TM 5-3810-289-34 CRANE-SHOVEL, CRAWLER MOUNTED; 12 ½ TON-1970

DEPARTMENT OF THE ARMY TECHNICAL MANUAL

Direct Support And General Support Maintenance Manual CRANE-SHOVEL CRAWLER MOUNTED; 12 ½ -TON, ¾ -CU YD; DIESEL ENGINE DRIVEN (BUCYRUS-ERIE MODEL 22BM) FSN 3810-869-3092

HEADQUARTERS, DEPARTMENT OF THE ARMY
JUNE 1970

WARNING

EXPLOSION AND FIRE HAZARD

Is present when servicing batteries and filling fuel tank.

DEATH

Or severe injury may result if personnel fail to observe safety precautions. Do not smoke or use open flame around flammable material or when servicing the batteries. Do not fill the fuel tank while the engine is running. Be sure there are no open flames or exposed heated parts that can ignite fuel vapors while tank is being filled. Keep fuel container and funnel in contact while tank is being filled, or provide a ground to prevent static sparks from igniting the fuel. Do not attempt to weld a fuel tank unless the tank has been filled with water and thoroughly, flushed to eliminate combustible fuel vapors.

HIGH VOLTAGE HAZARD

Is present if the boom accidentally contacts a power line.

DEATH

Or severe injury may result if personnel fail to observe safety precautions. Keep the boom away from power lines. If the boom accidentally contacts a power line, jump from the machine; do not step off.

Changes in force: C 1 and C 3

CHANGE
No. 3

HEADQUARTERS
DEPARTMENT OF THE ARMY
Washington D.C., *24 June 1991*

Direct Support and General Support Maintenance Manual
CRANE-SHOVEL, CRAWLER MOUNTED, 12 1/2-TON, 3/4 CU YD;
DIESEL ENGINE DRIVEN (BUCYRUS-ERIE MODEL 22BM)
NSN 3810-00-869-3092

TM 5-3810-289-34, 12 June 1970, is changed follows:

Cover and page i. The manual title is changed to read as shown above.

Page ii, List of Illustrations. Add Number "2-0, Measuring gradual bends in bent lacing, page 2-4"

Page iii, List of Illustrations.

Add the following entries:

Number 3-104.1, Air intake manifold replacement, page 3-36.

Number 3-104.2, Throttle control assembly, page 3-36.

Delete the following entries:

Number 3-105.

Number 3-109.

Page vi, List of Illustrations.

Figure numbers and titles for Figures 4-6 are superseded as follows:

Number 4-6A, Lower track and frame assembly, page 4-6.

Number 4-6B, Vertical propel shaft, center propelling shaft and outer clutch shaft, page 4-7.

Number 4-6C, Steering clutch linkage an lock linkage, page 4-8.

Figure numbers and titles for Figures 4-11 are superseded as follows:

Number 4-11lA, Front drum shaft assembly, lens boom hoist clutch, page 4-13.

Number 4-1lB, Rear drum shaft assembly, page 4-14.

Number 4-11C, Swing and propel clutch, hoist clutch crowd and retract clutch, page 4-15.-

The title of Figure 4-20 is changed as follows:

Number 4-20, Independent boom hoist assembly and boom hoist clutch, exploded view, page 4-24.

Page 1-1.

Paragraph 1-2. Change"TM38-750" to "DA Pam 738-750".

Paragraph 1-3 is superseded as follows:

1-3. Reporting Errors and Recommending Improvements

You can help improve this manual. If you find any mistakes or if you know of a way to improve the procedures, please let us know. Mail your letter or DA Form 2028 (Recommended Changes to Publications and Blank Forms) direct to: Commander, U.S. Army Tank-Automotive Command, ATTN: AMSTA-MB, Warren, MI 48397-5000. A reply will be furnished to you.

Paragraph 1-3.1 is added after paragraph 1-3.

1-3.1. Reporting Equipment Improvement Recommendations (EIRs)

If your crane-shovel needs improvement, let us know. Send us an EIR. You, the user, are the only one who can tell us what you don't like about your equipment. Let us know why you don't like the design or performance. Put it on an SF 368 (Quality Deficiency Report). Mail it to us at: Commander, U.S. Army Tank-Automotive Command, ATTN: AMSTA-MP, Warren, MI 48397-5000. We'll send you a reply.

This change supersedes C2, 12 November 1971.

Page 2-1, paragraph 2-3. Change "TM. 5-3810-289-35P" to "TM 5-3810-289-34P".

Page 2-4. Paragraph 2-8.1 is added after graph 2-8.

2-8.1. Boom Repair

Repairs authorized at direct support level are cold straightening of gradual bends and replacing bolts sheaves, and bearings. A "gradual bend" is determined by laying a straightedge across the bend (figure 2-0). Measure the length of the straightedge between both points of contact and measure the maximum gap between the angle iron (lacing) and the straightedge. Multiply the distance between contact and measure the maximum gap between the angle iron (lacing) and the straighthedge. Multiply the distance between contact points by 0.025. If the product is equal to or less than the maximum gap, the bend is considered "gradual" and may be cold straightened. If the product exceeds the maximum gap, the lacing should be replaced. However, replacement of lacing is authorized at depot level only and will not be attempted by a lower maintenance level. Repair to chord angles are not authorized below depot level. During boom inspection, if it is determined that more than one-third of the lacing is damaged on any one side, per boom section, it will render the boom not mission capable (deadlined) and will not be used until the deficiency is corrected.

A = DISTANCE BETWEEN STRAIGHTEDGE CONTACT POINTS
B = MAXIMUM DISTANCE BETWEEN STRAIGHTEDGE AND BENT LACING
C = A x 0.025
IF C IS EQUAL TO OR LESS THAN B, THE BEND MAY BE COLD STRAIGHTENED.
IF C IS GREATER THAN B, THE LACING SHOULD BE REPLACED BY DEPOT LEVEL MAINTENANCE.

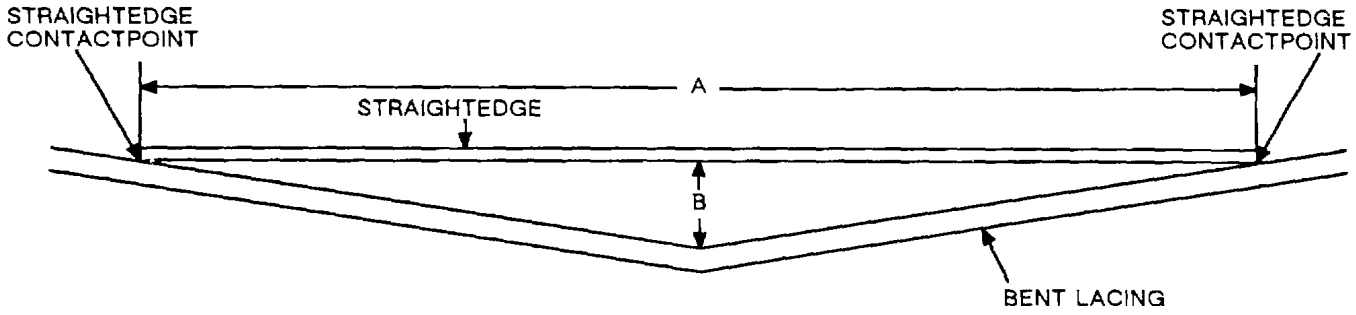


Figure 2-0. Measuring gradual bends in bent lacing.

Page 3-36.

Paragraph 3-19a is superseded as follows:

a. General. Refer to TM 5-3810-289-12 for wiring diagrams.

Paragraphs 3-19.1 and 3-19.2 are added after paragraph 3-19.

3-19.1. Air Intake Manifold Replacement.

Refer to Figure 3-104.1 and replace the air intake manifold.

3-19.2. Throttle Control Assembly Replacement.

Refer to Figure 3-104.2 on page 4 and replace the throttle control assembly.

Paragraph 3-21b is superseded as follows:

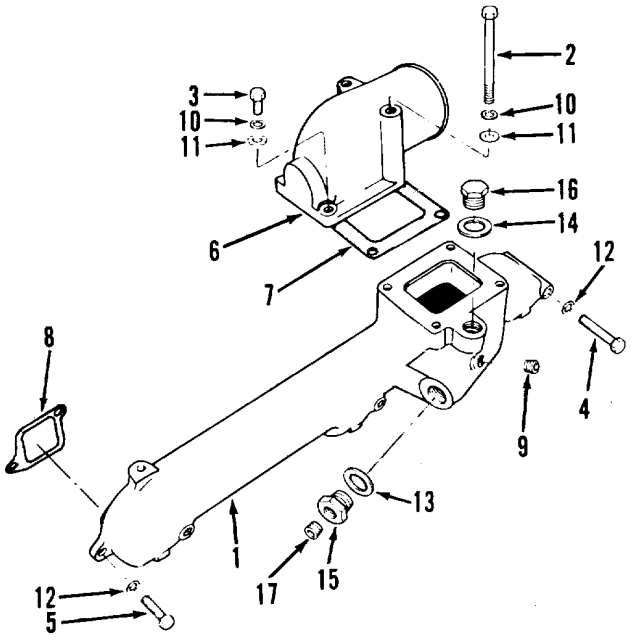
b. Removal. Refer to TM 5-3810-289-12.

Page 3-38.

Paragraph 3-21e is superseded as follows:

e. Installation. Refer to TM 5-3810-289-12.

Figure 3-109 is rescinded.



2. Capscrew (long) (2)
3. Capscrew (short) (2)
4. Capscrew, manifold (3)
5. Capscrew, manifold (2)
6. Connection, air intake
7. Gasket, connection
8. Gasket, manifold (3)
9. Plug, pipe (1/8" hex-head) (2)
10. Lockwasher (7)
11. Washer, plain (6)
12. Washer, copper (6)
13. Gasket
14. Gasket
15. Plug
16. Plug
17. Pipe plug

Figure 3-104.1. Air intake manifold replacement.

Page 4-1.

Paragraph 4-2b(1) is superseded as follows:

(1) Drain oil out of both transmission chain case and gear case. Remove chain case cover and seal (20 and 79, fig. 4-1).

Paragraph 4-2b(4) is superseded as follows:

(4) Remove hoist clutch yoke fulcrum pin from right bearing cover (3) on right side of gear case.

Paragraph 4-2b (5) (a). Add "after removing access plate from machinery deck." to the end of the sentence.

Paragraph 4-2b(5.1) is added after paragraph 4-2b(5)(c).

(5.1) Remove oil gear shaft (56). Catch oil gear (12) under gear case before it drops free.

Paragraph 4-2d(2). Change the first sentence to read Aline splines and press sprocket on shaft.".

Paragraph 4-2d(3) is superseded as follows:

(3) Install retainer plate on end of shaft, fasten securely with two capscrews, and lock with wire.

Paragraph 4-2d(11). Add "Replace" machinery deck access plate." to the end of the paragraph.

Paragraph 4-2d(14) is superseded as follows: (14) Install chain case. Install gasket seal and chain case cover.

Page 4-2. Figure 4-1 is superseded as shown on page 5.

Page 4-3.

Add "79 seal" at the end of the legend f6r, figure 4-1.

Figure 4-2 is superseded as follows:

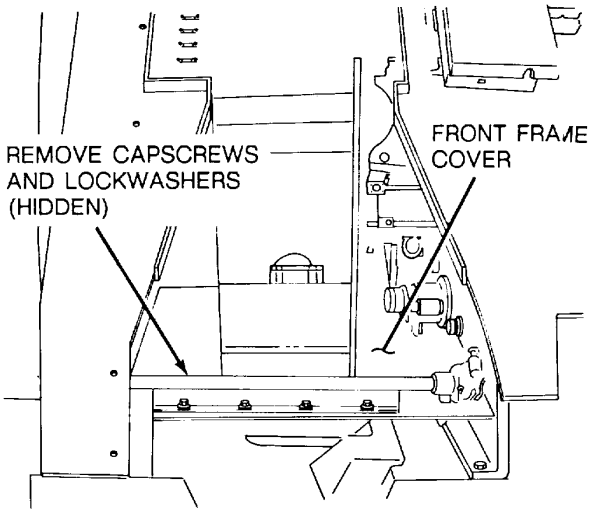
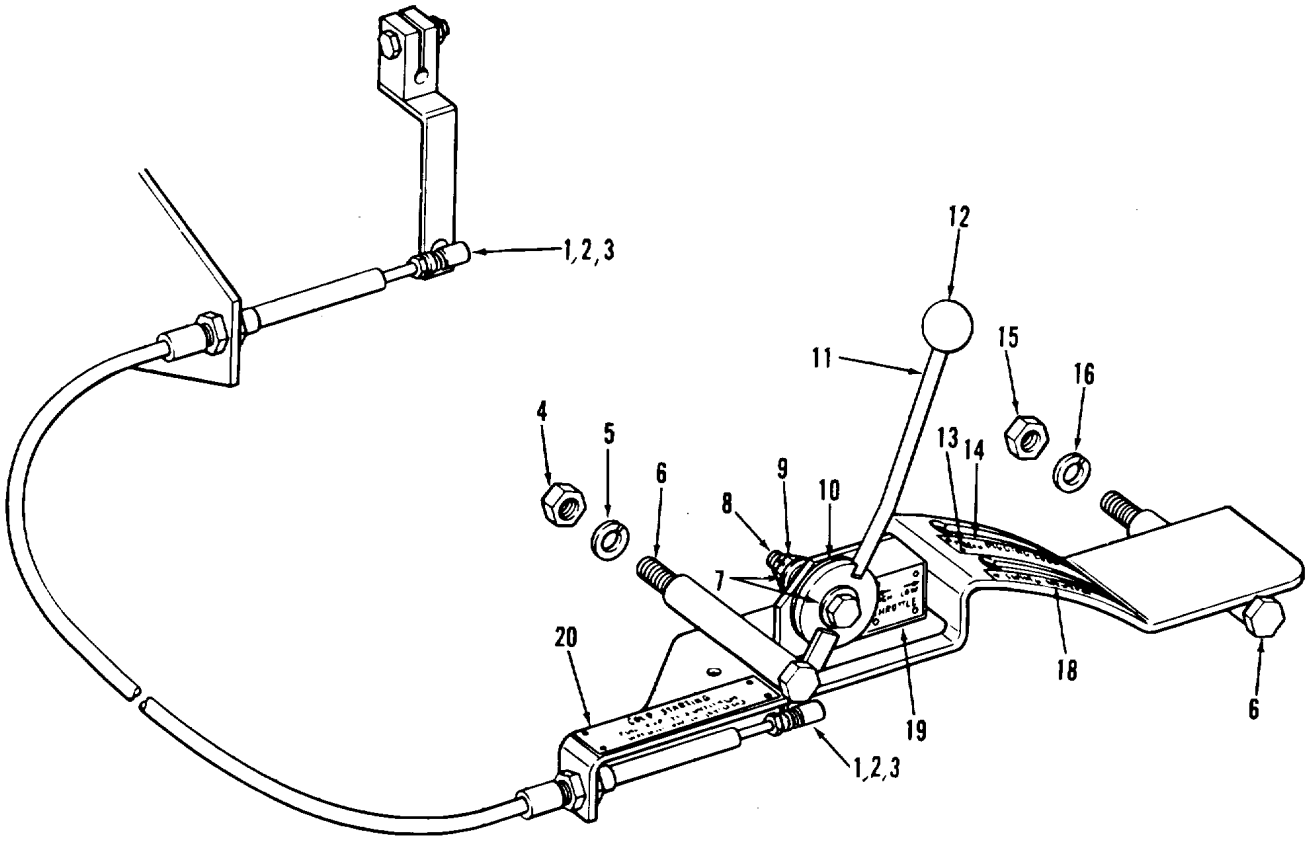


Figure 4-2. Front frame cover.



1. Ball joint
2. Nut, hexagon
3. Lockwasher
4. Nut, hexagon
5. Lockwasher
6. Bolt, hexagon
7. Washer, plain
8. Locknut
9. Spring
10. Disk
11. Arm
12. Knob
13. Screw, drive
14. Instruction plate
15. Nut, hexagon
16. Lockwasher
17. NOT USED
18. Instruction plate
19. Instruction plate
20. Instruction plate

Figure 3-104.2. Throttle control assembly.

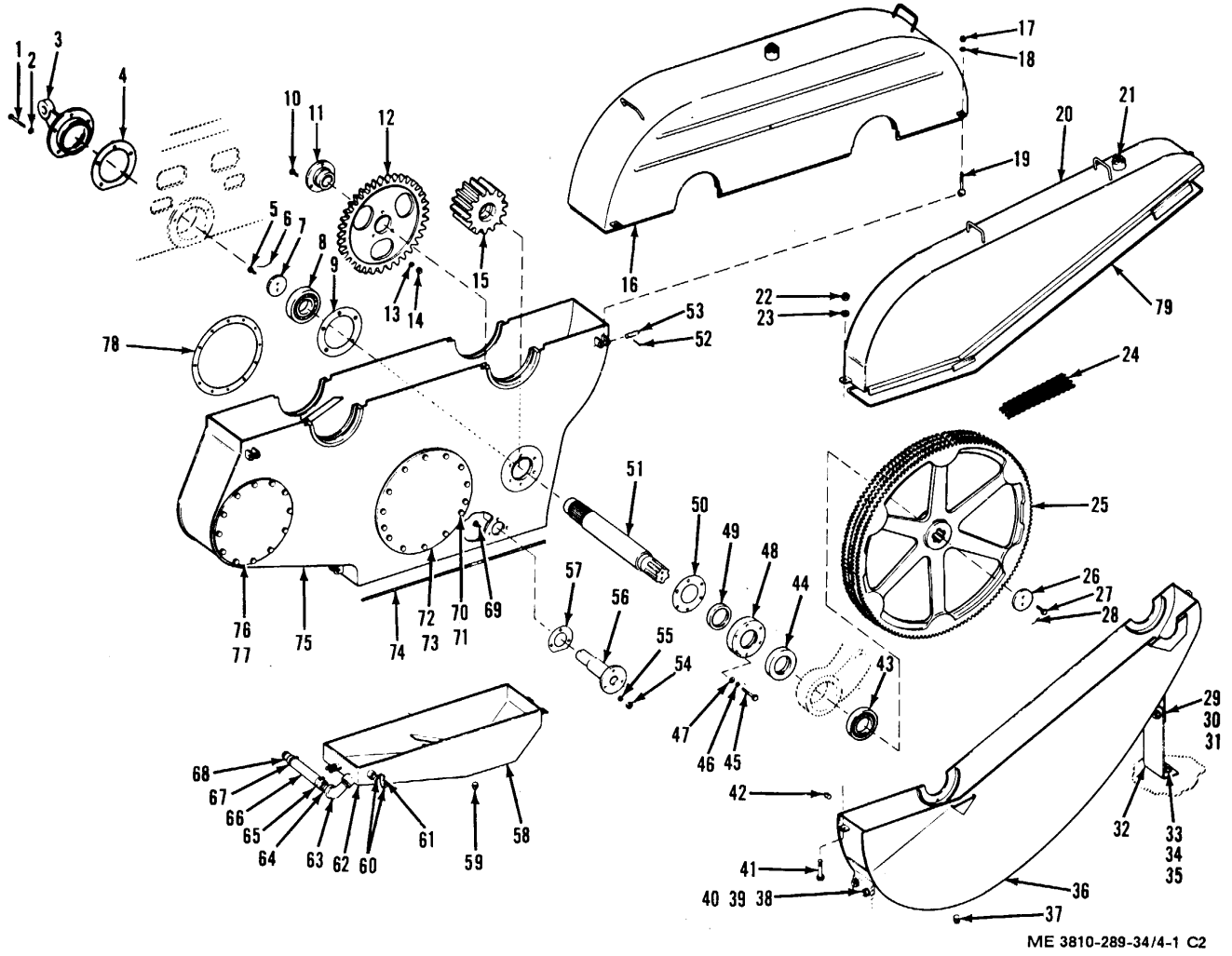


Figure 4-1. Transmission shaft, exploded view.

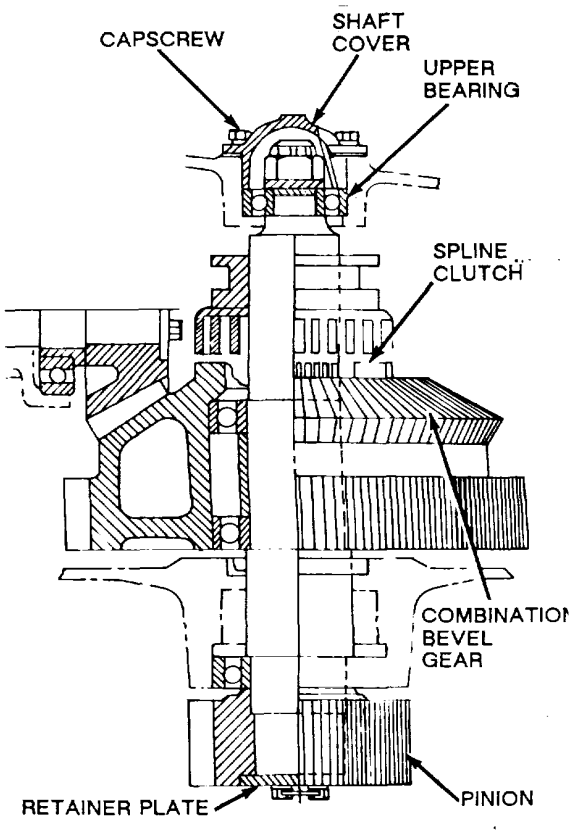


Figure 4-4. Vertical swing shaft.

Figure 4-5 is superseded as shown on the following page.

Page 4-5.

Paragraph 4-3b(2). Add "(6, figure 4-5)" to the end of the sentence.

Paragraph 4-3b(3) is superseded as follows:

(3) Remove locknut and nut from mounting studs. Insert force bolts in tapped holes provided in retainer and remove shaft (11), retainer (9) and shim pack (12).

Paragraph 4-3e is superseded as follows:

e. Assembly and Installation.

(1) Remove retainer from shaft.

(2) Insert roll pin (10) in cone nut (1).

(3) With roll pin, cone nut and O-ring (2) place, put roller on roller path in position to insert shaft (11). Insert shaft, and align roll pin with hole in end of shaft.

(4) Insert adjusting rod (6) and tighten until end play is removed but cone roller turns freely on shaft.

Caution: Do not overtighten or O-ring will be damaged.

(5) Install shim pack retainer capscrews and mounting stud nuts. Check for 0.025 to 0.030 inch tolerance between roller and roller path. Remove or add shims as required.

Page 4-6, Figure 4-6 (sheet 1 of 3). Figure number and title are superseded as follows:

Figure 4-6A. Lower frame and track assembly.

Page 4-7, Figure 4-6 (sheet 2 of 3) Figure number and title are superseded as follows:

Figure 4-6B. Vertical propel shaft, center propelling shaft and outer clutch shaft.

Page 4-8, Figure 4-6 (sheet 3 of 3). Figure number and title are superseded as follows:

Figure 4-6C. Steering clutch linkage and digging lock
linkage.

Page 4-9.

Paragraph 4-6. Change the word "JAW" to "SPLINE" throughout this paragraph.

Paragraph 4-6a(11). In the Note following paragraph 4-6a(11), change the last line to read "paragraph 10.".

Paragraph 4-6b. Change sentence 4 to read "Rebuild broken or worn clutch splines by welding and grinding.".

Page 4-11.

Paragraph 4-8. Change "secondary hoist" to read "retract" throughout this paragraph.

Paragraph 4-8a(7). Change the first sentence to read "The retract clutch on the right side of rear shaft is also used to power control load lowering of front shaft crane hoist line.".

Paragraph 4-8b(5) is superseded as follows:

(5) Remove secondary hoist brake band.

Page 4-12, paragraph 4-8d(2). Add "Figure 4-11B" to the end of the sentence.

Page 4-13, Figure 4-11 (sheet 1 of 3). Figure number and title are superseded as follows:

Figure 4-11A. Front drum shaft assembly less boom hoist clutch.

Page 4-14, Figure 4-11 (sheet 2 of 3). Figure number and title are superseded as follows:

Figure 4-11B. Rear drum shaft assembly.

Page 4-15, Figure 4-11 (sheet 3 of 3). Figure number and title are superseded as follows:

Figure 4-11C. Swing and propel clutch, hoist clutch crowd and retract clutch.

Page 4-16.

Paragraph 4-8d(2)(h) is superseded as follows:

(h) Remove secondary hoist by driving from left; left drum bearing usually remains in place.

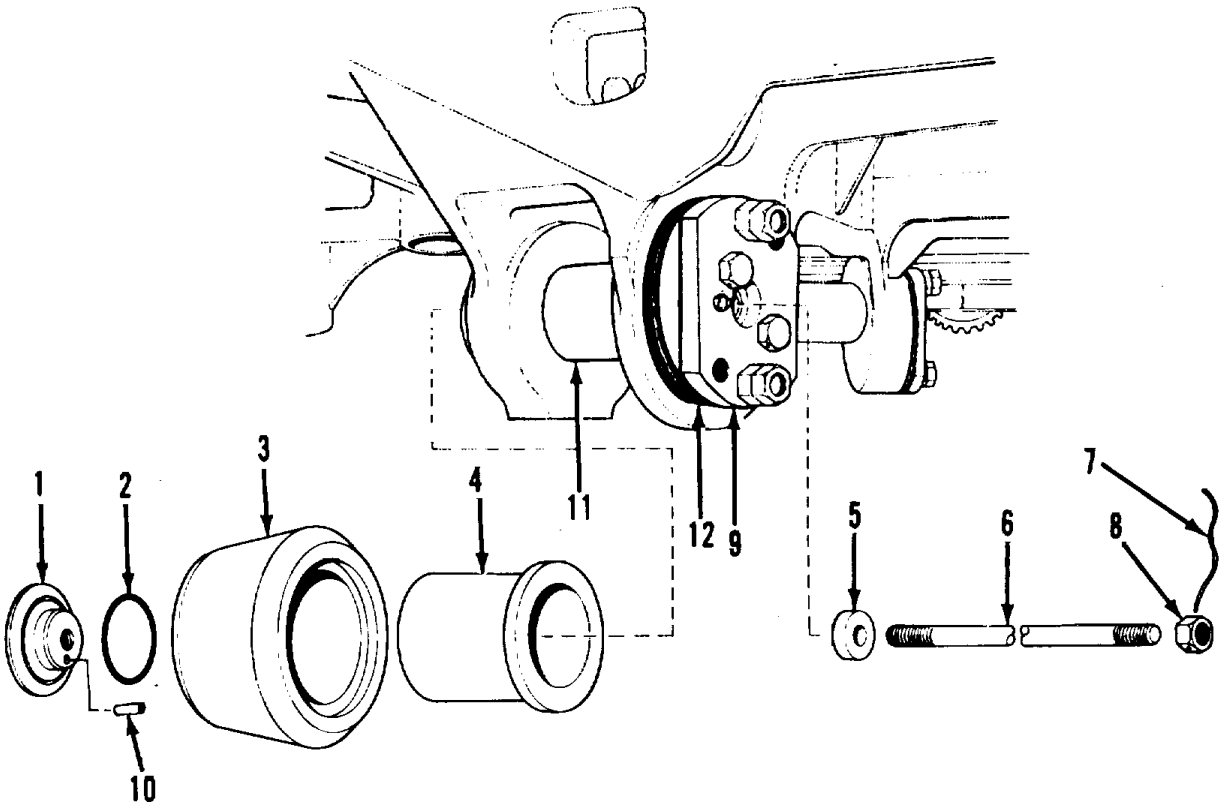


Figure 4-5. Cone roller replacement.

Paragraph 4-8d(2) (k). Change the first sentence to read "Slide off secondary hoist clutch assembly by loosening hub bolt and wedging hub open.".

Paragraph 4-8d(3)(a) is superseded as follows:

(a) Remove swing and propel clutch driver and entire clutch assembly from housing by loosening driver bolt and wedging split hub open. Remove driver key.

Paragraph 4-8f(2)(d) is superseded as follows:

(d) Replace swing gear on clutch drum housing using a 20 to 30 ton press (long hub away from housing).

Page 4-17.

Paragraph 4-8f(3)(b). Change the first sentence to read "Remove clutch driver from secondary hoist clutch assembly and slide on shaft.".

Paragraph 4-8f(3)(h) is superseded as follows:

(h) Tap on the inner bearing of the retract clutch housing and sprocket with shield side next to spacer.

Paragraph 4-8f(3)(m). The Note following para graph 4-8f(3)(m) is superseded as follows:

Note. In assembling parts all across the shaft from the secondary hoist drum clutch driver to retract clutch driver, seat each part solidly against the part ahead of it. When the retract friction clutch driver has been thus seated, back it off 1/32 inch before clamping in place on shaft to provide a free running fit for all parts across the right side of the shaft.

Paragraph 4-8g(1) is superseded as follows:

(1) Lower shaft into place, carefully matching bearing housing and their dowel pins.

Paragraph 4-8h(3) is superseded as follows:

(3) Reassemble retract clutch band.

Page 4-18.

Paragraph 4-10a(7). Add "This clutch is also used as the crowd clutch and the primary hoist clutch." To the end of the paragraph.

Paragraph 4-10b(6). Add "(fig. 4-16)" to the end of the sentence.

Paragraph 4-10b(8) is superseded as follows:

(8) Remove crowd brake band (fig. 4-15).

Page 4-19.

Paragraph 4-10c. Change "figure 4-11" to "figure 4-11A".

Paragraph 4-10c(4). Change "paragraph 4-12" to "paragraphs 4-10 and 4-12".

Paragraph 4-10c(6). Change "4-11" to "4-12".

Paragraph 4-10d(2). Change "fig. 4-11" to "fig. 4-11A".

Paragraph 4-10d(2) (d). In the Note following paragraph4-10d(2) (d), change "figure 4-11" to "figure 4-11C".

Paragraph 4-10d(2) (f). Change the first sentence read “Now pull the primary hoist or crowd friction clutch housing which is integral with the drum sleeve.".

Paragraph 4-10d(3)(a) is superseded as follows:

(a) Loosen swing and propel clutch drive bolt, wedge driver hub open, remove entire clutch assembly as a unit or disassemble in place as may be most convenient.

Page 4-20.

Paragraph 4-10f(2)(a) is superseded as follows:

(a) Refer to figure 4-12 and paragraph 4-8f/(2) and follow the assembly procedure for the left side of the shaft.

Paragraph 4-10f(2)(b). Change "figure 4-11” to "figure 4-11A".

Paragraph 4-10f(3) (g). Change the first sentence to read "Tap inner crowd (primary hoist) clutch housing bearing.".

Page 4-21.

Paragraph 4-10f(2) (n). In the Note following paragraph 4-10f(2)(n), change the second sentence to read "When the primary hoist crowd friction clutch driver has been thus seated, back it off 1/32 inch before clamping in place on shaft.".

Paragraph 4-10g(1). Change "shear" to "dowel”

Paragraph 4-11 is rescinded.

Paragraph 4-12a title is superseded as follows:

a. Lowering Pawl Removal (fig 4-18).

The title of figure 4-18 is superseded as follows:

Figure 4-18. Boom lowering speed control pawl.

Paragraph 4-13 is superseded as follows:

4-13. Boom Hoist Clutch

Refer to figure 4-11 and follow disassembly of the drum shaft as required to remove the boom hoist assembly. Disassemble the boom hoist clutch as shown on figure 4-20.

Page 4-22. Figure 4-19 is superseded as shown on the following page.

Page 4-24. The title of figure 4-20 is superseded as follows:

Figure 4-20. Independent boom hoist assembly and boom hoist clutch, exploded view.

Page 4-25, paragraph 4-14a. Change "figure 4-11” to "figure 4-11C".

Page 4-26.

Paragraph 4-15a(1). Change "figure 4-6" to "figure 4-6B".

Paragraph 4-15a(3). The last sentence is rescinded.

Paragraph 4-15b(4). Change "(6)" to "(75)".

Paragraph 4-15b(5) is superseded as follows:

(5) Remove swing-and-propel jaw clutch shifter yoke and lift spline clutch (67) off splines.

Paragraph 4-15b(6) is superseded as follows:

(6) Lift out spur gear (68).

Paragraph 4-15b(8), line 1. Add "(86)" after "bevel pinion split retainer".

Page 4-2 7.

Paragraph 4-15d(7) is superseded as follows:

(7) Install spline clutch and shifter.

Paragraph 4-16, title. Change "(fig. 4-6)" to "(fig. 4-6B)".

Paragraphs 4-16a(4) through (11) are superseded as follows:

(4) Remove propel chains.

(5) Remove sprocket (79) from outer clutch shafts (78).

(6) Remove both clutch shaft locking collars (100).

(7) Pull outer clutch shafts out, disengaging them from center propelling shaft. Be prepared to catch locking collars and outer half of jaw clutch which will fall free as shaft is removed.

(8) Remove two jam nuts (106) and two nuts (105) holding main bearing cap, and remove the cap.

Note. The main bearing bushing is split in half and held from turning by shims between truck frame and bearing cap. When removing cap keep shims in groups as removed so reassembly can be made with the same bearing fit, or, if necessary, adjusted for a snug free running fit.

(9) Remove lock ring (117) and slide left jaw clutch (110) from end of center propelling shaft. Remove shaft.

(10) Place jack beneath bevel gear (113) or attach suitable lifting device and remove lockring (117).

(11) Remove bevel gear from right jaw clutch splines (114). Remove jaw clutch from bushing (116) in truck frame.

Paragraph 4-16b is superseded as follows:

b. Inspection and Repair.

(1) Clean all parts thoroughly and examine for damage or excess wear. Inspect clutch bushing (116), which remains in truck frame, as well as jaw clutch bushings (115) and (103) which come out with the clutches.

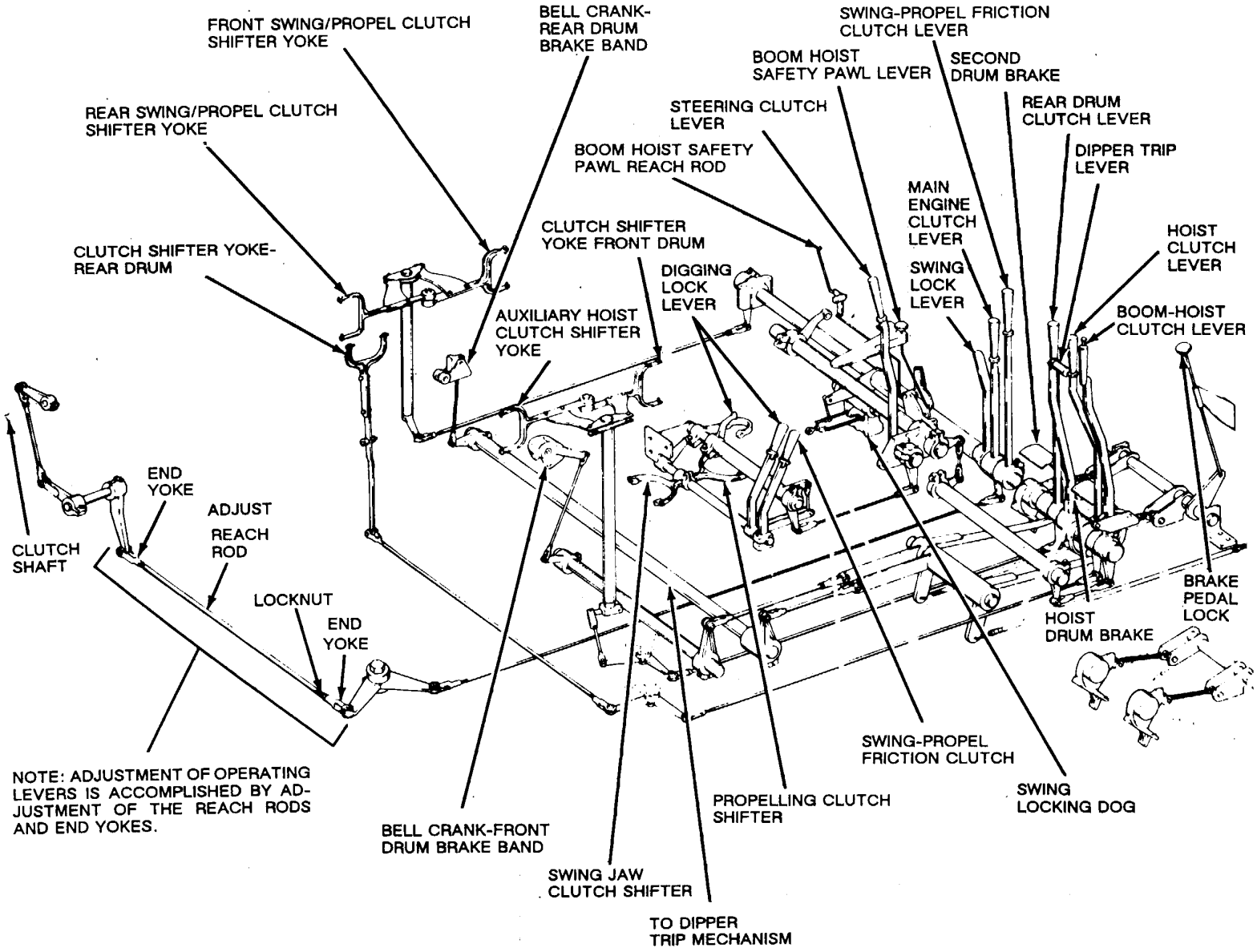


Figure 4-19. Control levers.

(2) Repair worn clutch teeth by welding and grinding. Damaged clutch and shaft splines may be dressed down with a file. Severe damage will require replacement of the port. If truck frame bushing requires replacement it can be driven or pressed out Jaw clutch bushings must be cut out with a pointed chisel. Press the new bushings into the truck frame and into the jaw clutches.

Paragraph 4-17, title. Change "(fig. 4-6)" to "(fig. 4-6B)"

Paragraph 4-17a(1) is superseded as follows:

(1) Drain and remove center gear case and steering clutch guards as a unit. The complete unit is attached by four bolts.

Paragraph 4-17a(8) is superseded as follows:

(8) Remove clutch shaft locking collar (100)

Paragraph 4-17c(2) is superseded as follows:

(2) Insert clutch shaft locking collar and caps crew (99).

Page 4-28.

Paragraph 4-17c(6) is superseded as follows:

(6) Attach steering clutch, guard and center gear case with four bolts.

Paragraph 4-18c. Change "figure 4-6" to "figure 4-6B".

Page A-I.

Paragraph A-1. Change "TB 5-4200-200-10" and its title to read "TB 5-4200-200-100, Hand Portable Fire Extinguishers Approved for Army Users".

Paragraph A-3.

Change "TM 38-750" and its title to read "DA Pam 738-750, The Army Maintenance Management System (TAMMS)".

Change "TM 5-3810-289-35P" to "TM 5-3810-289-34P".

Change "TM 9-6140-200-15" and its title to read "TM 9-6140-200-14, Operator's, Organizational, Direct Support and General Support Maintenance Manual for Lead-Acid Storage Batteries".

Paragraph A-4. Change "TM 11-483" and its title to read "FM 11-65, High Frequency Radio Communications".

Pages 1-1 through I-3, Index.

The following entries are added or superseded alphabetically:

By Order of the Secretary of the Army:

GORDON R. SULLIVAN
General, United States Army
Chief of Staff

Official:

PATRICIA P. NICKERSON
Brigadier General, United States Army
The Adjutant General

Distribution:

To be distributed in accordance with DA Form 12-25-E, Block 0528, Direct and General Support Maintenance Requirements for TM 5-3810-289-34.

* U S. GOVERNMENT PRINTING OFFICE. 1991 -5 4 3 - 0 2 5 1 4 0 1 3 0

Changes in Force: C 1 and C 2

TM 5-3810-289-34
C 2

CHANGE
No. 2

HEADQUARTERS
DEPARTMENT OF THE ARMY
WASHINGTON, D.C., *12 November 1971*

Direct and General Support Maintenance Manual

CRANE-SHOVEL, CRAWLER MOUNTED; 12-1/2 TON; 3/4 CU. YD;

DIESEL ENGINE DRIVEN (BUCYRUS-ERIE MODEL 22BM)

FSN 3810-869-3902

TM 5-3810-289-34, 12 June 1970 is change follows:

Page 4-1, paragraph 4-2*b*(1), line 2 is change follows:
Remove chain case cover and seal (20 and 79, 4-1).

Paragraph 4-2b(1), line 3 and 4. Delete the tire sentence.

Paragraph 4-2b(4), line 1. Delete "53" from sentence.

Paragraph 4-2b(4), line 2. After cover add “3”.

Paragraph 4-2b(5)(a), line 2, after "plates” add "after removing access plate from machinery deck."

After paragraph 4-2b (5) (*c*), add paragraph 5.1. (5-1) Remove oil gear shaft (56). Catch oil gear (12) under gear case before it drops free.

Paragraph 4-2d(2), line 1 is changed as follows:
Aline splines and press sprocket on shaft.

Paragraph 4-2d(3), is superseded as follows:
Install retainer plate on end of shaft, fasten securely with two capscrews and lock with wire.

Paragraph 4-2d(11), line 2. After "fulcrum pin", add "Replace machinery deck access plate".

Paragraph 4-2d(14). Sentence 2 is changed as follows:
Install gasket seal and chain case cover.

Page 4-2, figure 4-1 is superseded as follows:

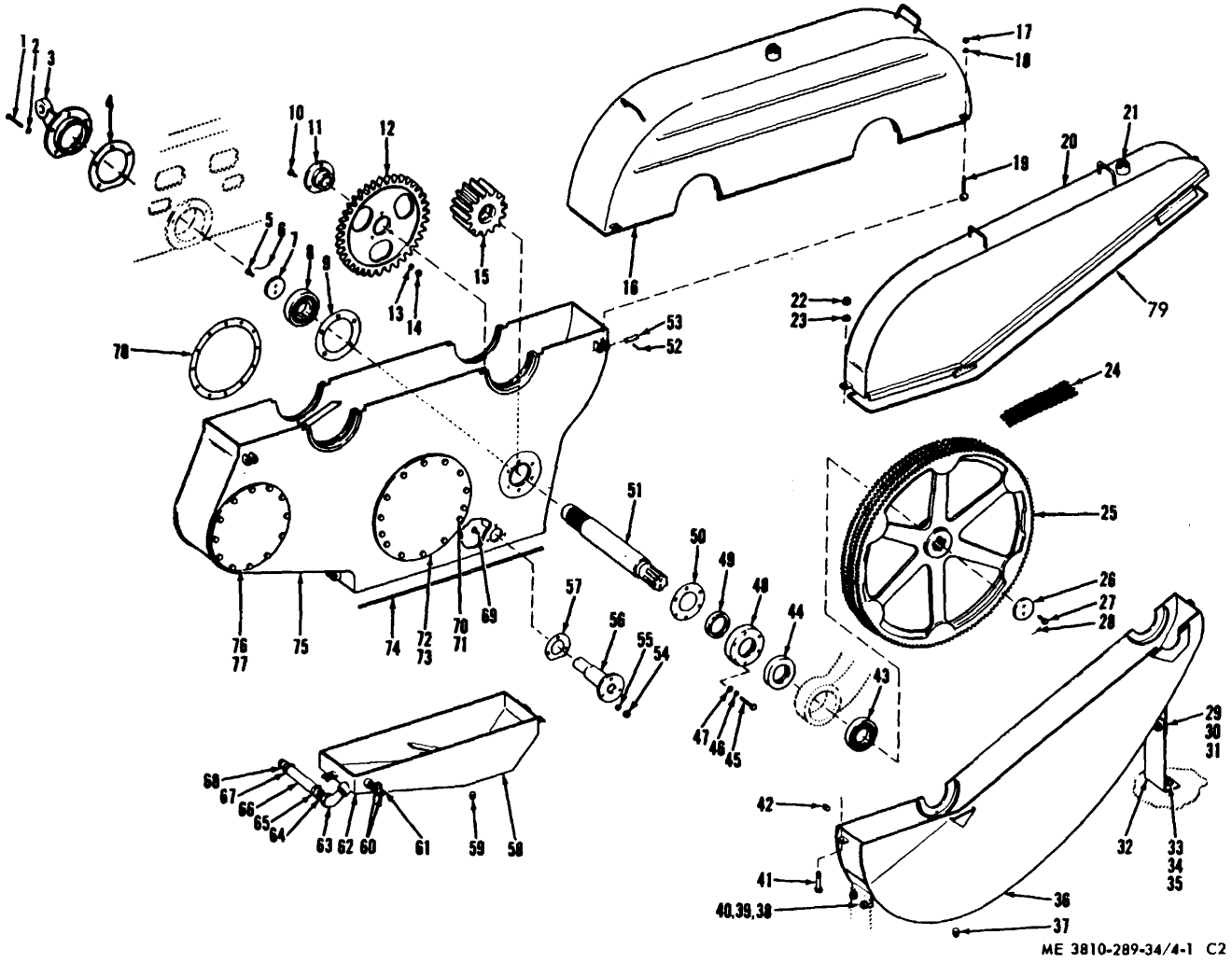


Figure 4-1. Transmission shaft, exploded view.

Page 4-3, legend for figure 4-1. Add at end of legend “79 seal”.

Page 4-3, figure 4-2 is superseded as follows:

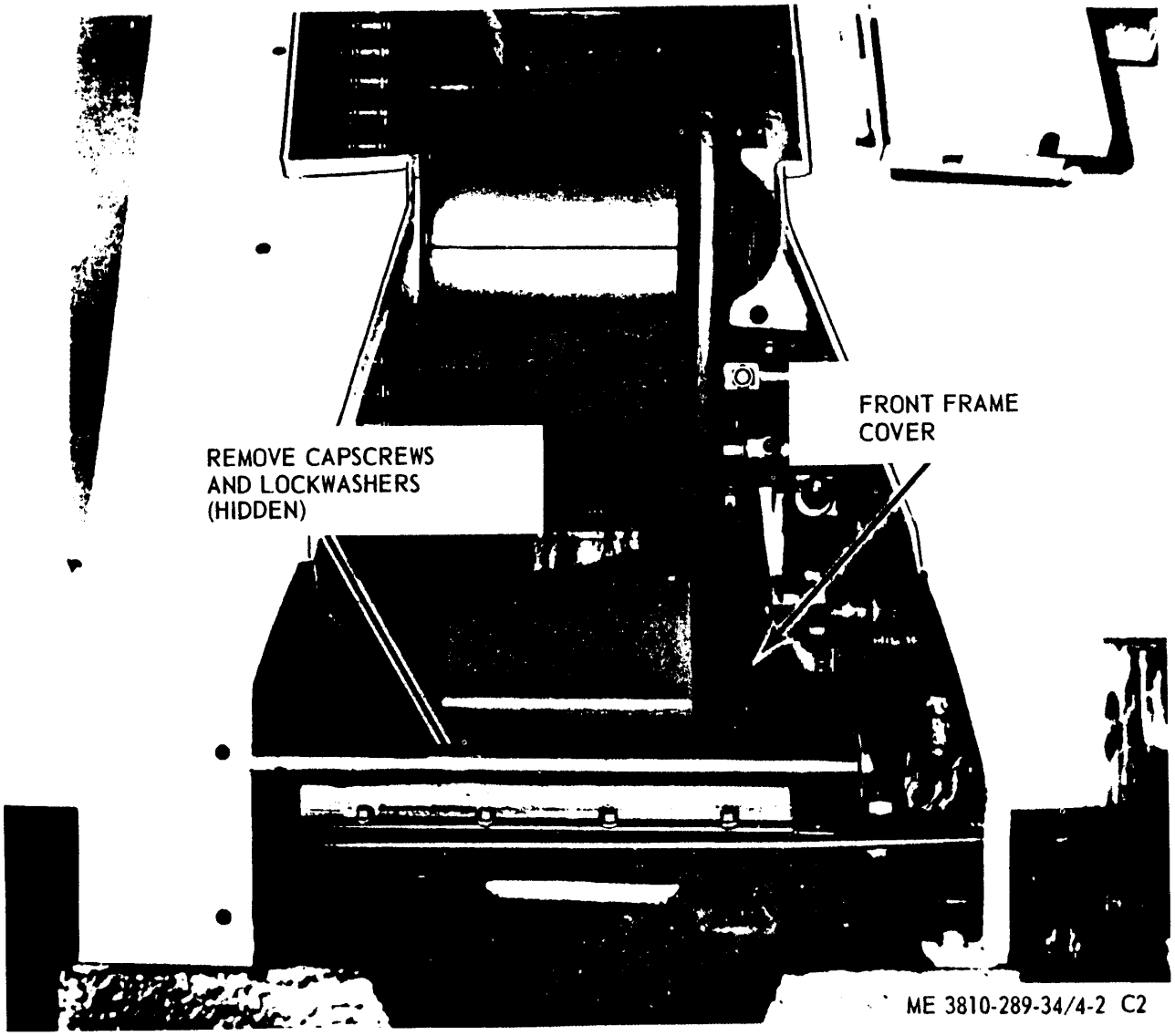


Figure 4-2. Front frame cover.

Page 4-4, figure 4-4 is superseded as follows:

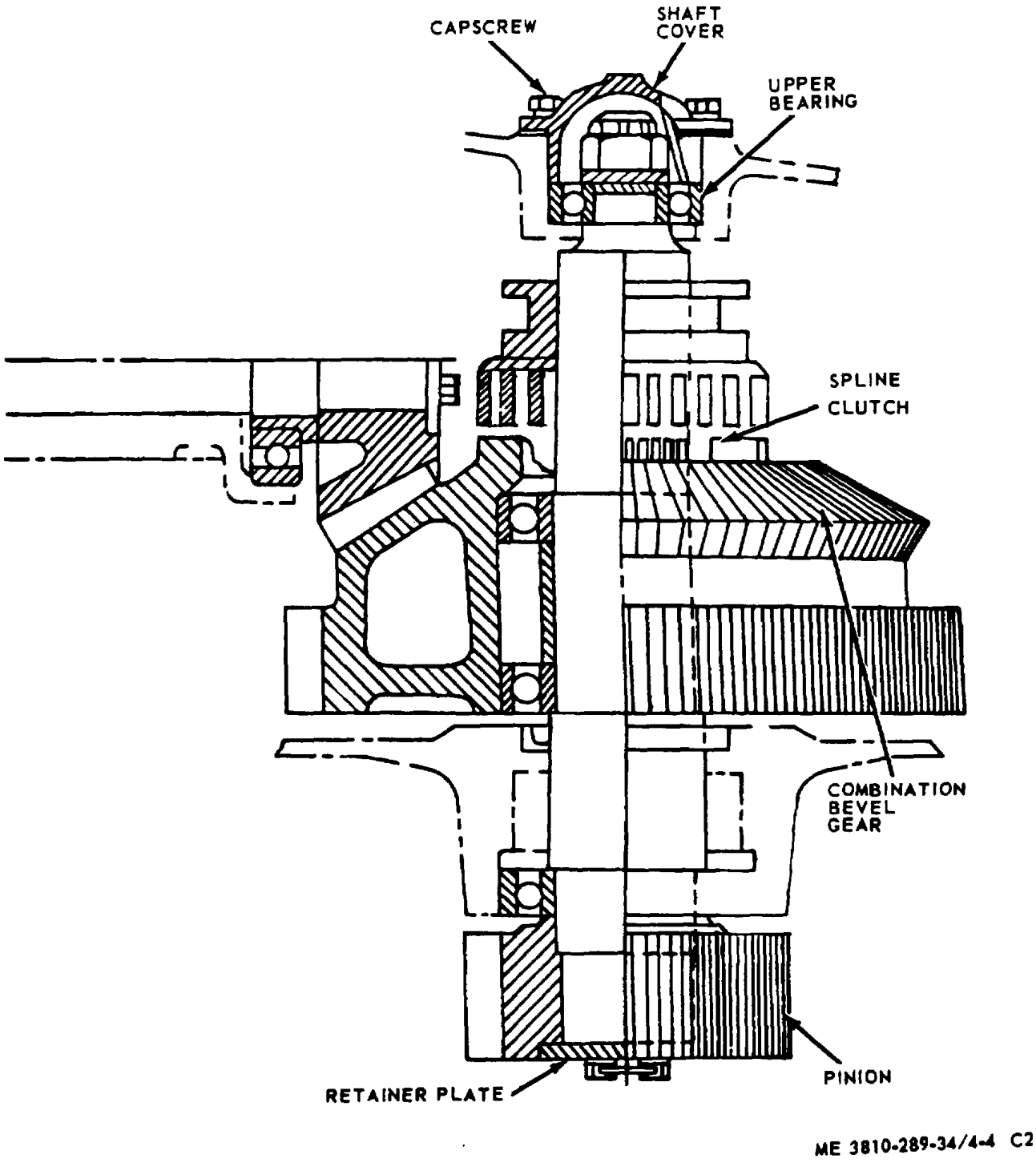


Figure 4-4. Vertical swing shaft.

