	32V0126	34V0127
23	Open Steam Chest Head Bracket Bolt Washer	33V0128	38V0128	32V0127	34V0128
28	Valve Stem - Trip Shifting	33V0137	38V0137	32V0136	34V0137
28	Valve Stem Complete	33V0909	38V0909	32V0909	34V0910
29	Valve Spring	33V0135	38V0135	32V0134	34V0135
30	Valve Spring Rivet	33V0136	38V0136	32V0135	34V0136
48	Slide Bar - Nylon Complete	33V0917	38V0917	32V0917	34V0918
110	Cylinder - Trip Shifting	33V0702	38V0702	32V0702	34V0702
110	Vari-Cycle Cylinder Complete	33V0915	38V0915	32V0915	34V0916
111	Cylinder Head - Trip Shifter	33V0708	38V0708	32V0708	34V0708
112	Cylinder Head Gasket - Trip Shifter	33V0709	38V0709	32V0709	34V0709
113	Cylinder Head Cap Screw	33V0710	38V0710	32V0710	34V0710
113	Cylinder Head Cap Screw Washer	33V0711	38V0711	32V0711	34V0711
114	Cylinder Head Pipe Plug	33V0712	38V0712	32V0712	34V0712
115	Cylinder Bolt	33V0703	38V0703	32V0703	34V0703
115	Cylinder Bolt Washer	33V0704	38V0704	32V0704	34V0704
116	Cylinder Pipe Plug	33V0707	38V0707	32V0707	34V0707
117	Cylinder Sleeve - Trip Shifter	33V0720	38V0720	32V0720	34V0720
118	Compression Spring	33V0721	38V0721	32V0721	34V0721
119	Compression Spring Seat	33V0722	38V0722	32V0722	34V0722
120	Piston - Trip Shifting	33V0713	38V0713	32V0713	34V0713
121	Piston Rings	33V0714	38V0714	32V0714	34V0714
122	Piston Seal O-Ring	33V0715	38V0715	32V0715	34V0715
123	Piston Collar	33V0716	38V0716	32V0716	34V0716
124	Piston Washer	33V0717	38V0717	32V0717	34V0717
125	Piston Nut	33V0718	38V0718	32V0718	34V0718
126	Cotter Key for Piston Nut	33V0719	38V0719	32V0719	34V0719