Page 4-4, figure 4-5 is superseded as follows:

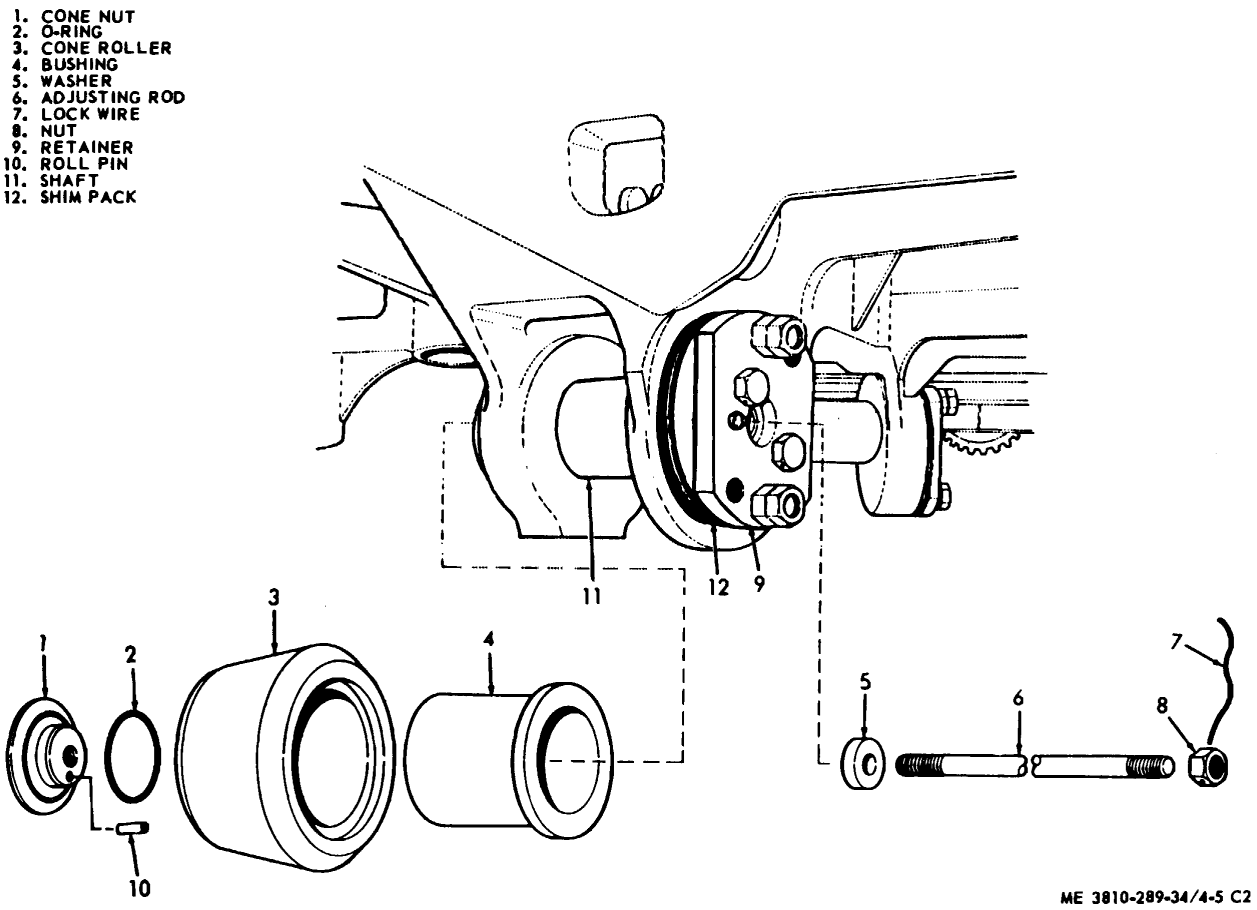


Figure 4-5. Cone roller replacement.

Page 4-5. paragraph 4-3b(2), line 1. Add at end sentence "(6, figure 4-5)".

Page 4-5, paragraph 4-3b (3), line 1 is superseded as follows:

(3) Remove lock nut and nut from mounting studs. Insert force bolts in tapped holes provide in retainer and remove shaft (11), retainer (9) shim pack (12).

Page 4-5. Paragraph 4-3e, is superseded as follows:

e. Assembly and Installation.

(1) Remove retainer from shaft.

(2) Insert roll pin (10) in cone nut (1).

(3) With roll pin, cone nut and O-ring (2) In place, put roller on roller path in position to insert shaft (11). Insert shaft, align roll pin with hole end of shaft.

(4) Insert adjusting rod (6) and tighten until end play is removed but cone roller turns freely shaft.

CAUTION

Do not overtighten or O-ring will be damaged.

(5) Install shim pack retainer capscrews mounting stud nuts. Check for 0.025 to 0.030 in tolerance between roller and roller path. Remove or add shims as required.

Page 4-6. Legend line to figure 4-6 is supersede as follows:

Figure 4-6A. Lower frame and track assembly.

Page 4-7. Legend line to figure 4-6 is superseded as follows:

Figure 4-6B. Vertical propel shaft center propelling shaft and outer clutch shaft.

Page 4-8. Legend line to figure 4-6, is superseded as follows:

Figure 4-6C. Steering clutch Linkage and digging lock linkage.

Page 4-9, paragraph 4-6. The word "JAW" is changed to read "SPLINE" wherever it appears in this paragraph.

Page 4-9, paragraph 4-6a(11), line 6. Last line note is changed to read "paragraph 10".

Page 4-9, paragraph 4-6b, line 4. Sentence 4 is changed to read as follows:

Rebuild broken or worn clutch splines by weld and grinding.

Page 4-11, paragraph 4-8, add "retract" in place of "secondary hoist" whenever it appears in this paragraph.

Page 4-11, paragraph 4-8a(7), line 1 is changed read:

The retract clutch on right side of rear shaft is also used to power control load lowering of front shaft crane hoist line.

Page 4-11, paragraph 4-8b(5), line 1 is changed to read:

(5) Remove secondary hoist brake band.

Page 4-12, paragraph 4-8d(2), line 1. After right, add the following "Figure 4-11B".

Page 4-13. Figure number and title is superseded as follows:

Figure 4-11A. Front drum shaft assembly less boom hoist clutch.

Page 4-14, Figure number and title is superseded as follows:

Figure 4-11B. Rear drum shaft assembly.

Page 4-15. Figure number and title is superseded as follows:

Figure 4-11C. Swing and propel clutch, hoist clutch crowd and retract clutch.

Page 4-16, paragraph 4-8d(2) (h), line 1. Sentence is superseded as follows:

(h) Remove secondary hoist by driving from left; left drum bearing usually remains in place.

Paragraph 4-8d(2)(k), line 1. Line one is changed to read:

(k) Slide off secondary hoist clutch assembly by loosening hub bolt and wedging hub open.

Paragraph 4-8d(3)(a), line 1 is superseded as follows:

(a) Remove swing and propel clutch driver and entire clutch assembly from housing by loosening driver bolt and wedging split hub open.

Paragraph 4-8f(2)(d) -is superseded as follows:

(d) Replace swing gear on clutch drum housing using a 20 to 30 ton press (long hub away from housing).

Page 4-17, paragraph 4-8f (3) (b). Line 1 is changed to read:

(b) Remove clutch driver from secondary hoist clutch assembly and slide on shaft.

Paragraph 4-8f(3) (h) is superseded as follows:

(h) Tap on the inner bearing of the retract clutch housing and sprocket with shield side next to spacer.

Paragraph 4-8f(3)(m). Note is superseded as follows:

NOTE

In assembling parts all across the shaft from the secondary hoist drum clutch driver to retract clutch driver seat each part solidly

against the part ahead of it. When the retract friction clutch driver has been thus seated, back it off 1/32 inch before clamping in place on shaft to provide a free running fit for all parts across the right side of shaft.

Paragraph 4-8g(1). In line 2 "Shear" is change read "dowel".

(1) Lower shaft into place, carefully matching bearing housing and their dowel pins.

Paragraph 4-8h(3), line 1 is superseded as follows:

(3) Reassemble retract clutch band.

Page 4-18, paragraph 4-10a(7), line 3. After word "bearings" add the following:

This clutch is also used as the crowd clutch and primary hoist clutch.

Paragraph 4-10b(6). At end of sentence, add figure 4-16.

Paragraph 4-10b(8) is superseded as follows:

(8) Remove crowd brake band (fig. 4-15).

Page 4-19, paragraph 4-10C. Figure reference is changed to read:

"See figure 4-11A".

Paragraph 4-10c(4). After "refer to", add the following:

"Paragraphs 4-10 and 4-12".

Paragraph 4-10c(6), line 1. "4-11" is change read "4-12".

Paragraph 4-10d(2), line 2. Change figure reference as follows:

Figure 4-11A.

Paragraph 4-10d(2)(d), *Note*. Second sentence changed to read as follows. Refer to figure 4-11*c* disassemble in numerical sequence.

Paragraph 4-d10(2)(f), line 1 is changed to read:

(f) Now pull the primary hoist or crowd friction clutch housing which is integral with the drum sleeve.

Paragraph 4-10d(3)(a). Line 1 is changed to read:

(a) Loosen swing and propel clutch drive bolt, wedge driver hub open, remove entire clutch assembly as a unit or disassemble in place as may be most convenient.

Page 4-20, paragraph 4-10*f* (2) (*a*). Sentence one is changed to read:

(a) Refer to figure 4-12 and paragraph 4-8*f*(2) and follow the assembly procedure for the left side of the shaft.

Page 4-20, paragraph 4-10*f*(2) (*b*). Line 2 "Figure 4-11" is changed to read "Figure 4-11A".

Paragraph 4-10f(3)(g). Line 1 is changed to read:

(g) Tap inner crowd (primary hoist) clutch housing bearing *** see figure 4-17.

Page 4-21, paragraph 4-10*f*(2) (*n*), *Note*. Line 2 is changed to read:

When the primary hoist crowd friction clutch driver has been thus seated, back it off 1/32 inch before clamping in place on shaft.

Page 4-21, paragraph 4-10*g*(1). Line 2 "Shear" is changed to read "dowel".

(1) Lower shaft into place, carefully matching bearing housings and their dowel pins.

Page 4-21, paragraph 4-11. Delete entire paragraph.

Paragraph 4-12a, is superseded as follows:

a. Lowering Pawl Removal (fig. 4-18).

Page 4-21, legend line to figure 4-18 is superseded as follows:

Figure 4-18. Boom lowering speed control pawl.

Page 4-21, paragraph 4-13 is superseded as follows:

4-13. Boom Hoist clutch

Refer to figure 4-11 and follow disassembly of the drum shaft as required to remove the boom hoist assembly". Disassemble the boom hoist clutch as shown on figure 4-20.

Page 4-22, figure 4-19 is superseded as follows

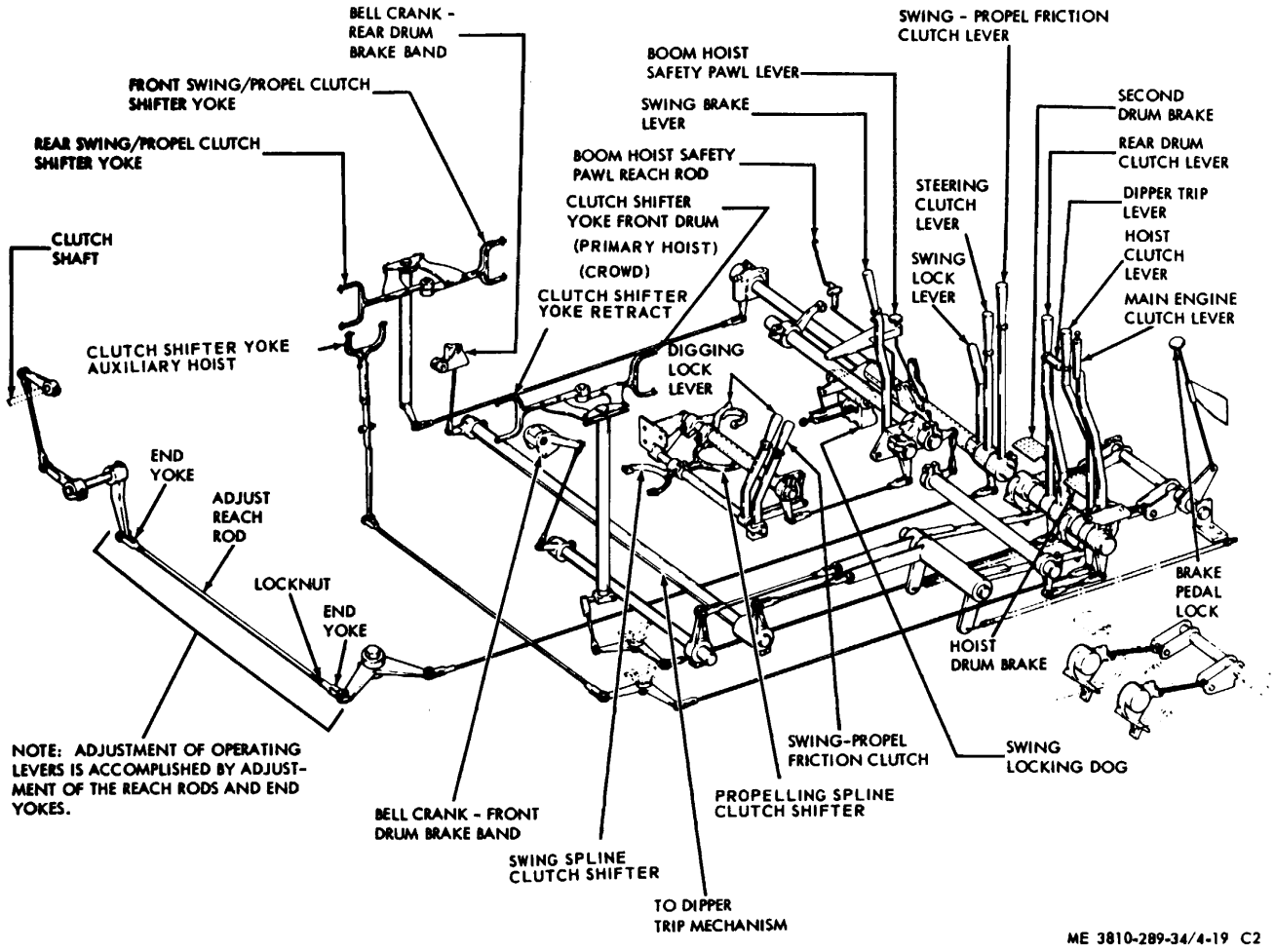


Figure 4-19. Control levers.

Page 4-24, figure 4-20 legend line is superseded follows:

Figure 4-20. Independent boom hoist assembly and boom hoist clutch, exploded view.

Page 4-25, paragraph 4-14*a*. "Figure 4-11" is changed to read "figure 4-11c."

Page 4-26, paragraph 4-15*a* (1). "Figure 4-16" changed to read: "Figure 4-6B".

Page 4-26, paragraph 4-15*a*(3). Delete "To remove the vertical propel shaft, the upper works must be removed".

Page 4-26, paragraph 4-15*b* (4), line 2 (6) is changed to read "(75)".

Page 4-26, paragraph 4-15*b* (5) is superseded as follows:

Remove swing-and-propel jaw clutch shifter and lift spline clutch (67) off splines.

Page 4-26, paragraph 4-15*b* (6). Line 1 is changed to read:

(6) Lift out spur gear (68).

Page 4-26, paragraph 4-15*b* (8). Line 1 is changed to read:

(8) Remove bevel pinion split retainer (86) which * * *

Page 4-27, paragraph 4-15*d*(7) is changed to read:

(7) Install spline clutch and shifter.

Page 4-27, paragraph 4-16. "Figure 4-6" is changed to read "Figure 4-6B".

Paragraph 4-16a. Subparagraphs (4) through (8) superseded as follows:

4-16*a*.

(4) Remove propel chains.

(5) Remove sprockets (79) from outer clutch shafts (78).

(6) Remove both clutch shaft locking c (100).

(7) Pull outer clutch shafts out, disengaging them from center propelling shaft. Be prepared to catch locking collars and outer half of jaw clutch which will fall free as shaft is removed.

(8) Remove two jam nuts (106) and two nuts (105) holding main bearing cap, remove the cap.

NOTE

The main bearing bushing is split in half and held from turning by shims between truck frame and bearing cap. When removing cap keep shims in groups as removed so reassembly can be made with the same bearing fit, or, if necessary, adjusted for a snug free running fit.

(9) Remove lock ring (117) and slide left jaw clutch (110) from end of center propelling shaft. Remove shaft.

(10) Place jack beneath bevel gear (113) or attach suitable lifting device and remove lockring (117).

(11) Remove bevel gear from right jaw clutch splines (114). Remove jaw clutch from bushing (116) in truck frame.

Paragraph 4-16b, is superseded as follows:

b. Inspection and Repair.

(1) Clean all parts thoroughly and examine for damage or excess wear. Inspect clutch bushing (116) which remains in truck frame, as well as jaw clutch bushings (115) and (103) which come out with the clutches.

(2) Repair worn clutch teeth by welding and grinding. Damaged clutch and shaft splines may be dressed down with a file. Severe damage will require replacement of the part. If truck frame bushing requires replacement it can be driven or pressed out. Jaw clutch bushings must be cut out with a pointed chisel. Press the new bushings into the truck frame and into the jaw clutches.

Page 4-27, paragraph 4-17 is changed to read. Outer clutch shaft figure 4-6B.

Page 4-27, paragraph 4-17*a* (1) is superseded as follows:

(1) Drain and remove center gear case and steering clutch guards as a unit. The complete unit is attached by four bolts.

Page 4-27. Paragraph 4-17*a* (8) is superseded as follows:

(8) Remove clutch shaft locking collar (100).

Page 4-27. Paragraph 4-17*c* (2) is superseded as follows:

(2) Insert clutch shaft locking collar and capscrew (99).

Page 4-28, paragraph 4-17*c*(6) is superseded as follows:

(6) Attach steering clutch, guard and center gear case with four bolts.

Paragraph 4-18, line. "Figure 4-6" is changed to read "Figure 4-6B".

By Order of the Secretary of the Army:

W. C. WESTMORELAND,
General, United States Army,
Chief of Staff.

Official:

VERNE L. BOWERS,
Major General, United States Army,
The Adjutant General

Distribution:

To be distributed in accordance with DA Form 12-25, Section II (qty rqr block No. 343) Direct and General Support Maintenance requirements for Crane Shovels, Crawlers, 10 Ton.

☞U.S. GOVERNMENT PRINTING OFFICE: 1982 0-380-451 (80)
PIN: 02527-002

TM 5-3810-289-34
C1

CHANGE }
No. 1

HEADQUARTERS
DEPARTMENT OF THE ARMY
Washington, D.C., *11 March 1971*

Direct Support and General Support Maintenance Manual
CRANE-SHOVEL, CRAWLER MOUNTED; 12 1/2-TON; 3/4-CU YD;
DIESEL ENGINE DRIVEN (BUCYRUS-ERIE MODEL 22BM)
FSN 3810-869-3092

TM 5-3810-289-34, 12 June 1970, is changed as follows:

Page 1-1, Paragraph 1-1*c* is added as follows:

c. Instructions for administrative storage of the crane-shovel will be found in TM 740-93-3. Instructions for destruction to prevent enemy use will be found in TM 750-244-3.

Page 3-7. Figure 3-8 is superseded as follows:

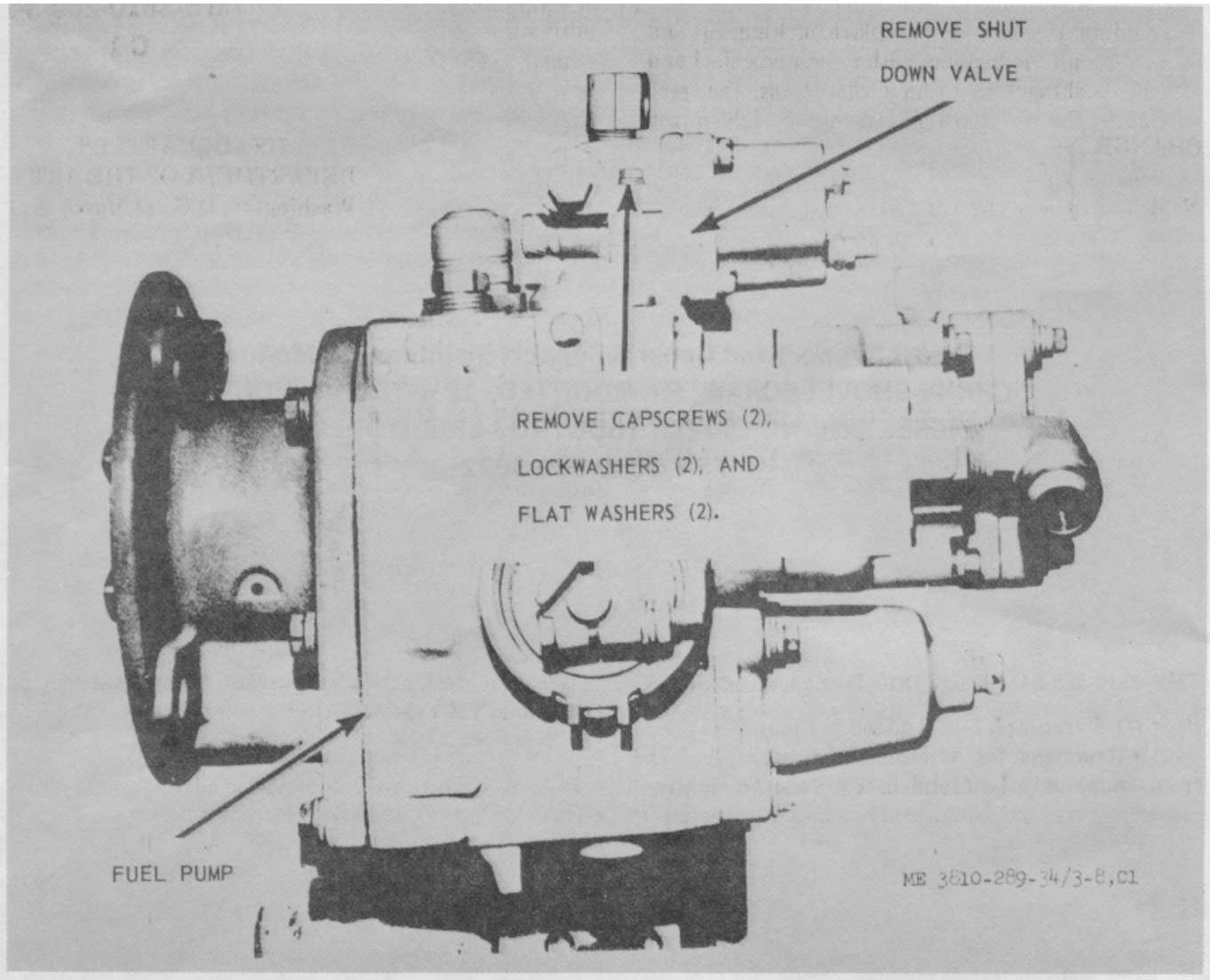


Figure 3-8. Shutdown valve removal.

Page 4-27. Paragraph 4-16 is superseded.

4-16. Center Propelling Shaft
(fig. 4-6)

a. Disassembly.

(1) Drain and remove center gear case and steering clutch guards as a unit. The complete unit attached by four bolts.

(2) Disconnect one end of spring rod assembly removing reach rod end pin.

(3) Move both steering jaw clutches out to disengaged positions.

(4) Remove propel chains.

(5) Remove sprocket from end of shaft.

(6) Remove both clutch shaft blank bolts.

(7) Pull outer clutch shafts out.

(8) Remove two bolts holding main bearing cap, remove cap.

NOTE

The main bearing bushing is split in half and held from turning by shims between truck frame and bearing cap. When removing bearing cap, keep shims in groups as removed.

(9) Remove the retaining ring that holds the left jaw clutch in position on the horizontal shaft.

(10) Slide the left jaw clutch out (use a jack to aid in lowering the clutch).

(11) Remove retaining ring from right side, slide jaw clutch out of bevel gear (the bevel gear weighs approximately 100 pounds so should be secured before removing right jaw clutch). Lower bevel gear and jaw clutch to floor.

b. Inspection and Repair. Clean all parts thoroughly and inspect for damage and excessive wear. If clutch teeth are worn or rubbed off, rebuild by welding

and grinding. If necessary to replace bushing, cut groove through the bushing with a pointed chisel pull the bushing out without disturbing the and clutch. The new bushing can then be driven place.

c. Reassembly.

(1) Use reverse steps of disassembly procedure.

(2) When installing the main bearing cap, make sure bolts pass through the shims properly. Add or remove shims if necessary to provide snug but running fit.

(3) Fill case with lubricant in accordance lubrication order.

Page A-1. The following changes are made to appendix A:

Reference TM 38-750 is changed to read: "TM 38-750, The Army Maintenance Management System (TAMMS)."

A-5. Shipment and Storage

TM 740-93-3 Administrative Storage of Equipment.

Paragraph A-6 is added as follows:

TM 750-244-3 Destruction of Materiel to Prevent Enemy Use.

By Order of the Secretary of the Army:

W. C. WESTMORELAND,
General, United States Army,
Chief of Staff

Official:

KENNETH G. WICKHAM,
Major General, United States Army,
The Adjutant General

Distribution:

To be distributed in accordance with DA Form 12-25, Section II, (qty rqr block No. 343) Direct and General Support maintenance requirements for Crane Shovels, Crawlers, 10 Ton.

☞U.S. GOVERNMENT PRINTING OFFICE: 1995 - 388-421.03409

TM 5-3810-289-34

Technical Manual
No. 54810-28944

HEADQUARTERS
DEPARTMENT OF THE ARMY
Washington, D. C., *12 June 1970*

DIRECT SUPPORT AND GENERAL SUPPORT MAINTENANCE MANUAL

CRANE-SHOVEL, CRAWLER MOUNTED; 12 ½ -TON, ¾ CU. YD; DIESEL ENGINE DRIVEN (BUCVRUS-ERIE MODEL 22 BM) FSN 3810-869-3092

***This manual supersedes the direct support, general support and depot maintenance portions of TM 5-3810-289-15, 3 July 1968.**

LIST OF ILLUSTRATIONS

CHAPTER 1
INTRODUCTION

Section I. GENERAL

1-1. Scope

a. This manual contains instructions for use by direct and general support maintenance personnel maintaining the Bucyrus Erie Model 22-BM Crane-Shovel. It provides information on maintenance of the equipment, which is beyond the scope of tools, equipment, personnel, or supplies normally available to using organizations.

b. Numbers in parentheses following nomenclature callouts on illustrations indicate quantity; numbers preceding callouts indicate preferred sequence.

1-2. Maintenance Forms and Records

Maintenance forms, records, and reports which are to be used by maintenance personnel at all maintenance levels are listed in and prescribed by TM 38-750.

1-3. Report of Equipment Publication Improvements

Report of errors, omissions, and recommendations for improving this publication by the individual user is encouraged. Reports should be submitted on DA Form 2028 (Recommended Changes to Publications) and forwarded direct to Commanding General, U. S. Army Mobility Equipment Command, ATTN: AMSME-MPP, 4300 Goodfellow Boulevard, St. Louis, Mo. 63120.

Section II. DESCRIPTION AND DATA

1-4. Description

Refer to TM 5-3810-289-12 for complete description of the Model 22-BM Crane-Shovel.

1-5. Differences Between Models

This manual covers only the Model 22-BM Crane Shovel. No known unit differences exist for the model covered by this manual.

1-6. Tabulated Data

a. Crane-Shovel.

Manufacturer	Bucyrus-F Erie Co.
Model	22-BM
Type	Crawler mounted
Serial numbers	129566-129742
	129905-130081
	131944--131963
	132052-132151

b. Engine.

Manufacturer	Cummins
Model	JN-6-1
Number of cylinders	4
Type of engine	Diesel
Cycle	4
Unit	Fan to fly wheel
Bore (in.)	4-1/in
Stroke (in.)	5 in.
Displacement (ea .in)	401
Compression ratio	16.3:1
Type drive	Mechanical
Type air intake	Naturally aspirated
Altitude-range (ft)	0-5000 + 107 F.
Rotation	Counter-clockwise
Cooling	Liquid
Fuel	fuel oil
Exhaust valve opens	62 BRC
Exhaust valve closes	44 ATC
Intake valve, opens	44 BTC
Intakes valve closes	40 ABC

(1) Governor.

Make	Cummins
Type	Mechanical variable-speed

(2) Fuel Injector.

Make	Cummins
Model	PT

(3) Fuel pump.

Make	Cummins
Model	G

c. Capacities

(1) Engine.

Crankcase	16 quarts
Oil filter	4 quarts
Fuel tank	50 gallons
Fuel filter	3 quarts
Coolant system	7 gallons

(2) Crane-shovel.

Transmission gear case	3 quarts
Machinery gear case	8 quarts
Propel gear case	2 quarts

CHAPTER 2
DIRECT SUPPORT AND GENERAL SUPPORT MAINTENANCE INSTRUCTIONS

Section I. REPAIRS PARTS, SPECIAL TOOLS, AND EQUIPMENT

2-1. Tools and Equipment
Tools and equipment required to perform direct support and general support maintenance on the Crane-Shovel are listed in table 2-1. References to graphs and illustrations indicating the use of tools and equipment are listed in the table.

2-2. Special Tools and Equipment
Table 2-1 lists special tools and equipment required for direct support and general support maintenance on the crane-shovel.

2-3. Maintenance Repair Parts
Maintenance repair parts are listed and illustrated in TM 5-3810-289-35P.

Table 2-1. Special tools and equipment

Item	FSN or part No.	Paragraph reference	Use
Leakage tester	ST-990	3-13	Check injector cup for leaks.
Liner puller	ST-777 51203645416	3-48	Pull cylinder liners from block.
Camshaft bushing mandrel	ST-783 67342	3-45	Replace camshaft bushing.
Pulley assembly tool	ST-386	3-22	Assemble pulley.
Mandrel	ST430	3-2	Tachometer drive assembly installation.
Puller	ST-709	3-5	Governor weight shaft removal.
Liner bore tool	ST-676 51330728366	3-45	Resurface cylinder liner counterbore.
Adapter plate	ST-679	3-45	Used with cylinder liner counterbore tool.
Mandrel set block	ST491 34609991210	3-29	Replace rocker liner bushings.
Guide spacer	ST-707	3-47	Press in new solid guides in lead.
Belt tension gage	ST-968	3-36	Check belt tension.
Standard puller	ST-647	3-23	Remove accessory drive pulley.
Grinding machine	ST-685 Model-SG	3-46	Grind valve seats.
Seal driver	ST480	3-44	Install crankshaft oil seal.
Regrooving tool	ST483	3-43	Regroove top ring groove on piston.
Hold-down adapter	ST-1010	3-28	Hold-down injector sleeve for repair.
Plug gage	ST-504	3-43	Check piston pin bushing diameter.
Oil assembly tool	ST419 51208968097	3-6	Assemble drive cover on fuel pump.
Packing tool assembly	ST422	3-2	Install O-ring on throttle shaft of fuel pump.
Valve spring compressor	ST448 51209813114	3-28	Remove valves and springs from cylinder head.
Seat cutter pilot	ST-843	3-14	Guide seat cutter in drill press.
Grooving tool	ST-913 49109991499	3-28	Regroove cylinder head.
Holding tool	ST-923	3-28	Hold injector sleeve while testing for cracks.
Cup wrench	ST-934		Remove injector cup.
Guide puller	ST-667 51209813110	3-46	Remove valve cross-head guides.
Grooving tool	ST-597	3-28	Regroove cylinder head
Holding tool	ST-383 51207664758	3-28	Hold injector sleeve while testing for cracks.
Drill ream fixture	ST406	3-34	Ream dowel holes in flywheel housing.
Checking bar	ST409	3-45	(heck bore alignment.
Main bearing bore reamer	ST401 51209991266	3-45	Ream out main bearing bore.

Table 2-1. Continued

Item	FSN or part No.	Paragraph reference	Use
Valve tester	ST-417 49108980645		Check valves and seats for leakage.
Reamer driver	ST-219	3-45	Hard driver to turn main bearing bore reamer.
Valve seat insert kit	ST-257 51803453708	3-46	Hold and drive cutter when removing insert.
Sleeve expander	ST-297 51207664756	3-14	Seal upper portion of injector sleeve.
Ball joint vise	ST-302		Holds fuel pump for disassembly.
Injector seat cutter	ST-379 51207664757	3-14	Cut injector seat to give proper seat and tip protrusion.
Valve guide driver	ST-740	3-31	Install valve guides.
Cutter	ST-S25	3-14	Cut injector sleeve.
Piston ring compressor	ST-755	3-43	Install piston into skirt end of liner.
Chamfering tool	ST-861 49109991498	3-43	Chamfer tapered piston pin bushing bore.
Flange puller	ST-887	3-38	Pull crankshaft hub.
Wrench adapter	ST-669 M 1302A	3-47	Adapts torque wrench to locknuts of valve crossheads.
Spot facing tool	ST-542 51207664754	3-13	Repair inlet and drain connection surfaces of injector body.
Pump mounting plate	ST-546	3-2	Hold fuel pump for disassembly.
Gage block	ST-547 51206907949	3-45	Measure block counterbore depth.
Seal tool assembly	ST-558	3-42	Guides rear cover and seal into position.
Wear gage	ST-560 51209991209	3-43	Check ring groove wear.
Valve facing machine	ST684 Model-VS	3-31	Grind valves.
Lifting fixture	ST-756	3-28	Lift engine for mounting.
Sleeve rolling tool	ST-819 5130777529	3-14	Seal injector sleeve in lower seating area.
Packing tool assembly	ST-835 49109991505	3-2	Install preformed packing on throttle shaft of fuel pump.
Bead cutting tool	ST-839	3-14	Machine bead in sleeve seat area of bead.
Locating mandrel	ST-562	3-13	Measure connecting rod alinement.
Holding fixture	ST-569 51203645417	3-13	Hold fuel injector for repair.
Checking fixture	ST-570 51206907950	3-13	Check inject plunger seating for leaks
Holding fixture	ST-583 49207119307	3-28	Hold cylinder head for disassembly.
Cylinder liner driver	ST-594 51209991206	3-48	Cylinder liner installation.
Ring expander	ST-760 P407-R	3-43	Expands piston ring for installation.
Boring machine	ST-0526 PM 9000D	3-43	Bore out new piston ring for installation
Plate puller	ST-77S8	3-48	Used with cylinder liner puller.
Checking fixture	ST-561 49109777507	3-43	Check rod alinement.
Camshaft bushing driver.	ST-782 51209 39664	3-45	Replace camshaft bushing.
Mandrel and block	ST-605	3-43	Replace piston pin bushing.

Section II. TROUBLESHOOTING

2-4. General

This section provides information for diagnosing and correcting unsatisfactory operation or failure of the crane-shovel and its components.

2-5. Troubleshooting Chart

In chart 2-1, each malfunction listed is followed by probable causes of the trouble. The corrective action required is described opposite the probable cause.

Chart 2-1. Troubleshooting

Malfunction	Probable cause	Corrective action
1. Engine fails to start.	a. Injectors clogged b. Defective fuel pump	a. Replace injector (para 3-13) b. Replace fuel pump (para 3-2)
2. Irregular firing of engine	a. Injectors defective b. Piston rings worn	a. Replace injector (para 3-13) b. Replace piston rings (para 3-43)
3. Engine smokes.	a.. Injector defective b. Piston rings worn	a. Replace injector (para 3-13) b. Replace piston ring (para 3-43)
4. Engine knocks excessively	a. Injectors defective b. Main bearings c. Connecting rod bearings	a. Replace injectors (para 3-13) b. Replace plain hearings (para 3-44) c. Replace connecting rod hearing- (para 3-43)
5. Low or no lubricating oil pressure indication.	a. Loose bearings b. Oil pump gear worn	a. Replace bearings (para 3-37) b. Replace gears (para 3-37)
6. Starter will not crank engine.	Armature burned out.	Replace armature.
7. Alternator not charging.	Alternator inoperative.	Repair or replace alternate (para 3-1)
8. Alternator output low or unsteady.	Open or shorted silicon rectifier.	Replace rectifier (para 3-1)
9. Batteries will not hold charge.	Alternator regulator not operating properly.	Refer to para 3-1.

Section III. GENERAL MAINTENANCE INSTRUCTIONS

2-6. General

This section contains general reference data and instructions for use by direct and general support maintenance as authorized by the maintenance allocation chart. It provides dimensions, tolerances, wear limits, torque data, and miscellaneous information required for maintenance of the crane-shovel.

2-7. Reference Data

a. Table 2-2 provides the following reference data:

(1) Engine dimensions, tolerances, and wear limits.

(2) Crane dimensions, tolerances, and wear limits.

(3) Specific engine torque data.

(4) General engine torque data.

(5) Miscellaneous data.

(6) Shovel dimensions, tolerances, and wear limits.

b. Paragraph 2-8 contains general maintenance instructions for the crane-shovel upper and lower works gears and bearings.

2-8. Maintenance of Gears and Bearings

a. General. Every power transmitting part on the crane-shovel revolving frame that is used in the work cycle is mounted on anti-friction bearings. This includes shafts and parts turning on shafts. Anti-friction bearings maintain concentricity, resulting in longer service life and lower maintenance.

Note. While the following instructions show ball bearings, the same procedure will apply to roller bearings.

b. Bearing Removal.

(1) An arbor press is one of the best demounting tools and should be used wherever it is adaptable. Rest the bearing inner ring or both rings (never the outer ring only) against a pair of flat blocks of the same size and using a firm, stead pressure, force the shaft out.

(2) Keep the shaft straight to avoid drainage from cocking.

(3) Where press is not adaptable, use a puller of a type which can be inserted behind the bearing inner race. Be sure that the jaws are set so that they will not slip over the inner race when pressure is applied. Exert an even pressure and pull straight.

(4) In cases where gears or other removable parts do not allow the puller to contact the bearing directly, use the puller on the parts directly back of the bearing.

(5) The use of a hammer is to be avoided unless other methods cannot be employed. Split sections of pipe or tubing, with welded lugs, can be used for shafts of various sizes. Alternating blows on opposite sides will prevent serious cocking. Be careful that pipe is free of chips that would be shaken into the bearing. In removing a bearing by pounding, care must be observed not to hit or scrape locknut threads on the shaft.

(6) Cover bearings with cloth or paper as soon as they are removed.

Caution: Do not spin bearings before they are clean. If bearings are spun, dirt can cause scratch marks which may later lead to spilling.

c. Bearing Cleaning

(1) Place bearings in a wire basket, so there is plenty of space for-cleaner to reach all parts and

immerse in a solvent. Tank should have a screened false bottom to prevent settings from being stirred up into the bearings. Agitate basket frequently until grease, oil or sludge is thoroughly loosened and can be flushed out.

(2) Bearings that contain especially heavy carbon deposits or hardened grease should be put in a basket by themselves and soaked in a separate container or solvent.

(3) Using a spray gun with air filter and a clean solvent, flush each bearing until all dirt or residue is removed. Turn one of the races slowly while flushing to help dislodge dirt from around balls and separator sockets.

(4) With dry, filtered air, blow solvent out of bearings, being careful not to spin by force of air Since dry bearings rust quickly, lubricate them at once.

(5) Dip bearings in clean light spindle oil. Rotate them a few times and after draining the excess oil place them in a covered container for inspection.

d. Bearing Inspection. Discard bearings which show any of the following:

(1) Rusted balls or raceways. Usually caused by water passing worn or defective seals or by condensation inside housing.

(2) Fractured ring. Forcing a cocked bearing on or off a shaft will do this, as will too heavy a press fit.

(3) Worn, galled or abraded surfaces. Can be caused by too loose a fit, or bearing locked by dirt and turning on shaft or in housing.

(4) Broken or bent shields, seals or separator Usually caused by improper uses of tools during mounting or removal.

(5) Badly discolored balls and races. Usually due to inadequate supply of lubricant. Moderate discoloration of balls and ball track is not a cause of discard.

(6) General feeling of roughness which remains unchanged by thorough cleaning, indicating damage to raceways or balls, such as indenting by dirt or pitting by corrosion.

(7) Catchy or rough feeling at one or more points which repeated flushing will not remove and which may be a spalled or fatigued spot. Thorough flushing is necessary to be sure it is not caused by dirt.

(8) Excessive looseness or end play, indicating lapping by dirt of abrasive in lubricant. If in doubt, check against endplay feel of identical new bearing. Races and balls are dull gray when lapped by dirt.

(9) Any looseness or endplay which can be detected by hand feel is a cause for rejection only in the case of double row angular contact bearings.

e. Bearing Mounting.

(1) An arbor press is the most satisfactory tool for mounting bearings. Used properly, no Slows are struck and there is no danger of loosening shields or seals from this cause.

(2) Place the bearing on two flat blocks of equal size so that they contact the inner ring of the. bearing. Then press shaft straight until the bearing is seated solidly against the shaft shoulder. Be sure that the blocks do not scrape or damage the threads if the shaft is threaded for a bearing locknut.

(3) Use of blocks that contact both rings is also good practice, provided the blocks are flat and the faces parallel.

(4) Where the distance from shaft end to bearing seat is short, a piece of pipe or tubing may be used. The pipe must be clean inside and out and the ends squared.

(5) In cases where a press is not available a piece of tubing may be used with a hammer. A plug in the tubing and a shield outside help to prevent jarring dirt into bearing. The hammer should be applied alternately at opposite points to avoid cocking and particular care should be taken when' the bearing is started.

f. Gear Inspection and Repair.

(1) Clean gear with an approved cleaning solvent being particularly careful to clean out between gear teeth, and dry thoroughly. Inspect gear for cracks or breaks. Inspect key ways in gear hub. Be sure they are clean and open and in good condition. Check gear for warpage and if it is out of true more than the tolerance given in table 2-2 replace the gear. Inspect teeth for wear and if worn in excess of the tolerance given, replace the gear. Check teeth for any broken or nubbed teeth and also for other irregularities.

(2) Repair cracks or other defects in the gear by welding and grinding. If a considerable amount of welding is done on one side of the gear, check before reinstalling.

Table 2-2. Reference Data

Component points of measurement	Manufacturer's dimensions and tolerance in inches		Desired clearance		Maximum allowable wear and clearance
	Minimum	Maximum	Minimum	Maximum	
a. Cylinder Block					
Installed Camshaft	1.8745	1.8765			
Bushing Inside Diameter					1.8780
Camshaft Bushing Bore					
In Block No. 2-7	2.0035	2.0045			2.0055
No. I Bore for Thrust Plate	2.1245	2.1255			2.1265
Cylinder Liner Counterbore					
Inside Diameter	4.874	4.876			
Oversize Flange Linen	4.894	4.896			
Cylinder Liner Counterbore					
Depth	0.3092	0.3105			0.4023
Idler Gear Shaft	1.4975	1.4985			1.4995
Cylinder Block Height					
From Main Bearing Bore	15.122	15.124			15.114
From Top of Alinement Bar	13.0600	13.0615			13.0500
Cylinder Liner Counterbore Pt No.43782-A	0.0063	0.0077			
Shims Pt. No. 437824	0.0072	0.0088			
Pt. No. 43782-C	0.0081	0.0099			
Pt. No. 114552	0.018	0.022			
Pt. No. 114523	0.028	0.034			
Pt. No. 124455	0.056	0.068			
Pt. No. 124569	0.093				
Cylinder Liner Protrusion	0.004	0.006			
Liner-to-Block Clearance	Liner may contact block if it does not force liner out of round				
Liner Bore					
Diametrical	0.005	0.009			
Lower Liner Bore:					
Inside Diameter	4.619	4.21			
Main Bearing Bore	4.1240	4.1250			4.1255
Tappet Bore in Block:					
Injector	1.3120	1.3130			1.3145
Valve	1.1870	1.1880			1.1895
Main Bearing Cap Fit In Block	0. 4.002	4.004			0.001
b. Cylinder Liner.					
Cylinder Liner (ID)—Cast Iron	4.1250	4.1260			4.1300
Cylinder Liner Protrusion	0.004	0.006			
c. Idler Gear.					
Idler Gear Bushing (ID)	2.125	2.126			2.127
Gear Hub Bushing (ID.)	1.500	1.501			1.502
Idler Gear Hub	2.1225	2.1235			2.1215
Idler Thrust Washers					
Part Nos.:					
68631 .	0.096	0.106			0.091
68632	0.061	0.063			0.059
68633-1	0.192	0.194			0.190
d. Bearings.					
Standard Bearing Shell Thickness					
Main Bearing	0.1231	0.1236			0.1216
Connecting Rod	0.0722	0.0727			0.0710
Journal Oil Clearance					
Main	0.0018	0.0048			0.0068
Connecting Rod		0.0020	0.0045		0.0080
Crankshaft Thrust Bearings--					
Part No. 150310	0.151	0.153			
Crankshaft End Clearance	004	0.015			0.022
Vibration Dampers:					
Eccentricity and Wobble		0.030			0.030

Table 2-2. Reference Data-Continued

Component points of measurement	Manufacturer's dimensions and tolerance in inches		Desired clearance		Maximum allowable wear and clearance
	Minimum	Maximum	Minimum	Maximum	
Connecting Rod Dimensions:					
Crank pin Bore	2.7725	2.7730			
Out of Round					0.0015
Piston Pin Bushing	1.5000	1.5005			1.5015
Connecting Rod Twist:					
Without Bushing					0.020
With Bushing					0.010
Connecting Rod Length	9.498	9.500			
Bore Misalinement					0.001
Piston and Piston Rings:					
Piston Ring Gap (new or reconditioned liner)					
Pt. No. 68788	0.013	0.023			
Pt. No. 109410	0.013	0.023			
Pt. No. 144980	0.013	0.023			
Pt. No. 126480	0.013	0.025			
Pt. No. 146140	0.015	0.055			
Standard Piston Skirt Diameter (700 F)					
130360, 130500, 11738, 144840, 149200,					
168430, compression ratio					
16.3:1 Gage Point BC	4.1180	4.1190			4.1150
Piston Pin Bore	1.4988	1.4990			1.5000
Piston Pin Diameter	1.4988	1.4990			1.4978
Pistons and Rings Oversize	0.020	0.030			0.040
e. Camshaft.					
Camshaft Journal Diameter:					
No. 1 Journal only	1.747	1.748			1.746
All Other Journals	1.872	1.873			1.871
Camshaft Lobe Lift					
f. Injection Spec BTC 64°, A r 19°. Valve Overlap 880.					
Exhaust Opens BBC 620. Intake Opens BTC 440°.					
Exhaust Closes ATC 440°. Intake closes ABC 400.					
Valve Lobe Lift 0.251 in.					
Injection Lobe Lift 0.112 in.					
g. Gear Cover.					
Accessory Drive Bushing I.D.:					
139810 Std	1.314	1.319			1.3205
139811 0.010 in	1.304	1.309			1.3105
139812 0.020 in	1.294	1.299			1.3005
h. Cylinder Head.					
Crosshead Guide Dimensions:					
Solid type (OD.)	0.3750	0.3755			0.3740
Head Height	5.000	5.010			4.970
i. Valve Seats and Insert					
Valve Seat Insert Run-Out		0.002			
Oversize Diameter Std. Depth Std. Insert O.D.					
1.4300/11.4305. Cylinder Head I.D. 1.427/1.428.					
Insert Thickness 0.156/0.161.					
I. Valve Crossheads.					
Crosshead Dimensions:					
Solid Stem	0.3708	0.3713			0.370
k. Valves, Guides and Springs.					
Valves Stem Dimensions:					
Four-valve Head	0.3400	0.3410			0.3390
Valve Guide I.D.:					
Four-valve Head	0.3425	0.3432			0.3442
Valve Guide Protrusion:					
Four-valve Head	1.240	1.260			

Table 2-2. Reference Data-Continued

Component points of measurement	Manufacturer's dimensions and tolerance in inches		Desired clearance		Maximum allowable wear and clearance
	Minimum	Maximum	Minimum	Maximum	
Valve Spring Data					
Free Length is 2.364. Pounds Force Required to Compress 105 Lbs. 50 117 Lbs. No. of Coils 91/2. Wire Diameter 0.148. Length 1.610.					
1. Rocker Levers and Cover.					
Rocker Lever Bushing (I.D.)	1.1245	1.1275			1.1285
Rocker Lever Shaft (O.D.)	1.1230	1.1235			1.1220
m. Push Tubes					
Valve Push Tube:					
Ball End	0.624	0.625			
Socket End (Spherical I.D.)	.0.4995	0.5005			
Injector Push Tube					
Ball End	0.685	0.687			
Socket End (Spherical I.D.)	0.4995	0.5005			
n. Tappets.					
Injector Tappet Assembly:					
Body (O.D.)	1.3100	1.3110			1.3090
Roller (O.D.)	1.1230	1.1250			1.1210
Roller (I.D.)	0.5655	0.5665			0.5675
Roller Pin (O.D.)	0.5620	0.5626			0.5610
Roller, Side Clearance	0.0050	0.0170			0.0220
Roller Concentricity Assembled		0.0005			
Roller Squareness Assembled		0.0010			
Valve Tappet Assembly:					
Body (O.D.)	1.1850	1.1860			1.1840
Roller (O.D.)	1.0610	1.0630			1.0590
Roller (I.D.)	0.5030	0.5040			0.5050
Roller Pin (O.D.)	0.4995	0.5000			0.4985
Roller Side Clearance	0.0080	0.0220			0.0270
Roller Concentricity Assembled		0.0010			
Roller Squareness Assembled .		0.0010			
o. Lubricating Oil Pump.					
Lubricating Oil Pump Dimensions:					
Idler and Drive Shaft Bushing (I.D.)	0.6165	0.6175			0.6185
Idler and Drive Shaft (O.D.)	0.6150	0.6155			0.6140
Idler Gear Bushings (I.D.)	0.9925	0.9935			0.9945
Idler Gear Shaft (O.D.)	0.9900	0.9910			0.9890
Idler and Driven Gear (O.D.)	1.8320	1.8330			1.8310
Gear Pockets (Minor I.D.).	1.8400	1.8420			1.8430
Gear Pocket Depth	1.6230	1.6250			1.8430
Balance Drive Shaft		0.8095			0.8105
Balance Drive Shaft Bushing	0.8145	0.8150			0.8170
Idler Gear Thrust Washer	0.0610	0.0630			
Balance, Drive Gear Thrust Washer	0.600	0.620			
Lube Pump Drive Shaft Bushing	0.6165	0.6175			0.6185
p. Pressure Regulator.					
Pressure Regulator Dimensions:					
Low Pressure (I.D.)	0.621	0.626			0.627
Low Pressure (O.D.)	0.740	0.741			0.739
High Pressure (Large Outside)	0.740	0.741			0.739
High Pressure (Small Outside)	0.615	0.617			0.614
Housing Bore	0.740	0.741			0.739
Spring Load @ 2.055 in	16.4 lb.	18.01 lb.			14.0 lb.

Table 2-2. Reference Data-Continued

1. Engine dimensions, tolerance and wear limits.

Component points of measurement	Manufacturer's dimensions and tolerance in inches		Desired clearance		Maximum allowable wear and clearance
	Minimum	Maximum	Minimum	Maximum	
q. Water Pump.					
Belt-Driven (Six Cylinder)					
Cover Face to Impeller Hub	0.620	0.625			
r. Fuel Pump Drive.					
Fuel Pump Drive					
Bushing (I.D.)	1.314	1.319			1.322
Available for Service in Shaft (O.D.)	1.3115	1.312			1.310
s. Engine Assembly.					
Crankshaft End Clearance	0.004	0.015			0.022
Cylinder Liner Protrusion	0.004	0.006			
Connecting Rod Side Clearance	0.008	0.012			0.040
Gear Train Backlash (Six-Cylinder)	0.004	0.007			0.020
Camshaft End Play	0.007	0.011			0.015

2. Crane dimensions, tolerance and wear limits

Component points of measurement	Manufacturer's dimensions and tolerance in inches		Desired clearance		Maximum allowable wear and clearance
	Minimum	Maximum	Minimum	Maximum	
510889K 1					
Bushing (Susp. Sheave)					
Inside Diameter		3.014	3.016		0.50
Outside Diameter		3.628	3.629		
600094K2					
Sheave 10" Pitch Diameter					
Sheave Inside Diameter	3.625	3.626			
Bushing (510889K1) Outside Diameter	3.628	3.629			
Bushing Inside Diameter	3.014	3.016			0.50
704686K2					
Boom Hoist Drum					
Inside Diameter	6.2990	6.3002			
Diameter of Flange	8.374	8.376			
Inside Diameter and Diameter of Flange Must Be Within 0.001 Inch Total Indicator Reading					
Outside Diameter		24.375			
500304K 1					
Rober					
Inside Diameter	0.502	0.505			.025
Outside Diameter	0.900	0.902			.025
520692K1(					
Bearing					
Inside Diameter	1.377	1.380			
520700K21					
Sleeve					
Inside Diameter	1.385	1.395			.030
617095K(1					
Cam					
Inside Diameter	0.625	0.627			.025
Inside Diameter of Slot	0.905	0.907			.025
533612K1					
Clutch Shoe, Horizontal Propel Shaft					
Inside Diameter	0.502	0.505			050/080

Table 2-2. Reference Data-Continued

2. Crane dimensions, tolerance and wear limits

Component points of measurement	Manufacturer's dimensions and tolerance in inches		Desired clearance		Maximum allowable wear and clearance
	Minimum	Maximum	Minimum	Maximum	
528440Ki					
Bushing					
Inside Diameter	7.016	7.018			.040
Outside Diameter	7.879	7.881			
265265					
Dust Shield Bore	2.5032.507	.050			
265302					
Dust Shield Bore	3.5033.507	.050			
506456K1					
Bushing					
Inside Diameter	3.505	3.517			.050
Outside Diameter	4.130	4.131			
510685KI					
Bushing					
Inside Diameter	4.386	4.388			.050
Outside Diameter	5.129	5.130			
500845K1					
Bushing					
Inside Diameter	2.507	2.509			.040
Outside Diameter	3.002	3.003			
533417K1					
Bushing, Guide Roller					
Inside Diameter	2.010	2.012			.050
Outside Diameter	2.379	2.381			
533418K1					
Bushing, Boom Point Sheave					
Inside Diameter	3.011	3.013			.060
Outside Diameter	3.504	3.506			
533420K1					
Guide Roller					
Inside Diameter	2.375	2.377			.050
Outside Diameter	2.01	2.012			
600305K I					
Sheave10" Pitch Diameter					
Sheave Inside Diameter	3.000	3.001			
Bushing Outside Diameter (500845K)	3.002	3.003			
Bushing Inside Diameter	2.507	2.509			.060
533463KI					
Boom Foot Pin					
Diameter	2.241	2.242			.040
533436K1					
Boom Foot Bushing					
Inside Diameter	2.260	2.261			.050
Outside Diameter	2.754	2.755			
SSIO002CP					
Improved Heavy Duty Quick Disconnect Ball Joint-Marine Type-K-28 Thread					
Bell Stud Ball Diameter	0.347	.015			
Ball Stud Neck Diameter	0.192	.010			
511446KI					
Disc, Friction Throttle with Detent					
Thickness			3/8"		
Radius of Disc		2 11/16"			
Radius to Detent		7/8"			
230571					
Clutch Housing:					
Inside Diameter at Bearing	6.2990	6.3002			
Outside Diameter of Bearing	.2982	6.2992			
Inside Diameter of Bearing	3.9362	3.9370			

Table 2-2. Reference Data-Continued

2. Crane dimensions, tolerance and wear limits

Component points of measurement	Manufacturer's dimensions and tolerance in inches		Desired clearance		Maximum allowable wear and clearance
	Minimum	Maximum	Minimum	Maximum	
232650					
Clutch Driver Bore	3.937	3.938			
293351					
Bushing:					
Bushing Inside Diameter	1.254	1.255			.040
Bushing Outside Diameter	1.626	1.628			
725084					
Clutch Band:					
Inside Diameter (2)	1.252	1.254			.060
617062K2					
Bearing Housing:					
Housing Inside Diameter at Bearing	5.5116	5.5128			
Diameter of Flange	4.500	4.502			
606857K 1					
Bushing Adjusting Cone Roller:					
Inside Diameter	1.718	1.720			.050
Inside Diameter	0.337	0.340			
Outside Diameter	4.190	4.191			
Length of Bushing Interior	2.809	2.815			
Bushing Interior to 170 Bevel	0.337	0.340			
Width of Interior 450 Bevel		0.125			
606858K2					
Roller, Cone, Adjusting Cone Rollers:					
Inside Diameter	4.187	4.188			.050
Depth of Recess	0.372	0.378			
606860K2					
Shaft, Adjusting Cone Roller:					
Outside Diameter	3.372	3.373			.050
Inside Diameter of Recess.	1.685	1.688			
Depth of Recess	0.122	0.125			
Length of Shaft	12.422	12.437			
518890K1 I					
Bushing, Horizontal Propel:					
Inside Diameter	2.945	2.947			.060
Bushing Outside Diameter	3.564	3.565			
Flange Outside Diameter	3.984	4.000			
M224					
Ball Bearing 306SFFC:					
Outside Diameter	2.8341	2.8346			
Flywheel Shaft Bore	2.8344	2.8350			
272794					
Split Sprocket Bore	7.753	7.755			
725071K1					
Sprocket, Front Shaft (Hoist Load Lowering):					
Caliper Diameter	23.512	23.524			
Pitch Diameter		24.282			
Outside Diameter		25.000			
Inner Flange Diameter	21.505	21.508			
61 Cut Teeth, 1% inch Chain Pitch, Use With ASA ·100 Roller Chain					
520637K1					
Seal Ring:					
Inside Diameter	2.767	2.773			.025
Outside Diameter	4.333	4.334			
617073K1					
Oil Gear, 36 Hobbed Spur Tooth:					
Inside Diameter	2.750	2.751			.030
Total Assembled Feeler Backlash Limits	0.065	0.073			.150_

Table 2-2. Reference Data-Continued

2. Crane dimensions, tolerance and wear limits

Component points of measurement	Manufacturer's dimensions and tolerance in inches		Desired clearance		Maximum allowable wear and clearance
	Minimum	Maximum	Minimum	Maximum	
Circular Backlash Cut in This Gear		0.063			
Running Pitched Diameter		14.400			
Running Total Assembled Feeler Backlist			0.058	0.076	.150
625516K1					
Horizontal Shaft:					
Diameter at bearing LH-212WD	2.3621	2.3626			
Diameter of Shaft	2.749	2.750			
Diameter at Bearing RH-312W	2.3621	2.3626			
625517KI (Meshes with 610086K3, 617073K1)					
Hoist Pinion, 14 Tooth:					
Inside Diameter	2.752	2.754			
Inside Diameter	2.417	2.420			
Outside Diameter	6.795	6.800			
Total Assembled Feeler Backlash Limits	0.067	0.071			.150
Running Total Assembled Feeler Backlash	0.009	0.028			
Based On a Center Distance of 17.600 t0.005 0.010					
525880K1					
Bushing, Propel Shaft, Truck Frame:					
Inside Diameter	5.262	5.264			.125
Outside Diameter	6.004	6.006			
810009K1					
Bridge Casting, Horizontal and Swingshaft:					
Inside Diameter at Bearing 310WD	4.3305	4.3315			
Outside Diameter of Bearing 310WD	4.3301	4.3307			
Inside Diameter of Bearing 310WD	1.9680	1.9685			
711015K1 (Meshes with 612266KI, 710264K1)					
Swing Gear, Vertical Shaft:					
Inside Diameter, Gear	7.0864	7.0876			
Inside Diameter, Hub Gear	7.250	7.255			
Inside Diameter, Hub Gear	7.804	7.834			
Pitch Diameter, Hub Gear		7.500			
Pitch Diameter, Bevel Gear	17.000	17.002			.150
Pitch Diameter, Outer Gear					.150
Diameter of Outer Gear		19.500			
Total Assembled Feeler Backlash Limits (with 612266K1)	0.014	0.018			.150
Total Assembled Feeler Backlash Limits (with 710264K1)	0.017	0.021			.150
725703K1					
Shaft, Vertical Swing:					
Shaft End Diameter, LH	3.799	3.805			
Diameter at Bearing ·220WD	3.9368	3.9375			
Diameter at Bearings *220W, 22OWD	3.9356	3.9363			
Diameter at Bearing *310WD	1.9676	1.9681			
Shaft End Diameter, RH		1.492			
808730K1					
Bridge:					
Inside Diameter at Bearing 3101D	4.3305	4.3315			
Outside Diameter of Bearing 310WD	4.3301	4.3307			
Inside Diameter at Bearing 310WD	1.9680	1.9685			
Inside Diameter at Bearing 220W	7.0864	7.0876			
Outside Diameter of Bearing 220W	7.08)6	7.0866			
Inside Diameter of Bearing 220W	1.3336	1.3386			
Inside Diameter of Lugs	1.259	1.261			
602430K1					
Pinion, Large, Swing Machinery:					
Inside Diameter	3.312	3.314			

Table 2-2. Reference Data-Continued

2. Crane dimensions, tolerance and wear limits

Component points of measurement	Manufacturer's dimensions and tolerance in inches		Desired clearance		Maximum allowable wear and clearance
	Minimum	Maximum	Minimum	Maximum	
Inside Diameter	3.940	3.941			
12 Special Cast Teeth, 2.0944 Inch C.P., 4 Inch Face, 8.000 Inch Pitch Diameter.					
610203KI (Meshes with 710255K, 610212KI)					
Gear, Horizontal Swing Shaft:					
Total Assembled Feeler Backlash Limits	0.016	0.024			.150
Running Total Assembled Feeler Backlash	0.009	0.028			
Based on Center Distance Variations of +0.005 -0.010.					
611296K1					
Clutch, Jaw, Vertical Swing, Airshift:					
Inside Diameter	3.625	2.629			.060
Outside Diameter	7.740	7.750			
4/8 Diametrical Pitch, 30 Teeth, Involute Spline to SD5151.					
8/16 Diametrical Pitch, 30 Teeth, Involute Spline to SDS151, Acceptable Tolerance Measured Between Pins Plus 0.010 Minus 0.000					.125
Pitch Diameter		7.500			
Root Diameter	7.166	7.196			
625466K1					
Horizontal Shaft:					
Diameter at Bearing, LH (Assemble Bearing with Shield Side Toward Center of Shaft)	3.1485	3.1491			
Diameter at Bearing, RH	3.145	3.147			
Diameter at Spline, RH	3.118	3.125.			.010
D246652					
Ball Bearing MRC 310-MF					
Inside Diameter	1.9680	1.9685			
Outside Diameter	4.3301	4.3307			
Individual Ring Width	1.0625	1.0630			
M-4418-C					
Ball Bearing 220WDN:					
Inside Diameter	3.9362	3.9370			
Outside Diameter	7.0856	7.0866			
Individual Ring Width	1.3336	1.3386			
310WDH					
B3l Bearing:					
Inside Diameter	1.9680	1.9685			
Outside Diameter	4.3301	4.3307			
Note. Bore and Outside Diameter Tolerances Are Checked Before Shield is Inserted.					
Individual Ring Width	1.0580	1.0630			
43751					
C/R Oil Seal Type "P":					
Sirrene 407080 Nitrile					
Seal Outside Diameter	5.754	5.759			
Seal Inside Diameter	5.736	5.766			.015
Seal Width	0.546	0.578			
602429K1					
Pinion, Swing Machinery:					
Inside Diameter	3.312	3.314			
Inside Diameter	3.940	3.941			
12 Special Cast Teeth, 2.054 Inch CP., 4 Inch Face, 7.847 Inch Pitch Diameter					.250

Table 2-2. Reference Data-Continued

2. Crane dimensions, tolerance and wear limits

Component points of measurement	Manufacturer's dimensions and tolerance in inches		Desired clearance		Maximum allowable wear and clearance
	Minimum	Maximum	Minimum	Maximum	
711262K21					
Clutch Band:					
Inside Diameter (2)	.0.887	0.879			
714533K21					
Bell Crank, Boom Hoist Clutch:					
Inside Diameter	0.749	0.750			.050
Inside Diameter (2).	0.874	0.875			.050
Inside Diameter	1.093	1.095			
Outside Diameter of Dowel	0.874	0.875			
801775K1 (Meshes with 265190AC)					
Ratchet Housing, Boom Hoist:					
Inside Diameter	3.5433	3.5442			
Outside Diameter of Bearing 21OW	3.5427	3.5433			
Inside Diameter of Bearing 210W	1.9680	1.9680			
Outside Diameter of Bearing 210WD					
Inside Diameter of Bearing 21OWD					
Total Assembled Feeler Backlash Limits			0.016	0.024	.125
Running Pitch Diameter		7.215			.125
Running Total Assembled Feeler Backlash			0.009	0.028	
Based On a Center Distance of 18.640 +0.005 -0.010					
Outside Diameter of Housing		10.5			
520635K1					
Bushing:					
Inside Diameter	0.749	0.751			.025
Outside Diameter	1.001	1.003			
603216K2					
Cam:					
Cam Inside Diameter	1.093	1.095			0.10
Bushing Outside Diameter 503546KI 1		1.094			
Bushing Inside Diameter	1.0015	1.0030			030
Lever Inside Diameter	1.000	1.001			
619385K1					
Sprocket, Boom Hoist:					
Inside Diameter	20.995	21.005			
Caliper Diameter	24.835	24.846			
Sprocket Width	0.563	0.575			
80 Cut Teeth, I Inch Chain Pitch, 25.471 Inch Pitch Diameter					
Chain ASA o80, Roller I Inch Pitch, Single Strand, Riveted Type					
619464K1					
Ratchet, 16 Tooth, Boom Hoist:					
Inside Diameter	8.377	8.379			.125
Hole Diameter (3)	1.002	1.003			
703487K 1					
Lowering Control Shaft:					
Diameter At Bearing 210W and Ratchet Housing (LH)	1.9675	1.9681			
Diameter at Bearings 210WD (Center)	1.9686	1.9690			
Diameter at Anchor Bracket, Bearing *210W, Spacer and Collar (RH)	1.9675	1.9681			
Diameter at Ends of Shaft	1.874	1.876			
Shaft Inside Diameter (RH)	1.123	1.125			
L03954-B					
Bali Bearing 210 GWD:					
Inside Diameter	1.9680	1.9685			
Outside Diameter	3.5427	3.5433			

Table 2-2. Reference Data-Continued

2. Crane dimensions, tolerance and wear limits

Component points of measurement	Manufacturer's dimensions and tolerance in inches		Desired clearance		Maximum allowable wear and clearance
	Minimum	Maximum	Minimum	Maximum	
Individual Ring Width.....7824.7874					
503544K 1					
Bushing					
Inside Diameter	1.2515	1.2530			050
Outside Diameter	1.343	1.344			
503546KI					
Bushing:					
Inside Diameter	1.0015	1.0030			.030
Outside Diameter		1.094			
505705K 1					
Bushing:					
Inside Diameter	1.001	1.003			.025
Outside Diameter		1.094			
505825KI					
Lining, Brake Band					
Thickness			0.25		
514285K1					
Lining. Band, Boom Hoist Brake					
Thickness			0.25		
D246650					
Ball Bearing MRC210-M:					
Inside Diameter	1.9680	1.9685			
Outside Diameter	3.5427	3.5433			
Individual Ring Width.....	0.7824	0.7874			
D2-46651					
Ball Bearing MRC210-MF:					
Inside Diameter	1.9680	1.9685			
Outside Diameter	3.427	3.433			
Individual Ring Width.....	0.7824	0.7854			
M-1941C					
Ball Bearing 210W:					
Inside Diameter	1.9680	1.9685			
Outside Diameter	3.5427	3.5433			
Individual Ring Width.....	0.7824	0.7874			
265846					
Booster Housing Bore	3.506	3.508			.125
Booster Housing Pin Bore	0.750	0.752			.025
Booster Housing Pin Outside Diameter	0.745	0.747			.050
288350					
Cam Roller					
Cam Roller Bore.....	0.505	0.506			.025
Cam Roller Outside Diameter.....	1.25				.050
290886					
Collar (Used on Boom Hoist Lowering Control)					
Collar Inside Diameter.....	1.967	1.968			.125
Collar Outside Diameter	2.495	2.505			
706066K 1					
Front Shaft:					
Charge shaft bent beyond .030 at any point.					
Diameter at Shifter Sleeve 232774 and Clutch Driver 7082801(1.....	2.874	2.876			
Diameter at Clutch Housing 804134KI, Gear Y-780-A, Spacer 511257K1, wad4 Bearing 215-W	2.9517	1 2.9523			

Table 2-2. Reference Data-Continued

2. Crane dimensions, tolerance and wear limits

Component points of measurement	Manufacturer's dimensions and tolerance in inches		Desired clearance		Maximum allowable wear and clearance
	Minimum	Maximum	Minimum	Maximum	
Diameter at Hoist Gear 268029	3.732	3.733			
Diameter at Hoist Gear 268029	3.7401	3.7408			
Diameter to Right End of Shaft	3.9355	3.9363			
Diameter at Right End of Shaft	3.1495	3.1501			
706067K 1					
Rear Shaft:					
Change shaft if bent beyond .030 at any point.					
Diameter at Shifter Sleeve and Clutch Driver	2.874	2.876			
Diameter at Clutch Housing 804134K1, Gear Y-7807-A, Spacer 511257K1, and Bearing 215-W	2.9517	2.9523			
Diameter at Hoist Gear 268028	3.732	3.733			
Diameter at Hoist Gear 268028	3.7401	3.7408			
Diameter to Right End of Shaft	3.9355	3.9363			
Outside Diameter at Right End of Shaft	3.1495	3.1501			
Inside Diameter at Right End of Shaft	2.4985	2.5000			
804143KI					
Clutch Housing, Hoist Shaft:					
Inside Diameter at Bearings	5.249	5.253			
Outside Diameter of Hub	6.503	6.504			
Note. Place cup 606974 K21 over end of shaft Insert capscrew and tighten driver against bearing to provide tight assembly between bearings and spacer and to give proper squeeze to O-ring. Clamp driver in place, remove cup and capscrew. Clutch rotates clockwise when viewed from end. Shifter sleeve has 1-11/16 inch total travel between set and released positions.					
808727K3					
Clutch Housing, Drag, Backhaul:					
Inside Diameter at Bearing 220WD	7.0864	7.0876			
Outside Diameter of Bearing 220WD	7.0856	7.0866			
Inside Diameter of Bearing 220WD	3.9362	3.9370			
Outside Diameter of Hub	8.498	8.500			
Inside Diameter at Bearing 120-WD 2N	6.2990	6.3002			
Outside Diameter of Bearing 120-WD-2N	6.2982	6.2992			
Inside Diameter of Bearing 120WD-2N	3.9362	3.9370			
Outside Diameter of Flange at Housing	8.623	8.625			
Outside Diameter of Housing		27.5			
813677K 1					
Hoist Drum, 17 Inch Pitch Diameter, Rear Shaft:					
Inside Diameter at Bearing F345, 120Wd2N	6.2990	6.3002			
Outside Diameter of Bearing F345, 120WD2N	6.2982	6.2992			
Inside Diameter of Bearing F345, 12OWD2N	3.9362	3.9370			
500665K 1					
Bushing (Toggle Yoke):					
Inside Diameter	0.625	0.626			.030
Outside Diameter	1.123	1.124			
500682K1					
Bushing (Toggle Yoke):					
Inside Diameter	1.127	1.129			.050
Outside Diameter	1.376	1.378			
520650K1 (Meshes with Part No. 610203K1)					
Gear					
Inside Diameter	6.500	6.501			
Total Assembled Feeler Backlash Limits			0.016	0.024	.125
Running Total Assembled Feeler Backlash			0.009	0.028	
520661K1					
Bushing					
Inside Diameter	1.003	1.004			.030
Outside Diameter.	1.251	1.252			

Table 2-2. Reference Data-Continued

2. Crane dimensions, tolerance and wear limits

Component points of measurement	Manufacturer's dimensions and tolerance in inches		Desired clearance		Maximum allowable wear and clearance
	Minimum	Maximum	Minimum	Maximum	
525550K1					
Main and Swing Clutches Band Lining Thickness.....		3/8"			
525552KI					
Main and Swing Clutches Band Lining Thickness.....		3/8"			
618483 (Meshes with 200442, 61741K2)					
Hoist Gear, Rear Shaft, 74 Tooth					
Inside Diameter	3.729	3.731			
Outside Diameter		30.000			
Total Assembled Feeler Backlash Limits			0.016	0.024	125
Running Total Assembled Feeler Backlash based on Center Distance Variations of +0.015, -0.010 Inch			0.009	0.028	
D247204					
Ball Bearing MRC215-M:					
Inside Diameter	2.9522	2.9528			
Outside Diameter	5.1173	5.1181			
Individual Ring Width.....	0.9793	0.9843			
M4381-C					
Bali Bearing 120WD-2N:					
Inside Diameter	3.9362	3.9370			
Outside Diameter	6.2982	6.2992			
Individual Ring Width.....	1.0974	1.1024			
232405					
Clutch Driver Bore.....	2.875	2.876			
232489					
Clutch Driver Bore.....	3.937	3.938			
232774					
Shifter Sleeve Bore	2.878	2.880			.125
269885					
Toggle Lever Bore	1.630	1.632			060
Toggle Lever Bushing Outside Diameter	1.626	1.628			.025
Toggle Lever Bushing Inside Diameter.....	1.254	1.255			.025
520663K1					
Bushing:					
Inside Diameter	1.003	1.005			.060
Outside Diameter	1.495	1.497			
516295KI					
Bushing, Vertical Propel Shaft:					
Inside Diameter	4.886	4.888			.150
Diameter					
Outside Diameter	5.629	5.631			
520597K 1					
Bushing, Center Gudgeon:					
Inside Diameter	4.386	4.388			
Outside Diameter	5.130	5.131			
5M603L1					
Bushing, Horizontal Propel Shaft:					
Inside Diameter	5.262	5.264			.125
Diameter					
Outside Diameter	6.004	6.006			
5M605KI					
Bushing, Outer Clutch:					
Inside Diameter	4.011	4.013			.125 diameter
Outside Diameter	4.754	4.755			
506456KI					
Bushing, Take-Up Idler:					
Inside Diameter	3.515	3.517			.250
Diameter					
Outside Diameter	4.130	4.131			
570684KI1					
Bushing, Drive Tumbler:					

Table 2-2. Reference Data-Continued

2. Crane dimensions, tolerance and wear limits

Component points of measurement	Manufacturer's dimensions and tolerance in inches		Desired clearance		Maximum allowable wear and clearance
	Minimum	Maximum	Minimum	Maximum	
Inside Diameter	4.386	4.388			.250 Diameter
Outside Diameter	5.129	5.130			
506459K1I Bushing Roller:					
Inside Diameter	2511	2.512			250 Diameter
Outside Diameter	3.001	3.003			

3. Specific engine torque data

Component point of measurement	Minimum	Maximum
Engine Mounting Capscrews	20 ft.4b.	21 t.-lb.
Cylinder Block Pipe Plugs		
1/8 in	5ft.-lb.	15 ft.-lb.
1/4 in	20 ft.4b.	25 ft.-lb.
3/8 in	25 ft.-lb.	35 ft.-lb.
1/2 in	15 ft. lb.	20 ft.-lb.
3/4 in	60 ft.-lb.	70 ft.-lb.
Main Bearing Capscrew Tightening:		
1. Tighten to	65 ft.-lb.	75 ft. lb.
2. Advance to	140 ft.4b.	150 ft.-lb.
3. Loosen	All	
4. Tighten to	45 f.-lb.	50 ft.-lb.
5. Advance	600	
Crankshaft Pipe Plugs		5 ft.4b.
Template Tightening U Bolt Nuts:		
1. Tighten to	15 ft.-lb.	20 ft.-lb.
2. Advance to	30 ft.-lb.	
3. Loosen	All	
4. Tighten to	15 ft4b	20 ft.-lb.
5. Advance to	30 ft4b.	
6. Advance	60°	
Torque Check	38 fL4b.	
Cylinder Head Pipe Plugs		
1/8 in.	ft.-lb.	10 ft.-lb.
Fuse Plug	5 ft. lb.	10 ft.-lb.
3/8 in.	35 ft4b.	45 ft.-lb.
1/2 in	60ft. lb.	70 ft.-lb.
3/4 in.	65 ft.-lb.	75 ft.-lb.
I in.	135 ft.-lb.	145 ft.-lb.
*Injector Hold Down Capscrews	10 fL4b.	12 ft.-lb.
Gear Cover Mounting Capscrews	30 ft.4b.	35 ft.-lb.
Camshaft Thrust Plate Capscrews	30 ft-lb.	35 ft.-lb.
Tappet Guide Screws	95 ft.-lb.	115 ft.-lb.
Fuel Inlet and Drain Connections	20 ft.-lb.	25 ft.-lb.
Cylinder Head Capscrews	390 ft4b.	400 ft.-lb.
Gear Cover Capscrews	30 ft. lb.	35 ft.-lb.
Vibration Damper Flange Capscrews	120 ft.4b.	140 ft.-lb.
Flywheel Housing Capscrews	80 ft.4b.	100 ft.-lb.
Flywheel Mounting Capscrews	100 ft.-lb.	110 ft.4b.
Exhaust Manifold Capscrews or Stud Nuts		25 ft.-lb.
Accessory Drive Pulley Capscrew or Nut	90 ft.4lb.	100 ft.-lb.
Fuel Filter Fitting and Mounting Capscrews	25 ft.-lb.	30 ft lb.
Fan Hub Nut	400 ft.-lb.	450 ft.-lb.
Injector and Valve Adjustment	60 ft.-lb.	70 ft.-lb.
Shut-Down Valve	15 in.-b.	20 in.-lb.
Fuel Pump Drive Cover Capscrews	90 in.-lb.	95 in.-lb.
Injector Cup	45 ft.-lb.	

4. General engine torque data

Bolt body size					
Inches	**Thread**	**Grade 1 or 2**	**Grade 5**	**Grade 6**	**Grade 8**
¼	20	5	8	10	12
	28	.6	10		14
5/16	18	11	17	19	24
	24	13	19		27
3/8	16	18	31	34	44
	24	20	35		49
7/16	14	28	49	55	70
	20	30	55		78
½	13	39	75	85	105
	20	41	85		120
9/16	12	51	110	120	155
	18	55	120		170
5/8	11	83	150	167	210
	18	95	170		240
¾	10	105	270	280	375
	16	115	295		420
7/8	9	160	395	440	605
	14	175	439		675
	18	235	590	660	910
	14	250	660		990

5. Miscellaneous data

a. Crankshaft Dimensions (146450)

A	B	D	E
39.3700	2.4950	3.8750	2.6235
39.3900	2.5050	3.8750	2.6250
F	G	X	J
1.4320	2.0000	1.1510	1.4320
1.4420	2.0030	7.1610	1.4420
K	L	M	
1.4340	0.1410	54980	
1.4360	0.1640	5.5000	

5. Miscellaneous data--continued

b. Magna-Flux Magnetization (4-Turn Coil)

Direction of Deflect	Longitudinal	Circumferential
DC or rectified AC	1200 Amps	360000- 0 Amp Turns
AC Equipment	1400 Amps	4200-4700 Amp Turns
Magnetizing Method	Head Shot	Coil Shot

c. Camshaft Keys

		Amount of Offset	
Part No.	**Color**	**Cam Degree**	**Dimension**
S-302	None	0	0

d. Valve Setting

Valve		70°F	90°F
Intake		0.017	0.015
Exhaust		0.027	0.025

e. Injector Timing Specifications **5. Miscellaneous data**--continued

			Push Tube Travel		
Engine Model	**Crank Angle**	**Piston Travel**	**Normal**	**Fast**	**Slow**
JN	19° BTC	-0.1711	-0.0295	-0.0265	-0.0315
	12° BTC	-0.0689	-0.0162	-0.0137	-0.0172
	5° BTC	-0.0120	-0.0055	-0.0037	-0.0067

Table 2-2. Reference Data--Continued.

f. Injector Spring Data

Part Number	9337
Free Length	1-7/8 inches
No. Coils	8-1/2
Wire Diameter	.177inches
Pounds Required to Compress	135/149

5. Miscellaneous data--continued

g. Injector Cap Gaskets

Part Number	62410
Gasket Notches	None
Body and Plunger Size Markings	A B C D 0-1-2-3-4-5-6-7-8

h. Cranking Motor—Cable sizes.

Circuit Voltage	Max. Circuit Resistance	100 Ft.	1000 Ft.	110000 of Two #8	Two #09
12-V	0.001 Ohm	To 10	10/12	12/15	15/19
Starting Motor	0.00075 Ohm	To 6	6/8	8/10	10/13
24V to 32V	0.002 Ohm	To 20	20/27	27/35	35/45

i. Normal Lubricating Oil Pressure

Idle	10/30 PSI
Rated Speed	40/75 PSI

j. Shut-down Valve.

Part Number	134074
Type	24 VDC Single Terminal
Coil Resistance	30 ± 2 Ohms

k. Governor Plungers.

Code	Red	Blue	Green	Yellow	Brown	Black	Gray	Purple
Size	0	1	2	3	4	5	6	7
Part No.	169660	169661	169662	169663	169664	169665	169666	169667

l. Governor Spring

Part No.	107787
Code	Yellow/Blue
Wire Diameter	.072
Number Coils	12.5
Pounds Load	8.75/7.45
Length	1.12 in.
Free Length	1.522/1.442

m. Throttle Shaft ½'' PT.

Code	Red	Blue	Green	Yellow	Brown	Black
Size	0	1	2	3	4	5
Part No.	157940	157941	157942	157943	157943	157944
Type	Solid Shaft					

n. Idle Spring Plunger

Code 200
Part Number 145959
Counter Bore Diameter .3985/.4015

o. Oversize Governor Plungers (service replacement only)

Part Number	Size	Dia. Inches	Color Code
154460	0	0.31140/0.31159	Red
154463	1	0.31160/0.31179	Blue
168906	2	0.31220/0.31239	Green
168907	3	0.31250/0.3i269	Yellow

Table 2-2. Reference Data--Continued.

Part Number	Size	Dia. Inches	Color Code
154461	0	0.31140/0.31159	Red
154462	1	0.31160/0.31179	Blue
168908	2	0.31220/0.31239	Green
168909	3	0.31250/0.31269	Yellow

p. Fuel Pump.

Pump Size	Gear Width	Gear Packet Depth
¾"	0.7483/0.74861	0.7478/0.7483

q. Torque Springs.

Part Number	142698
Color Code	White/Brown
Wire Diameter	.035
Number Coils	6.73
Pounds Load at Length Inches	1.16/1.24 at .350
Free Length	.640/.660

r. Generator Belt Tension.

Belt Width	Deflection Per Ft. Of Span
1/2	13/32
11/16	13/32
3/4	7/16
7/8	1/2
1	9/16

s. Dynameter Test

Model	JN-6-1
Max. HP	130 at 2500
Max. Fuel Rate	55 lb./hr.
Rating at Altitude Max.	Sea level
Crankcase Pressure (ST-487)	5 in. of Water
Phase I to Temperature	56 at 1875
Phase 2 15 Minutes	97 at 2500
Phase 3 15 Minutes	111 at 2500
Phase 4 15 Minutes	117 at 2200
Power Check 5 Minutes	125 at 2500

t. Regrooving Tool Block

Engine Series	Thickness Spacer	Center of Pilot Pin to Center of Cutter
J	0.140	2.388/2.392

u. Hose Sizes

	Minimum Size
Full-Flow Filter	No. 12
Turbo Oil Supply	No. 6
Turbo Oil Drain	No. 16

v. Hose Bends

Hose Size	Inside Diameter	Outside Diameter	Minimum Bend Radius
4	3/16	31/64	2
5	1/4	31/64	2 1/4
6	5/16	39/64	2 3/4
8	13/32	47/64	4 5/8
10	1/2	53/64	5 1/2
12	5/8	61/64	6 1/2

Table 2-2. Reference Data—Continued.

Hose Size	Inside Diameter	Outside Diameter	Minimum Bend Radius
16	7/8	1 13/64	7 3/8
20	1 1/8	1 31/64	9
24	1 3/8	1 23/32	11

w. Thermostats

	Initial	Final
High Range	180° F	195° F

6. Shovel Dimensions Tolerances and Wear Limits

Component points of measurement	Manufacturer's dimensions and tolerances in inches		Desired clearance		Maximum allowable wear and clearance
	Min.	Max.	Min.	Max.	
Boom Point Suspension Sheave Bushing	2.507	2.509	.007	.011	2.569"
Pin	2.498	2.500			2.470"
Boom Point Hoist Sheave Bushing	3.014	3.016	.014	.020	3.114"
Pin	2.996	3.000			2.940"
*Boom Foot Pin Bore	2.270	2.280	.020	.034	2.340"
Boom Foot Pin	2.246	2.250			2.220"
*Dipper Trip Guide Sheave	.757	.750	.010	.016	7.90"
Pin	.744	.747			7.17"
Padlock Sheave Bushing	2.507	2.508	.007	.010	2.607"
Pin	2.498	2.500			2.475"
Dipper Door Bushing	2.046	2.078	.046	.081	2.200"
Pin	1.997	2.000			1.875"
Shipper Shaft Bushing	3.515	3.517	.015	.019	3.579"
Shipper Shaft	3.498	3.500			3.470"
Crowd Drum Bushing	3.014	3.016	.014	.020	3.106"
Crowd Drum Pin	2.996	3.000			3.970"

Section IV. REMOVAL AND INSTALLATION OF MAJOR COMPONENTS

2-9. General

This section contains instructions for removal and installation of the crane-shovel engine assembly, 2-10.

2-10. Engine Assembly Removal and Installation

a. Removal.

(1) Remove all lines, fittings and cables necessary for removing the engine and identify each item removed to facilitate the reassembly procedure.

(2) Refer to TM 5-3810-289-12 and remove exhaust system components.

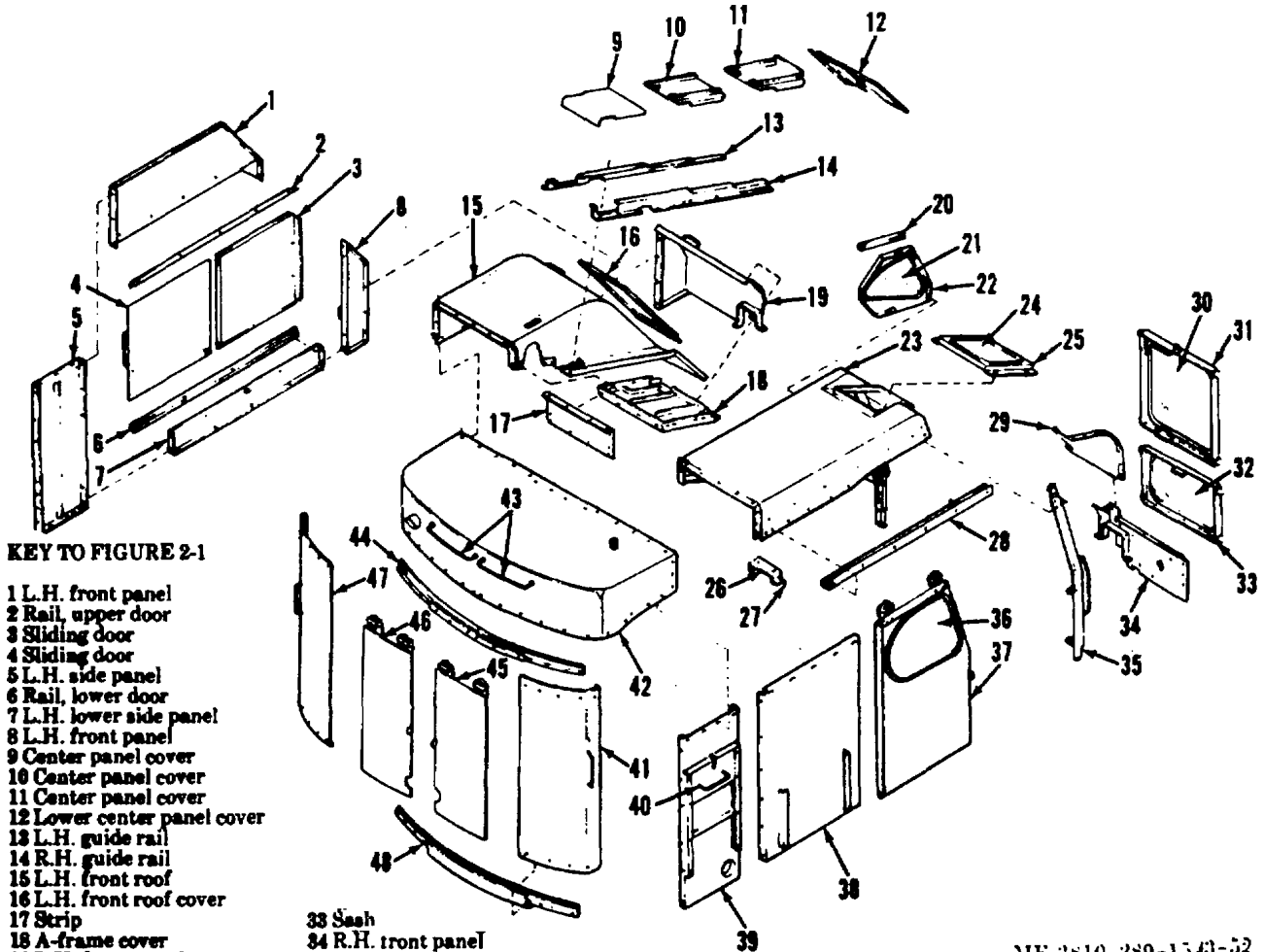
(3) Refer to paragraph 4-2 and remove the transmission chain.

(4) Refer to figure 2-1 and remove cab sections as required.

(5) Remove capscrews holding engine supports to the revolving base (fig. 2-2).

(6) Screw lifting eyes tightly into tapped holes provided in top of cylinder head and remove engine.

b. Installation. Installation procedure is reverse of removal, a above.



KEY TO FIGURE 2-1

1 L.H. front panel
2 Rail, upper door
3 Sliding door
4 Sliding door
5 L.H. side panel
6 Rail, lower door
7 L.H. lower side panel
8 L.H. front panel
9 Center panel cover
10 Center panel cover
11 Center panel cover
12 Lower center panel cover
13 L.H. guide rail
14 R.H. guide rail
15 L.H. front roof
16 L.H. front roof cover
17 Strip
18 A-frame cover
19 L.H. front panel
20 Strip
21 Glass
22 Sash
23 R.H. front roof
24 Glass
25 Sash
26 Spring bracket
27 Spring bar
28 Strip
29 Lower R.H. center panel
30 Glass
31 Sash
32 Glass
33 Sash
34 R.H. front panel
3 Corner post
36 Glass
37 R.H. door
38 R.H. side panel
39 Radiator panel
40 Grab iron
41 Corner post
42 Rear roof
43 Grab irons
44 Strip
45 R.H. rear dooe
46 L.H. rear door
47 Corner post
48 Rear lower rail

Figure 2-1. Cub assembly, exploded view.

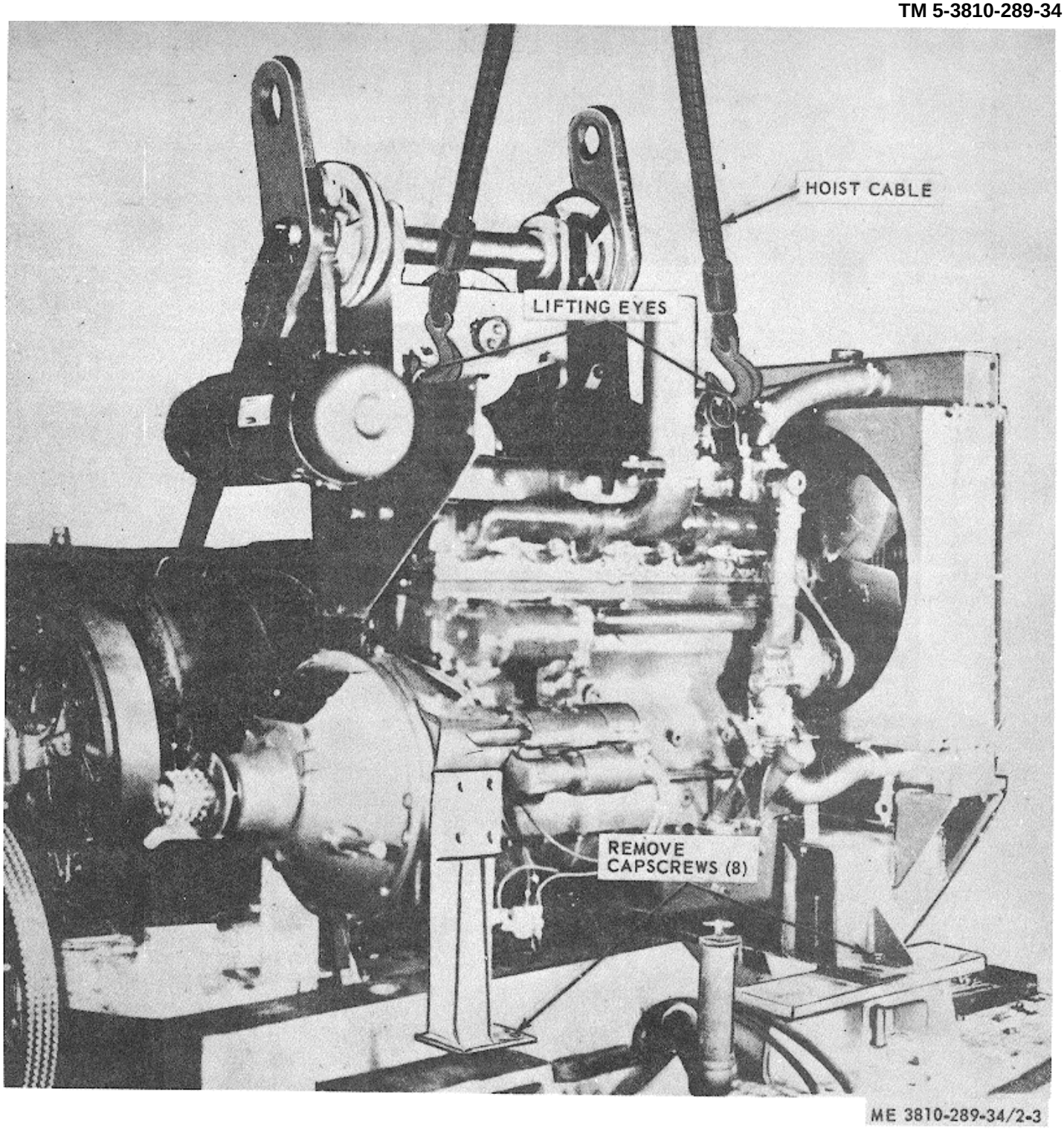


Figure 2-2. Engine assembly removal and installation.

CHAPTER 3
REPAIR OF ENGINE AND ACCESSORIES

Section I. ENGINE ACCESSORIES

3-1. Alternator Assembly

a. General The alternator sustains the operating load requirements and at the same time recharges the batteries for subsequent engine starts. The alternator is self-rectifying, using six rectifier diodes to convert the AC voltage to DC. Voltage regulation is provided by an internally mounted voltage regulator assembly.

Caution: Before performing work on the alternator or associated circuitry several precautions should be observed to prevent damage to the alternator.

(1) When installing a battery, always make absolutely sure that the ground polarity of the battery and ground polarity of alternator are the same.

(2) When connecting a charger to battery, connect charger positive lead to battery positive terminal and charger negative lead to battery negative terminal.

(3) Never operate an alternator on open circuit. Make absolutely certain all connections in the circuit are secure.

(4) Do not short across or ground any of the terminals on the alternator.

(5) Do not attempt to polarize the alternator. This procedure will almost certainly ruin the dicodes.

b. Removal Refer to TM 5-3810-289-12 and remove the alternator.

c. Disassembly. Refer to figure 3-1 and disassemble alternator to the extent necessary to perform the required maintenance.

d. Inspection and Repair. The frequency of inspection is determined largely by the type of operating conditions. High-speed operation, high temperatures, and dust and dirt all increase the wear of brushes and slip rings.

(1) Inspect terminals for corrosion and loose connections.

(2) Inspect wiring for frayed insulation.

(3) Inspect mounting bolts for tightness.'

(4) Inspect belt for proper alinement and tension. Inspect for excessive belt wear.

(5) Inspect slip rings and brushes. These can be inspected through the end frame assembly. Replace brushes if necessary. If slip rings are dirty, clean with fine sandpaper.

Caution: Never clean slip rings with emery cloth. Blow out with compressed air after sanding. If slip rings are rough or out-of-round, alternator must be removed and disassembled so slip rings can be trued in a lathe. The minimum diameter to which the slip rings can be undercut is 0.015 of an inch on each side or a total of 0.030 inch.

e. Reassembly. Reassemble alternator in reverse of disassemblv, c above.

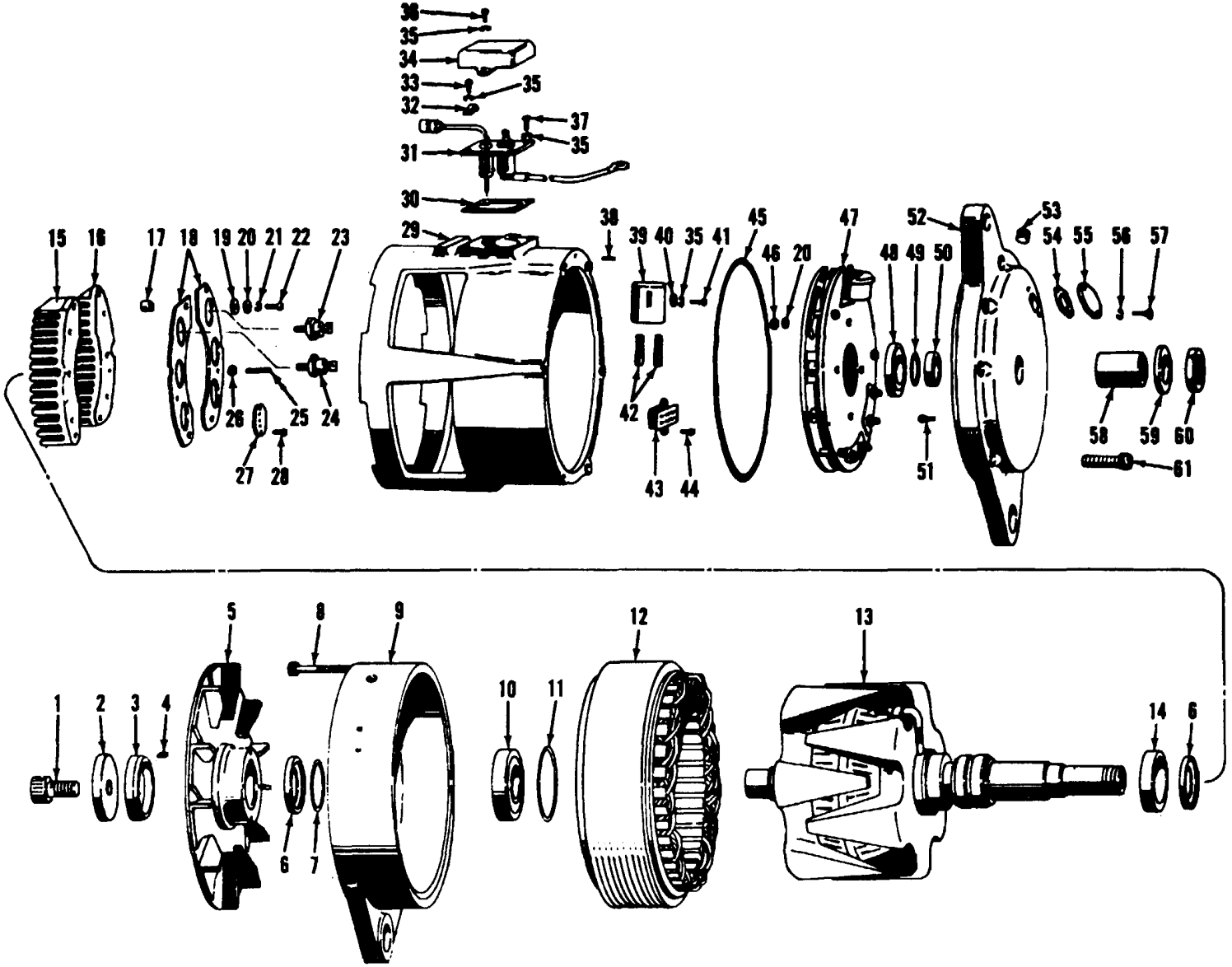


Figure 3-1. Alternator assembly, exploded view.

KEY TO FIGURE 3-1

1 Screw, 1/4 20x 3/4 Fl. Hd.
2 Washer
3 Seal, sleeve
4 Key, 156 Sq. x 'A Lg.
5 Fan & hub assembly
6 Seal, teflon lip (3)
7 O-ring
8 Screw, 1032 x 4% soc. hd. (6)
9 Housing, anti-D.E.
10 Bearing
11 O-ring
12 Stator assembly
13 Rotor assembly
14 Seal
15 Mount rectifier (-)
16 Mount rectifier(--
17 Bushing (3)
18 Insulator, mount (2)
19 Washer, insulation (5)
20 Washer, guard (4)
21 Lockwasher, #10 (2)
22 Screw, 10-32 x 5/8 rd. hd. (4)
23 Silicon rectifier (3)
24 Silicon rectifier (3)
25 Stud, 10-32 x 11/
26 Nut, 10-32 hex
27 Support, insulator
28 Screw, 8-32 x 3/8 rd. hd. (2)
29 Intermediate housing assembly
30 Gasket
61 Screw, ¼-2D x 1 1/8 soe. hd. (6)
31 Capacitor & lead assembly
32 Clamp
33 Screw, 842 x 3/8 fl. hd. (4)
34 Cover
35 Lockwasher, #8 (10)
36 Screw, 82 x ' rd hd (2 rqr)
37 Screw, 842 x 3/8 fil. hd. (4)
38 Dowel pin
39 Brush holder
40 Washer, guard (2)
41 Screw, 832 x 7/16 rd hd. (2)
42 Brush (2 rqr)
43 Socket connector
44 Screw, 6-32 x 3/8 rd. hd. (2)
45 0-ring
46 Nut, 10-32 Hex.
47 Regulator assembly
48 Bearing
49 Spring
5OSpacer
51 Screw, 10-342 x 5/8 soc. hd. (4)
52 Housing, D.E.
53 Pipe plug 'A-18
54 Gasket
55 Plate cover
56 Lockwasher, #6 (2)
57 Screw, flat hd. 6/32 (2,
58 Spacer
59 Washer, guard
60 Nut, 5/8-18 thd. lock

f. Testing.

(1) Bench test. Bench test complete unit as follows:

(a) Make electrical connections as shown in figure 3-2.

(b) Operate alternator at 2000 rpm.

(c) Adjust load resistor for 27.5 to 28-volt reading on voltmeter. If voltage is above or below this reading, readjust by removing pipe plug from top of drive end housing and turning voltage adjusting screw with a small screwdriver. Increase voltage by turning screw counterclockwise; decrease by turning screw clockwise.

Note. Be sure to replace plug after adjustments have been made, to keep out the dirt and moisture.

(d) The ammeter should read 55-60 amperes. A slightly low reading is an indication of an open silicon rectifier. A considerably lower reading is an indication of a shorted silicon rectifier. The latter is usually accompanied by a hum or growling sound made by the alternator.

(2) Rotor test. The rotor can be tested with an ohmmeter and should read 7 to 7.8 ohms from slip ring to slip ring.

Note. Slide the three insulating sleeves away from the splices and unsolder the splices to disconnect rotor from the rectifier.

(3) Stator test.

(a) Ground test. Connect a test light from each stator lead to the stator core or frame of alternator. If the bulb lights, the stator is grounded and must be replaced.

(b) Continuity test. Connect the test light between each phase of the stator. If the bulb fails to light, the stator is open and should be replaced.

(4) Negative heat sink-rectifier test (fig. 3-3). The negative heat sink is grounded to the housing by means of its mounting screws and stud. Be sure that these screws are clean and tight so the negative heat sink makes good contact with the housing. Connect negative lead of ohmmeter to test point one and touch positive lead to terminals 4, 5, and 6. A high resistance reading should be obtained. If a low resistance reading is obtained, the diode is shorted and must be replaced.

g. Installation. Refer to TM 5-3810-28912 and install the alternator.

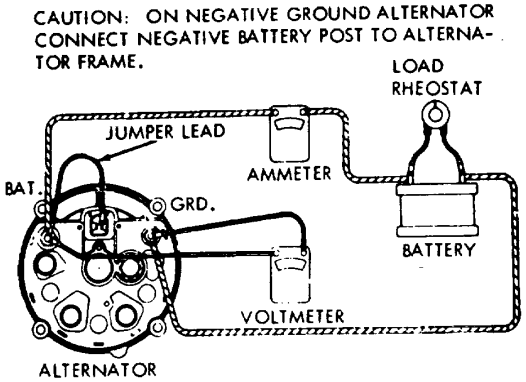


Figure 3-2. Alternator test connections.

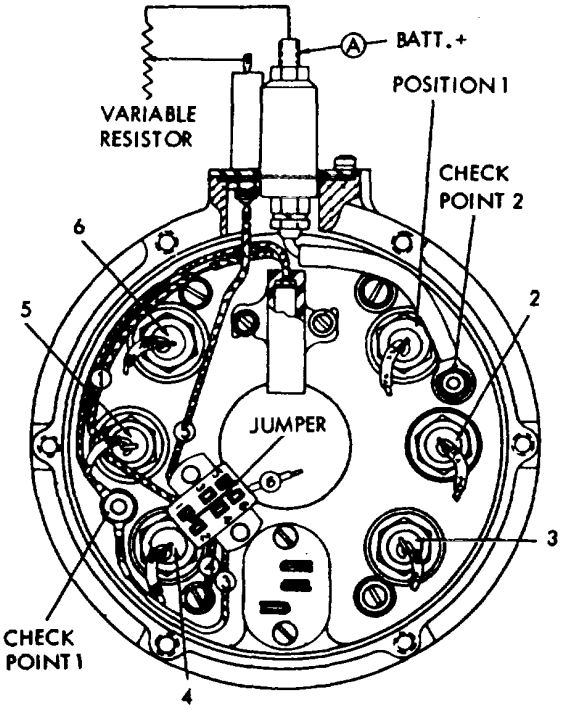


Figure 3-3. Diode rectifier test

3-2. Fuel Pump Assembly

a. General.

(1) The fuel pump consists of a shut down valve, pulsation damper, front drive cover, governor plunger, throttle assembly, gear pump, governor spring pack, filter screen cap, and tachometer drive.

(2) The gear pump section of the fuel pump draws fuel from the fuel tank and delivers it, under pressure, to the injector supply manifold under control of the governing and metering sections of the fuel pump. In this manner, the speed of the engine is controlled by the fuel pump which, in turn, controls the supply of fuel to the engine.

b. Removal.

(1) Remove pump fuel return line (fig. 3-4).

(2) Remove fuel line from solenoid shutdown valve to fuel supply manifold (fig. 3-5).

(3) Remove fuel pump mounting capscrews and lockwashers and lift fuel pump from engine (fig. 3-6). Discard gasket.

(4) Remove and discard buffer from coupling.

c. Disassembly.

(1) Clean and mount.

(a) Clean outside of fuel pump thoroughly with an approved cleaning solvent. Remove lockwires and seals.

Caution: Many solvent cleaners are injurious to aluminum. Make sure your cleaner is suitable before using it on aluminum.

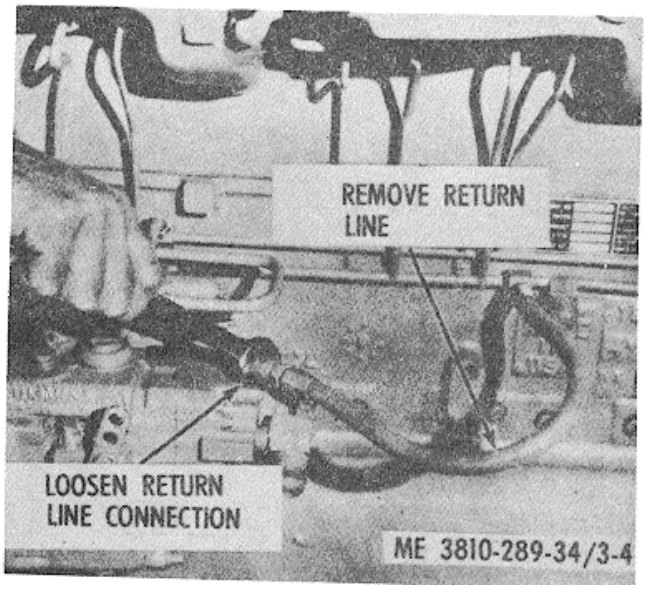


Figure 3-4. Fuel pump return line removal.

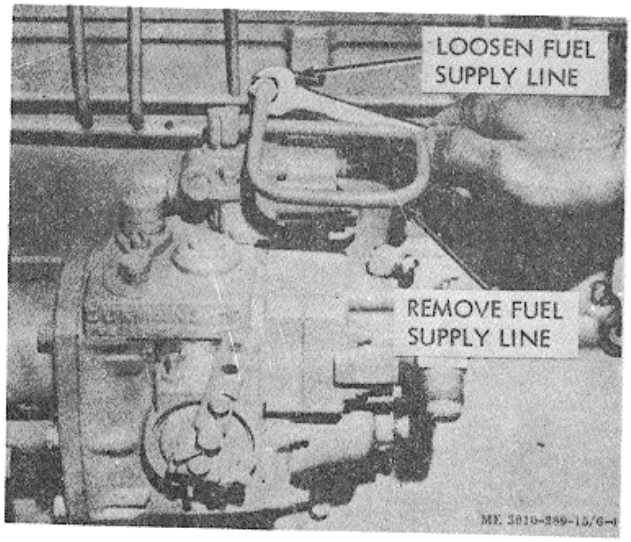


Figure 3-5. Fuel supply line disconnection.

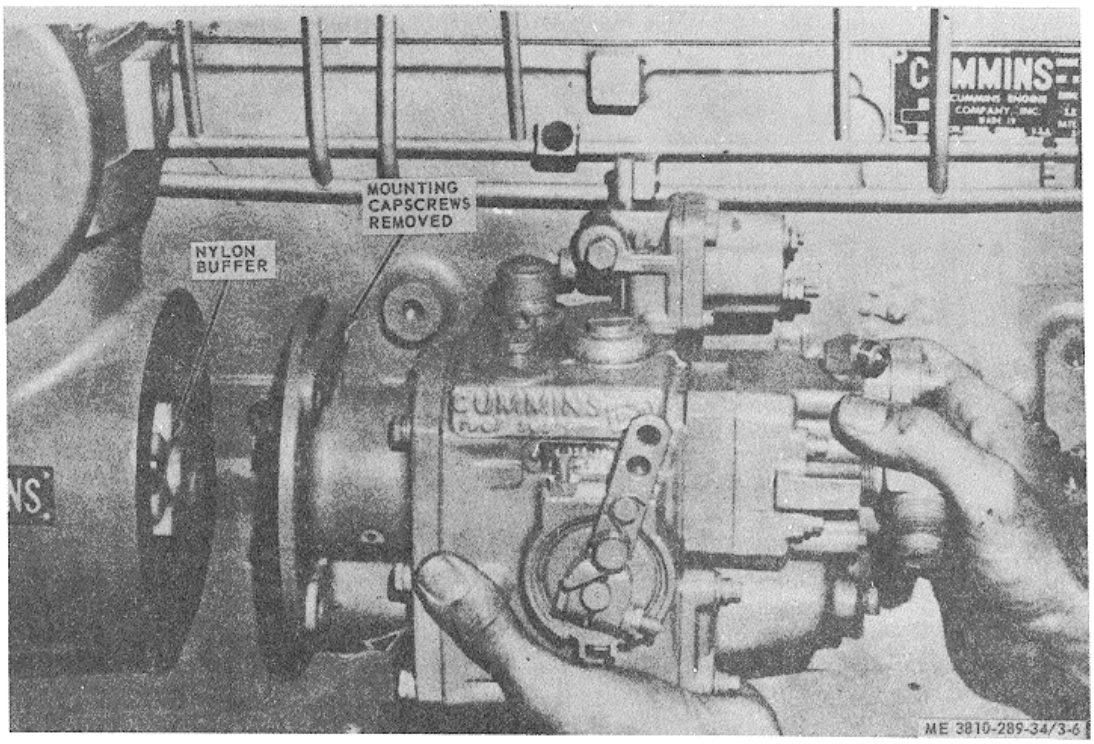


Figure 3-6. Fuel pump removal.

(b) Mount fuel pump on ST-546 Pump Mounting Plate and ST-302 Ball Joint Vise (fig. 3-7).

(2) PT (Type G)fuelpump service cooling kit.

(a) Remove check valve and orifice elbow assembly from bottom or back side of fuel pump.

(b) Clean parts in clean fuel oil and dry with compressed air blown through both ends.

(3) Shut-down valve.

(a) Remove capscrews, lockwashers and flatwashers securing valve to top of main housing (fig. 3-8).

(b) Lift off shutdown valve and discard performed packing.

(4) Pulsation damper.

(a) Remove the capscrews, lockwashers and flatwashers securing pulsation damper to gear pump. Some dampers are fitting mounted and are removed by screwing damper from fitting on gear pump (fig. 3-9).

(b) Lift off damper and discard performed packing.

(5) Front drive cover.

(a) Remove capscrews, lockwashers and flatwashers securing drive cover to main housing (fig. 3-10).

(b) Tap edge of cover lightly with a plastic hammer to loosen.

(c) Lift cover off dowels and discard gasket (fig. 3-11).

Caution: Never use a steel hammer on aluminum, or on a finished surface, it can cause extensive damage.

(d) Remove weight assist plunger, spring and shims from weight carrier assembly.

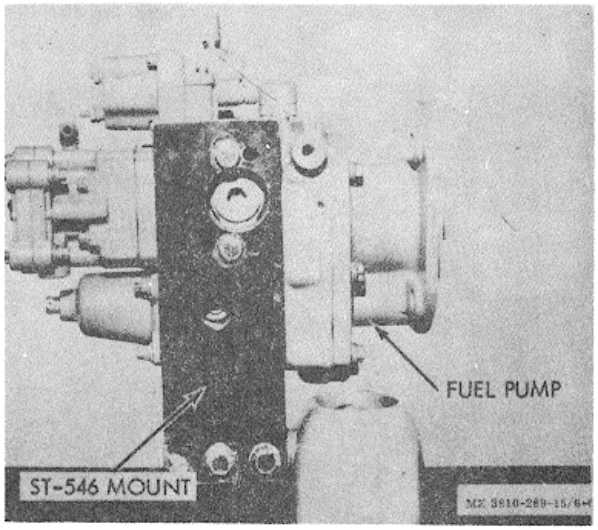


Figure 3-7. Fuel pump mounted to ST-546.

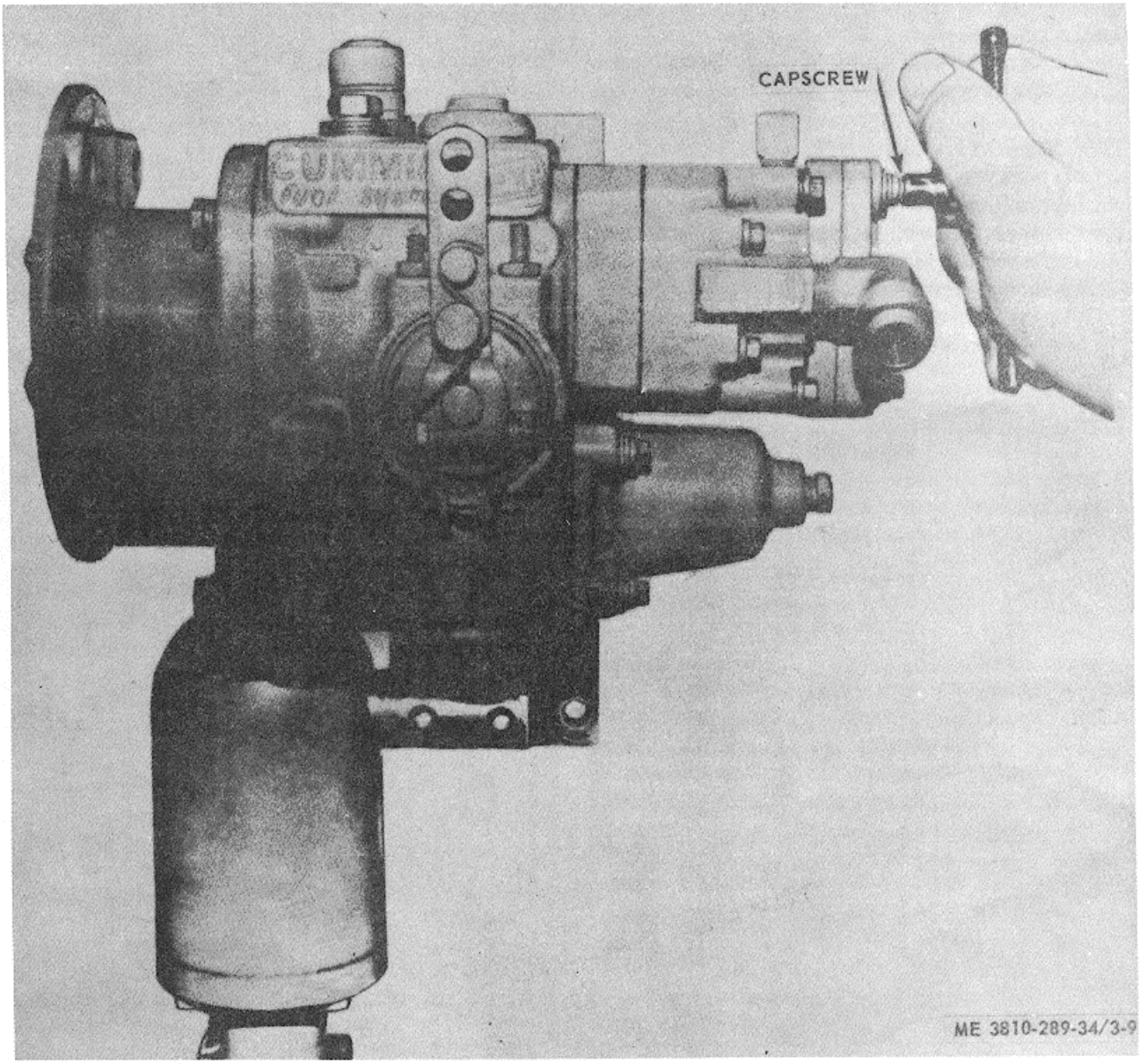


Figure 3-9. Pulsation damper removal and installation.

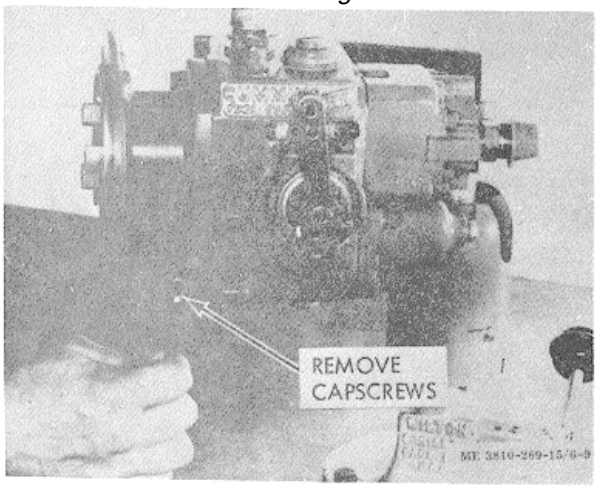


Figure 3-10. Drive cover capscrew removal.

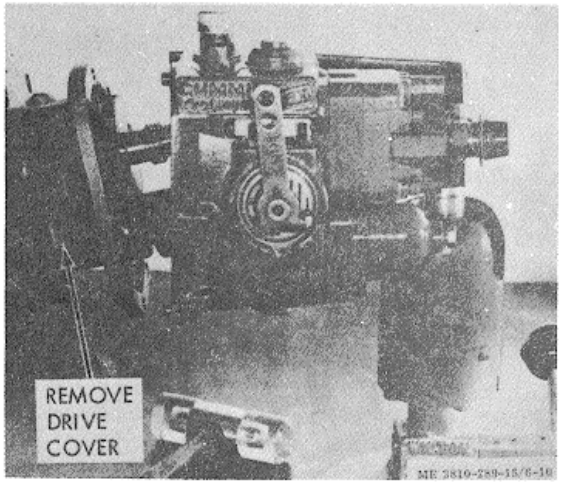


Figure 3-11. Drive cover removal.

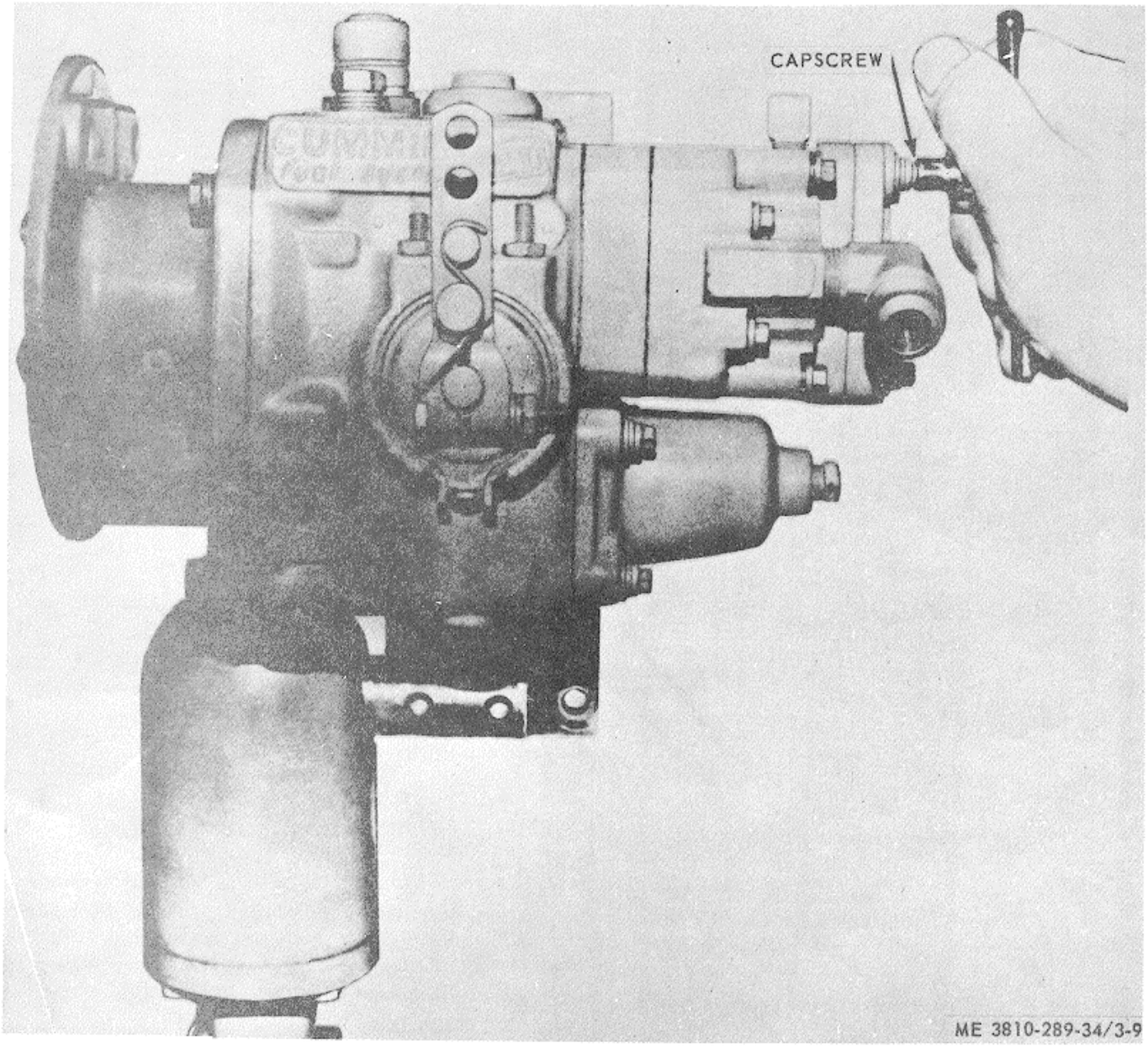


Figure 3-8. Shut down valve removal.

(6) Governor plunger. Slide governor plunger from barrel, figure 3-12.

Caution: Place plunger where it will not be damaged, a slight nick can cause extensive damage.

(7) Throttle assembly.

(a) Compress nameplate retaining ring and remove from groove.

(b) Pull throttle assembly from pump, figure 3-13. The throttle shaft is a select fit in its sleeve and sizes are identified by color code.

Caution: Handle throttle shaft with care.

(8) Gear pump.

(a) Remove capscrews and lockwashers securing gear pump to main housing.

(b) Tap side of gear pump with a plastic hammer to loosen from dowels.

(c) Lift gear pump off and discard gasket; figure 3-14.

(9) Governor spring-pack.

(a) Remove capscrews, lockwashers and flat washers securing governor spring-pack cover to main housing.

(b) Lift off cover and discard gasket, figure 3-15

(c) Remove snap ring which holds governor spring pack in sleeve with a pair of snap ring pliers.

(d) Remove high-speed spring, spring retainer and shims from spring-pack housing.

(e) Remove idle-spring plunger guide, idle spring or springs, idle spring plunger, and spring rest washer, figure 3-16.

(10) Filter screen cap.

(a) Loosen filter screen cover on top of main housing.

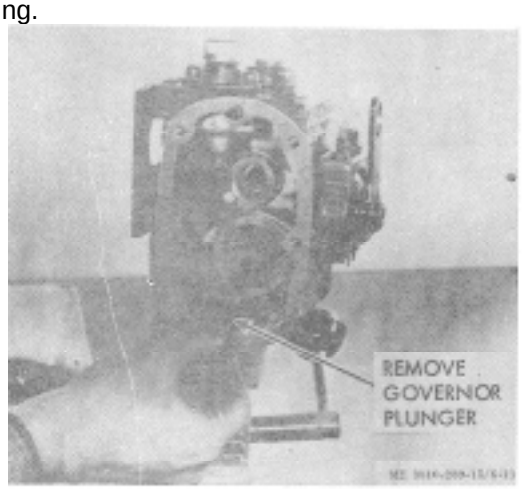


Figure 3-12. Governor plunger removal.

(b) Lift cap, spring and filter screen assembly from main housing; discard performed packing. The screen assembly is made up of a screen, magnet and two retainers. The bottom retainer has a hole in center to permit fuel flow; this retainer is soldered to the screen, figure 3-17.

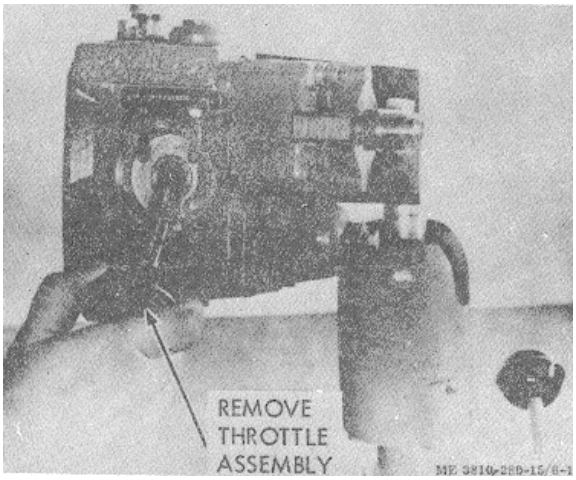


Figure 3-13. Throttle assembly removal.

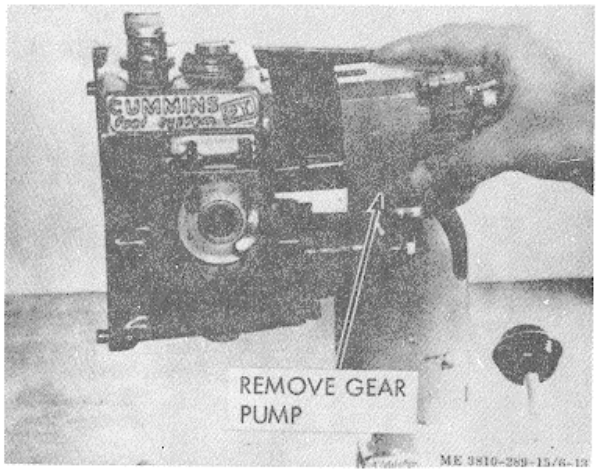


Figure 3-14. Gear pump removal.

Figure 3-15. Spring pack cover removal.

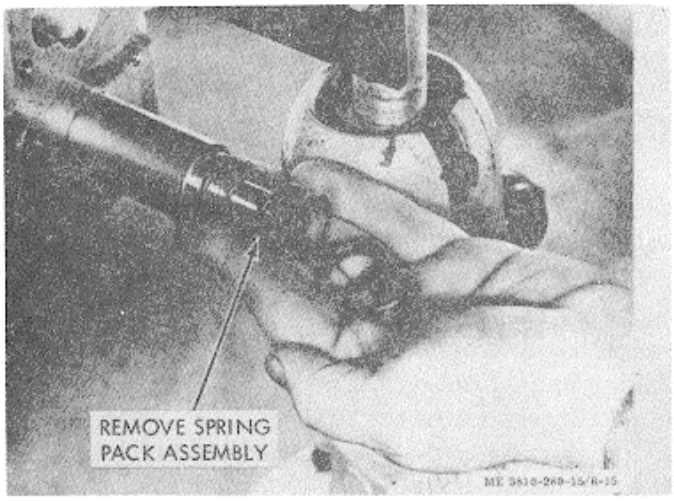


Figure 3-16. Spring pack assembly removal.

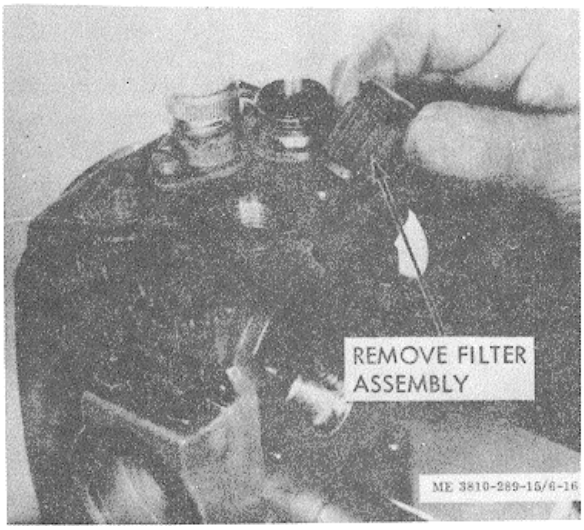


Figure 3-17. Filter assembly removal.

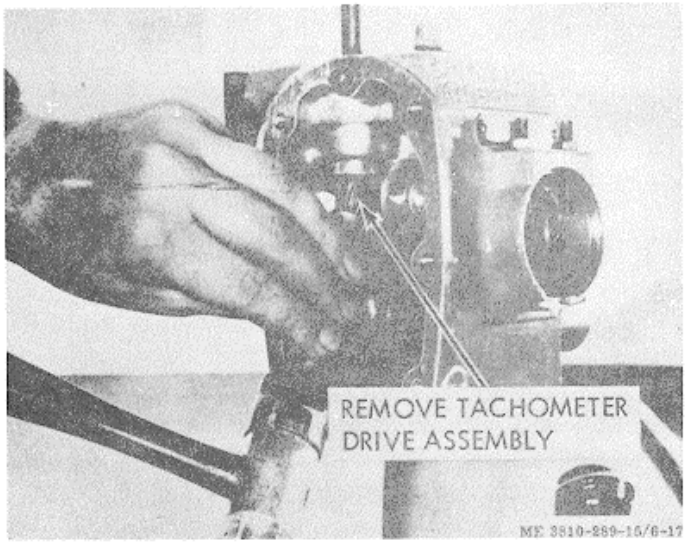


Figure 3-18. Tachometer drive assembly removal.

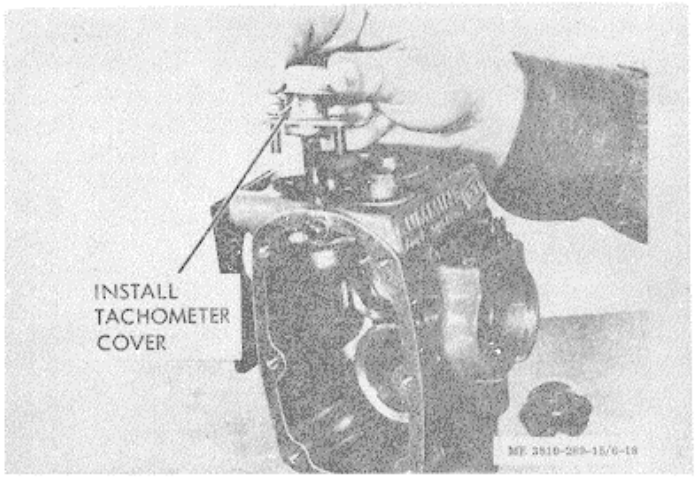


Figure 3-19. Tachometer cover installation.

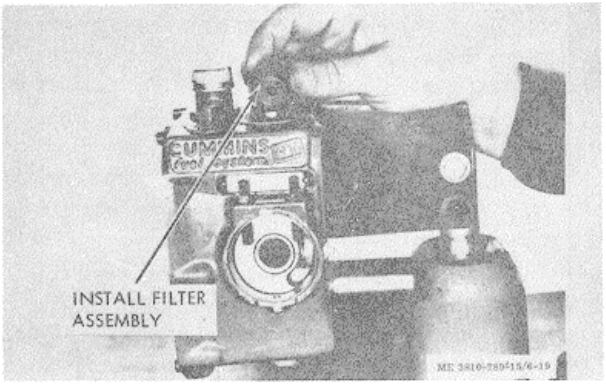


Figure 3-20. Filter assembly installation.

(c) Clean magnet before reassembly; it is soldered to top retainer and is designed to catch particles of iron which are worn or chipped from pump parts or enter with the fuel supply.

Note. Governors have double screen arrangements. The upper screen can not be disassembled.

(11) Tachometer drive

(a) Remove tachometer drive cover screws.

(b) Lift drive cover and gasket from main housing. Discard gaskets.

(c) Carefully drive tachometer drive assembly from main housing, using a brass punch and hammer, figure 3-18.

(d) Remove seal from shaft and discard.

d. Assembly.

(1) Vise and holding figure. Mount the fuel pump housing on Pump Mounting Plate ST-546 and Ball Joint Vise ST-302.

(2) Tachometer drive.

(a) Install tachometer drive assembly into fuel pump main housing. Press assembly into housing using ST430 Mandrel.

(b) Press oil seal on the tachometer drive with sealing lip down. Seal must seat on the drive bushing.

(c) Assemble tachometer cover and new gasket to the fuel pump housing, figure 3-19.

(d) Install screws and washers in cover.

(3) Filter screen

(a) Assemble the filter screen assembly into the housing, the hole in the bottom retainer goes down, figure 3-20.

(b) Install performed packing using grease to hold in place.

(c) Position spring and tighten cover in place. Torque cap to 25/30 ft.-lbs. Overtightening is not necessary or desirable.

Note. MVS governors and special electric governors contain two screen assemblies.

(4) Governor spring pack.

(a) Assemble screw into plunger guide, place small copper washer over screw point inside plunger guide, figure 3-21. Place small idle spring into plunger guide and place idle plunger (button) against spring in plunger guide (fig. 3-22). See table 2-2(5)o for correct plunger to use. The plunger controls maximum fuel pressure produced by the fuel pump. All plungers with code number 170 or higher require adapter part number 144676.

(b) Place the maximum-speed spring over the rear of plunger guide and place shim against spring, install retainer and snap ring securing assembly into governor sleeve (fig. 3-24).

Note. There are different maximum-peed spring available and each is identified by color stripes. See Table 2-2 for tabulation.

Note. Shims are available in P0.005, 10.010 and #0.020 inch thickness. The final number of shims must be determined during fuel pump calibration.

© Install the spring: pack cover and gasket. Install capscrews and washers securing cover to housing.

(5) Gear pump.

(a) Assemble the gear pump to the main housing using a new gasket, figure 3-25. Locate notch to upper right hand corner (looking from behind the fuel pump).

Note. Use correct gasket and be sure it is positioned correctly.

(b) Install capscrews, lock, washers and plain washers: torque in increments to 7/9 ft-lbs, figure 3-26. Check gear pump rotation freedom.

(c) Install fuel inlet connection using a pipe sealer. Use sealer sparingly to keep out of pump. Cover connection to keep out dirt.

(d) Install cooling check valve and/or elbow into top of gear pump.

(6) Throttle shaft (fig. 3-27). Throttle shafts vary with applications. Replace with identical throttle shaft, if replaced, table 2-2.

(a) Install new O-ring on throttle shaft using ST-835 Packing Tool Assembly for 1/2 inch (ST-422 for larger) shaft to avoid damage to O-ring; oil before assembly, figure 3-28.

(b) Insert the throttle shaft in sleeve so the "ears" of the stop are curved downward or if pin is used so open side of pin is down, lubricate with fuel oil.

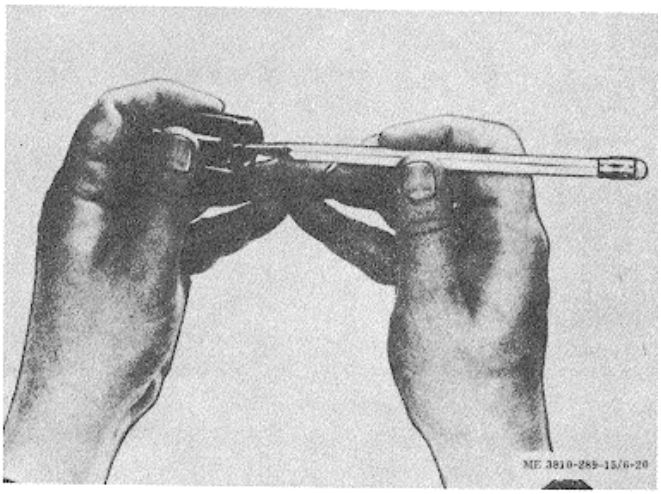


Figure 3-21. Washer being installed over plunger.

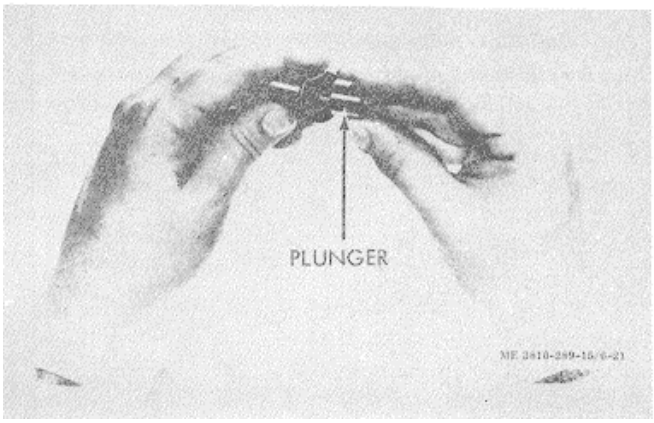


Figure 3-22. Governor plunger installation.

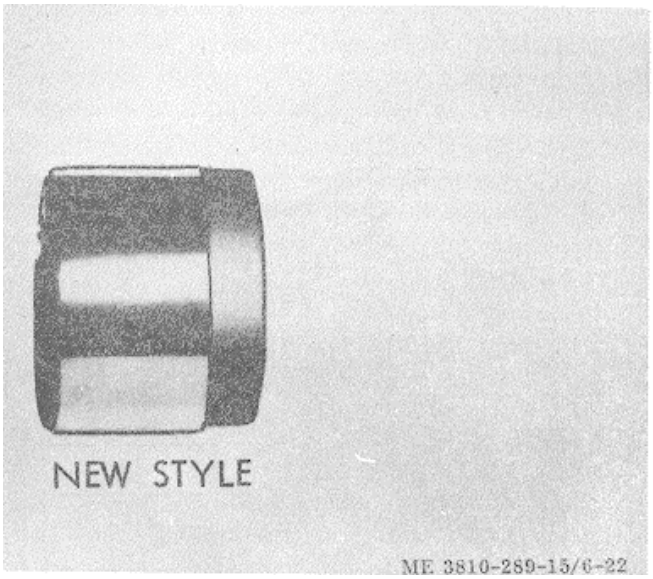


Figure 3-23. Governor idle plunger.

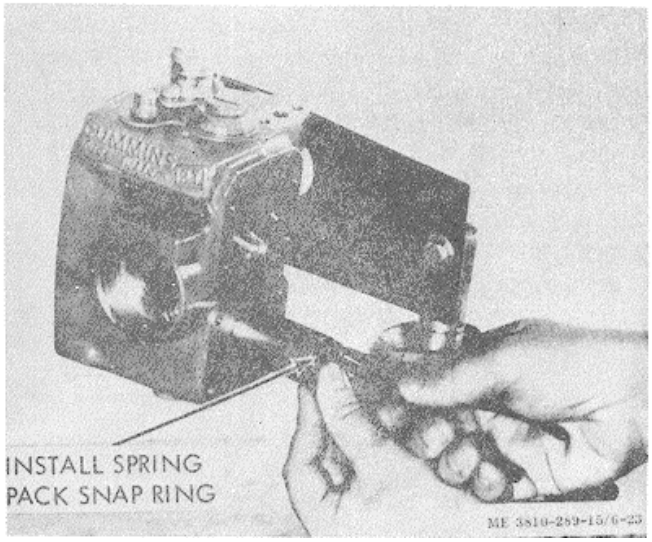


Figure 3-24. Spring pack snap ring installation.

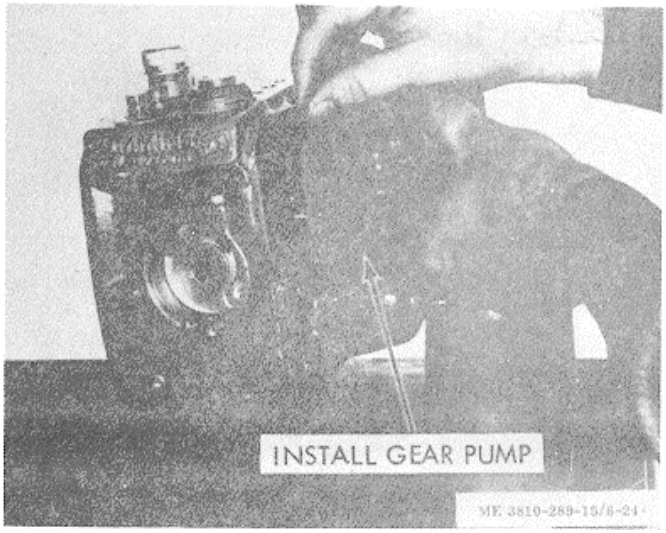


Figure 3-25. Gear pump installation.

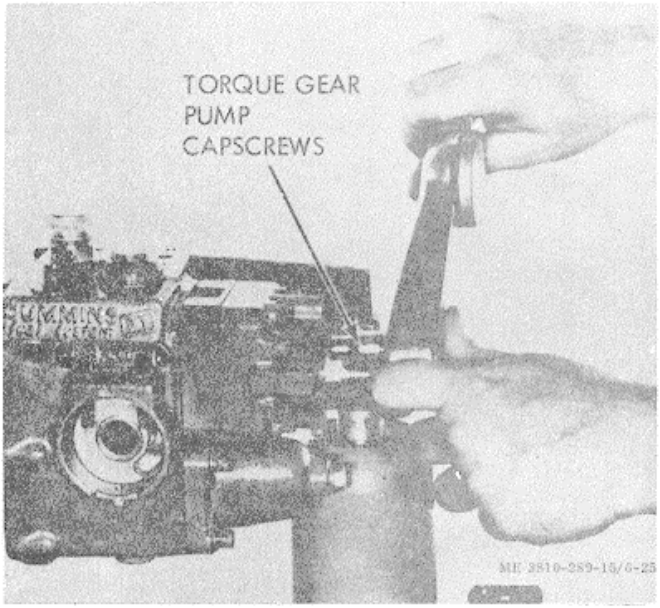


Figure 3-26. Gear pump capscrews, torquing.

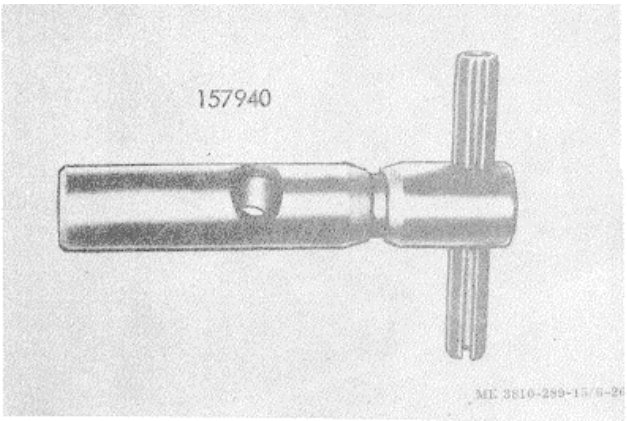


Figure 3-27. Current PT (type G) throttle shaft.

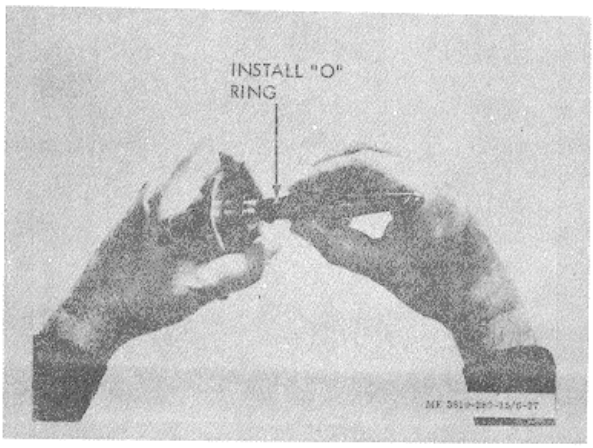


Figure 3-28. Throttle shaft O-ring installation.

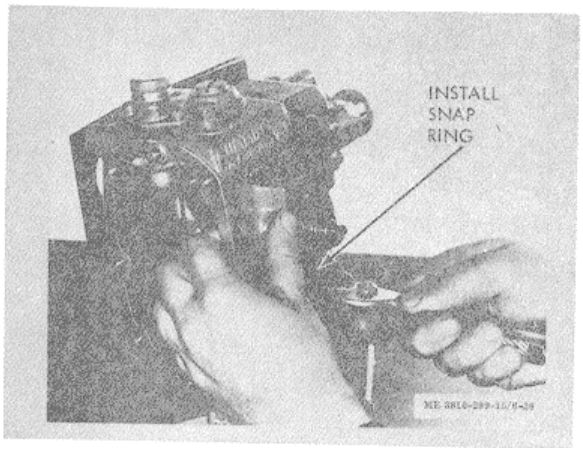


Figure 3-29. Snap ring installation.

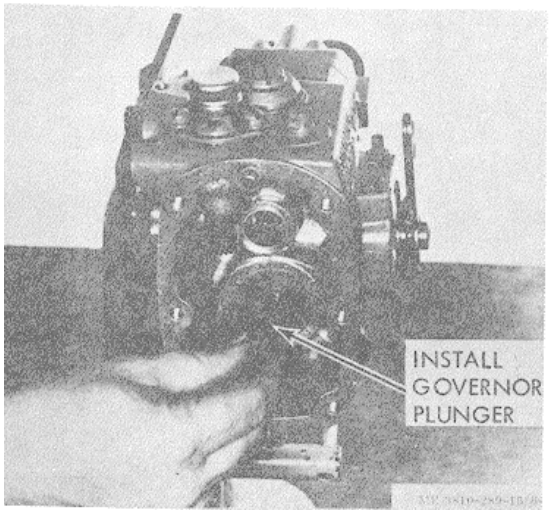


Figure 3-30. Governor plunger, installation.

Caution: Counter bored port on throttle must go down.

(c) Install the snap ring and lock in the groove in front of the nameplate, figure 3-29.

(7) Throttle lever. Install the throttle lever on throttle shaft and tighten securely.

(8) Governor plunger. Lubricate and install the plunger into barrel, figure 3-30. Make sure plunger is correct fit and correct number if replaced. Remark governor barrel if oversize plunger is used, so size of barrel and plunger correspond.

(9) Drive cover assembly.

(a) Place a new gasket over the drive housing cover dowel pins.

(b) Place the assist plunger in the weight shaft bore with spring and shims.

(c) Hold the governor weights in to hold the assist plunger while assembling cover to housing, meshing the tachometer gears, figure 3-31. Position plunger drive tang horizontally-position weight carrier horizontally.

Note. The weights straddle the governor plunger driver.

(d) Assemble the capscrews, flat washers and lockwashers securing cover to housing and torque to 90/95 inch pounds.

(10) Shutdown valve.

(a) Put grease on the O-ring and install the shutdown valve on top the fuel pump housing.

(b) Secure with capscrews, lockwashers and flatwashers.

(11) Pulsation damper.

(a) Put grease on O-ring and install damper to the gear pump.

(b) Secure with capscrews, lockwashers and flatwashers.

(12) Refer to table 2-2, L, R, and T for fuel pump test specifications.

e. Installation.

(1) Mount pump and new gasket to compressor with buffer, figure 3-32, or to accessory drive flange with splined coupling.

(2) Install lockwashers and capscrews; tighten mounting capscrews.

(3) Install No. 10 fuel inlet hose to fuel pump.

(4) Install fuel pump bypass or fuel coolant line.

f. Adjustment.

(1) General. Before making fuel system checks or adjustments on engine be sure the following rules are observed:

(a) Engine is at operating temperature.

(b) Injectors are correct part number, functionally satisfactory, flowed to specifications and properly adjusted in engine.

(c) Camshaft is as specified for engine and particular pump calibration and is in good condition.

(d) Pistons in use are those specified for the particular pump calibration specifications.

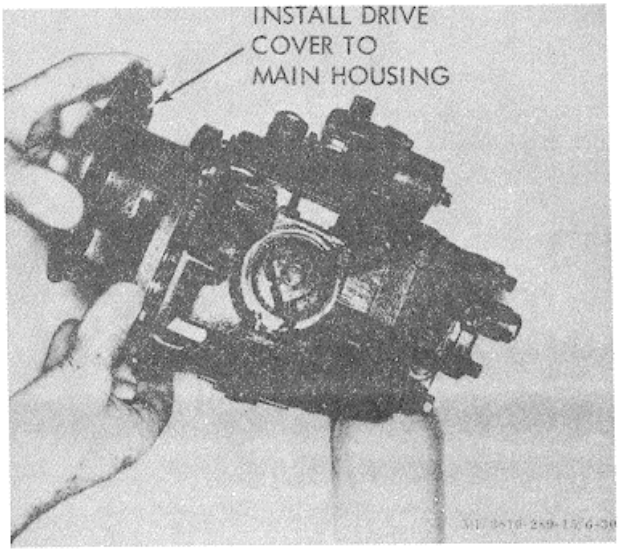


Figure 3-31. Drive cover to main housing installation.

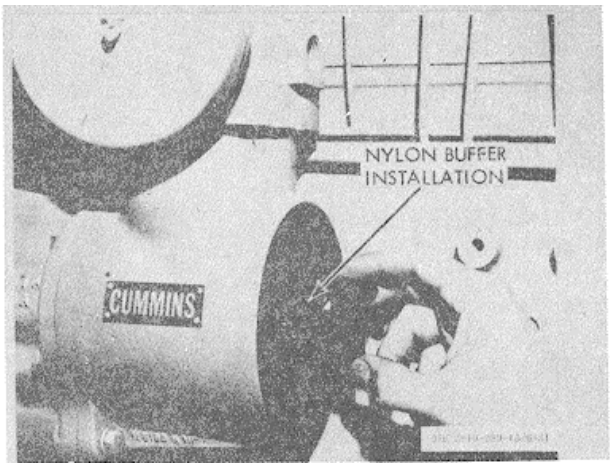


Figure 3-32. Nylon buffer installation.

(e) Instrumentation (gages and tachometers) must have high accuracy.

Caution: Do not alter pump settings to satisfy gages and tachometers of unknown accuracy.

(f) Vehicle throttle control linkage is adjusted so full throttle is obtained and when released throttle is stopped by front throttle adjusting screw (throttle leakage adjusting screw).

Note. Vehicle throttle control linkage should have a maximum throttle stop, so when fuel pump full throttle is obtained override pressure will not be on throttle shaft.

(2) Governor setting.

(a) After fuel pump installation, engine must be operated a sufficient period of time to purge all air from the fuel system and to bring engine up to operating temperature (at least 165 F. oil temperature).

Note. Idle speed adjustment should never be made on a cold engine.

(b) Remove pipe plug from spring pack cover.

(c) The idle adjusting screw is held in position by a spring clip. Turn screw in to increase or out to decrease the speed. Use ST-984 to adjust idle speed while engine is running. This tool seals the spring pack housing, permitting an accurate adjustment.

(d) Replace pipe plug when idle speed is correct.

(e) The maximum and idle adjusting screws are located on governor cover.

1. To adjust idle loosen rear idle adjusting screw lock nut.

2. Screw adjusting screw in or out to get speed required.

3. Tighten adjusting screw lock nut immediately after adjustment to prevent air entrapment.

(f) Some problems with excessive vibrations have occurred at engine idle speeds.

(g) In these cases it has been found that a substantial amount of vibration can be eliminated by an adjustment of the engine idle speed to compensate for component cyclic vibrations present in each particular application.

Note. The recommended idle speed is 625 RPM 20.

(h) This is a reference speed and is intended as a reference point. Judicious deviation from this speed can be made although it should be noted that extreme care must be taken to prevent new problems by extreme variations in idle speed.

(i) Problems such as difficult gear engagement can be encountered with excessively high idle speeds. Poor load pickup can be a problem if idle speeds are adjusted too low.

3-3. Shutdown Valve

a. General The shutdown valve controls fuel flow from the pump to the injectors. The electric valve is equipped with a knob which will open the valve in case of electrical power failure. Keep knob in counter-clockwise position to operate electrically.

b. Removal Refer to figure 3-8.

c. Disassembly.

(1) Remove screws and lockwashers securing coil housing to valve housing (fig. 3-33).

(2) Remove coil housing (1, fig. 3-34), fuel shield (8), and O-ring (4). Discard O-ring.

(3) Remove spring washer (9) and plate-type valve (10).

(4) If necessary, remove manual override knob (3) and unscrew override shaft (7) from coil end. Discard shaft O-ring (16).

d. Cleaning and Inspection.

(1) Clean all parts except the coil assembly in an approved cleaning solvent.

Note. Do not wet the coil with solvent; instead, wipe it clean with a lint free cloth.

(2) Visually check valve and valve seat for wear, bonding failure or corrosion. Replace if necessary. Valve seat should have a minimum seat 0.015 inch wide (fig. 3-35).

(3) Check coil assembly with an ohmmeter; replace if below values given in table 2-2.

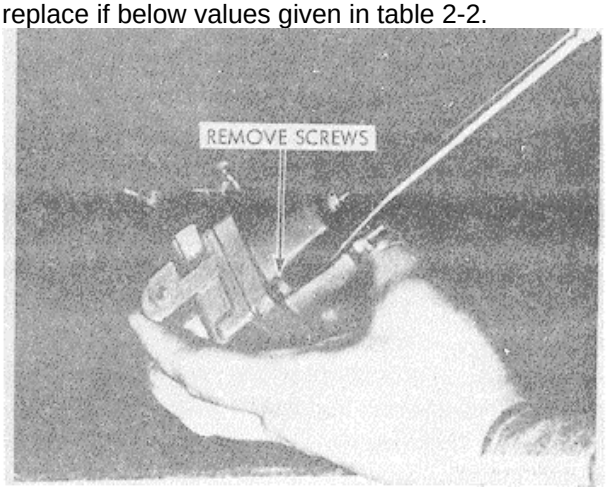


Figure 3-33. Screw removal from shutdown valve

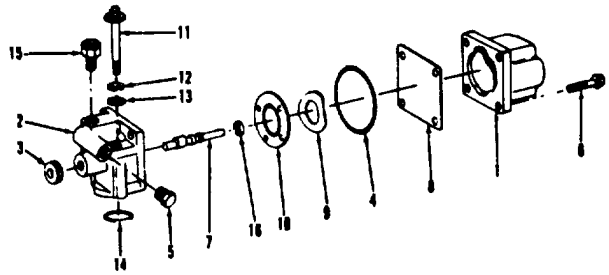


Figure 3-34.

2	Housing, valve	10	Valve
3	Knob, override	11	Capscrew (2)
4	0-ring, coil to housing.	12	Lockwasher (2)
5	Plug, pips	13	Washer, plain (2)
6	Screw, filter washer head (4)	14	O-ring
7	Shaft, override	15	Connection
8	Shield, override	16	Shaft O-ring

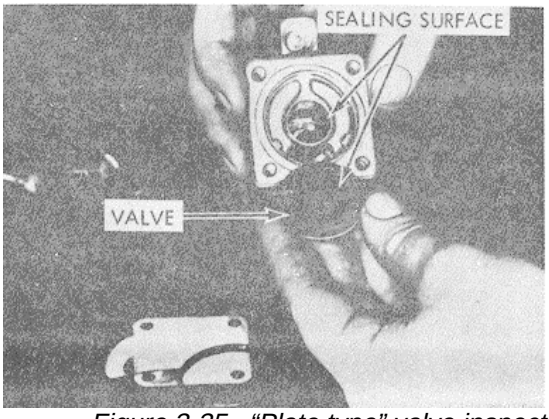


Figure 3-35. "Plate type" valve inspection.

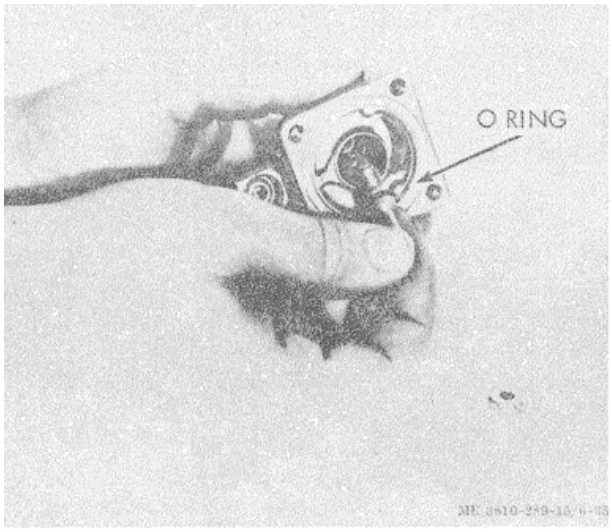


Figure 3-36. Override shaft installation.

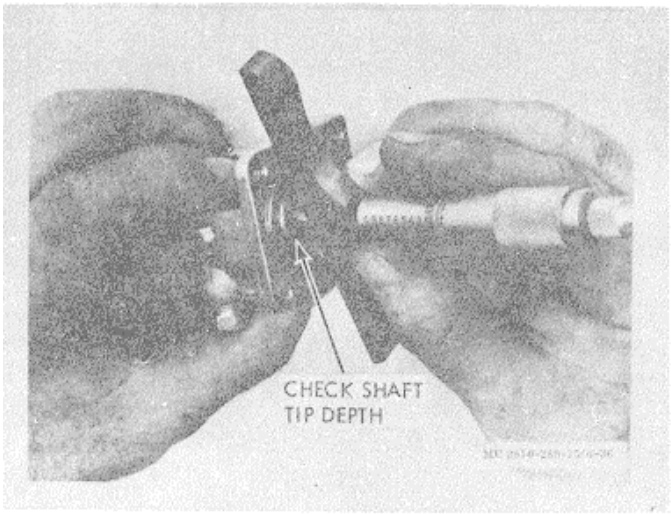


Figure 3-37. Shaft tip depth check.

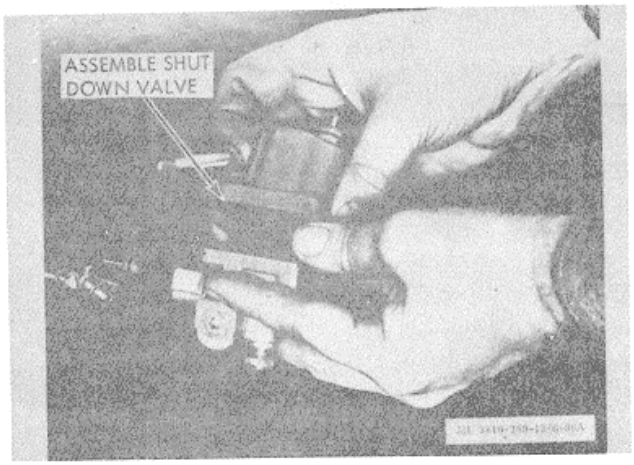


Figure 3-38. Valve assembly.

Caution: Be sure that starting switch is in off position when checking coil.

(4) Refer to table 2-2 (5) j. for current solenoid valve coil assembly and coil resistances.

e. Assembly.

(1) If removed, install a new O-ring on override shaft and coat with lubricant (fig. 3-36).

(2) Screw shaft into housing until it reaches bottom of its bore. Use depth micrometer set at 0.118 inch and check distance from face of valve housing to tip of shaft. If necessary, screw shaft out until it is 0.118 inch below housing face. Press on knob until it contacts valve housing; thus it will act as a stop (fig. 3-37).

(3) Seat valve into valve housing.

(4) Apply lubricant to housing O-ring and seat in groove.

(5) Drop spring washer on valve with concave side up and piloted around valve bore (fig. 3-38).

(6) Place fuel shield (8, fig. 3-34) on coil housing and secure to valve housing assembly with lockwashers (12) and capscrews (11). Tighten capscrews to 15/20 inch-pound torque.

(7) Energize valve and pump fluid through valve at 300 psi. Deenergize valve; valve should with stand the 300 psi load with no leakage through valve.

(8) Should leakage exist, check the main body for nicks or depressions where body and place come in contact. Check the rubber seal in the plate for swelling or other defects.

f. Installation. Refer to figure 3-8 and install valve.

3-4. Fuel Pump Housing

a. General. The fuel pump housing is the largest - part of the fuel pump and contains the governor barrel and throttle shaft. Other units attach to the housing.

b. Removal and Disassembly. Refer to paragraph 3-2 and figure 3-39.

c. Inspection and Repair.

(1) Check drive shaft bushing for sign of seizure or burs.

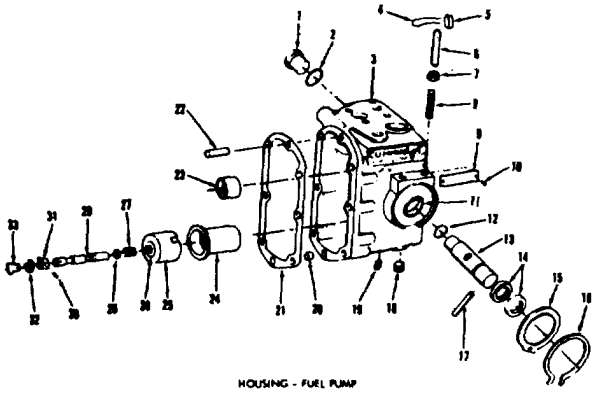
(2) Check drive shaft bushing I.D. with inside micrometers; if worn beyond 0.7525 inch replace bushing.

(3) Remove worn bushing using a gage chisel or half inch pipe tap. After tapping bushing, screw a half inch pipe cap on a close nipple and screw the half inch nipple into the bushing. Insert a punch through the rear of the housing and drive out the bushing.

(4) Apply a thin coat of high pressure lubricant to a new front drive shaft bushing; press bushing into housing flush with housing bore using an arbor press.

(5) Line ream bushing to 0.7495/0.7505 inch with ST-490 Ream Fixture, and a well oiled 0.750 in. (3/4 in.) reamer (fig. 3-40). Check bushing I.D.

d. Reassembly and Installation. Refer to paragraph 3-2 and figure 3-39.



3	Housing Assembly	29	Plunger, governor
4	Clip	30	Pin, governor plunger
5	Plug	31	Sleeve, stop
6	Nut, throttle adjusting screw	32	Spacer, governor plunger
7	Nut, throttle adjusting screw	33	Drive, governor plunger
8	Screw, throttle adjusting		
9	Plate, name		
10	Screw, drive, nameplate		
11	Sleeve, throttle shaft		
12	Seal, O-ring		
13	Shaft, throttle		
14	Spring, throttle shaft		
15	Cover, throttle shaft		
16	Ring, snap, throttle shaft cover		
17	Pin, throttle stop		
18	Plug, pipe		
19	Clip, governor barrel		
20	Dowel, ring		
21	Gasket		
22	Dowel, body to cover		
28	Bushing, tachometer drive gear		
24	Sleeve		
25	Barrel assembly, plunger		

Figure 3-39.

Figure 3-40. Drive shaft bushing reaming.

3-5. Pulsation Damper

a. Removal Refer to figure 3-9 and remove pulsation damper.

b. Disassembly (fig. 3-41).

(1) Remove mounting capscrews (2), flatwashers (9) and lockwashers (4), and separate the body (1) from plate (7).

(2) Remove the spring steel diaphragm (3), nylon washer (10) and O-rings (5and 6); discard O-rings and nylon washer.

c. Cleaning and inspection.

(1) Clean the body, plate and diaphragm in solvent which is not harmful to aluminum.

(2) Check for corrosion, excessive wear, or cracked plate or diaphragm.

Reassembly.

(1) Install new O-rings in grooves and new nylon washer.

(2) Coat the diaphragm with OE10 lubricating oil and lay in cover plate.

(3) Assembly cover plate (7) to body (1); secure with flatwashers (9), lockwashers (4) and cap screws (2).

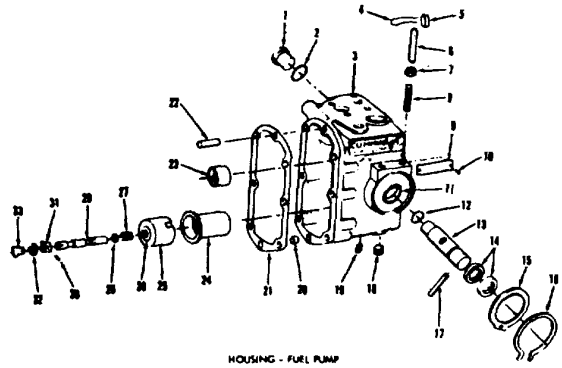
e. Installation. Refer to figure 3-9 and install damper.

3-6. Drive Cover Assembly

a. Removal. Refer to paragraph 3-2 and figure 3-42 and remove drive cover assembly.

b. Disassembly and inspection.

(1) Check governor weight carrier shaft in its bushing before removal.



1	Body, camper	6	O-ring, body to plate
2	Capscrew, body to plate (2)	7	Plate, damper
3	Diaphragm, damper	8	Ring, sealing
4	Lockwasher, body to plate (2)	9	Washer, plain, to plate (2)
5	O-ring, body to	10	Washer, nylon body to plate

Figure 3-41. Pulsation damper, exploded view.

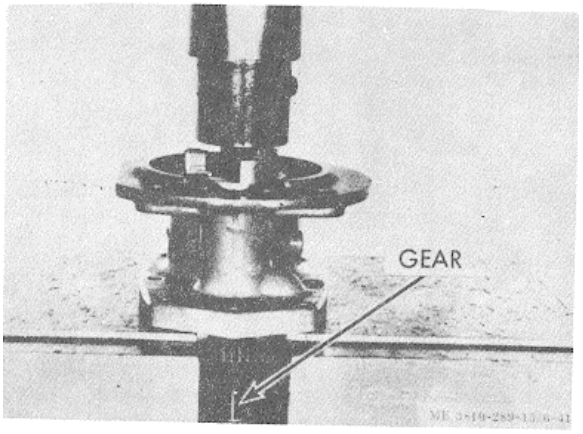


Figure 3-42. Drive cover assembly pressed from front cover.

(a) excessive wear can be felt by moving shaft from side to side in the bushing.

(b) Observe excessive lash between weight shaft gear and drive gear.

Note. Remove weight assist plunger if not previously removed.

(2) To remove governor weight carrier assembly from drive cover, heat housing in hot water and use ST-709 Puller to pull weight shaft assembly and bushing from front cover (fig. 343). The bushing is locked on shaft with a snap ring (fig. 344) and will usually(2) To remove of cover with weight shaft assembly; however, if snap ring pulls off shaft leaving bushing in front cover, use an internal engaging puller of ST-709 to pullbushing.

(3) Remove fuel pump drive coupling retainer capscrew (1,fig. 3-45), lockwasher (22) and flat washer (24).

(4) Remove large snap ring from pump end of drive shaft between drive cover and drive gear (fig. 3-44).

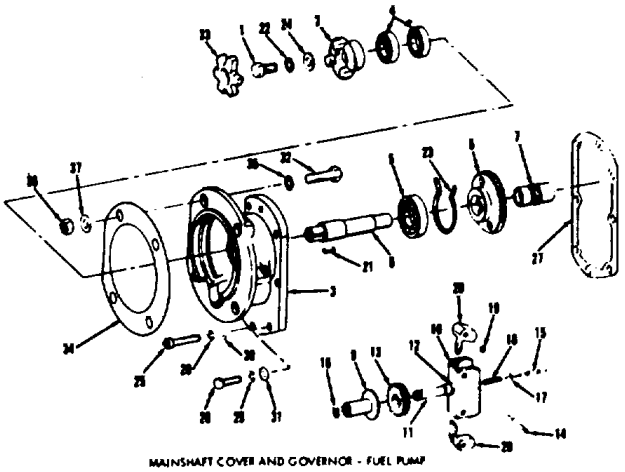
(5) Install a longer capscrew in place of drive coupling retainer capscrew (1, fig. 3-45) press on cap screw to press drive gear assembly from front cover (fig. 3-42).

(6) Press drive shaft oil seals from drive cover.

(7) Governor assembly can be disassemble to change gear, weights and bushing. The governor carrier and shaft can only be replaced as an assembly. If shaft is 0.338/0.392 inch O.D. or smaller and requires replacement, the use of 0.515/0.519 inch O.D. shaft and carrier assembly and new bushing as replacement parts is recommended (fig. 3-45).

Figure 3-43. Weight shaft assembly being pulled with ST-709.

Figure 3-44. Snap ring removal from groove.



1 Capscrew, coupling
2 half coupling
3 Cover
4 Seal (2)
5 Ball bearing
6 Drive shaft gear
7 Tachometer drive gear
8 Drive shaft
9 Weight carrier shaft bushing
10 Weight carrier (NSS)
11 Weight shaft (NSS)
12 Brazing wire drive (4)
13 Governor drive shaft gear
14 Weight pivot pin (2)
15 Weight assist plunger
16 Retaining ring
17 Weight assist shim drive (4)
18 Weight assist spring
19 Washer thrust (4 rqr)(4)
20 Governor weight (2)
21 Governor drive key
22 Lockwasher coupling
23 Snap ring
24 Washer, plain, coupling
25 Capscrew, cover
26 Capscrew, cover (6)
27 Gasket, cover to housing
28 Lockwasher, cover
29 Lockwasher, cover (6)
30 Washer, plain, cover
31 Washer, plain, cover
32 Capscrew, pump to accessory
33 Coupling, fuel pump drive
34 Gasket, pump to accessory drive
35 Lockwasher, pump to accessory
36 Nut, pump to accessory drive
37 Washer, plain, pump to accessory drive (4)

Figure 3-45. Governor carrier weight assembly-exploded view.

Caution: Governor weights can only be replaced in pairs to maintain balance.

c. Replacement of Governor Weight Carrier Parts.

(1) If governor gear, shaft, weights or weight carrier are damaged, press gear from shaft (fig. 3-46).

(a) If removed, press on gear. Do not press against weights as weight pins may be damaged. Press against end of the carrier shaft.

(b) The rough beveled edge of gear goes toward carrier weight and the smooth side goes toward the bushing.

(2) Slip governor carrier bushing on the carrier shaft with flanged end of bushing next to gear and secure bushing with snap ring.

d. Disassembly of Drive Shaft.

(1) Press tachometer drive gear and governor drive gear from drive shaft (fig. 3-47).

Note. Press away from bearing because shaft has a shoulder under bearing.

(2) Press drive bearing from shaft only if bearing is rough or shaft has worn grooves.

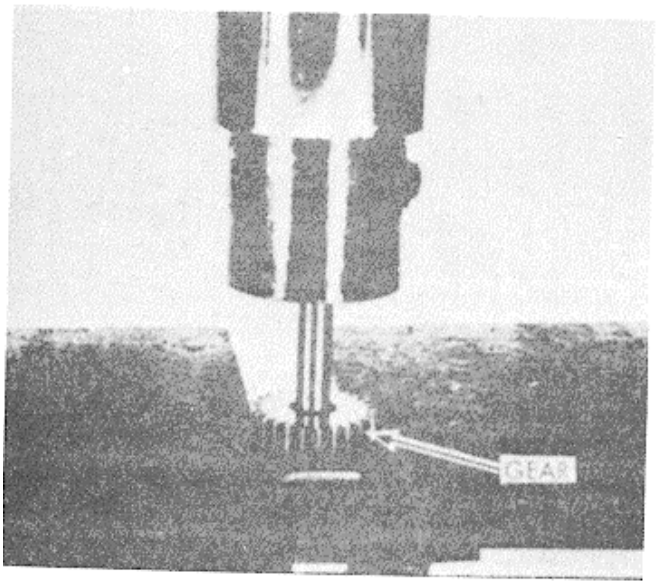


Figure 3-46. Gear removal from weight carrier.

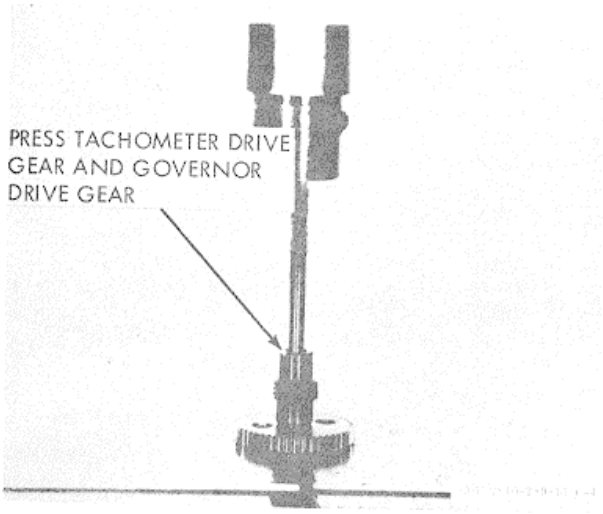


Figure 3-47. Tachometer drive gear and governor drive gear being pressed.

e. Assembly of Drive Shaft.

(1) If bearing or shaft is replaced new, lubricate shaft with Lubriplate or equivalent and press bearing over shaft, pressing against inner race of bearing, figure 348.

(2) Press governor drive gear to drive shaft bearing over shaft.

(3) Press tachometer drive gear on shaft and against governor drive gear, figure 3-49.

Note. Check gear to make sure it matches with tachometer gear to give proper rotation.

(4) Check to see if parts are firmly seated.

(5) Insert snap ring between ball bearing and governor drive gear.

f. Assembly of Driver Cover.

(1) Clean all parts thoroughly with mineral spirits or equivalent.

(2) Press first oil seal into drive cover with lip toward outside of pump, and press second oil seal into drive cover with sealing lip toward inside of fuel pump. Seals must be spaced so the "telltale" hole is not covered, figure 3-50.

(3) Lubricate ST-419 Oil Seal Assembly Tool and install tool over main shaft, figure 3-51. Press main shaft assembly into front cover and through seals. Secure snap ring in cover groove, figure 3-52.

(4) Install key and press coupling into position on drive shaft. Press slow and straight.

(5) Install retainer flatwasher, lockwasher and capscrew to shaft and tighten in place. Hold coupling or main shaft in a copper-jawed vise while tightening.

(6) Heat front cover in boiling water for 1 ½ to 2.

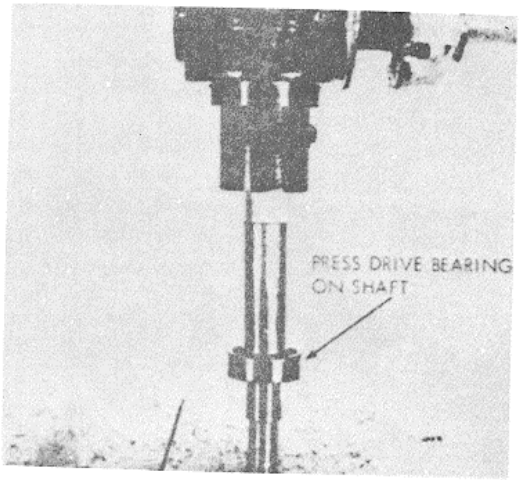


Figure 3-48. Drive bearing being pressed on shaft.

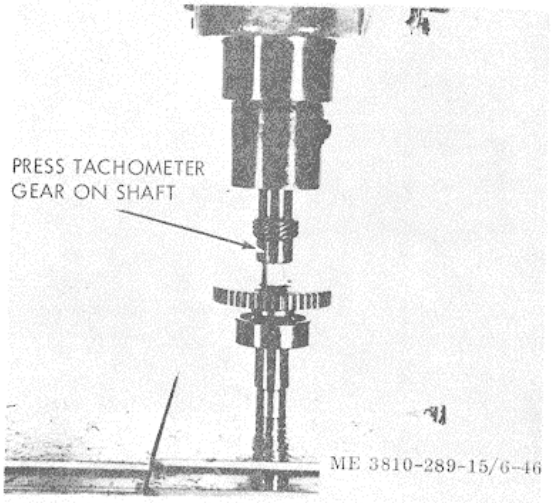


Figure 3-49. Tachometer gear being pressed on drive shaft.

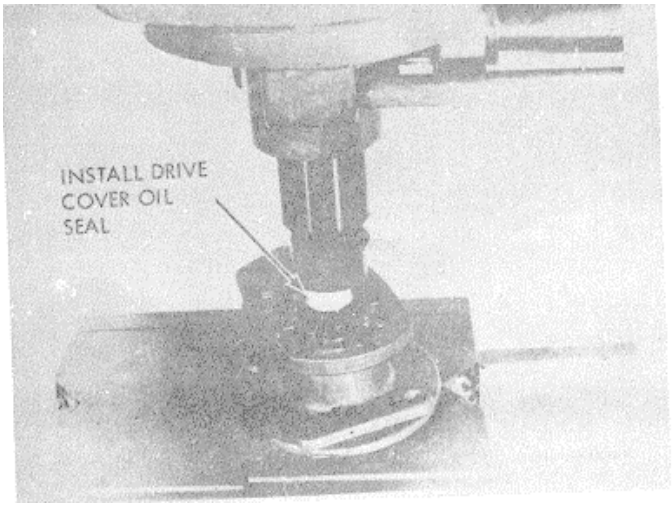


Figure 3-50. Drive cover oil seal installation.

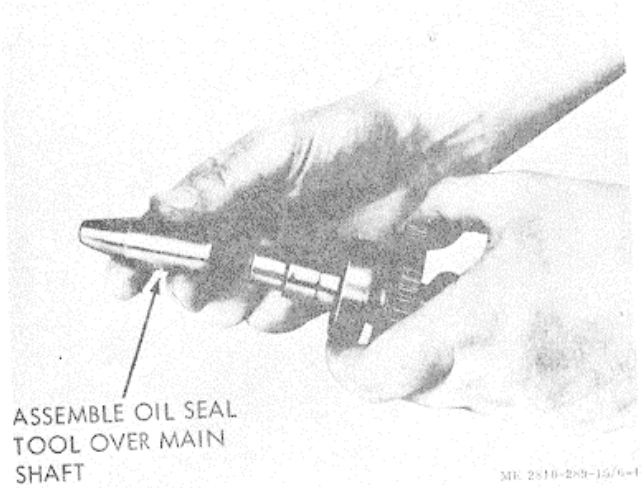


Figure 3-51. ST-419 oil seal tool assembled over main shaft.

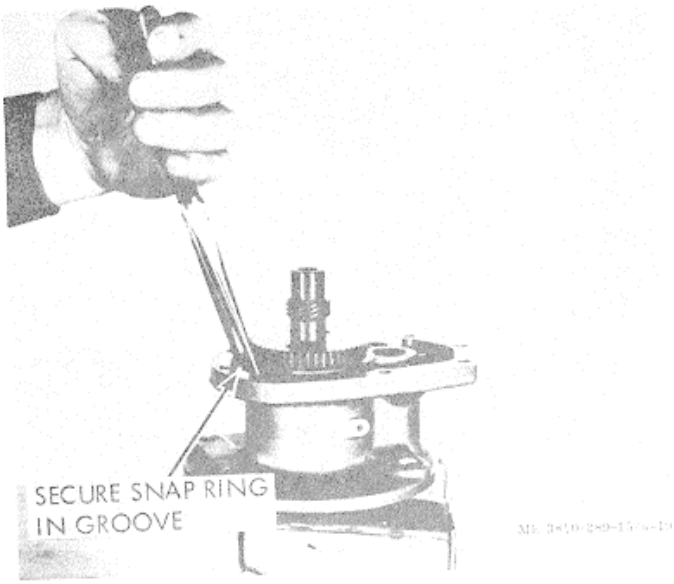


Figure 3-52. Snap ring secured in groove.

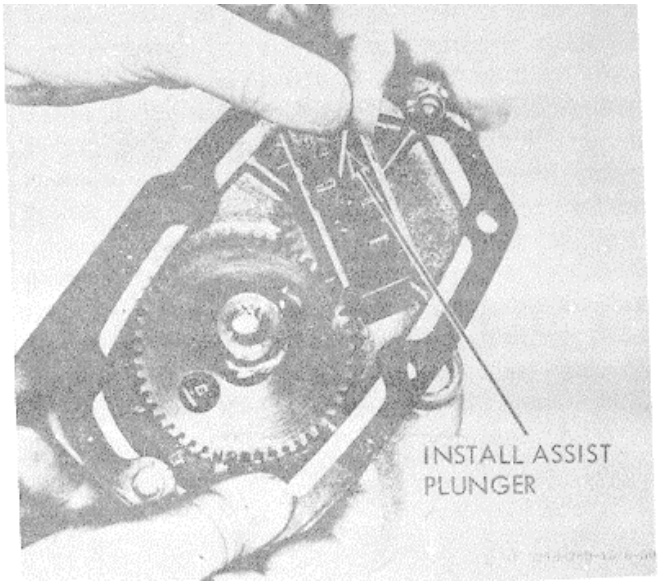


Figure 3-53. Assist plunger installation.

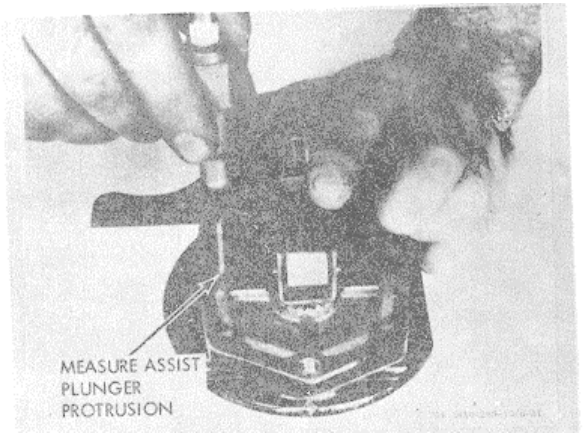


Figure 3-54. Assist plunger protrusion measurement.

minutes. Coat governor-carrier bushing with high pressure grease such as Lubriplate, or equivalent, and press assembly into front cover. Mesh gears to avoid damage to them. The bushing shoulder must seat against housing. Rotate weight assembly to be sure it will turn completely in housing. If weight assembly will not rotate it may be necessary to grind the housing so the weights will rotate freely.

Caution: Do not press against weights. Press against center of weight carrier shaft.

(7) Install shims, spring, and governor assist plunger between governor weight and into bore of governor weight carrier shaft, figure 3-53.

Caution: Always check and assemble weight assist plunger with smallest end of plunger to weights. This will prevent weights from sticking.

(8) Use enough shims back of spring to make governor assist plunger protrude above gasket face of front cover. Gage protrusion with a dial depth gage

having a base approximately 4 inches long.

(a) Place one leg of the depth mike base of pedestal across the carrier walls and measure down to the front cover gasket surface (no gasket), figure 3-54. Move the depth mike to the opposite side of the carrier and again measure to the front cover gasket surface directly across the cover from the previous measurement (do not turn carrier or cover). Average these two measurements. This procedure is necessary to eliminate any possible influence of uneven carrier wall heights.

(b) Position the depth mike across the carrier directly over the weight assist plunger. Measure down to the plunger. Do not depress spring.

(c) Substract "B" from the average determined under "A". The result is the weight assist protrusion.

g. Installation of Drive Cover. Refer to paragraph 3-2.

3-7. Governor Plunger

a. Removal. Refer to paragraph 3-2.

b. Disassembly.

(1) If necessary, remove torque spring by twisting spring off shoulder. Do not use a straight pull which will stretch spring beyond its elastic limit so it has to be replaced, figure 3-55.

(2) If governor plunger O.D. is worn, replace as an assembly.

(3) If only thrust washer is worn, drive retainer pin from plunger and pull governor plunger driver from plunger, figure 3-56.

Note. The chamfer on small diameter thrust washer is provided as ·a relief for fillets of plunger driver.

(4) If it is necessary to remove stop sleeve, press stop sleeve off shaft.

c. Assembly.

(1) If stop sleeve was removed, press stop sleeve on plunger with notched end going on plunger first (nothces toward governor barrel), figure 3-55.

(2) Assemble plunger driver through thrust washer and drive into plunger. Driver must have interference fit in plunger.

(3) Drive retainer pin through the plunger and plunger driver.

Note. The chamfered side of thrust washer must be installed next to driver. There must be at lest O.00 to 0.006 inch clearance between washer face and driver so washer will “float”, figure 3-57.

Caution: The plunger has a lubricate finish. Protect it by laying the plunger on a copper-jawed vise a V-block to prevent damage to the finish when installing pin.

(4) Install torque spring and shims as required, put the small end of the spring on the shoulder end of the plunger with a twisting motion to avoid distorting the spring.

Note: The torque spring determines point of maximum torque. In the engine, therefore, it is important to avoid changing spring characteristics by careless handling or assembly.

(5) If torque spring is replaced with new one, see table 2-{(5)r, and refer to fuel pump adjustment (para 3-2).

(6) One type of plunger failure is caused by excessive heat from contact of the stop collar and sleeve during long periods of overspeeding. Plunger stop collars machined from glass filled teflon eliminate this type of failure

d. Installation. Refer to figure 3-80.

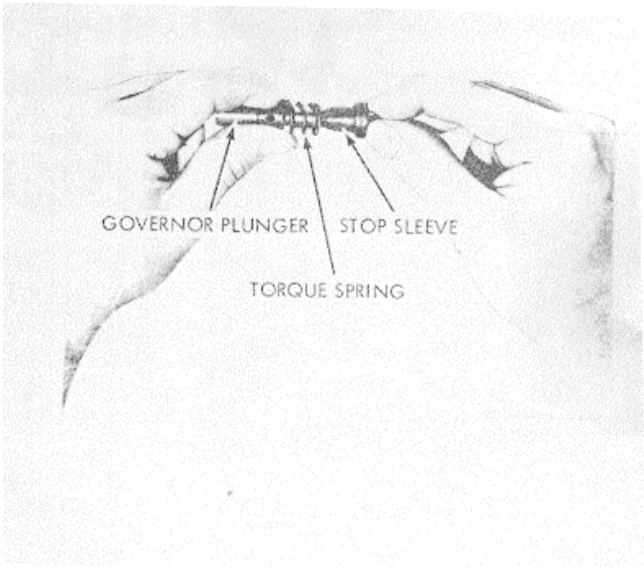


Figure 3-55. Torque spring removal.

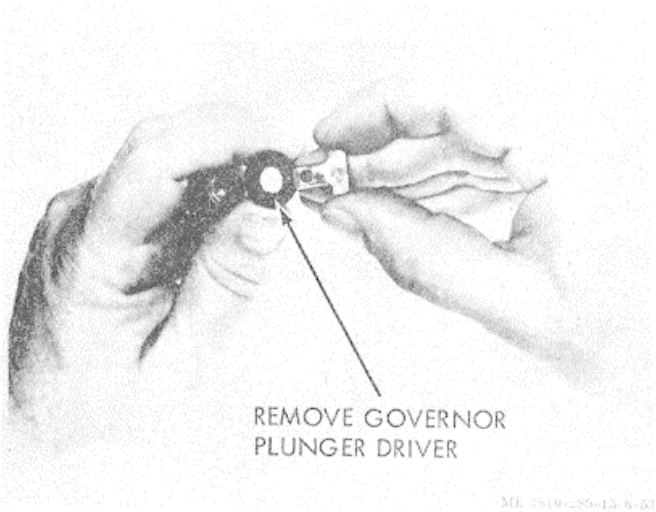


Figure 3-56. Governor plunger driver removal.

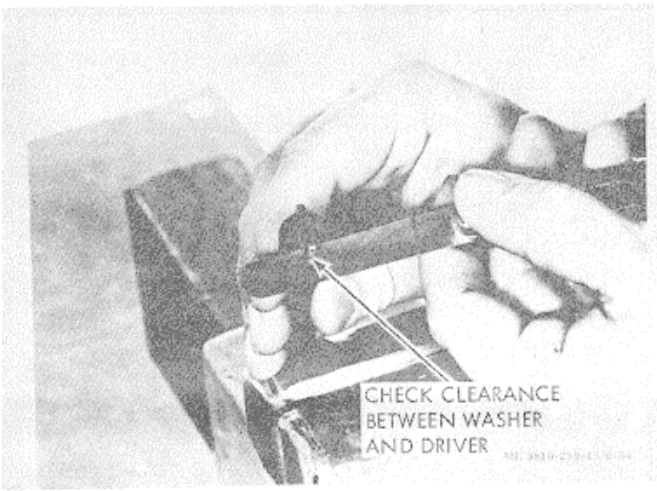


Figure 3-57. Clearance check between washer and driver.

3-8. Gear Pump

a. General. The gear pump draws fuel from the tank through a filter and supplies the fuel to the fuel pump. Fuel at a given pressure is then routed to the injectors.

Caution: Engines with integral cooling gear pumps (fig. 3-58) must not be run with the fuel bleed hole plugged.

b. Removal Refer to paragraph 3-2.

c. Disassembly.

(1) Remove capscrews securing gear cover (1, fig. 3-58) to housing (2).

(2) Install two long capscrews in cover and drive against capscrew heads to remove gear cover from dowels (4) in gear housing. Discard gasket (8).

(3) Lift drive and driven gears and shafts from gear pump housing.

d. Cleaning and Inspection.

(1) Check pump shafts for wear or scoring; discard if damaged. Replace shaft if worn smaller the 0.4998/0.5001 inch diameter.

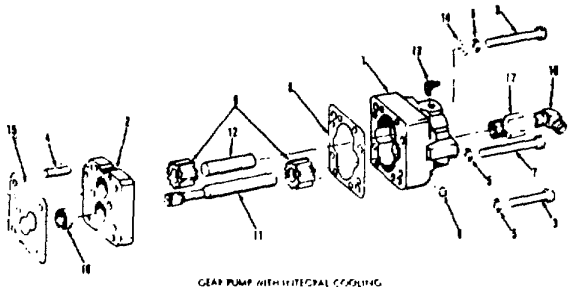
(2) Check gear width (table 2-2). If gears are scored or worn badly, the gears must be replaced (fig. 3-59).

(3) Check gear housing and cover for scoring or wear; replace as needed. Check gear pocket depth (fig. 3-60 and table 2-2).

(4) Shaft bore in cover and housing should be 0.5013/0.5016 inch I.D. If gears are removed from shaft, press gears on shaft 0.680/0.690 inch from housing end of shaft. Oil shaft before assembly.

(5) Check lubrication holes in cover and housing they be clean.

(6) Clean cooling kit components, if used, and dry with compressed air.



GEAR PUMP WITH INTEGRAL COOLING

1 Gear pump cover
2 Gear pump housing
3 Capscrew (6)
4 Cover to housing dowel (2)
5 Lockwasher (3)
6 Pipe plug
7 Capscrew, cover to housing(2)
8 Gasket, pump cover
9 Pump gear (2)
10 Dowel ring
11 Drive shaft
12 Driver shaft
13 Ball check valve
14 Washer, plain, cover to housing
15 Gasket, pump to housing
16 Elbow
17 Adapter

Figure 3-58. Gear pump with integral cooling, exploded view.

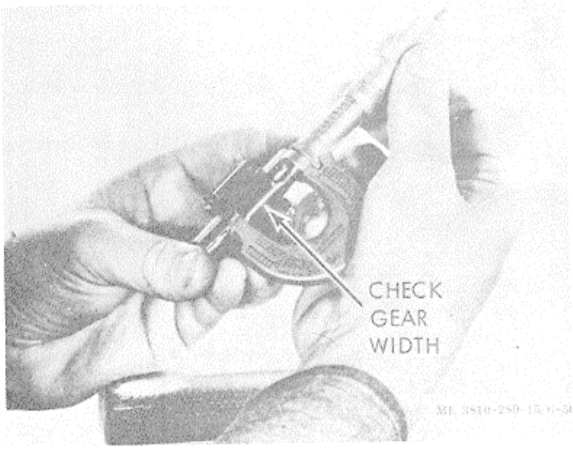


Figure 3-59. Gear width check.

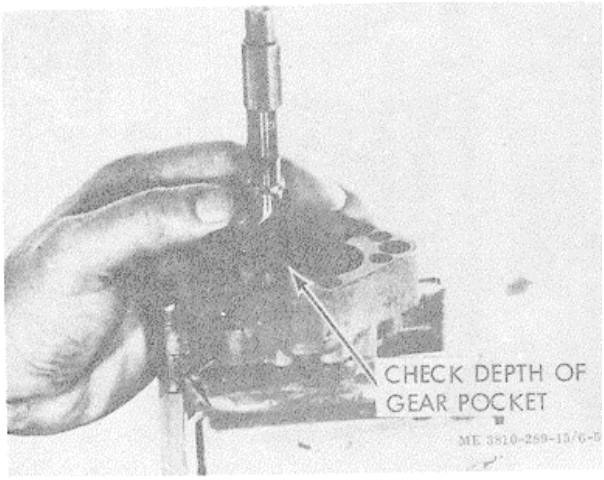


Figure 3-60. Gear pocket depth check.

Note. If shaft bore is scored 1/3 of circumference or more in cover or housing, scrap part. If scored less than 1/3 clean up and reuse pat.

e. Reassembly.

(1) Lubricate and slide shafts and gears into cover. Make sure parts are clean.

(2) Position new gasket (8) and install housing to cover. Aline locating notches together (fig. 3-61).

Note. Location of notches determine pump rotation.

(3) Secure cover to housing with dowels, cap screws and lockwashers. Tighten capscrews to 13/17 foot pounds (fig. '3-62). Check to see that pump turns freely with finger pressure.

Note. Total gear backlash must b 0.001/0.004 inch. The drive shaft must protrude 2 370/2 412 inch from the housing End clear mace should not exceed 0.0015 inch nor be less than 0.0009 inch.

Caution: If pump binds or has excessive play, check for error in assembly which must be corrected to prevent early pump failure.

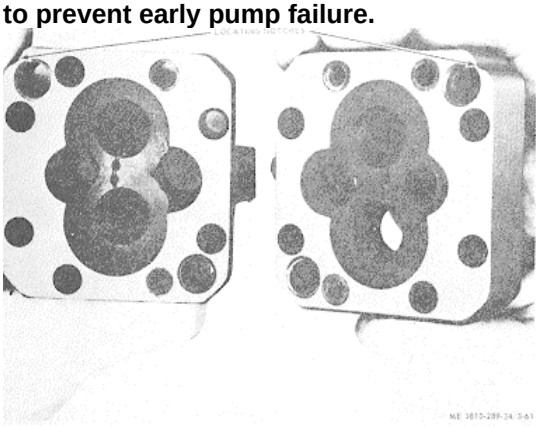


Figure 3-61. Locating notches.

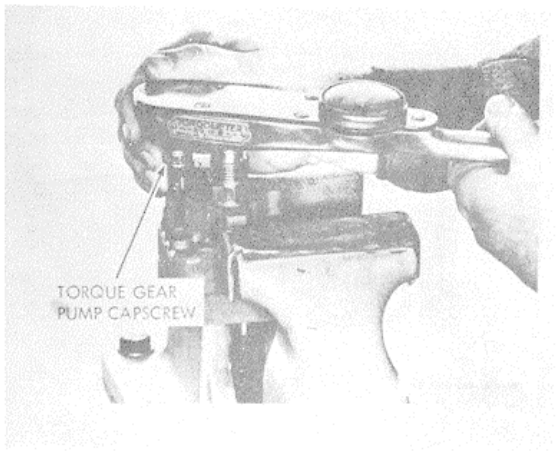


Figure 3-62. Gear pump capscrews torque.

3-9. Governor Spring Pack

a. General. The governor spring pack consists of the idle and maximum or high-speed springs, plungers, adjusting screw and shims. The springs control engine speed and adjustments are made by the shims or adjusting screw.

b. Removal Refer to paragraph 3-2.

c. Disassembly of Automotive Governor.

(1) Remove capscrews (16 and 17, fig. 3-31, lockwashers (19), and flatwashers (20) securing governor spring pack cover (1) to main housing.

(2) Lift off cover (fig. 3-15) and discard gasket (18, fig. 3-63).

(3) Remove snap ring (12) which holds governor spring pack in sleeve, with a pair of snap ring pliers.

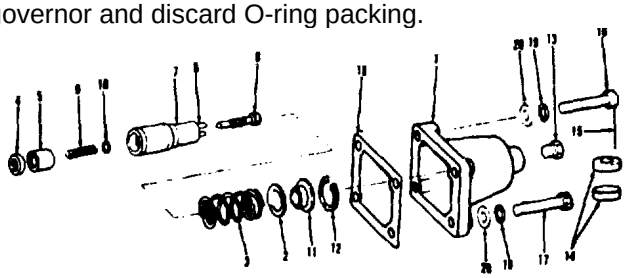
(4) Remove governor spring (3), spring retainer (11) and shims (2) from spring pack cover (1).

(5) Remove idle spring plunger guide (7), idle spring (9, or springs, idle spring plunger (5, , and spring rest washer. (fig. 3-16).

d. Disassembly of Mechanical Variable Speed Governor PT(type G) (f)fig. 3-64).

(1) Remove filter screen assembly (fig. 3-17), which is made up of cap, cap seal, spring, upper and lower filter screen, O-ring, and O-ring retainer (fig. 3-65).

(2) Remove capscrews and washers securing MVS governor to main housing. Lift off governor and discard O-ring packing.



1 Spring pack cover
2 Governor spring shim
3 Governor spring
4 Idle spring plunger adapter
5 Idle spring plunger
6 Idle adjusting screw clip
7 Plunger guide
8 Screw, idle adjusting
9 Idle spring
10 Washer, adjusting screw
11 Spring retainer
12 Snap ring
13 Pipe plug
14 Seal (2)
15 Seal wire (2)
16 Capscrew, spring pack cover
17 Capscrew, spring pack cover (3)
18 Spring pack cover gasket
19 Lockwasher, spring pack cover (4)
20 Washer, plain, spring pack cover (4)

Figure 3-63. Automotive governor - exploded view.

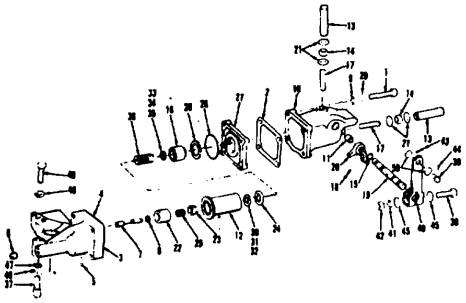


Figure 3-64.
2 Gasket
3 Governor barrel
4 Governor housing
5 Pipe plug2)
6 Pipe plug
7 Plunger
8 Spring
9 Lockwasher, cover to housing (4)
Spring and idle pack
Spring pack
Cover and bushing
10 Cover (NSS)
11 Throttle shaft bushing(2t
12 Spring pack housing
13 Nut, adjusting screw (2)
14 Nut, adjusting screw (2
15 Throttle shaft "0" ring (2)
capscrew
16 Throttle plunger
17 Screw, adjusting (2
18 Screw, throttle shaft
19 Throttle shaft
20 Throttle shaft stop
21 Washer, adjusting screw (4)
22 Governor spring plunger
23 Governor spring retainer
24 Snap ring
25 Idle Spring
26 Adapter plate O-ring
27 Adapter plate
28 Governor spring shim
29 Washer, plain, (4)
30 Shim
31 Shim
32 Shim
33 Governor spring shim
34 Governor spring shim
35 Governor spring shim
36 Governor spring
37 Governor housing adapte
38 Swivel block
39 Capscrew, throttle lever
40 Throttle lever
41 Lockwasher, throttle levt
42 Nut, throttle lever
43 Cotter pin
44 Screw, swivel block
45 Washer, throttle lever (21
46 O-ring packing
47 O-ring packing
48 Seal governor housing
49 Capscrew, governor hous
50 Washer, swivel block

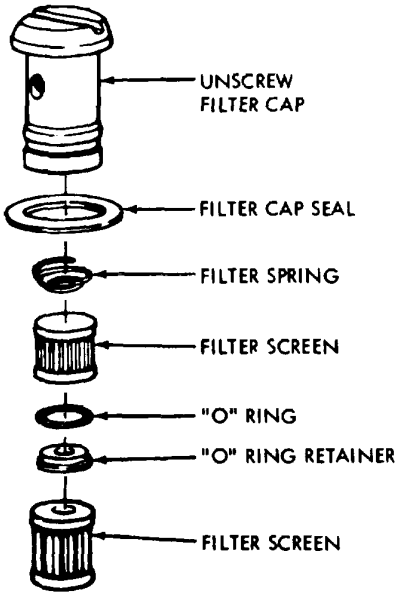


Figure 3-65. Fuel filter scree - MVS governor type.

(3) Screw adapter (37 fig. 3-64) from top of main housing if damaged.

(4) Remove capscrews (1), flatwashers (29) and lockwashers (9) securing cover (10) to governor housing (4). Lift off cover and discard gasket (2).

(5) Remove cover to housing plate.(27). Discard O-ring (26).

(6) Remove governor spring (36), plunger (16) and shims (33, 34, 35).

(7) Remove snap ring (24) from plunger housing.

(8) Remove shims (30, 31, 32) from plunger housing.

(9) Remove spring retainer (23), idler spring (25) and spring plunger (22).

(10) Remove small snap ring (8) and small plunger (7).

(11) Remove set screw (18) securing governor stop (20) on throttle shaft (19). Pull throttle shaft from cover and discard O-ring (15).

e. Replacement of Governor Barrel. Refer to paragraph 3-10.

f. Cleaning and Inspection.

(1) Replace shaft bushing (11, fig. 3-64) if worn beyond sealing capacity. Bushing I.D. should be 0.560/0.561 inch after assembly.

(2) Wash parts in a solvent that is not harmful to aluminum.

(3) Inspect parts for scoring, pitting and wear.

(4) Check plunger to barrel clearance. It should be 0.0001/0.0005 inch. Oversize plungers are available (table 2-2(5(k A.

g. Reassembly of Automotive Governor.

(1) Assemble screw (8, fig. 3-63) into plunger guide (7), place small copper washer (10) over-screw point inside plunger guide (fig. 3-21). Place small idle spring (9, fig. 3-63) into plunger guide and place idle plunger (5) against spring in plunger guide (fig. 3-22). The plunger controls maximum fuel pressure produced by the fuel pump.

(2) Place the governor spring (3, fig. 3-63) over the rear of plunger guide (7) and place shim (2) against spring; install retainer (11) and snap ring(12) securing assembly into governor sleeve (fig. 3-24).

Note. There are different maximum-speed springs available and each is identified by color stripes. (See table 2-2, (5) k.)

Note. Shims are available in 0.005, 0.010 and 0.020 inch thickness. The final number of shims must be determined during fuel pump calibration.

(3) Install the spring-pack cover (1, fig. 3-63) and gasket. Install capscrews and washers securing cover to housing.

(4) Install lockwire, twist up tight and snap seal over lockwire.

h. Reassembly of Mechanical Variable Speed Governor PT (type G).

(1) Install snap ring (8, fig. 3-64) on plunger (7) and insert plunger in main housing (4). Plunger must

drop freely of own weight into barrel.

Note. If fitting oversize plunger to worn barrel or if new plunger does not drop freely into new barrel it will be necessary to lap the plunger to the barrel. Do not over do this operation. Too much clearance increases throttle leakage and results in slow deceleration.

(2) Install new 0-ring (15, fig. 3-64) on throttle shaft (19) and insert shaft in cover (10) through throttle stop (20) with set screw (18).

(3) Slide plunger housing into plate and place assembly up against the governor barrel (3). If housing is loose in plate, add shims between housing and governor barrel until housing is tight and plate is spaced .003/.005 inch from barrel and sleeve assembly. Retain remainder of shims until later in calibration.

(4) Install large snap ring (24) in groove inside plunger housing.

(5) Install 0.030 inch of shims into housing from flange end so they seat on snap ring.

Note. Too few shims will result in stalling or too little throttle leakage. Too many shims will cause slow deceleration or excessive throttle leakage; therefore, the number of shims may vary from the 0.030 inch total specified after engine is started, although experience indicates 0.030 inch is correct in most cases.

(6) Slide plunger (22), spring (25) and shims (30, 31, 32) (usually about 0.100 inch of shim) into housing (12) from rear end.

(7) Slip spring and guide into plunger.

(8) Place gasket (2) over cover (10) and position plate (27) on gasket.

(9) Carefully slide housing with springs and plungers in plate.

(10) Install Oaring (26) into plate groove; add shims as determined in step (3) above, and tighten spring pack assembly to housing with capscrews, lockwashers and flatwashers.

i. Installation. Refer to paragraph 3-2.

3-10. Governor Barrel

a. Inspection.

(1) Check governor barrel and plunger visually for wear.

(2) If worn, replace governor plunger with a one or two class larger plunger and lap to fit with No. 80 fine grit lapping compound, figure 3-66. Remove all lapping compound from parts (flush thoroughly).

Note. Plunger must drop into barrel of its own weight. Proper fit can best be judged by comparison with a new assembly.

b. Removal.

Note. If governor barrel is worn too large for a Class 7 governor plunger on PT (type G) pumps it will be *necessary to replace the governor barrel.

Caution: Check through plug hole in bottom of PT (type G) pump for spring dowel which secure barrel before attempting to remove governor barrel. To pull spring dowel, insert wire hook into hole provided figure 3-67.

(1) Remove the 1/8 in. N.P.T.F. pipe plug from opposite end of housing so a 0.339 inch diameter rod may be inserted to press out the governor barrel. Heat housing and barrel assembly in 'boiling water for 1 1/2-2 minutes or in an oven at 3250-3500F. Press barrel from housings

(2) After removing the governor barrel, the aluminum governor barrel housing bore should be visually inspected for cracks, pits, scores, or other defects. In the event such defects are found, the housing should be discarded.

(3) Check barrel bore in housing to determine whether standard (1.5020/1.5015 O.D.) barrel, 0.010 inch or 0.020 inch oversize must be used. Minimum 0.001 inch interference fit is required. Check bore for score marks, remove if found.

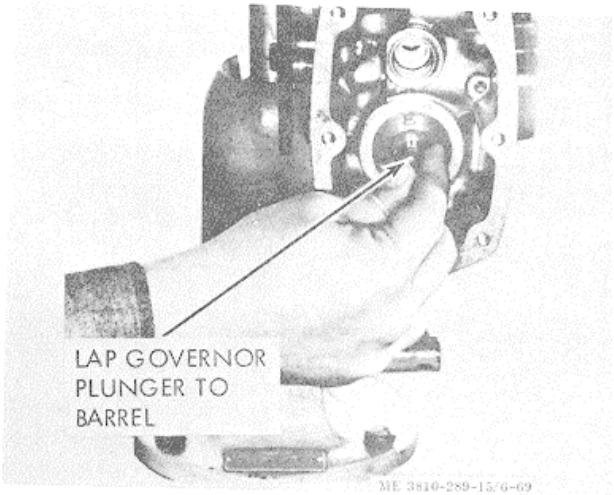


Figure 3-66. Governor plunger being lapped to burrel.

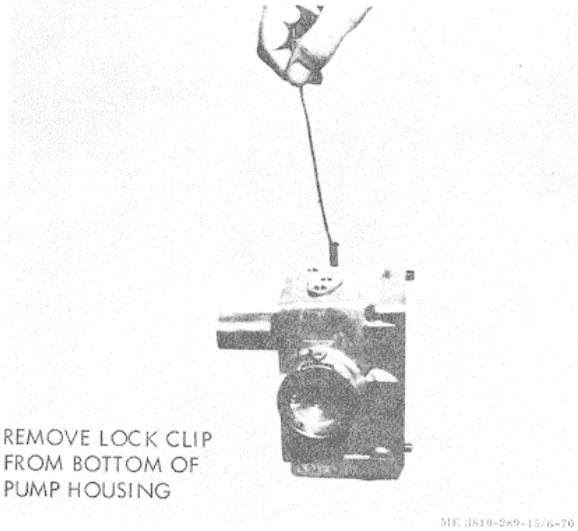


Figure 3-67. Locking clip being removed from bottom of fuel pump housing.

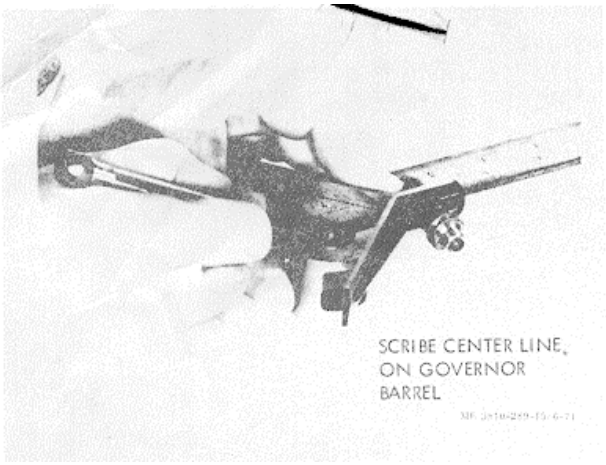


Figure 3-68. Center line being scribed on governor barrel.

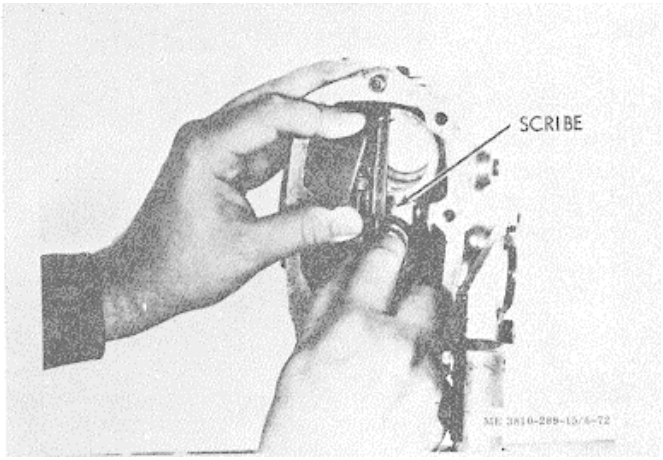


Figure 3-69. Center line being scribed on fuel pump housing.

c. Installation.

(1) To locate a new governor barrel in the housing, scribe a center line on barrel and housing, lining up the fuel passages so fuel now will not be restricted, figure 3-68 and figure 3-69.

(2) Heat housing in oven to 300 F.

(3) Cool barrel in dry ice or other method.

(4) Coat new governor barrel with high pressure lubricant.

(5) Drop spring pack housing in place.

(6) Place governor barrel in housing bore with chamfered end first and location pin hole on bottom side, lining up scribe marks, then press barrel in housing with arbor press until it bottoms against spring pack housing. This is important to aline barrel retaining pin holes. Scribe marks must aline within 0.040 inch to assure indexing of the vent holes.

Note. When installing the governor barrel into the heated housing, the pressure applied to governor barrel should not be released for 15-20 seconds after the governor barrel is pressed into the housing. Tests have indicated that this continued pressure is necessary to make certain the entering flat face of the governor barrel maintains contact with the housing when both the housing and barrel have cooled. There is a tendency for the governor barrel to "pop out" approximately 0.010-0.030 inch out of the heated housing.

(7) Select a new Class 2 (green color code) plunger and attempt to fit it in barrel, if plunger enters, try a Class 3 (yellow). Keep trying larger sizes until one will not enter barrel, then select one two sizes smaller for use. Plunger must drop into bore of its own weight. Lapping may be required to obtain desired plunger fit. Use caution and clean thoroughly if lapped. See table 2-2 and figure 3-70 for class size and color codes.

(8) Brush plunger lightly with crocus cloth to remove any lubrite crystals.

(9) Check plunger fit with a new fuel pump assembly as a fit comparison.

(10) If lapping is necessary, see steps 2 and 7 above.

(11) Install spring dowel into bottom of barrel with ST-853 Driver with slot of pin to front of housing, figure 3-71.

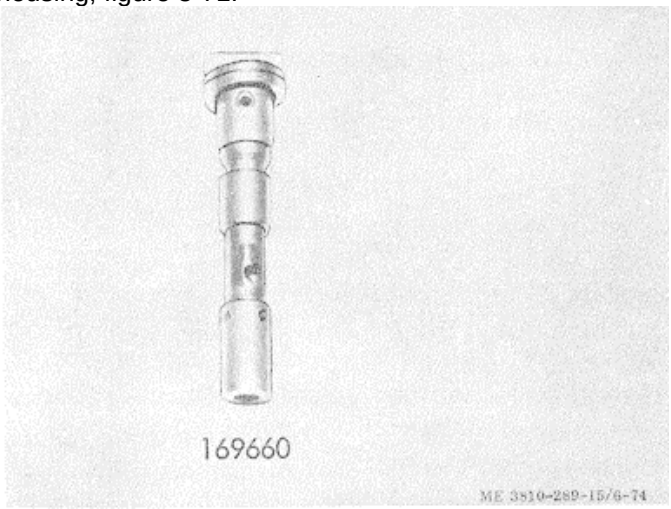


Figure 3-70. Current PT (type G) governor plunger.

3-11. Fuel Pump Filter Screen

a. Removal Refer to paragraph 3-2 c (10).

b. Disassembly. There are two screen assemblies. The top screen cannot be disassembled, but the bottom one can, figure 3-65.

c. Cleaning and Inspection.

(1) Clean upper and lower screen assemblies and retainers in fuel oil and dry with compressed air.

(2) Inspect screens for breaks or holes in mesh or other damage.

(3) Replace worn or damaged parts.

d. Assembly and Installation.

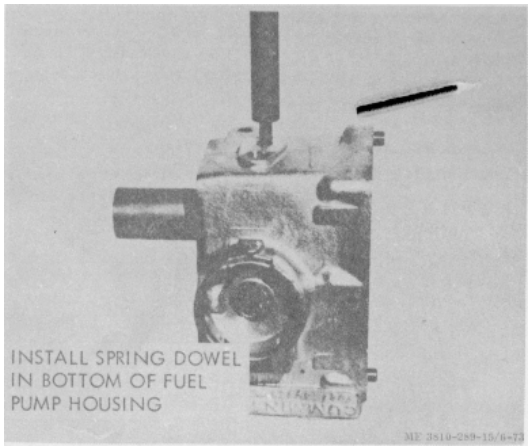


Figure 3-71. Spring dowel installation in bottom of fuel pump housing.

(1) Install lower screen; one with holes in each end.

(2) Install screen retainer and new O-ring packing.

(3) Install upper screen; hole down.

(4) Install spring.

(5) Lubricate new O-ring packing and place on cap.

(6) Install cap and torque to 25/30 ft. lbs.

3-12. Tachometar Drive

a. Removal Refer to paragraph 3-2

b. Disasse7n !9.

(1) Remove oil seal from tachometer drive shaft.

(2) Press tachometer drive shaft from drive gear and bushing if the gear is badly worn or shaft at bushing are galling or scoring check shaft O.D. it should be 0.3100/0.3105 in. and bushing I.D. should be 0.312/0.313 in. Replace if necessary.

c. Assembly. Place bronze bushing on tachometer shaft with chamfered end of bushing toward gear end. Press gear onto shaft until flush with end of shaft, figure 3-72. Check to see that shaft turns freely in bushing.

Note. Cheek gear to make sure it matches with tachometer drive gear, figure 3-73.

d. Installation. Refer to figure 3-19.

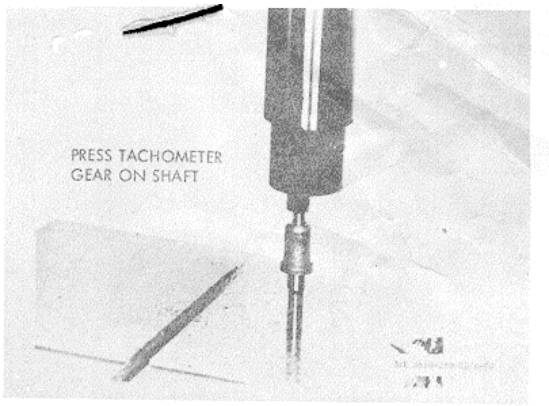
3-13. Fuel Injectors

a. General. The PT injector is a simple mechanical unit which receives fuel from the fuel pump under pressure. It then meters, injects and atomizes it through five injector cup spray holes into the combustion chamber.

b. Removal

(1) Remove injector holddown capscrews.

(2) Pry injectors loose and remove from



head,

Figure 3-72. Tachometer gear begin pressed.

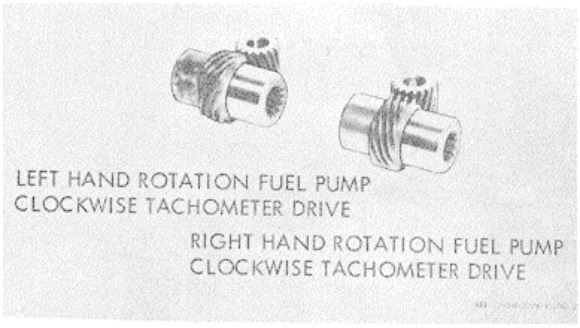


Figure 3-73. Tachometer gear.

figure 3-74 being careful not to damage injector cup tips.

(3) Number each injector according to the cylinder from which it was removed; I)lace in drain rack.

c. Disassembly.

(1) Lift out injector plunger and spring. Remove spring from plunger and then place plunger in body.

Note Injector bodies and plungers are class fit, do not interchange.

(2) Place injector in ST-569 Holding Fixture so the fixture spring tension is against injector plunger. Use spacers listed in table 2-2 to get required spring tension, figure 3-75.

Note. Do not remove adjustable office plug from inlet drilling.

(3) Remove injector cup with injector cup wrench listed in table 2-2.

Caution: Do not place injector body in vise to remove injector cup.

d. Cleaning.

(1) Clean injector parts thoroughly of any carbon or varnish by soaking in an approved solvent.

(2) Neutralize solvent after cleaning by dipping parts in mineral spirits.

(3) Dry with clean compressed air.

Caution: Do not use drills or other instruments to clean cup holes that will alter size of

holes. Wires may be used if a smaller size wire is used than the spray hole.

(4) A clean shop, clean tools and good cleaning practices are essential to good injector repair. Most injector failures occur because of dirt. Clean all parts before assembly:

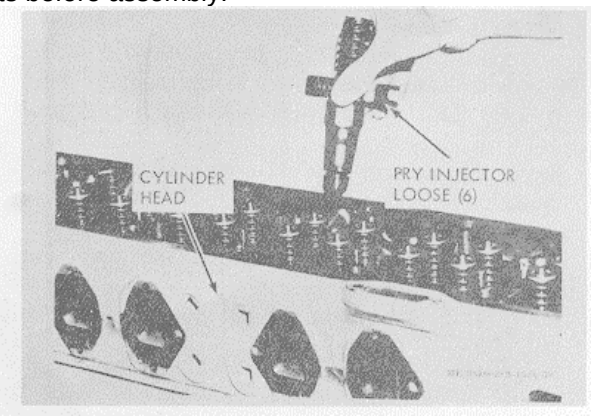


Figure 3-74. Injector removal.

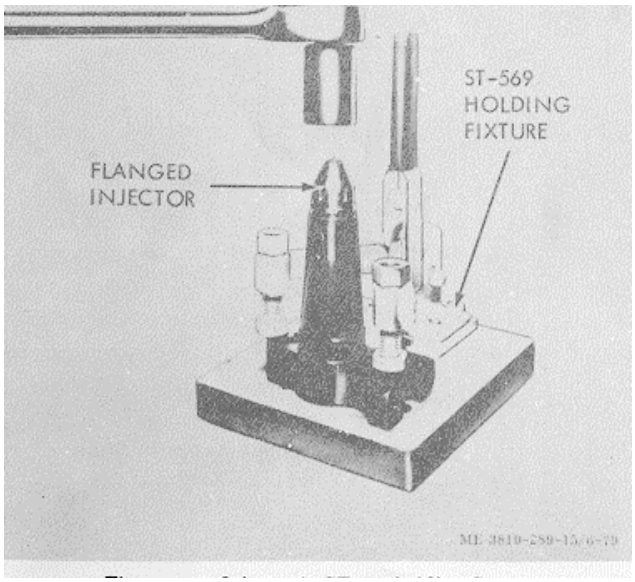


Figure 3-75. Injector in ST-569 holding fixture.

e. Inspection.

(1) Injector cup.

(a) Inspect injector spray holes and tip with magnifying glass. Compare with new cup shown in figure 3-76. Discard cup if any of the following conditions exist.

1. Abrasive wear: This wear can begin internally; therefore, inspect both interior and exterior, figure 3-77.

2. Corrosion damage and effect of excessive heat: This condition usually results from high acid or sulpher content in fuel or overload operating conditions, figure 3-78.

3. Enlarged or distorted spray holes: Caused by cleaning with drills or other instruments.

(b) Inspect cup for plunger seat pattern. If plunger seat covers 40 per cent continuous area around cup cone or plunger bore, it is possible cup may be reused. Seat location is not important, figure 3-79.

Caution: Never alter size of injector cup spray holes.

(2) Injector body.

(a) Inspect injector body plunger bore for scoring. If scores are not too deep, injector body should be honed and fitted with an oversized plunger.

(b) Use a strong magnifying glass to check for burs, carbon and distorted radii in orifices. When injector orifices are damaged, the injector will not function properly. Do not attempt cleaning with , wires, plug gages, etc; use solvent cleaners.

(c) Check injector inlet and drain connection holes for mutilation to threads and copper gasket surface, if multilated mark for repair.

(3) Injector plunger.

(a) Check closely for metal seizure. As a rule this is the only true indication of scuffing or scoring.

(b) Bright spots or surface disruption at top of plunger, on opposite side at bottom of plunger or at mid-point, usually are normal results of rocker lever thrust action. Unless metal is displaced or wear is measurable at these points, the plunger may be reused. If worn excessively install a new plunger.

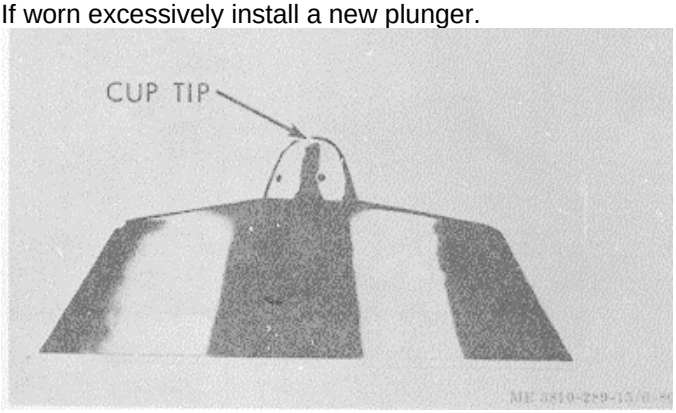


Figure 3-76. New injector cup tip.

(c) Narrow streaks running the length of the plunger usually are the result of the varying thickness of penetrate treatment used to prevent rusting and the plunger is satisfactory for reuse unless a surface disruption is evident.

(4) Injector spring.

(a) Check spring for excessive wear or mutilation.

(b) Test spring tension on spring tester, figure 3-80, that is capable of very accurate measurements

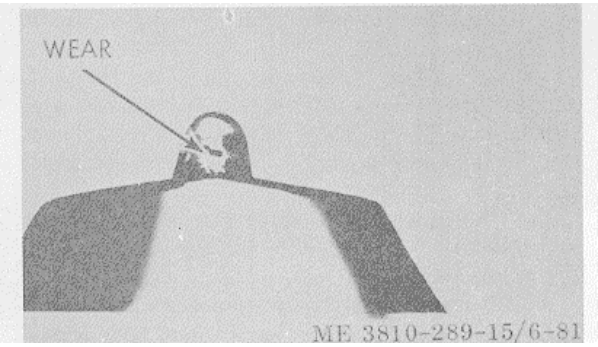


Figure 3-77. Worn injector cup tip.

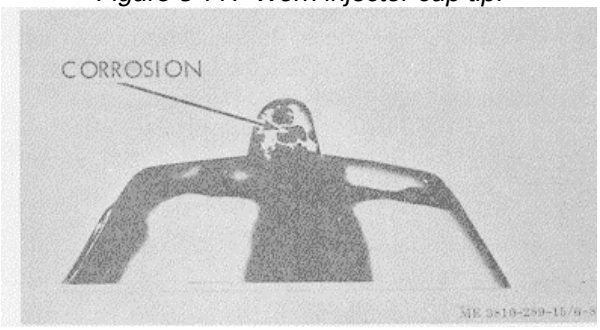


Figure 3-78. Corroded injector cup tip.

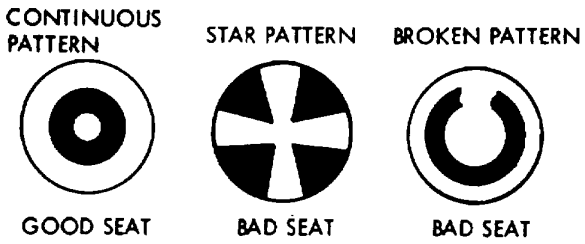


Figure 3-79. Seat pattern of plunger in cup.

of spring lengths and applied load by means standards and dial indicator gage, table 2-2.

(c) If injector springs compress to dimensions shown, at less than load indicated under - "wear limits", springs must be discarded, figure 3-81 and table 2-2(5).

f. Repair

(1) Plunger link replacement.

(a) Replace plunger link if worn excessively see figure 3-82.

(b) A collet type hand tap holder, such as shown in figure 3-83 may be used to pull sleeve type injector links:

1. Place tap holder over link and tighten holder.

2. Hold plunger and give tap holder a quick pull.

Note. Do not put plunger in vise to pull link.

(c) Place new retaining ring on new plunger link and press link into place, figure 3-84. If sleeve type retainer, press retainer flush to 0.010 inch below bore surface.

Caution: Handle injector plunger with care to prevent damage which could render it useless.

(2) PT flanged injector body.

(a) If connection threads in body were marked for repair, clean threads with a -1/2-20 tap.

(b) Repair connection gasket surface if mutilated with ST-542.

1. Screw pilot of ST-542 into inlet or drain connection to be spot faced.

2. Pilot cutter of ST-542 over pilot.

e. Turn cutter until a good gasket seat is cut, figure 3-85.

4. Clean body thoroughly after repair.

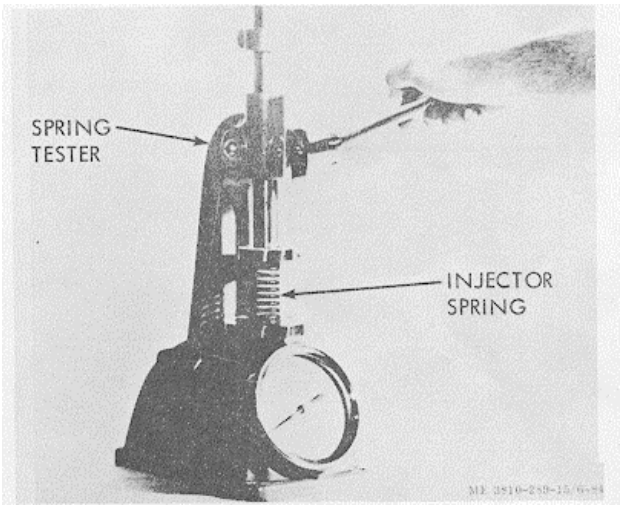


Figure 3-80. Injector spring test.

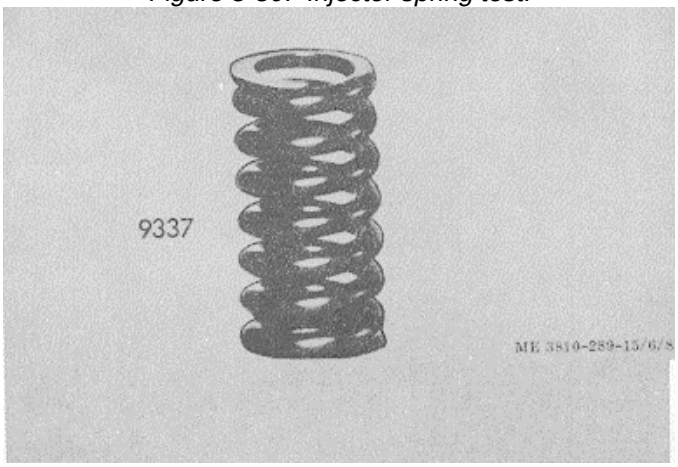


Figure 3-81. Injector spring.

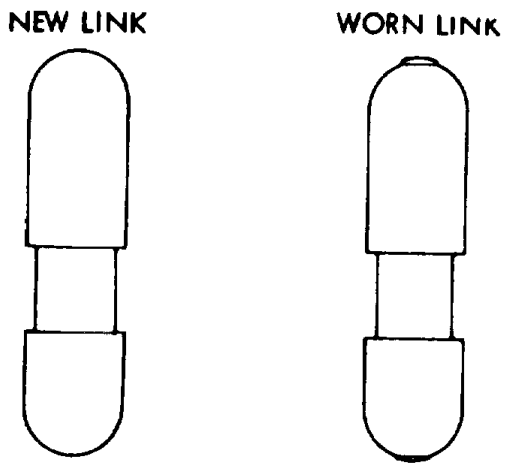


Figure 3-82. Plunger link wear.

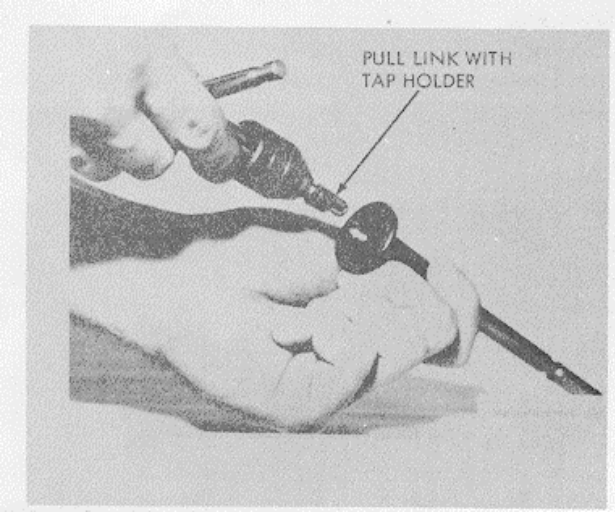


Figure 3-83. Pulling link with a tap holder.

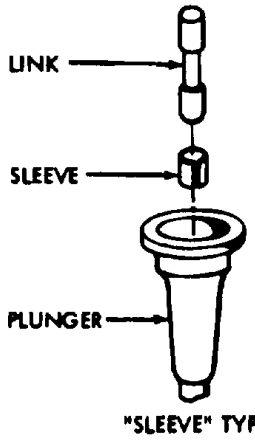


Figure 3-84. Plunger link assembly.

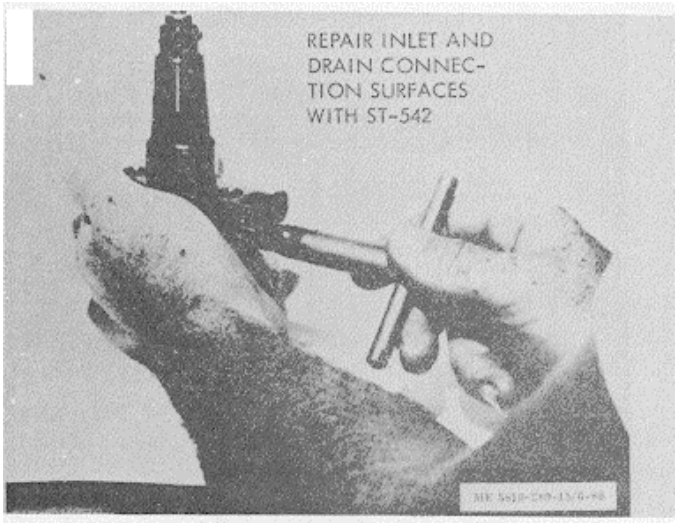


Figure 3-85. Repairing inlet and drain connection surfaces with ST-542.

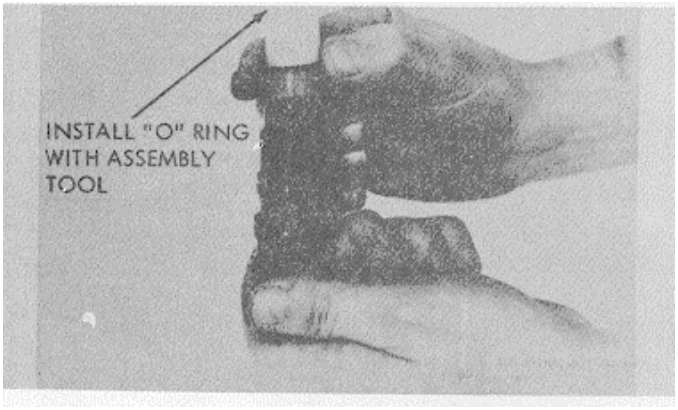


Figure 3-86. Installing O-ring with assembly tool.

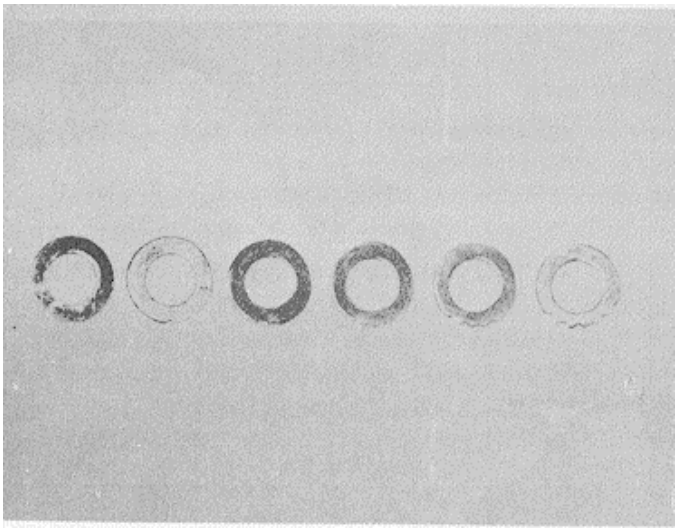


Figure 3-87. Injector cup gasket markings.

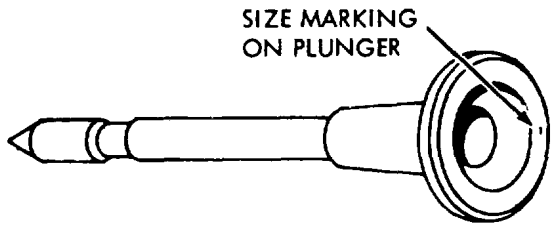


Figure 3-88. Size marking location on plunger.

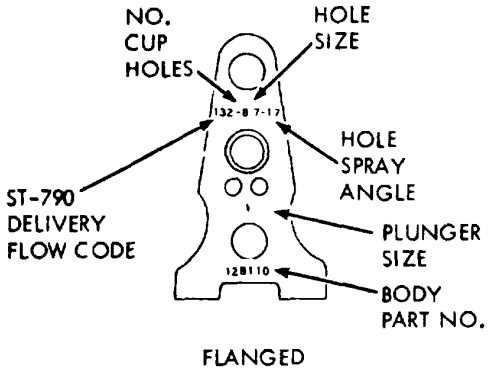


Figure 3-89. Size markings on injector body.

g. Assembly.

(1) Install new O-ring with proper assembly tool listed below each time cup is removed, figure 3-86.

(a) Dip O-ring in clean lubricating oil or liquid soap.

(b) Assemble proper tool over threaded end of injector body, table 2-2.

(c) Slide O-ring over tool into groove.

(2) Select new injector cup gasket corresponding to plunger body size, figure 3-87 table 2-2. See figure 3-88 for location of size markings on plunger and figure 3-89 for body markings.

Note. When PT flanged injectors are fitted with oversize plungers, thicker cup gaskets are used to provide the original relationship between plunger and metering orifice.

(3) Install proper cup on injector body finger tight (fig. 3-90). Back cup up one half turn.

(4) Immerse injector plunger in clean injector test oil and install in body without spring and place injector in ST-569 with correct spacer to align plunger in body. Tighten cup to specified torque with cup wrench listed in table 2-2.

Note. Two types of injector cup wrenches have been used, three spline and six spline, always use the six spline wrench if possible, figure 3-91.

Note. Unless proper gasket is used with corresponding body and plunger, the engine will develop a miss on cylinder containing the improperly rebuilt injector.

(5) Check injector assembly plunger seating on ST-570 or ST-990, preferably ST-990 if available.

(6) Remove injector plunger from body; lubricate plunger with test oil. Install injector spring and plunger in correct body; check to see that it does not bind as it seats in cup.

(7) Fill injector body two-thirds full of clean fuel. Insert plunger forcing fuel out cup spray holes to see that they are open and clean.

h. Installation.

(1) Clean the injector sleeve with a clean cloth wrapped around a wooden stick. Never use a screwdriver or other metal device for this operation; a scratched injector sleeve may cause a compression

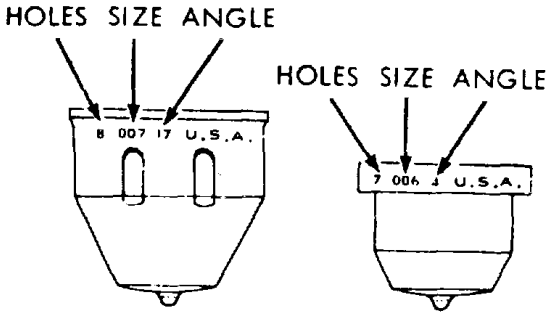


Figure 3-90. Markings on injector cups.

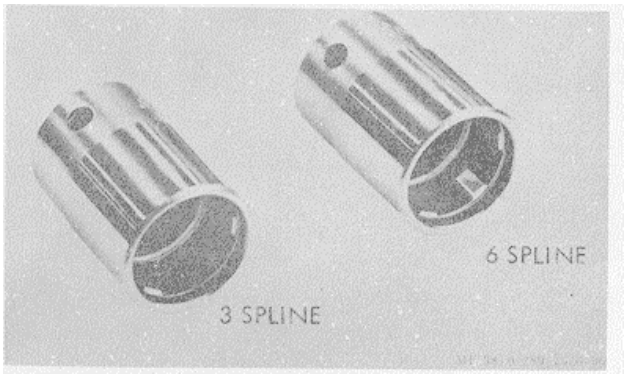


Figure 3-91. Injector cup wrenches.

(2) Place all injectors in injector bores in cylinder head, figure 3-92.

Note. When installing injectors in engine, position injector plunger so class marks on plunger sleeves are centered between fuel connection openings.

Caution: Be careful not to damage injector cup tips.

(3) Start, but do not tighten, hold-down capscrews into injector mounting holes in cylinder head.

(4) Place new gaskets on fuel inlet and drain connections; install drain connections in left holes and inlet connections in right holes of injectors.

(5) Start fuel connections into injectors; approximately three turns are required to align injector body with fuel connections.

(6) Tighten injector hold-down capscrews with torque wrench in alternate steps to 12 ft.-lbs., figure

3-93; begin tightening sequence with capscrew on opposite side of inlet and drain connections.

Caution: Excessive tightening may distort valve seats or crack cylinder head.

(7) Tighten inlet and drain connections to 20/25ft.-lbs., figure 3-94. Be sure that wrench engages nuts next to connection springs.

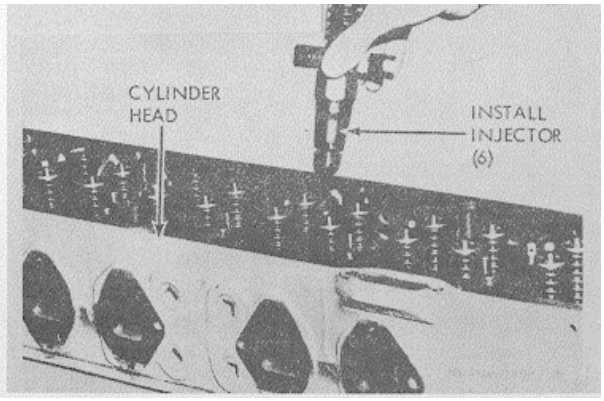


Figure 3-92. Installing injectors.

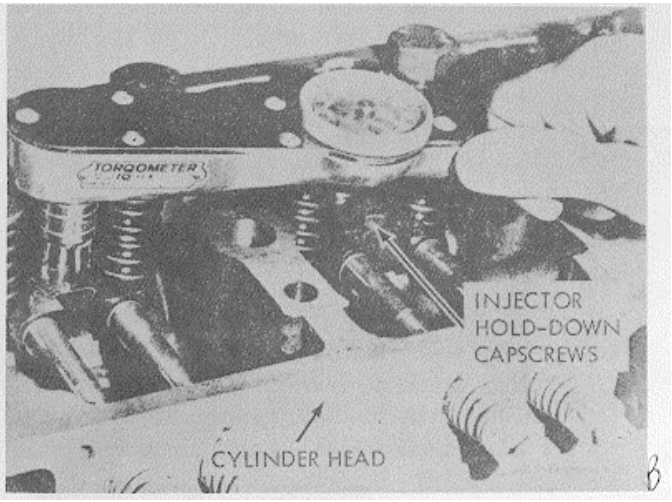


Figure 3-93. Torquing injector holddown capscrews.

3-14. Injector Sleeves

a. Removal

(1) Remove worn flange-mounted injector sleeves by cutting them from cylinder head with a 3/8 inch cutting tool) and driving out from lower end.

(2) Remove all foreign material from injector sleeve sealing are area.

b. Inspector Sleeve.

(1) Note results of water test. Leaks indicate need for replacement. Refer to paragraph 3-30c for water test.

(2) Visually check sleeves which pass the water test for scratches on cup seat area and mark for

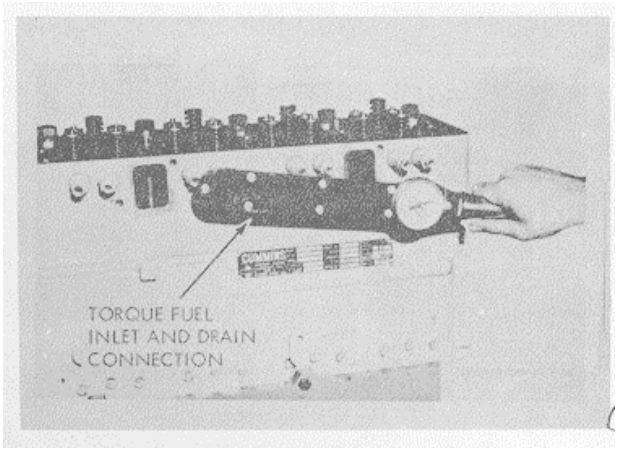


Figure 3-94. Torquing fuel inlet and rain connection.

replacement if seat area is scratched.

(3) Lightly coat a new injector cup) on injector body with Prussian Blue. Install in injector sleeve and torque injector into injector sleeve evenly to operating tension. Remove and check seat pattern. If indicated seat width does not show at least 0.060 in wide continuous contact, mark sleeve for replacement.

(4) Check seat depth.

(a) Install injector assembly. Torque, injector capscrews to 10/12 ft.-lbs. If so equipped, torque
nylock capscrews to 12/14 ft.-lbs.

(b) Measure tip protrusion with dial indicator as shown in figure 3-95. Injector cup tips should protrude 0.040/0.055 in. beyond cylinder head milled surface. Maximum allowable protrusion is 0.065 in.

c. Repair.

(1) Machine bead in sleeve seat area of head, if not previously beaded, with ST-839, figure 3-96. This will provide an improved seal.

(2) Install the bead cutter in ST-379-1 Seat Cutter Holder and position with ST-843 Seat Cutter Pilot in a drill press. Set drill press speed at not more than 75 rpm. Cutter may be turned by hand using a tap wrench.

Caution: Chattering may occur if drill press speed is over 75 rpm.

(3) Place cylinder head on drill press table, allowing clearance for the end of the bead cutter to protrude below the head surface into a pilot. The pilot can be made by recessing a '%2 inch drill bushing in a plate which is centered below the drill spindle and secured in place.

(4) Before starting drill press motor, insert cutter, adapter and pilot into injector bore to insure proper alignment.

(5) Lift cutter, adapter and pilot, lubricate cutter with cutting oil and start cutting operation, applying a steady moderate pressure.

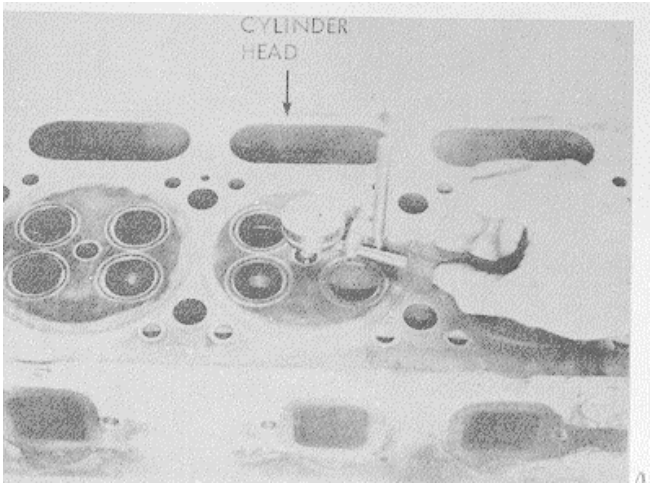


Figure 3-95. Measuring injector tip protrusion.

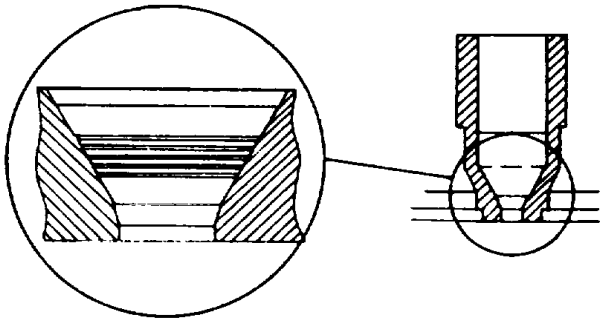


Figure 3-96. Sleeve seat bead and chamfer location.

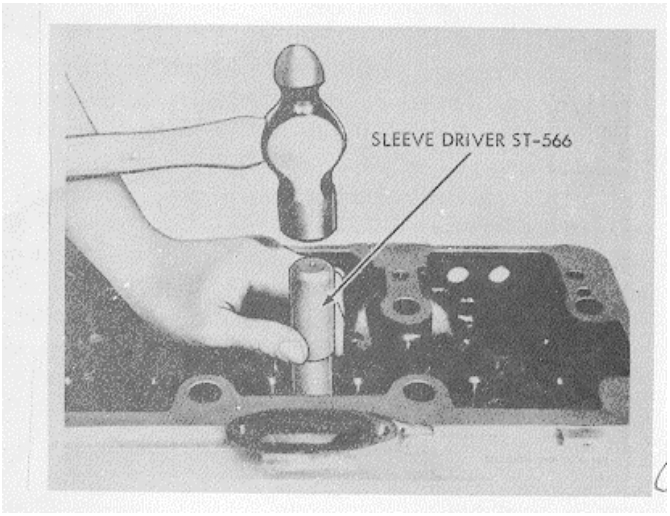


Figure 3-97. Installing injector sleeve.

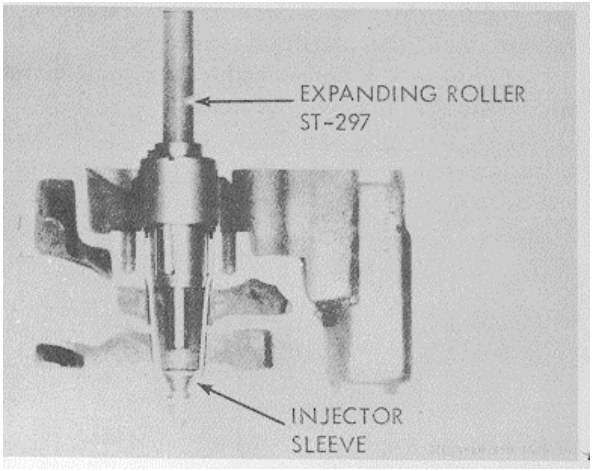


Figure 3-98. Sealing upper end of injector sleeve with ST-297.

Caution: Do not cut more than 0.010 in. deep.

(6) When the proper depth has been obtained, allow the cutter to dwell for approximately 10 seconds to insure a good seat and clean grooves.

(7) Lubricate and install ST-825 Cutter, adapter and ST-843 pilot. Attach a tap wrench to the adapter and rotate, applying a light even pressure. The ST-825 Cutter is used to cut a 30 degree angle chamfer at the lower edge of the 60 degree seat. When the upper end of the 30 degree angle chamfer is approximately 9/64 inch from the bottom bead, remove cutter, adapter and pilot.

(8) Remove bluing from 60 degree seat.

d. Installation.

(1) Drive in injector sleeve with ST-566 injector sleeve driver, figure 3-97.

(2) Remove driver from injector sleeve and install injector sleeve holding tool ST-923 or ST483.

(3) Seal upper portion of sleeves with expanding roller, ST-297, figure 3-98. Apply force to expand rollers until sleeve upper diameter reaches 1.375/1.380 in.

(4) Remove the injector hold down tool.

(5) Seal injector sleeve in lower seating (tapered) area with Angle Roller Tool, ST-819, figure 3-99.

(6) With roller in drill press set at 250 rpm, apply 500/650 lbs. axial force for 30 seconds. Lubricate roller during this operation.

(7) Cut injector seat to provide proper injector seat and injector tip protrusion. Use ST379 seating cutter and ST-379-2 pilot tool. It is very important that the cutter be ground to the exact dimensions shown in figure 3-100.

(8) To determine amount of cut, install injector and measure tip protrusion. Depth of cut should provide 0.040/0.055 inch protrusion of injector cup tip beyond milled face of cylinder head. Maximum allowable injector cup protrusion is 0.065 inch.

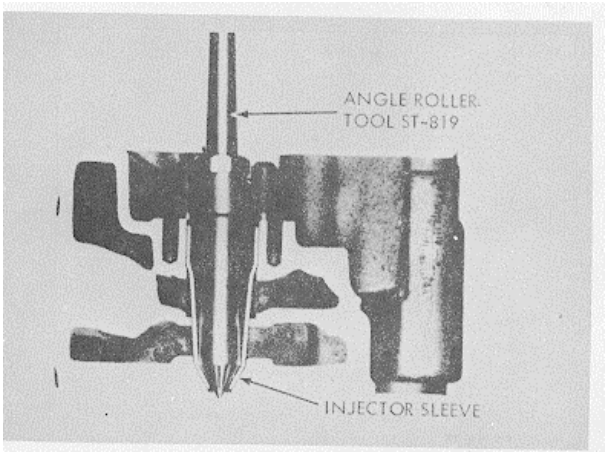


Figure 3-99. Sealing lower end of injector sleeve.

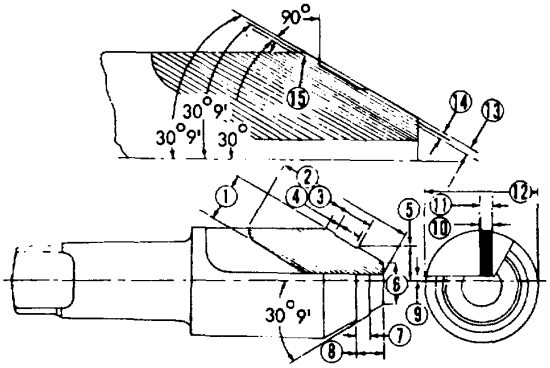


Figure 3-100. ST-397-3 injector seat cutter dimensions (inches).

3 0.3161	11 0.0937
4 0.145/0.155	12 0 923/0.925
5 0.300/0 310	13 0.0053/0.0073
6 0.3125	14 0.0015/0.0025
7 0.0937	15 0.040/0.060 R
8 0.250	

3-15. Clutch Assembly

a. Removal and Disassembly.

(1) Pull shaft and housing assembly.

(a) Disconnect control rod from shifter arm outside housing.

(b) Disconnect transmission chain and remove from small sprocket (TM 5-3810-289-12).

(c) Remove 12 clutch housing bolts (TM 5-3810-289-12).

(d) Remove clutch power take-off as a unit leaving driving ring bolted to flywheel.

(e) Press off pilot bearing (29, fig. 3-101), the remove hub nut (28) and lockwasher (27).

(f) Remove clutch with a few sharp taps on end of shaft with soft hammer. (Shaft in hub is tapered).

(g) Loosen operating shaft (15) by unclamping two capscrews (18).

(h) Pull operating shaft; remove key (14) soon as expose d and remove clutch shifter arm.

(i) Unfasten bearing retainer lock (7) and unscrew bearing retainer nut from housing.

(j) Remove clutch shaft (9) from housing by tapping pilot end of shaft with soft hammer.

(2) Takedown clutch shaft subassembly.

(a) Unscrew bearing locknut and take-off bearings. Do not remove bearings unless necessary.

(b) Press sprocket off shaft.

© Remove grease fitting.

(3) Disassemble clutch sleeve and hoke.

(a) Remove yoke (16) and sleeve assembly (13) from clutch.

(b) Take-off throwout collar (40) by removing the two bolts and nuts (split collar).

(c) Take eight link pins from levers and sleeve.

(d) Remove four levers by taking out four lever pins.

(4) Remove floating plate (20, fig. 3-101).

(5) Take-off driving plate (23).

(6) Remove six release springs.

b. Inspection and Repair. Clean all parts thoroughly and inspect for damage and excessive wear. If driving plate has been worn to the point where clutch can no longer be adjusted, replace with new driving plate. Be sure all clutch lever pin retaining links are in good condition and in place. Inspect clutch release springs for good condition; replace damaged or defective springs.

c. Reassembly and Installation..

(1) Assemble the clutch sleeve and yoke assembly as a unit (fig. 3-101).

(a) Place four levers into yoke (161.

(b) Place the lever links and throwout collar on sliding sleeve (13).

(2) Install yoke and sleeve assembly.

(3) Install six release springs, the driving plate (23), and the floating plate (20).

(4) Step on the floating plate and screw yoke and sleeve assembly on hub and back plate (241 until tight.

(5) Reassemble shaft subassembly and shaft into housing.

(a) Install operating shaft (15i and clutch shifter arm in housing.

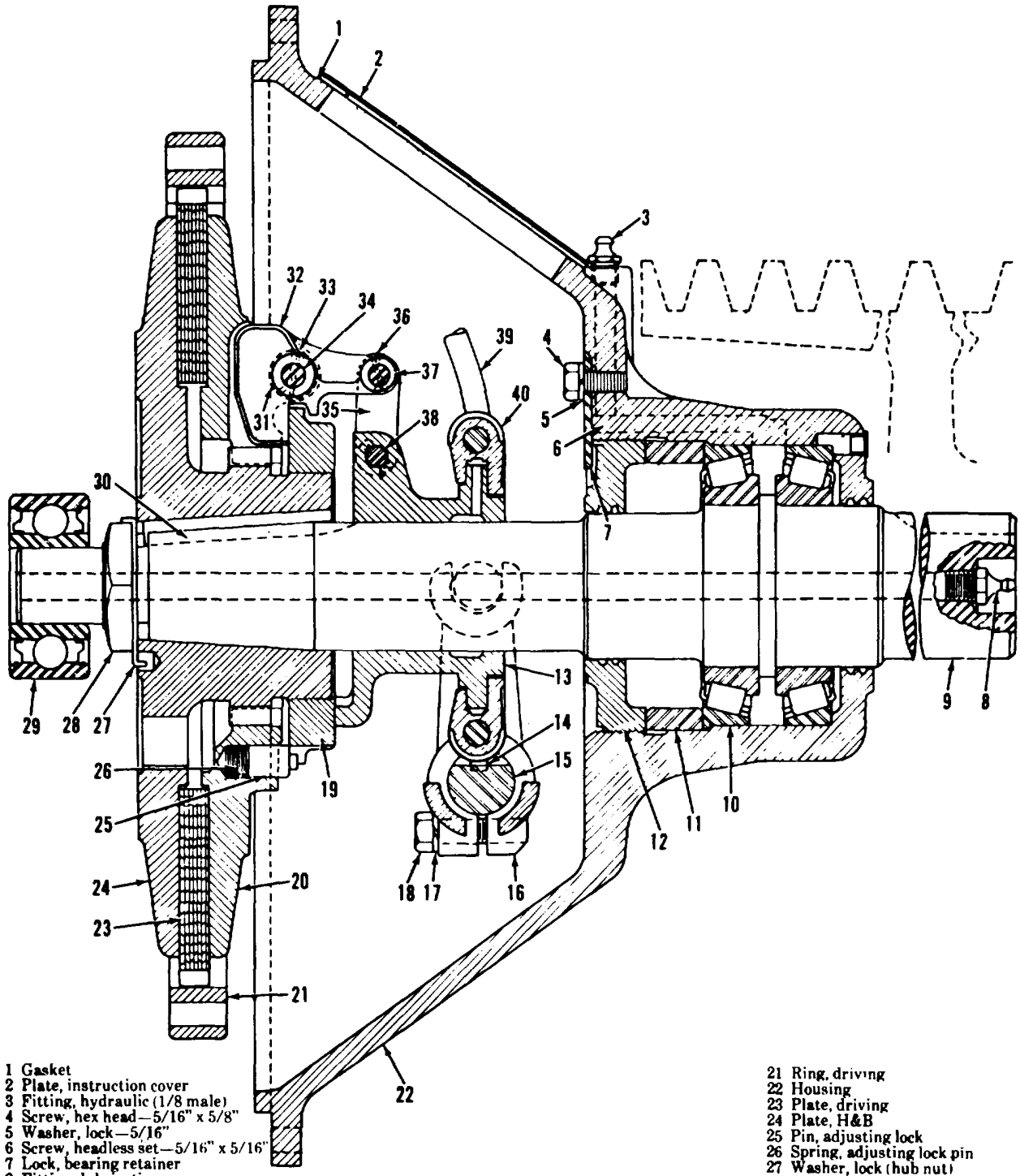
(b) Clean roller bearings (10) and press on shaft.

© Pull up bearing locknut tight; drill new hole if hole does not line up.

(d) Pack bearing with GAA general purpose grease.

(e) Install shaft (9) into housing (22), then press bearing cups into housing.

(f) Screw on bearing adjusting nut tight so that shaft cannot be turned, then back up three to four notches.



1 Gasket
2 Plate, instruction cover
3 Fitting, hydraulic (1/8 male)
4 Screw, hex head—5/16" x 5/8"
5 Washer, lock—5/16"
6 Screw, headless set—5/16" x 5/16"
7 Lock, bearing retainer
8 Fitting, lubrication
9 Shaft, clutch
10 Bearing, roller (2)
11 Spacer, bearing
12 Retainer, bearing
13 Sleeve, sliding
14 Key, woodruff
15 Shaft, operating (serrated)
16 Yoke, throwout
17 Washer, lock—3/8"
18 Screw, hex head—3/8" x 1½"
19 Ring, adjusting
20 Plate, floating
21 Ring, driving
22 Housing
23 Plate, driving
24 Plate, H&B
25 Pin, adjusting lock
26 Spring, adjusting lock pin
27 Washer, lock (hub nut)
28 Nut, hub
29 Bearing, pilot
30 Key, hub—3/8" x 3/8" x 2½"
31 Washer, spring
32 Lever
33 Pin, cotter
34 Pin, lever
35 Link, lever
36 Pin, cotter
37 Pin, lever link
38 Pin, lever link
39 Hose assembly, flexible
40 Collar assembly

Figure 3-101. Clutch assembly, cutaway view.

(g) Install retainer lock.

(6) Assemble clutch and sliding sleeve assembly into housing.

(a) Install clutch and sliding sleeve assembly onto shaft.

(b) Install lockwasher 127) and hub nut (28.

© Install pilot hearing (29).

3-16. Fuel Tank

a. General. The 50-gallon capacity fuel tank is located al the rear en(d of the turntable bed directly below the engine.

b. Removal. Refer to TM 5-3810()-289-12.

c. Cleaning and Repair (fig. 3-102).

(1) Flush tank out thoroughly with hot water and steam for about four hours to remove diesel fuel vapors.

(2) Fill tank completely full of water with puncture uppermost and all outlets closed or plugged.

Warning: The preceding procedure is important because it eliminates air space where diesel fuel vapors might linger to cause an explosion while welding.

(3) Repair puncture by welding and test for leak age.

(4) Drain water thoroughly and allow tank to stand upside down with cover removed until thoroughly dry.

d. Installation. Refer to TM 5-3810-289-12.

3-17. Primer Unit; Lines; Fittings

a. Removal. Refer to TM 5-3810-289-12.

b. Disassembly.

(1) Disconnect tubing t17, fig. 3-103) and cable (29), and remove coupler.

(2) Remove the valve and bracket assembly from the cylinder (3).

(3) Remove the clamp and cylinder.

c. Cleaning and Repair.

(1) Clean all parts in an approved cleaning solvent.

(2) Inspect all lines and fittings for breaks and cracks.

(3) Inspect valve for damage or wear; replace defective valve.

(4) Replace any lines or fittings found defective.

d. Reassembly. Refer to figure 3-103 and reassemble in reverse order of disassembly.

3-18. Radiator (fig. 3-104)

a. General The radiator is located at the front of the engine and provides the reservoir and cooling core for the cooling system. Refer to TM 53810-289-12 for removal and installation of the radiator.

b. Cleaning and Inspection.

(1) Drain radiator and remove deposits and scale

(2) Flush radiator and check for leaks.

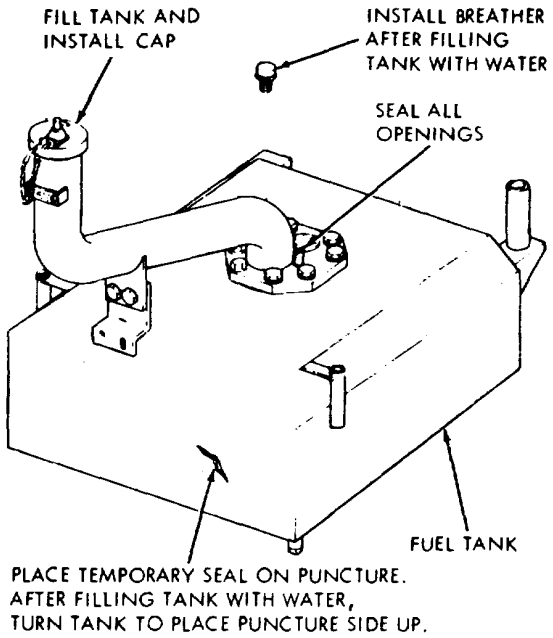
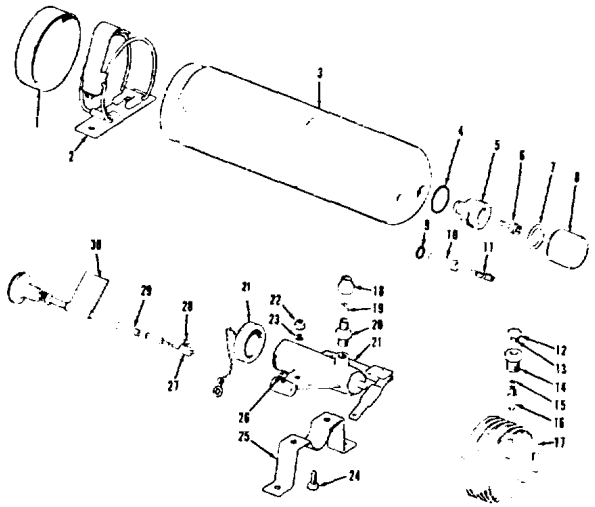


Figure 3-102. Fuel tank repair.



1 Ring	16 Atomizer
2 Cylinder clamp	17 Tubing
3 Cylinder	18 Nut
4 O-ring	19 Sleeve
5 Inlet	20 Body
6 Core	21 Valve and cap
7 Gasket	22 Nut
8 Cap	23 Washer
9 O-ring	24 Screw
10 Body	25 Bracket
11 Core	26 Screw
12 Tap	27 Stop
13 Nut	28 Screw
14 Connector	29 Cable
15 Screw	30 Instruction label

Figure 3-103. Primer unit: lines, fittings, exploded view.

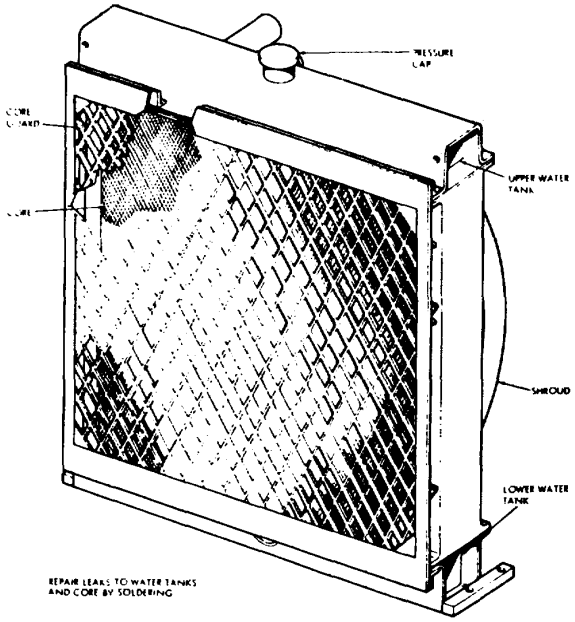


Figure 3-104. Radiator repair.

(3) Inspect all mounting hardware for damage or missing parts.

c. Repair.

(1) Repair leaky radiator by soldering.

(2) Replace damaged or missing hardware.

3-19. Wiring Harness

a. General Refer to TM 53810-289-12 for wiring diagram and repair of wiring harness.

b. Replacement.

(1) After determining that a wire is open or shorted, through the use of test equipment, disconnect faulty wire at both ends. This is accomplished by pulling connections apart.

(2) Attach a wire of approximately the same diameter and several feet longer to one end of the faulty wire. Tape the splice so that no sharp protrusions exist.

(3) Pull the faulty wire through the conduit until the opposite end is seen.

(4) Attach a new wire to "leader strip" and pull back through conduit.

(5) If damaged wire is severed, cutting half, pick out a neighboring complete wire, tape both wires to "leader, strip" and repeat above process.

(6) After installation of new wire(s) be sure that wire numbers match.

Section II. ENGINE COMPONENTS

3-20. General

The engine is a six cylinder, four cycle naturally aspired diesel. The power is transmitted from the engine, through the power takeoff unit, and the chain drive transmission, to the main machinery controlling the crane-shovel operations. The engine components are fully described in applicable paragraphs throughout this section.

3-21. Water Pump

a. General. The water pump assembly is mounted on the right front of the engine. It is belt driven and circulates the coolant through the engine block, cylinder head and radiator.

b. Removal

(1) Disconnect the water inlet and outlet hose and couplings from the water pump.

(2) Remove mounting capscrews and lockwashers securing water pump to block.

(3) Lift water pump from engine (fig. 3-105).

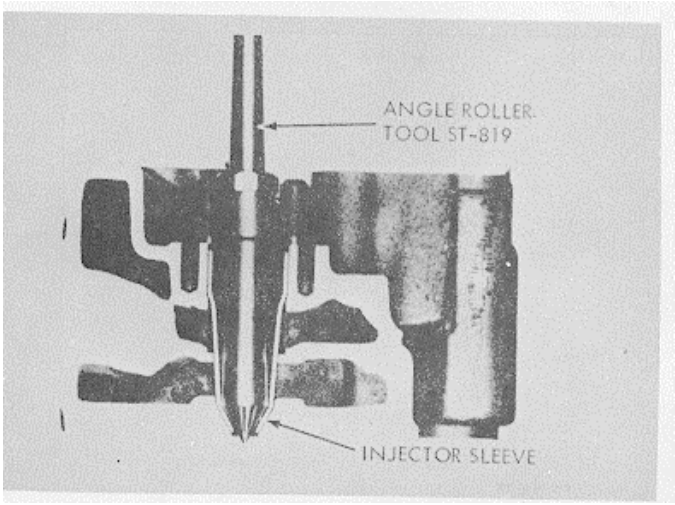


Figure 3-105. Water pump removal.

c. Disassembly.

(1) Remove capscrews (7, fig. 3-106) and lock washers (14); lift cover (8) and gasket (10) from pump body (3).

(2) Remove lock capscrew (4) from pulley end of shaft.

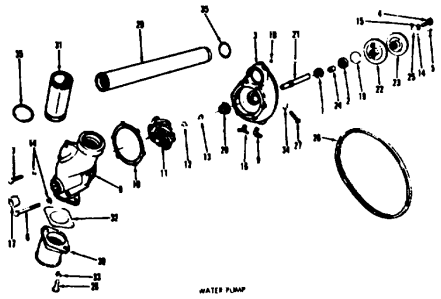
(3) Pull sheeve (22) from shaft using ST-647.

(4) Remove snap ring (19) from pump body (3).

(5) Support pump on body face near bearing location; press shaft and bearings (21, 1, and 2) from pump body (3) and impeller (11) toward drive pullley end of body.

(6) Remove carbon face seal (20) from body.

(7) Press two bearings (1 and 2) and spacer (24) from shaft (21).



1 Ball bearing
2 Ball bearing
3 Pump body
4 Screw , cap (7/16"-14x ")
S Screw, cap(5/16"--18 x 1)(3)
6 Screw, cap(S/16"- lSx)(2)
7 Screw, cap (5/16"-18 x7/8")
8 Pump cover
9 Flexible elbow
10 Gasket
11 Impeller(122294)
12 Bonding film
13 Impeller eat
14 Washer, look (5/16") (9)
15 Washer, lock (7/16"1
16 Drain eoek
17 Pipe plug (i"
18 Pipe plug(l/8"i
19 Retaining ring
20 Pump seal
21 Shaft
22 Fixed sheave
23 Adjusting sheave
24 Spacer
25 Washer, plain
26 Belt
27 Screw, cap(7/16"-14 x l'4"(3)
28 Screw, cap(3/8"-16x l"'(2)
29 Connection
30 Inlet connection
31 Bypass coupling
32 Gket, connection
33 Washer, lock (8") (2)
34 Washer, lock (7/16")(3)
35 Oringt4i

Figure 3-106. Water pump, exploded view.

Figure 3-107. Bearing and shaft assembly being pressed in.

d. Cleaning and Inspection.

(1) Clean all parts in an approved cleaning solvent. Remove all rust, scale and corrosion from cover, body and impeller.

(2) Inspect shaft, impeller and pulley sheaves for excessive wear or damage.

(3) Check shaft outside diameter in impeller area. Shaft must be 0.001 inch or more larger than impeller bore diameter. If interference fit between shaft and impeller is less than 0.001 inch, discard impeller.

(4) Check ball bearings for rough or binding operation, excessive looseness and worn or damaged races.

(5) Examine carbon face seal carefully to see that it is not cracked or chipped.

(6) Discard all defective parts.

e. Assembly.

(1) Lubricate shaft (21, figure 3-106) be, fore installing bearings.

(2) Press small bearing (1), spacer (24) al d larger bearing (2) on shaft (21).

(3) Support body on cover face: press in shaft and bearing assembly, figure 3-107.

Note. Just prior to assembly, apply a thin coating of sealer such as "Loctite" grade B or its equivalent (hearing mount J to I D. of housing, where bearing mounts Bearing C D. and housing I D must be free of grease and oil.

(4) Insert snap ring(l19, fig. 3-106f.

Note. Current production water pump bodies are machined for beveled snap rings. Older models use flat snap ring, Replace same type snap ring as removed. Flat and hexeled rings are not interchangeable

(5) Support housing on pulley end of body (3).

(6) Apply lead pipe sealer such as Job, Crane Plastic Lead Sealer No. 2 or equivalent to carbon face seal outside diameter that beats at bottom of bore.

(7) Locate body so carbon face seal (20) will press squarely into its bore.

(8) Press carbon face seal into pump body with force applied on driving lip (flange on seal housing) (fog. 3-108) of seal. Apply only enough force, to seat seal in housing bore.

Figure 3-108. Mandrel being placed on seal driving lip.

Caution: Seal does not seat on driving lip fange.

(9) Check to make sure carbon seal has not cracked during assembly.

(10) Lubricate carbon seal face with a light coat of petroleum jelly. Do not use grease.

(11) Lubricate shaft before installing impeller (11, fig. 3-106); support pump on pulley end of shaft.

(12) Press impeller (11) on shaft. Face of impeller huth should be 0.620/0.625 in. below cover face of body. Press impeller straight on pump shaft to prevent cracking ceramic seat, rendering seat useless, figure 3-106.

Note. Do not use old-style seal seats and rubber seat rings with carbon seals and ceramic face impellers. This combination will result in seal failure from excessive compression.

(13) Press pulley (23, fig. 3-106) on shaft with pump supported on impeller end of shaft.

(14) Assembly lockwasher (141 and capscrew (4) to shaft.

(15) Assemble lockwashers (151, capscrews (5) and new gasket (10t to cover (3) and mount cover to housing (8).

(16) Fill grease cavity with .80 to .95 ounces of grease meeting specification given in lubrication order.

e. Installation.

(1) Lift pump into position against side of block.

(2) Install lockwashers and capscrews; tighten securely, figure 3-109.

(3) Connect water inlet and outlet hose and couplings to water pump.

3-22. Fan Hub Assembly

a. Removal. Refer to figure 3-110 and remove fan hub assembly.

b. Disassembly.

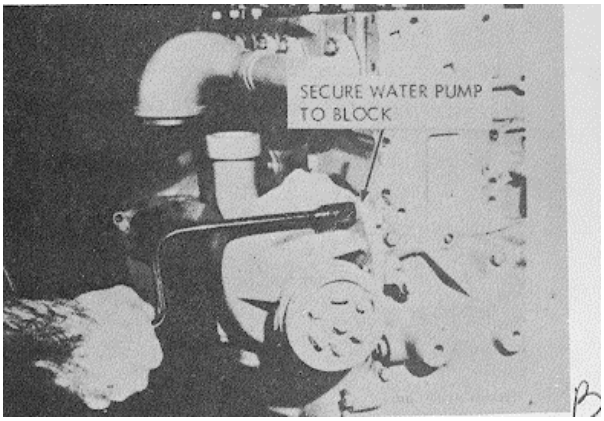


Figure 3-109. Water pump being secured to block.

(1) Remove capscrews and washers from fan spacer(12, fig. 3-111); remove spacer.

(2) Remove locknut (7) and washer (15).

(3) Press shaft (11 from pulley hub (8).

(4) Remove snap ring (9i from hub.

(5) Press tearings (1) and (2), and spacer (13) from fan hub.

(6) Remove nut (f), washer (14), and adjusting screw (10) securing shaft to bracket (3); lift shaft from back of bracket.

c. Inspection.

(1) Clean all parts in an approved cleaning solvent and dry with compressed air.

(2) Check shaft and bearings for scratches and wear.

(3) Discard all fan huh parts that are worn or defective and replace.

d. Reassembly.

(1) Place shaft (11, figure 3-111) through bracket (3); secure with washer (14) and nut (6). Assemble adjusting screw (10).

(2) Pack bearings with grease.

(3) Place spacer (13) and large bearing (21 in hub (8) and secure with snap ring (9).

(4) Press hub (8) on shaft.

(5) Assemble small bearing (1) over shaft into hub.

(6) Install washer 115) and locknut (7). Tighten nut until slight bearing drag is noticed.

(7) Install fan spacer (12) with capscrews and lockwashers.

(8) Remove pipe plug (17) and fill fan huh 60 per cent to 70 per cent full of grease.

e. Installation.

(1) Place fan hub and bracket assembly in position against front of block. Install flatwashers and capscrews; in 2 or 3 turns.

(2) Install all "V" belts.

(3) Tighten bracket mounting capscrews.

(4) If fan hub is adjusted with adjusting screw,

adjust belt tension by turning adjusting screw tighten shaft nut (behind bracket) to 400/450 ft.-lbs.

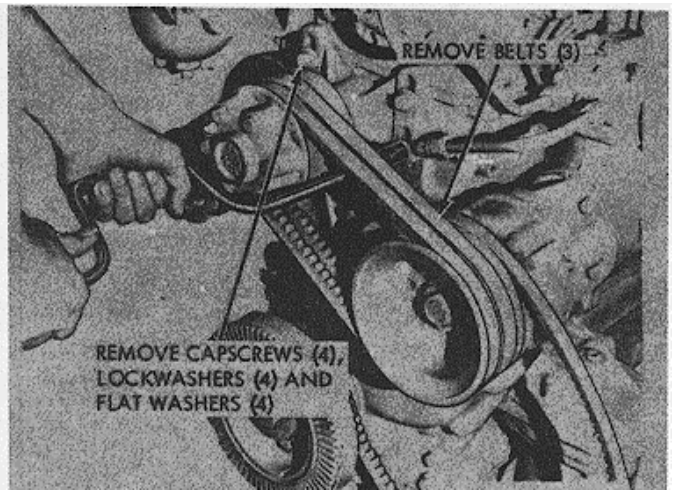


Figure 3-110. Fan hub assembly removal and installation.

3-23. Fuel Pump and Accessory Drive Pulley

a. Removal

(1) Remove locknut and flatwasher securing drive pulley to fuel pump drive.

(2) Install Standard Puller ST-647 onto the drive pulley as illustrated in figure 3-112.

(3) Turn center screw clockwise until pulley is loose.

(4) Remove pulley.

b. Cleaning and Inspection.

(1) Check for cracks and chips in hub, web and groove areas of pulley.

(2) Check for wear in grooves and oil seal sleeve. If wear on sleeve is visible, replace as outlined below.

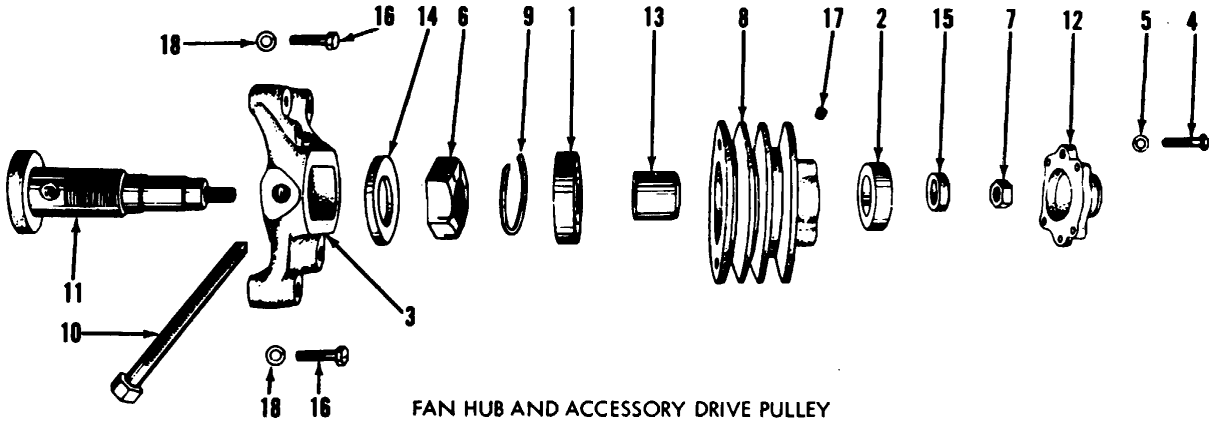
(3) Check mounting hardware; discard if damaged.

c. Repair.

(1) Remove worn oil sleeve by splitting with chisel. Do not damage pulley hub.

(2) Press new oil sleeve (fig. 3-113) onto pulley hub with mandrel.

Caution: Oil seal sleeve is special material and is closely machined to insure proper sealing. Resurfacing of this part is not practical.



1 Ball bearing
2 Ball bearing
3 Fan bracket
4 Capscrew, fan spacer (6)
5 Lockwasher. fan spacer (6)
6 Nut, shaft
7 Nut, shaft
8 Fan pulley
9 Snap ring
10 Screw, fan adjusting
11 Fan hub shaft
12 Fan spacer
13 Bearing spacer
14 Washer, fan hub
15 Washer, bearing nut
16 Capscrew, fan bracket 14
17 Pipe plug(2)
18 Lockwasher, fan bracket I4)

Figure 3-111. Fan hub assembly, exploded view.

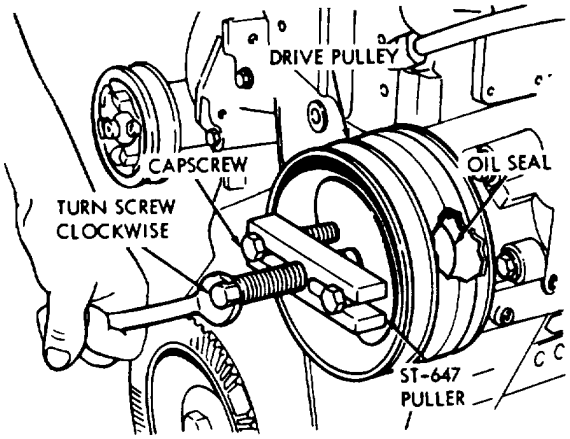


Figure 3-112. Accessory drive pulley removal.

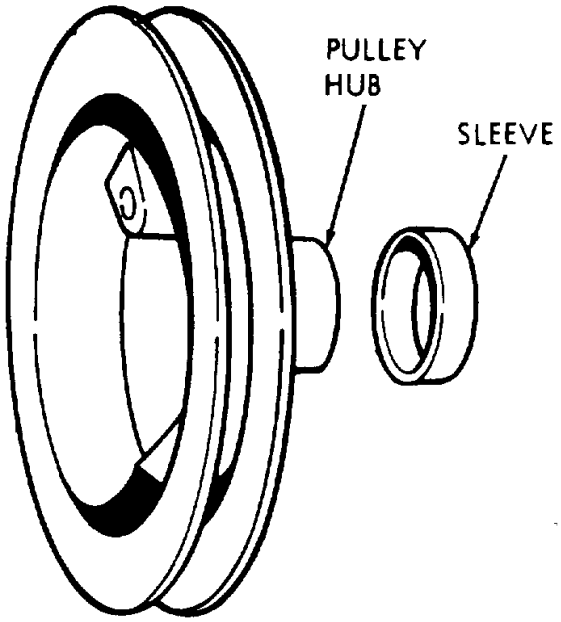
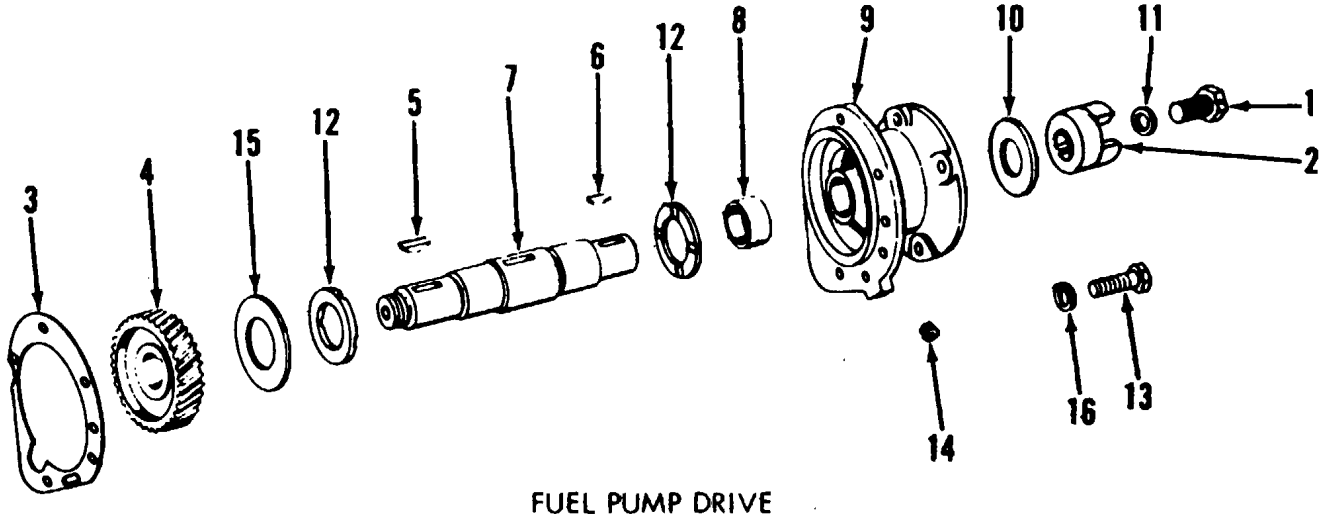


Figure 3-113. Pulley and sleeve.



FUEL PUMP DRIVE

1 Capscrew
2 Fuel pump coupling
3 Gasket
4 Accessory drive gear .
5 Key (2)
6 Key
7 Shaft
8 Bushing
9 Accessory drive support
10 Washer, clamping
11 Washer, plain
12 Washer. thrust (21
13 Capscrew Dowel in gear cover. Ref. (11)
14 Plug pipe
15 Seal, keyway
16 Washer

Figure 3-114. Accessory drive assembly, exploded view.

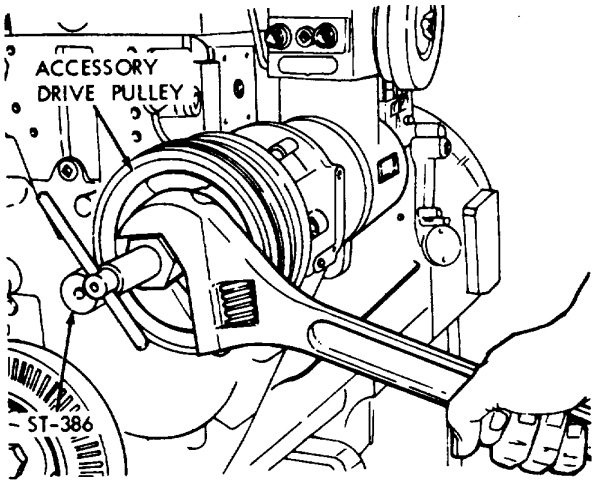


Figure 3-115. Accessory drive pulley installation.

d. Installation.

(1) Insert key (5, fig. 3-114 in accessory drive shaft.

(2) Slide pulley onto shaft until it binds.

(3) Using ST-386 Pulley Assembly Tool, press pulley onto drive shaft as illustrated in figure 3-115.

(4) Install flatwasher and locknut.

(5) Tighten locknut to 90/100 ft.-lb.

3-24. Fuel Pump Accessory Drive Assembly

a. Removal and Disassembly.

(1) Remove fuel pump accessory drive pulley (para 3-23).

(2) Remove four mounting bolts and remove and disassemble accessory drive (fig. 3-114).

b. Cleaning and Inspection.

(1) Clean parts in an approved cleaning solvent and dry thoroughly.

(2) Inspect for damaged or defective parts.

c. Repair. Replace damaged or defective parts.

d. Reassembly and Installation.

(1) Reassemble accessory drive assembly (fig. 3-114).

(2) Position drive assembly on mount; install and tighten four mounting bolts.

(3) Install accessory drive pulley (para 3-23).

3-25. Oil Transfer Connection

a. Removal

(1) Remove capscrews, lockwashers and flat washers from oil transfer connection (fig. 3-116).

(2) Remove connection from block and discard gaskets.

b. Installation. Position oil transfer connection and new gaskets to block; secure with flatwashers, lockwashers and capscrews.

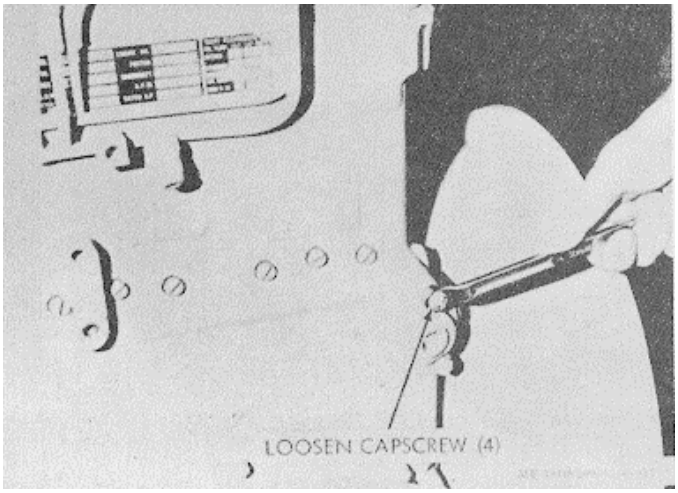


Figure 3-116. Oil transfer connection, removal and installation.

3-26. Oil Lines

a. General Hose used for lubricating or fuel oil lines should consist of a seamless synthetic rubber inner tube reinforced with fabric braiding and wire braiding, and covered with a synthetic rubber-impregnated oil-resistant fabric braid or rubber coating. The minimum flexible hose sizes and hose bends are given in table 2-2.

b. Inspections. Inspect oil and fuel oil lines for cracks, breaks, and other damage.

c. Replacement. Replace defective lines.

3-27. Water Header Plate

a. Removal

(1) Remove capscrews and lockwashers securing plate to block.

(2) Remove plate and gasket from engine, figure 3-117; discard gasket.

b. Installation. Position water header cover plate to side of cylinder block with new gasket; secure with lockwashers and capscrews.

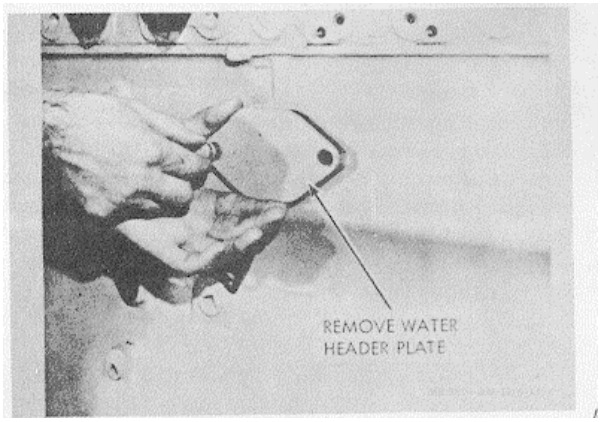


Figure 3-117. Water header plate, removal and installation.

3-28. Cylinder Head Replacement and Repair

a. Removal.

(1) Remove fuel inlet and drain manifolds (TM 5-3810-289-12).

(2) Remove air intake and exhaust manifolds (TM 54810-289-12).

(3) Remove thermostat and thermostat housing (TM 5-3810-289-12).

(4) Remove alternator assembly (TM 5-3810-289-12).

(5) Remove fuel injectors (para 3-13).

(6) Remove cylinder head cover and rocker arm assembly (para 3-39).

(7) Remove push rods (para 3-30).

(8) Remove valve crossheads and guides (para 3-47).

(9) Attach ST-756 Lifting fixture to cylinder head. Using a suitable hoist, lift head from block (fig. 3-118).

(10) Remove and discard head gasket, grommets, and retainers.

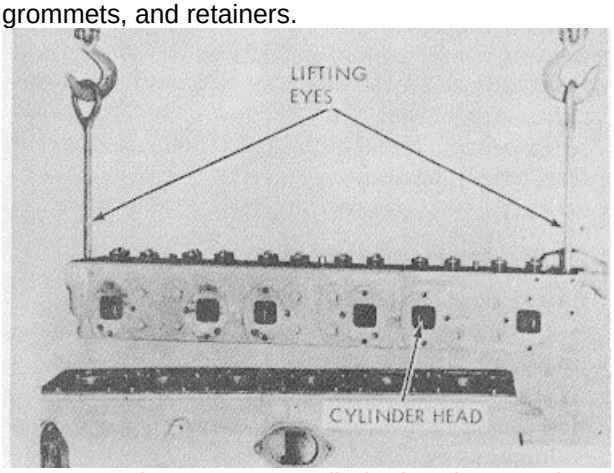


Figure 3-118. Cylinder head removal

b. Disassembly.

(1) Steam clean complete head assembly.

(2) Place cylinder head in ST-583 Head Holding Fixture or equivalent, see figure 3-119.

(3) Remove valves and springs. Use ST-448 Valve Spring Compressor to compress valve springs. ST-448 may be used at bench or on installed engine.

Caution: If removing valve springs on an installed engine, be sure piston is up to support valves in cylinder. Replace springs before barring the engine or valve will drop into cylinder necessitating cylinder head removal to retrieve valve.

(4) Screw stud from ST-448 in rocker lever bearing capscrew hole.

(5) Compress one valve spring at a time, figure 3-120. Tap valve head lightly to loosen; then remove half collets.

(6) Withdraw valves, valve springs and retainers (and valve spring guides.

(7) Remove ventilators.

c. Inspection and Cleaning.

(1) Water test cylinder head.

(a) Install injector Sleeve Holding Tool ST-383 or ST-923, or a scrap injector and cup assembly in each injector or sleeve.

(b) Tighten sleeve holding tool to 10/12 ft.-lbs. to seal lower end of injector sleeve, or install injectors and secure with capscrews torqued to same value, figure 3-121.

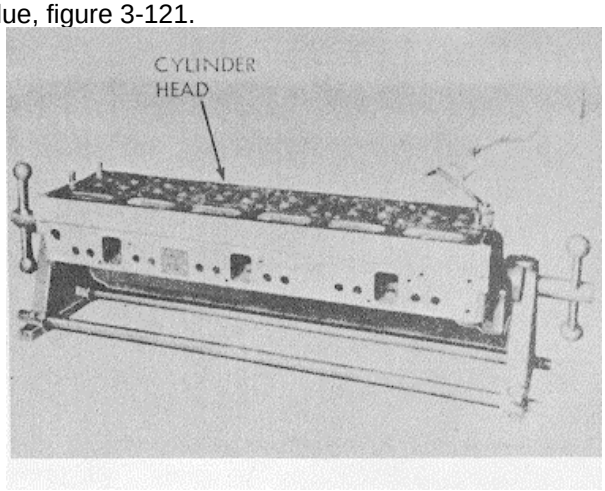


Figure 3-119. Cylinder head in head holding fixture.

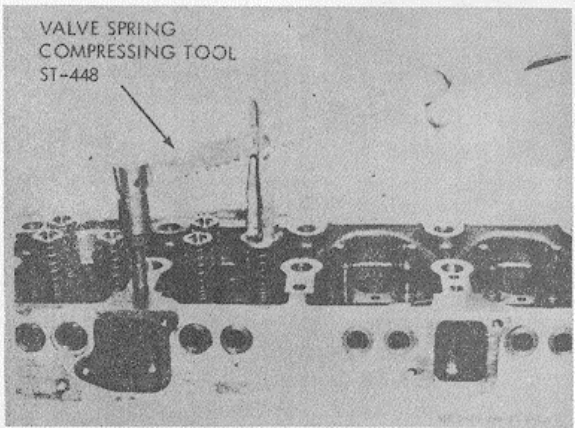


Figure 3-120. Compressing valve springs with ST-448.

(c) Test cylinder heads for leaks at 35/85 psi and, if possible, at 1750/2000F. (790/930 C.) water temperature. Check carefully around valve seats and injector sleeve seats for any cracks, even though such cracks might not show water leakage. This type crack is caused when injector capscrews are tightened beyond factory tc.rque recommendation. Discard head if cracked.

(d) Open water outlet valve of test fixture; check for free water circulation through cylinder head. If restriction is evident, remove plugs and injector sleeves; clean water jacket of salt, lime or sludge as follows:

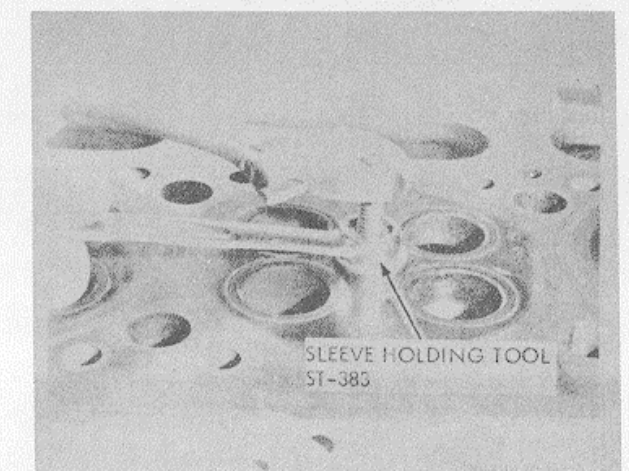


Figure 3-121. Install injector sleeve holding tool ST-383.

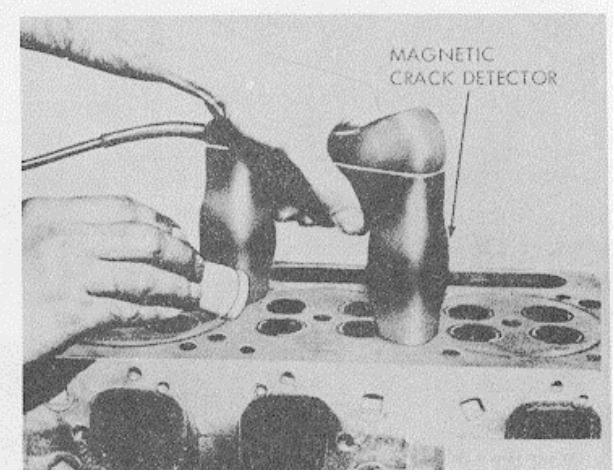


Figure 3-122. Inspecting valve and injector port areas.

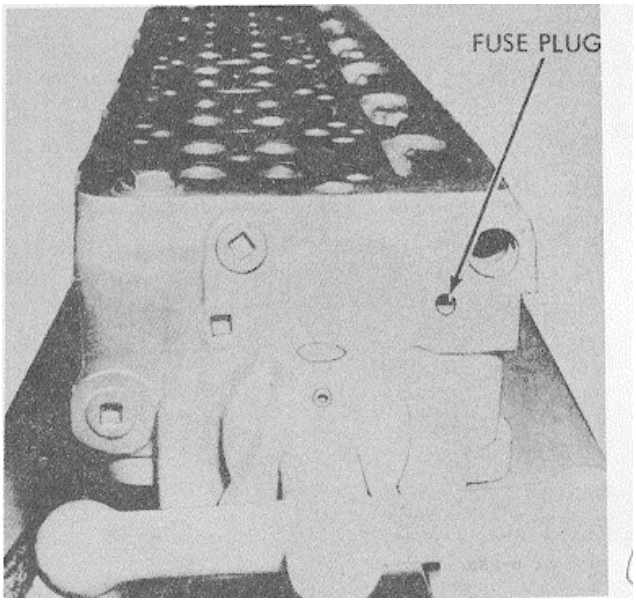


Figure 3-123. Fuse plug location

1. Remove all pipe plugs and the fuse plug from cylinder head.

2. After steam cleaning and disassembly, submerge head in tank of appropriate cleaning solution heated to near boiling temperature.

3. Circulate solvent to increase effectiveness on salt or lime deposits, grease, etc.

4. To remove heavy deposits of lime, use circulated acid-type cleaners.

Warning: The use of acid is extremely dangerous to workmen and injurious to machinery. Acid should never be used in machine shop or near any machine subject to rusting. Always provide a tank of strong soda water as a neutralizing agent.

(e) Check oil transfer dowel at center of head to make sure oil passage is open so oil will flow to the rocker lever bearings.

(2) Magnetic crack detection. Inspect the valve and injector port areas using a portable magnetic crack detector, figure 3-122. Instructions for the use of this device are on the inside cover of the carrying case.

(3) Cylinder head fuse plug. The cylinder head has a fuse plug containing a metal-alloy center that melts if the engine becomes overheated, figure 3-123.

(a) Examine fuse plug for signs of overheating.

(b) Install new plug if metal alloy has melted.

(c) As engine disassembly proceeds, check carefully for damage from overheating.

d. Repair.

(1) Sleeve eroded water holes. The cylinder head surfaces around the water holes must be free of any erosion, pits, scratches or blemishes which are more than 0.003 in. deep in the area 1/16 to 5/32-inch from edge of water holes. Repair as follows:

(a) Insert holddown adapter of ST-1010 into injector sleeve.

(b) Position tool on head with reamer guide hole over water hole to be repaired.

(c) Insert tool holddown knob into holder assembly and tighten down finger tight, figure 3-124.

(d) Insert locating pin into eroded hole and tighten holddown knob.

(e) To set depth of reamer assembly, insert assembly in guide. Place bushing between holder assembly and reamer adjustable stop collar. Insert 0.005 in. feeler gage between bushing and adjustable collar; tighten capscrew, figure 3-125.

Caution: Take care not to use too large a reamer.

(f) Attach drive adapter to a drill chuck and place grooved end of driver adapter into reamer assembly.

(g) Ream out eroded water hole until collar bottoms against tool.

(h) Remove drill, reamer assembly, hole assembly and holddown adapter.

(i) Drive bushing into reamed hole with driver, figure 3-126., Bushing should protrude about 0.003 to 0.005-in.

(j) If head is to be resurfaced, see (2) below. If head is not to be resurfaced, file bushing flush with head, using a wide flat mill file.

(2) Resurface cylinder head.

(a) Resurface head if it has been scratched, etched or worn unevenly at point of contact with gasket sealing areas. A head warped as much as 0.019 in. will flatten out when tightened in position; there fore, it is not necessary to resurface only because of warping. Also, check erosion around water holes which could cause failure of head gasket to seal. If eroded, install bushings before resurfacing head.

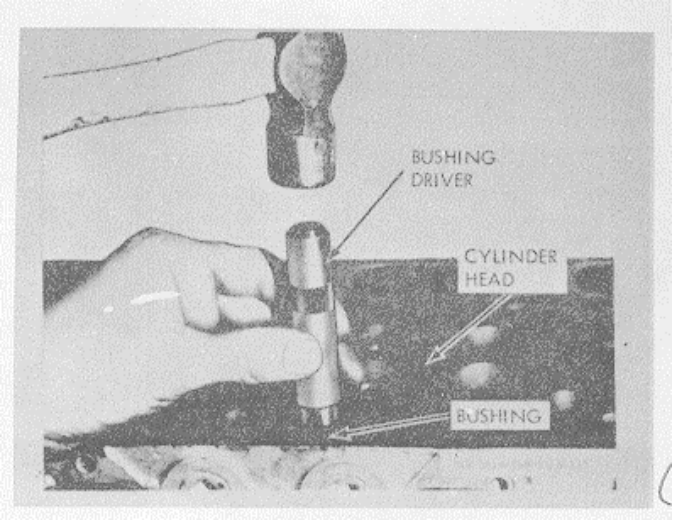


Figure 3-126. Driving bushing into hole.

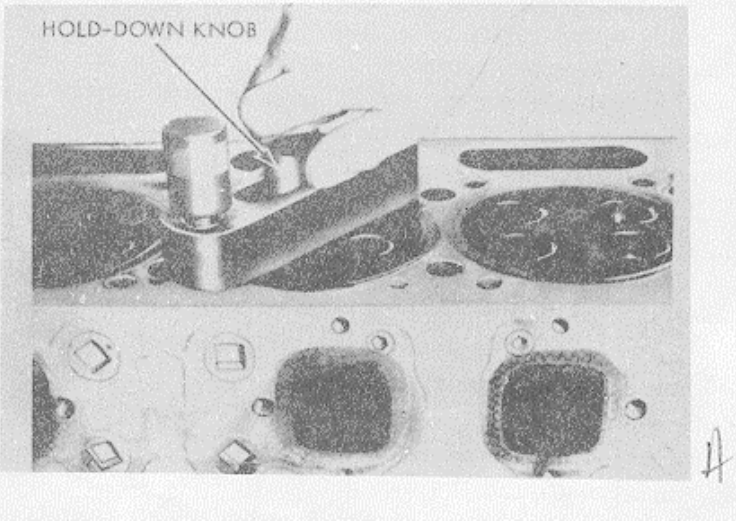


Figure 3-124. Inserting holdown knob into holder assembly.

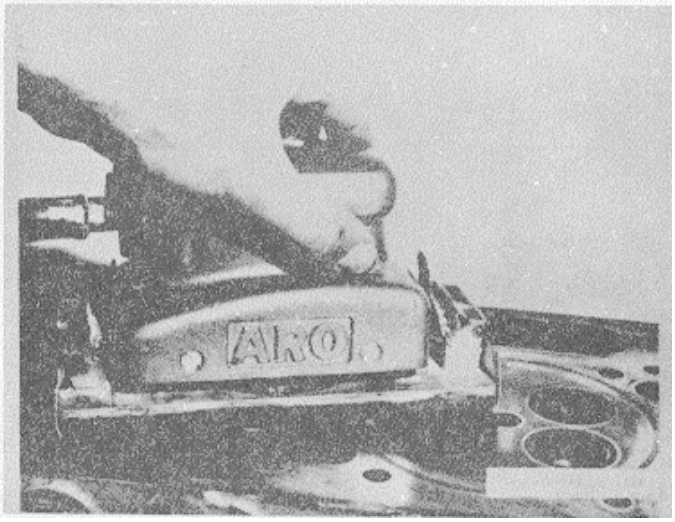


Figure 3-127. Sand cylinder head.

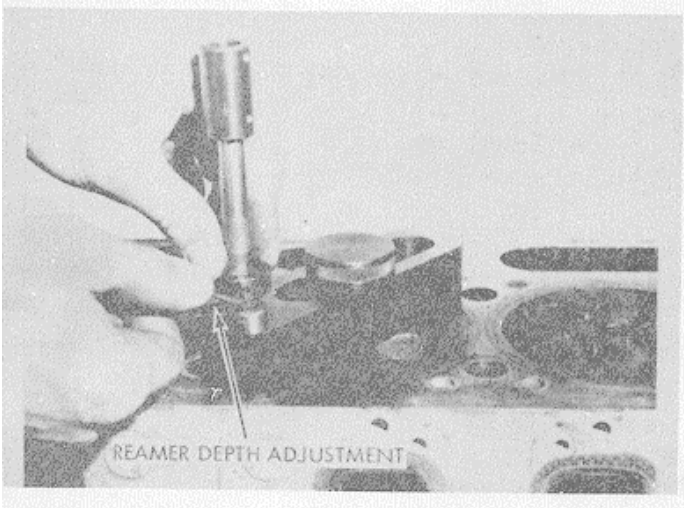


Figure 3-125. Setting reamer depth.

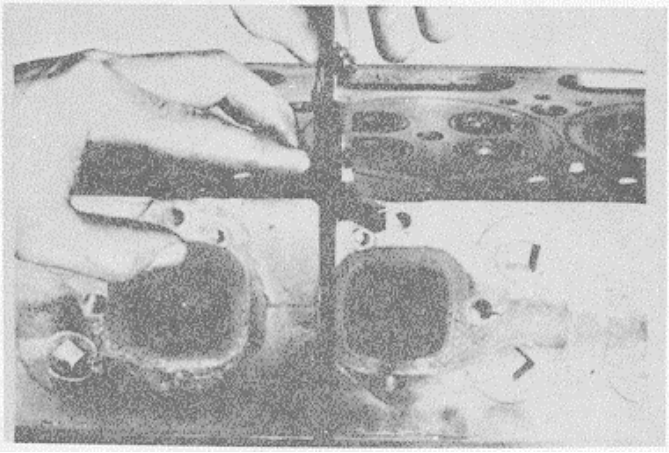


Figure 3-128. Check cylinder head height.

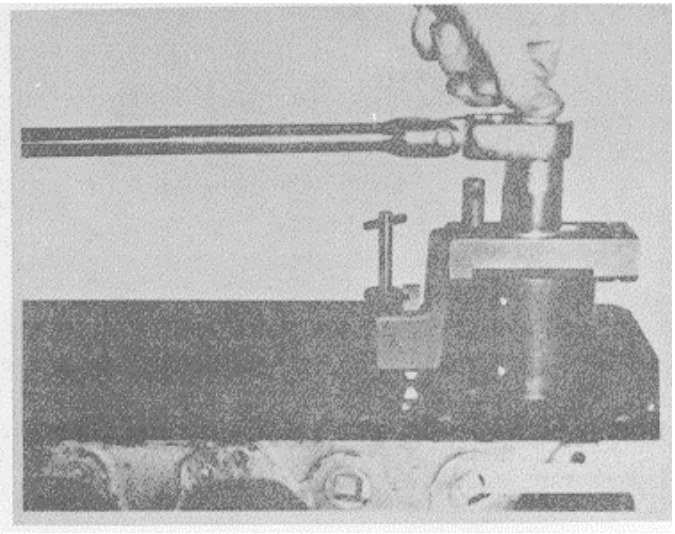


Figure 3-129. Regroove cylinder head.

(b) Remove 0.005/0.006 inch material at one time and no more than 0.030 inch total, table 2-2.

(c) Rework valve seat insert counterbore by removing amount of stock equal to that removed during head resurfacing operation. See paragraph 3-45.

(d) Sand surface of cylinder head with an orbital sander. Do not use a disc sander. Do not allow the sander to tilt or rock, since this may result in rounding of the machined edges, figure 3-127.

(e) After resurfacing.

1. Check head height; see table 2-2 for head dimensions. Use micrometer or vernier calipers for accurate measurement, figure 3-128.

2. Install new injector sleeves to maintain correct injector tip protrusion. See paragraph 3-14.

3. Check over-all height of assembled valve springs to see if it is necessary to install spacers (1/16 inch maximum) under springs to obtain correct assembled height.

Caution: Only 1/32 in. spacer can be used if head has not been resurfaced.

(3) Regroove cylinder head. Beaded cylinder liners, steel cylinder head gaskets and grooved cylinder heads are designed to operate in conjunction with each other. If the cylinder head has been resurfaced or has not been grooved previously, it will be necessary to cut grooves in the cylinder head over each cylinder liner. These grooves will assure a better seal between the cylinder head gasket and block during engine operation, figure 3-129. Use ST-597 or ST-913 Cylinder Head Grooving Tool to perform this operation.

(a) To use ST-597 grooving tool:

1. Place cylinder head in ST-583 Head Holding Fixture.

2. Select scrapped injector, preferably one with Class "O" plunger bore and injector cup. Cut off cup exposing plunger bore, maintaining cup seal area intact. Install reworked cup on injector body.

3. Install injector and cup in cylinder head and secure at operating torque.

4. Select ST-597 spacer block, table 2-2, for bore size desired. Loosen two socket head screws in end of ST-597. Assemble spacer between pilot pin and tool holder blocks.

5. Position largest pilot pin so it protrudes down in same direction as cutter and tighten assembly in place.

(b) Turn cylinder head upside down on head holding fixture and install ST-597 pilot pin into injector bore.

(c) Check position of stop in tool holder block to assure it will not contact water hole during grooving operation.

(d) Set stop on tool so cutter protrudes 0.006/0.008 inch below stop. Rotate tool clockwise to cut groove.

Caution: Do not attempt to cut deeper than cutter groove depth or cutter will break. Groove lands should be 0.010/0.015 in. wide and flush with head surface.

(4) To use ST-915 grooving toot

(a) Place cylinder head in ST-583'ffead Holding Fixture.

(b) Check data plate on housing to determine in which hole the locating plug is to be placed.

(c) Place tool holder into slit in housing with locating plug in proper hole and secure with 5/8 inch capscrew.

(d) If tool has not been adjusted previously, adjust as follows:

1. Place housing, with tool holder secured in place, on a surface plate or similar flat surface.

2. Loosen setscrews holding tool adjusting screw and turn adjusting screw down until tool cutting bit touches surface plate.

3. Remove grooving tool from surface plate and turn adjusting screw down three notches, or 60°' to lower cutting tool bit approximately 0.006 inch.

(e) Install grooving tool on head by placing the locking screw in' the injector holes and tighten hand tight. This locking screw can be used either with or without the injector sleeve.

Caution: Over-tightening of locking screw in head when injector sleeve has been removed may cause mutilation of the beads in the head.

(f) Check head to assure cutting tool bit will not contact water hole during grooving operation.

(g) Rotate grooving tool clockwise to cut groove. The tool bit is spring loaded in the tool holder and will ride over any "hard" spots on the head surface. It may take two or three revolutions to get a smooth even cut in the head, figure 3-129.

e. Installation.

(1) Cylinder head should have valve guides, valves, valve springs, injector sleeves and plugs in place as described in Cylinder Head Group.

(2) Clean the mating surfaces of cylinder block and cylinder head; be sure cylinder liner walls are clean and well lubricated with clean lubricating oil.

(3) Be sure all capscrew holes are free of dirt shavings, water, oil, etc.

(4) Place new grommets and new retainers in water passage holes in block, figure 3-130.

Note. Usually it is most convenient to install retainers in block first and then place grommets on retainers. However if desired, grommets may be inserted in gasket and retainers may be installed after gasket is laid in place on block.

(5) Install head gasket over dowels, figure 3-131, being careful not to dislodge grommets and/or retainers; be sure the word "top" is on top side of gasket.

(6) Install one stud (threaded at one end) into each end of cylinder block (or closer together, if desired) (fig. 3-132).

(7) Attach ST-756 Lifting Fixture to cylinder head and lift over cylinder block with suitable hoist carefully lower head onto cylinder block, using the two studs as guides, figure 3-132.

(8) Lubricate cylinder head capscrews with an anti-seize compound. Install short capscrews (with hardened washers) into cylinder head and block on exhaust side of head and tighten to 25 ft.-lb. to hold head securely during injection timing.

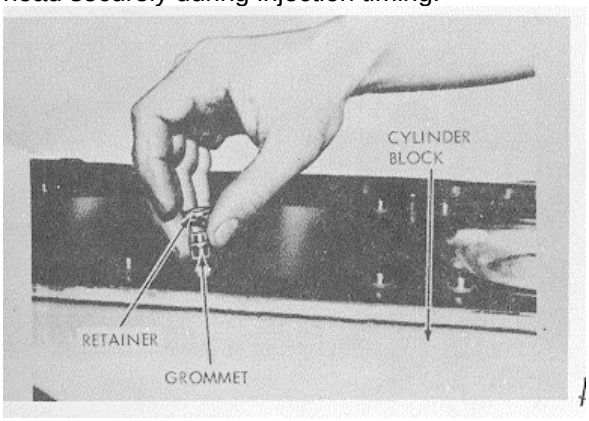


Figure 3-130. Installing grommets and retainers.

3-29. Rocker Arm Assembly and Cylinder Head Cover Replacement and Repair

a. Removal.

(1) Cylinder head cover

(a) Remove capscrews and seals securing cover to cylinder head.

(b) Lift cover and gasket from head, figure 3-133; discard gasket.

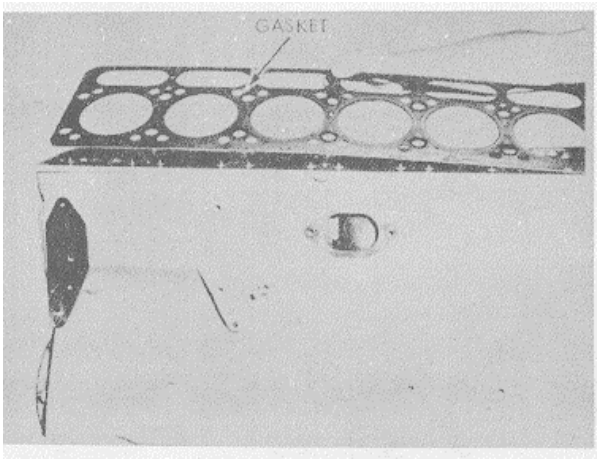


Figure 3-131. Installing cylinder head gasket.

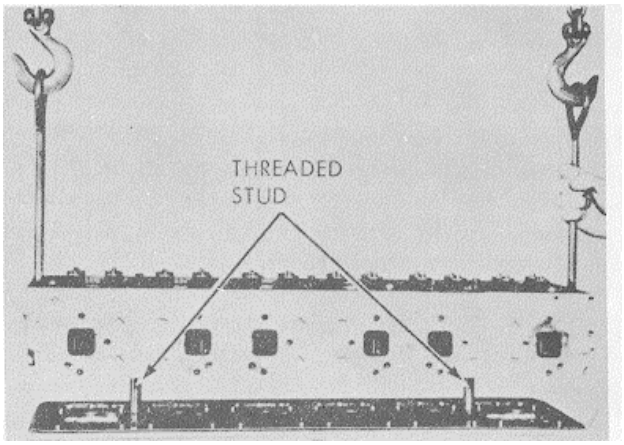


Figure 3-132. Installing cylinder head

(2) Rocker-arm assembly.

(a) Loosen all injector and valve rocker lever jamnuts and back off adjusting screws one or two turns, figure 3-134.

(b) Remove capscrews and flatwashers securing rocker lever assembly and cylinder head to block, figure 3-135.

(c) Carefully pry rocker lever assembly from dowels.

(d) Using a bar or wooden slat to hold levers in position, lift rocker lever assembly from engine, figure 3-136.

b. Disassembly.

(1) Cylinder head cover

(a) Remove lubricating oil filler cap (fig. 3-133).

1. To disassemble, remove nut (figure 3-137), flatwasher and gasket securing cover and element assembly to breather.

2. Lift off cover, element and gasket.

3. Separate cover from element. Discard element.

(b) Remove vapor tube, when used.

(2) Rocker arm assembly.

(a) Slide rocker lever shaft bearings and rocker levers off rocker lever shaft.

(b) Remove adjusting screw locknuts and adjusting screws from rocker levers.

c. Cleaning and Inspection.

(1) Cylinder head cover.

(a) Clean all parts except element in an approved cleaning solvent and dry with moisture-free compressed air.

(b) Remove all gasket material from sealing edge of cover.

(c) Inspect cover for cracks, dents and distorted sealing area; discard unserviceable parts.

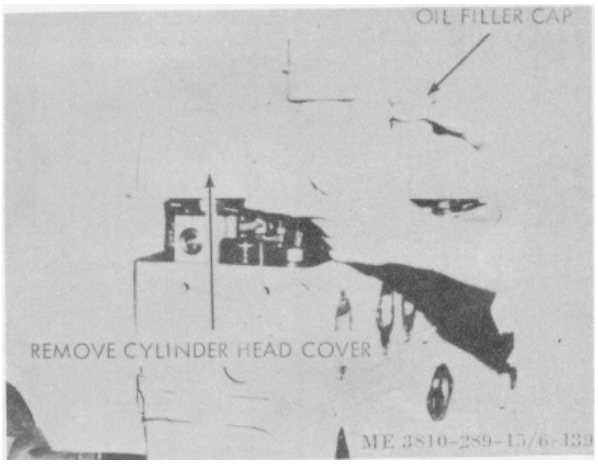


Figure 3-133. Cylinder head cover removal.

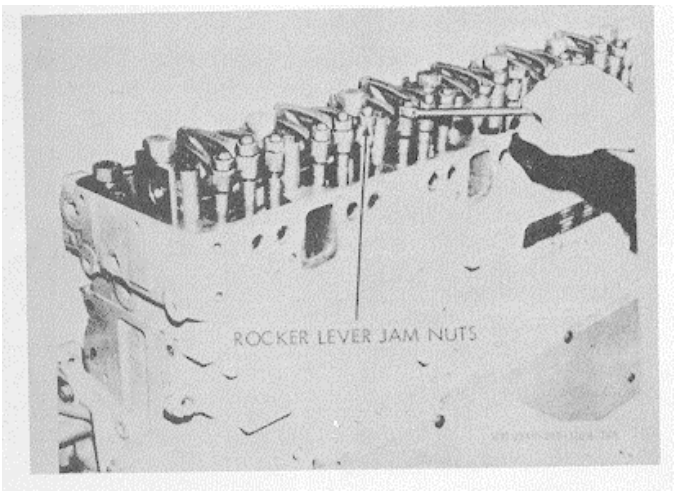


Figure 3-134. Loosening rocker arm lever jam nuts.

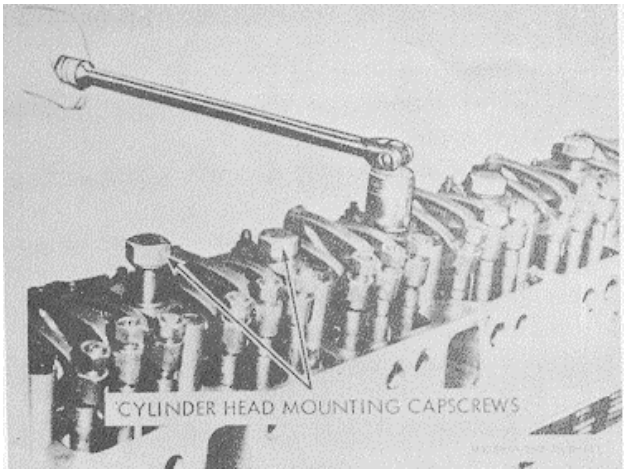


Figure 3-135. Rocker lever mounting capscrews removal.

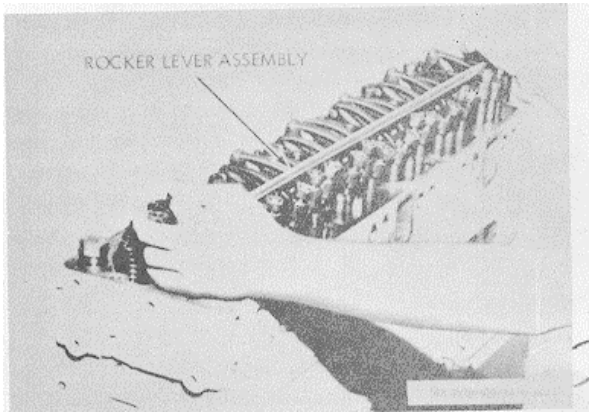


Figure 3-136. Rocker arm assembly removal.

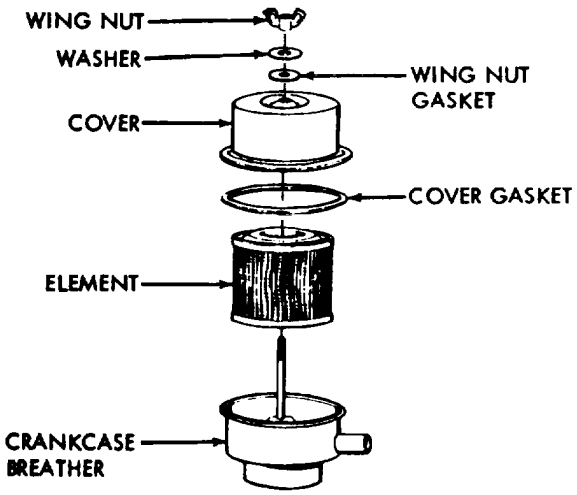


Figure 3-137. Crankcase breather-bottle stopper type.

(d) Splits or cracks may be welded except on sealing area.

(2) Crank cause breather.

(a) Inspect rubber washers and gaskets; replace as necessary.

Caution: Do not attempt to clean paper elements.

(b) Clean all parts in solvent. Use solver that is not harmful to rubber.

(c) Dry thoroughly with moisture-free compressed air.

(3) Rocker arm assembly.

(a) Clean all parts in cleaning solvent.

(b) Blow out lubricating oil passages with compressed air.

(c) Check for surface imperfections by magnetic inspection. Apply coil magnetization, amperage at 300 to 500. See figure 3-138 for most likely areas.

(d) The ball end of rocker lever adjusting screw must be a true sphere. Test with /4 inch radius gage. Replace if flat at bottom or there is evidence of scratching or galling, figure 3-139.

(e) Examine injector rocker lever sockets for a true fit on injector links. Check sockets with a radius gage or by observation of a small protrusion at bottom of socket. Pull and discard damaged or badly worn injector rocker lever sockets. If socket is broken press out by drilling a small hole in lever above socket; after socket is removed, weld hole closed or install and stake plug in hole.

(f) Check rocker lever bushings for scratches, pitting or scoring. Check rocker lever bushing inside diameter with inside micrometers.

(g) If steel bushing exceeds 1.1275 inch press out and replace with new bushing.

(h) Check intake and exhaust rocker lever valve contact surfaces. If worn or damaged, grind to original contour or replace with new rocker lever

(i) Check rocker lever shaft for wear or scoring.

If shaft ha s shoulders or ridges due to rocker lever action on shaft, replace with new rocker lever shaft.

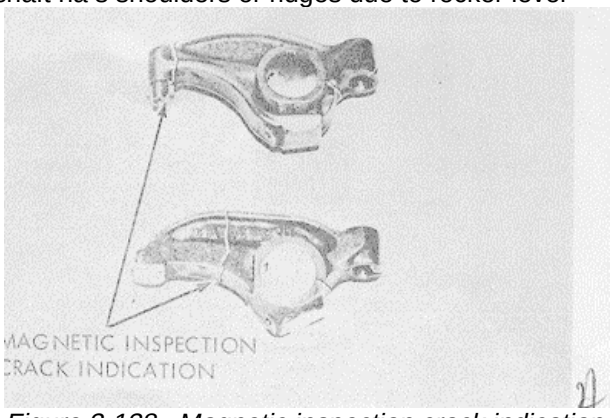


Figure 3-138. Magnetic inspection crack indication.

(j) Examine rocker lever shaft bearings for cracks, breaks and stripped threads. Replace as necessary.

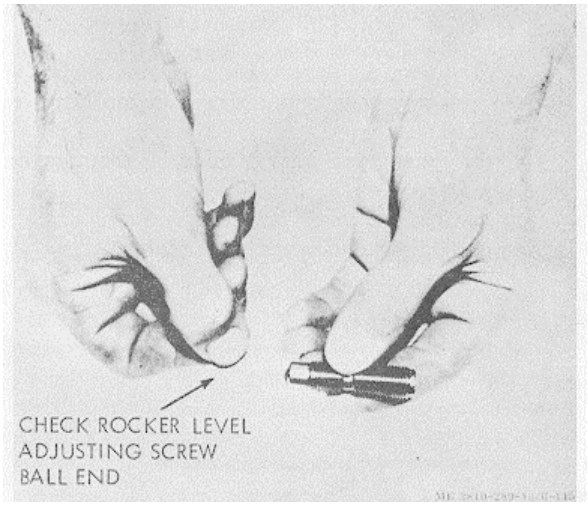


Figure 3-139. Checking rocker lever adjusting screw ball end.

(k) Visually check surfaces which mate with adjacent levers. If galled, restore surfaces to original smoothness.

d. Assembly.

(1) Cylinder head cover.

(a) Install clean breather element.

(b) Install new or usable filler cap.

(c) Reconnect vapor tube, when used.

(2) Crankcase breather.

(a) Install new element over center screw in breather housing.

(b) Place cover on housing with gasket in position.

(c) Install gasket, flatwasher and nut. Tighten securely.

(3) Rocker arm assembly.

(a) If rocker lever bushings were found unserviceable, press out with ST-691 (1, fig. 3-140). Aline oil hole in precision steel bushing (2) and oil hole in rocker lever and press bushing in with ST-691. Locate bushing so split is not at bottom or load area in lever. Check lever over shaft to make sure bushing has not "collapsed". Rocker lever assembly is lubricated through oil holes in shaft and in center bearing which indexes with oil passage in block. Oil line dowel pin in cylinder head indexes with center bearing.

(b) Install oil transfer dowels in end rocker lever shaft bearings (fig. 3-141);

(c) Install rocker lever socket in injector rocker levers.

(d) Install adjusting screws and locknuts in rocker levers.

(e) Coat rocker lever shaft with clean lubricating oil. C0 Position an end rocker lever shaft bearing on gear case end (A, fig. 3-142) of rocker lever shot.

(9) From opposite end of shaft, slide an exhaust (E), injector (F), and intake (I) rocker lever down against bearing.

(h) Slide a plain bearing, an intake, injector and exhaust rocker lever onto shaft and against levers previously assembled.

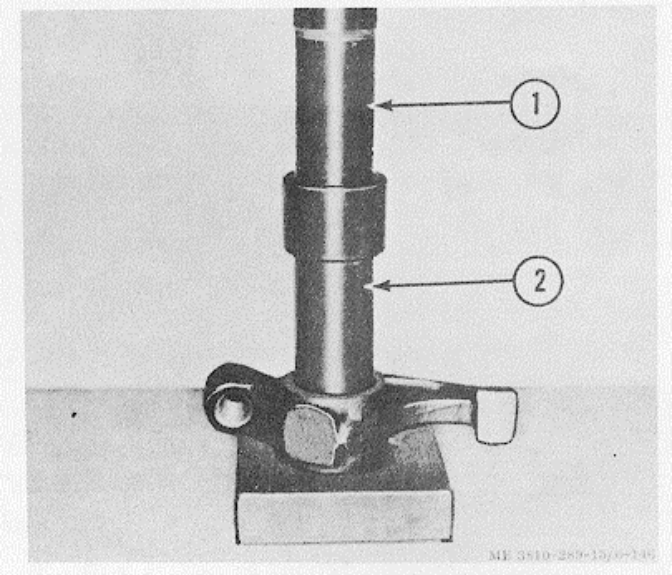
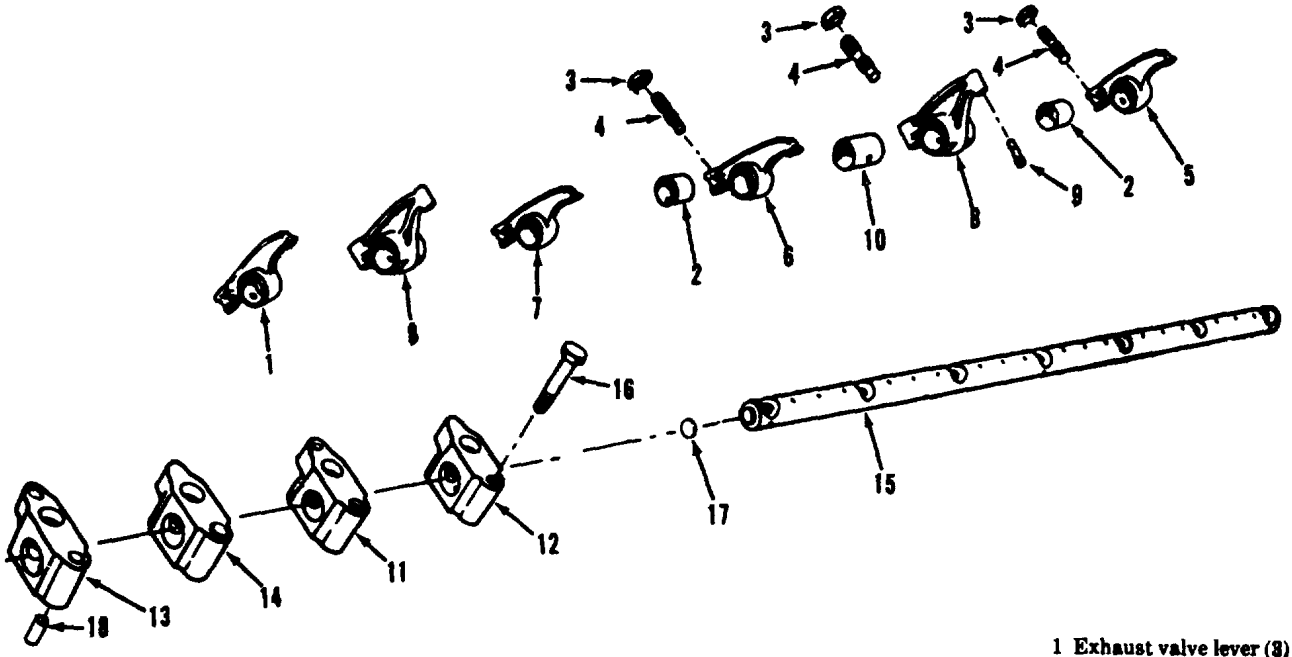


Figure 3-140. Installing vushing withST-691.



1 Exhaust valve lever (3)
2 Lever bushing (3)
3 Nut, adjusting screw (3)
4 Screw, adjusting (3)
5 Exhaust valve lever (3)
6 Intake valve lever (3)
7 Intake valve lever (3)
8 Injector rocker lever (6)
9 Injector socket (6)
10 Bushing (6)
11 Shaft bearing (2)
12 Shaft bearing (2)
13 Shaft bearing (2)
14 Shaft bearing (2)
15 Rocker lever shaft
16 Capscrew
17 Expansion plug (2)
18 Oil transfer dowel (2)

Figure 3-141. Rocker arm assembly, exploded view.

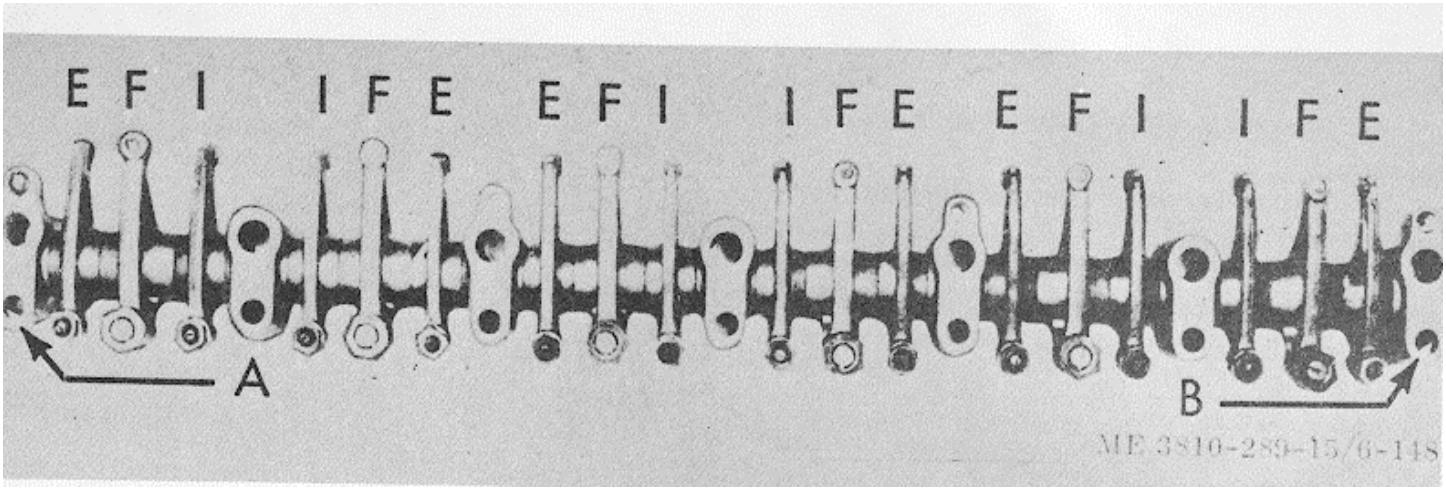


Figure 3-142. Rocker arm assembly.

(i) Slide a bearing, tapped to receive a rocker lever cover capscrew, onto shaft.

(j) Install an exhaust, injector, and intake lever and center bearing on shaft.

(k) Install an intake, injector, and exhaust lever and another tapped bearing on shaft.

(l) Install an exhaust, injector, intake lever, and plain bearing on shaft.

(a) Install an intake, injector, exhaust lever, and remaining bearing on flywheel end (B) of shaft.

e. Installation.

(1) Rocker arm assembly.

(a) Insert oil transfer dowel in cylinder head, figure 3-143.

(b) Using a bar or wooden slat to hold levers in place, mount rocker lever assembly on cylinder head.

(c) Engage push tubes with rocker lever adjusting screws; drive rocker lever assembly over dowels with soft hammer. Dowels often stick in rocker lever bearing rather than cylinder head.

(d) Lubricate rocker lever shaft bearing capscrews with clean lubricating oil; install and tighten securely.

(e) Lubricate long cylinder head capscrews with clean lubricating oil; place hardened washers on capscrews and install in cylinder head through rocker lever shaft bearings.

(f) Tighten all cylinder head capscrews to 25 ft.-lbs. in sequence shown in figure 3-144.

(g) Continue to tighten capscrews, in 100 ft. lbs. increments, to 300 ft.-lbs., figure 3-145.

(h) Then, in 50 ft.-lbs. increments, tighten to 390/400 ft.-lbs.

(i) After cylinder head is secured to block, check rocker levers to be sure they are not binding. Tightening the long cylinder head capscrews may shift the rocker lever shaft bearings, causing levers to bind.

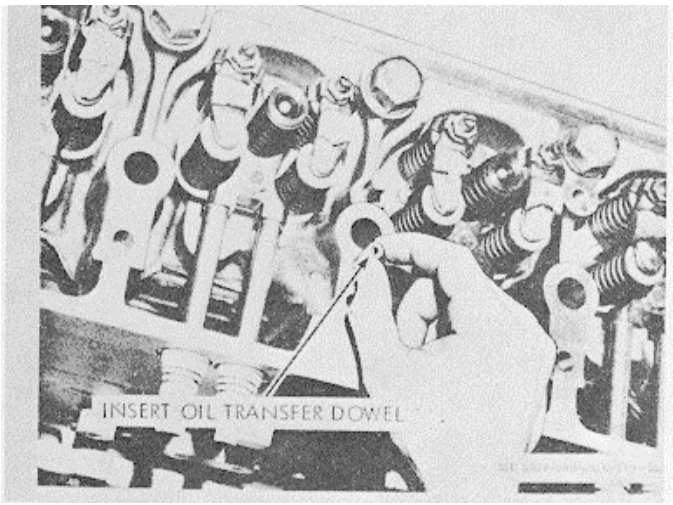
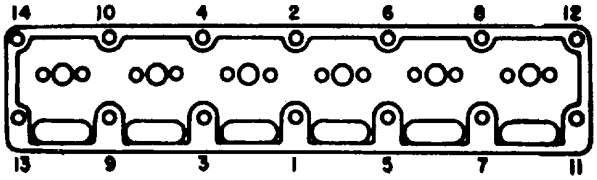


Figure 3-143. Oil transfer dowel insertion.



SIX-CYLINDER SEQUENCE

Figure 3-144. Cylinder head capscrew tightening sequence.

(j) Binding levers may be freed as follows:

1. Shift one set of injector and valve rocker levers toward rear of engine and against rocker lever shaft bearing.

2. Measure clearance between valve rocker lever and shaft bearing toward front of engine; if clearance is less than 0.009 inch, stock must be machined from each side of injector lever to increase clearance to 0.025 inch.

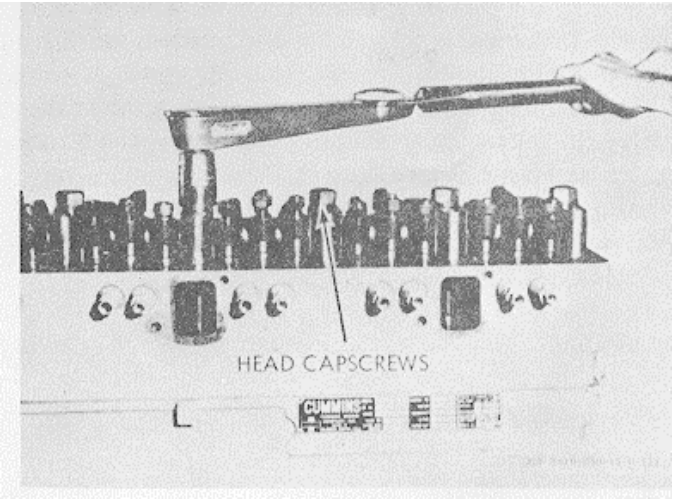


Figure 3-145. Torquing cylinder head capscrews.

3. Check each of the remaining sets of levers in the same manner as 1. and 2. above to determine which injector lever(s) must be machined and the amount of stock that must be removed from each side of lever(s).

4. Clean machined lever(s) thoroughly to prevent damage to other engine parts.

(2) Cylinder head cover.

(a) Assemble new gasket, washers and capscrews to cylinder head cover.

(b) Install crankcase breather on cylinder head cover.

(c) Mount cover on engine, figure 3-146. Tighten holddown capscrews.

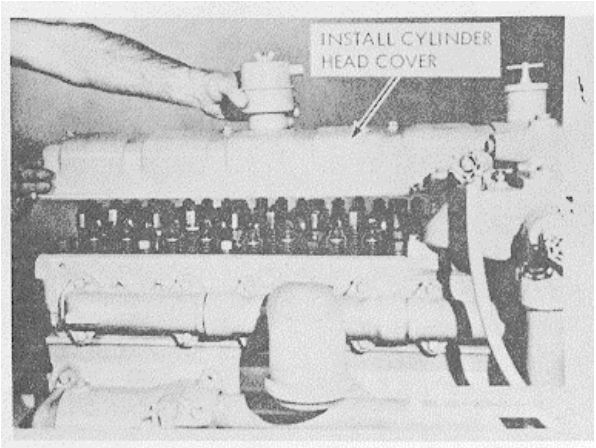


Figure 3-146. Cylinder head cover installation.

3-30. Push Rods Replacement

a. General Push rods are used to transmit camshaft action to injectors and valves.

b. Removal Lift all push rods from tappet sockets. Figure 3-147

Note. Each cylinder has an intake, exhaust and injector push rod.

c. Cleaning and Inspection.

(1) Clean push rods in an approved solvent.

(2) Check injector and valve push rod ball end with radius gage for wear, figure 3-148.

(a) Ball end diameter, intake and exhaust push tube: 0.623/0.625 in.

(b) Ball end diameter, injector push tube: 0.685/0.687 in. with 1/8 in. diameter flat at bottom.

(3) Check socket of push tube with ball end of a new rocker lever adjusting screw, figure 3-149, or with a % in. check ball which should "blue in" 80 percent of seat area; spherical inside diameter new is 0.4995/0.5005 in.

(4) Extreme wear on either end of push tube will result in loss of lubricating oil pressure and may interfere with correct injector and valve adjustment.

(5) Check push tubes to see if they are bent (out-of-round). Tubes should not be out-of-round more than 0.025 in. when located in centers of socket and ball. Push tubes that are bent have usually had the adjusting screws over-torqued.

(6) Push tubes with worn balls should never be installed in new tappet sockets.

(7) Push tubes which have become filled with lubricating oil should be drained by drilling a 1/16 inch hole in the tube 1 inch above where tube contacts ball insert.

d. Installation. Install push tubes in correct tappet sockets.

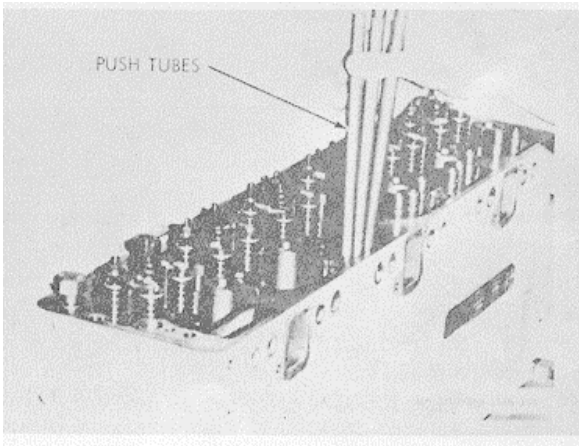


Figure 3-147. Push rod removal and installation.

3-31. Springs, Guides, Locks and Valves Replacement and Repair

a. Removal. Remove valves, locks, spring guides and springs. Use ST448 valve spring compressor to compress valve springs.

b. Inspection

(1) Valves. Inspect, then discard if:

(a) Heads are cupped, cracked, pitted or worn too thin to regrind within limits. Check valve head

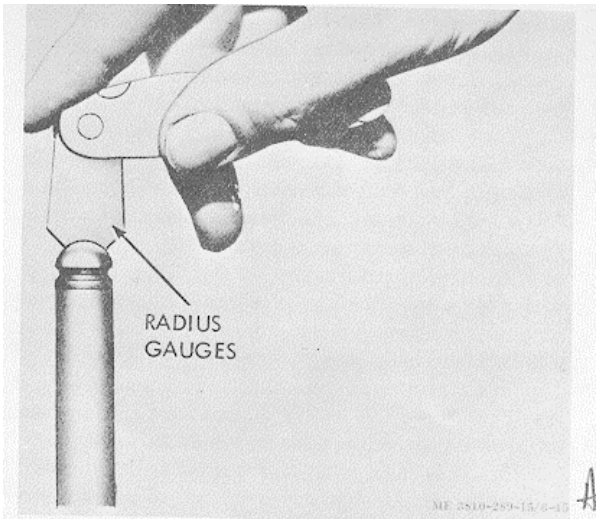


Figure 3-148. Checking push tube ball end with radius gage.

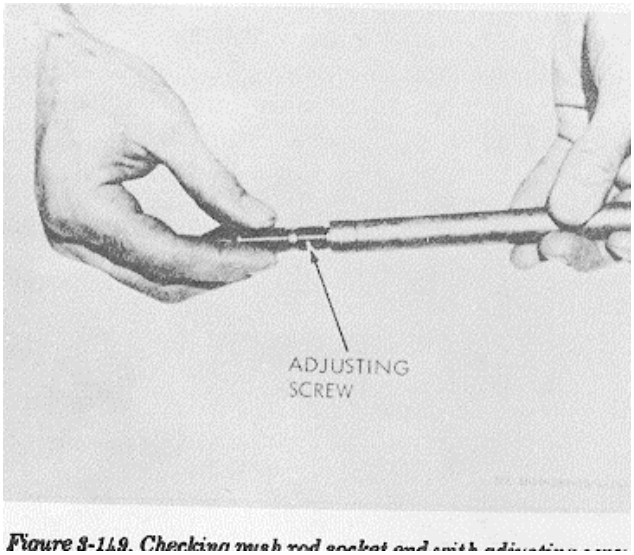


Figure 3-149. Checking push rod socket end with adjusting screw.

rim thickness (A, fig. 3-150); it should be a minimum of 1/16 inch.

(b) Stems, figure 3-151, are scored or worn beyond wear limits shown in table 2-2.

(c) Collet recesses are worn so new collets will not fit securely in recesses.

(2) Valve guides.

(a) A plug gage is not satisfactory to gage worn holes. It will not detect an out-of-round hole. Instead use a small bore gage.

(b) To use a small bore gage, set it with accurate micrometers at 0.0002 inch larger than worn replacement limit shown in table 2-2. Then use bore gage as a UNo-Go" gage, figure 3-152. Gage the hole at several points crosswise and endwise of head.

(c) If old valve guides are worn beyond wear replacement limits shown in table 2-2, mark for replacement.

(d) Inspect the sharp edge of tapered valve guides for chips, cracks, burs; if damaged, mark for replacement.

(3) Valve springs. Weak valve springs may cause valve flutter which results in excessive wear on both valve and seat. Valve flutter interferes with valve timing and may cause valve to strike the piston head. Valve warping, cracking and breaking are the results of weak valve springs.

(a) Test valve spring on spring tester that is capable of very accurate measurements of spring lengths by means of standards as listed in table 2-2 and dial indicator gage, figure 3-153.

(b) One spacer may be used under valve spring when insert and valve have been refaced to make valve check within load limit.

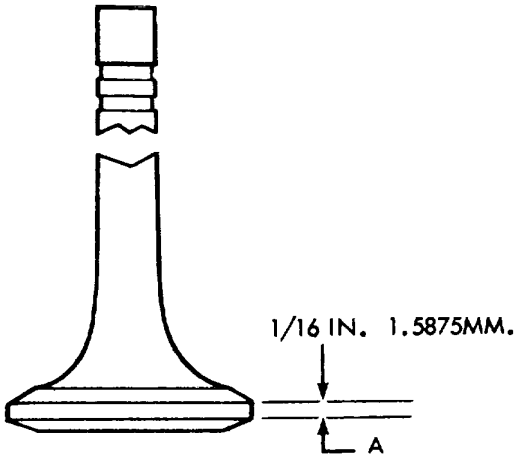


Figure 3-150. Minimum valve head rim thickness.

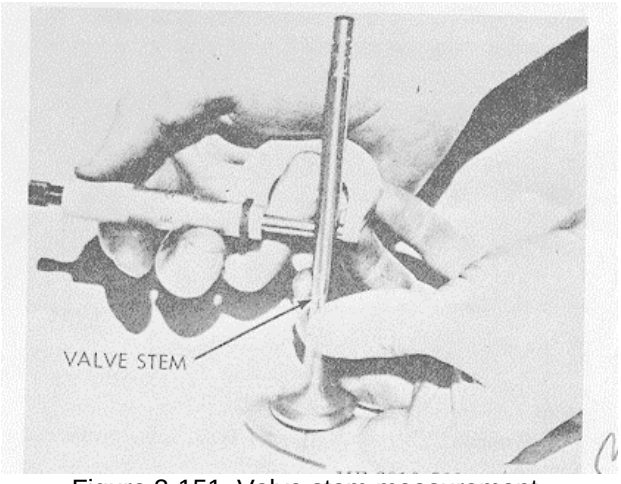


Figure 3-151. Valve stem measurement.

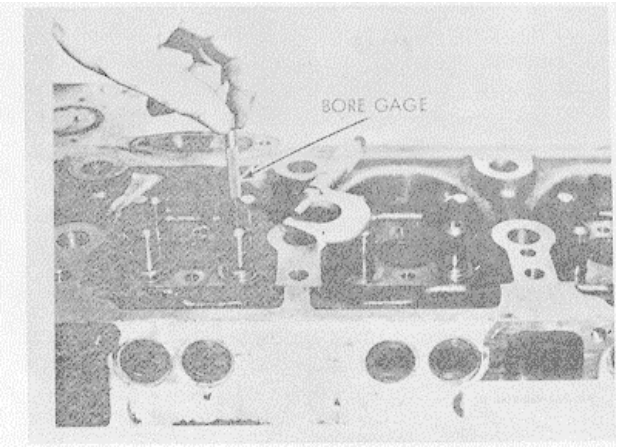


Figure 3-152. Valve guide measurement.

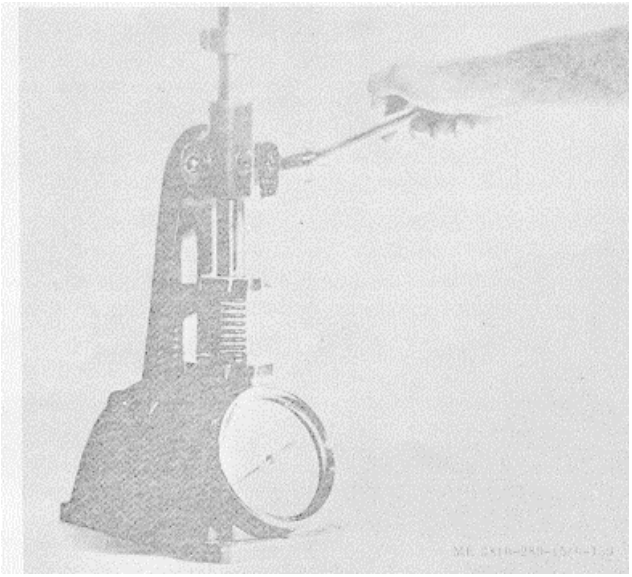


Figure 3-153. Valve spring testing.

Note. A maximum of 1/16 inch spacers may be used under valve spring when head has been resurfaced and valve and seat have been refaced.

(c) If valve springs compress to dimension shown, at less than load indicated under "worn limits" valve springs should be discarded, table 2-2.

c. Repair.

(1) Valves. Use ST-684 Valve Grinding Kit or tools of equal standards.

(a) Check valve grinder setting by using a new valve and an indicator gage.

1. Check valve on guide area of stem, figure 3-154. Relieved portions on both ends of guide area are not necessarily concentric to guide area of stem.

2. Indicate on ground face of valve.

3. Turn valve and mark high spat on head of valve.

4. Recheck the valve 1800 from first position.

5. Repeat a. and 3. If high spots are same for both 1. and 4. positions, valve is warped. If high spots occur in different positions, chuck is out of alignment. Runout should not exceed 0.001 in.

(b) Check bearings of machine.

(c) The grinding wheel must be the proper grade and properly dressed to avoid chatter and grind marks.

(d) Wet-grind valves to an exact 300 angle from horizontal.

(e) Valves and seats properly ground with precision equipment should not require lapping to effect an air-tight seal; however, a small amount of lapping is permissible if necessary in order to pass vacuum test.

(f) Check rim thickness as shown in figure 3-150. If rim is less than 1/16 in., valve is not suitable for use because of burning and cupping.

(g) Check valve in a finish-reamed guide and against a newly ground valve seat face. Pencil mark valve and drop into position; rotate valve 10". A good seat will be indicated if all pencil marks are broken, figure 3-155. If pencil marks are not broken, valve seat tools need dressing or machine has not been properly adjusted: final check should be made with a vacuum tester.

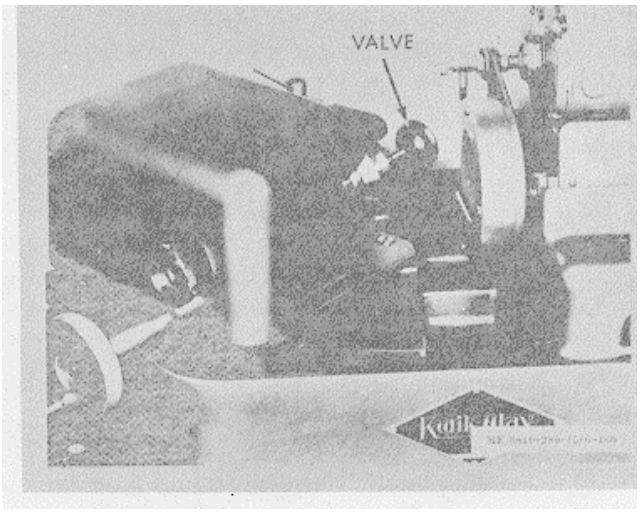


Figure 3-154. Valve grinding.

(h) Conditions of a good valve seat.

1. No grinding or reamer marks on seating surfaces and within guide.

2. Valve face a true 300 angle.

3. Width of grind is within limits.

4. Guide-to-stem clearance is within limits as determined from dimensions shown in table 2-2.

(2) Valve guides.

(a) Ream valve guide from bottom side of cylinder head, using a drill press and floating tool holder, figure 3-156.

Note Use lubricating oil or soluble oil and water solution for god finish.

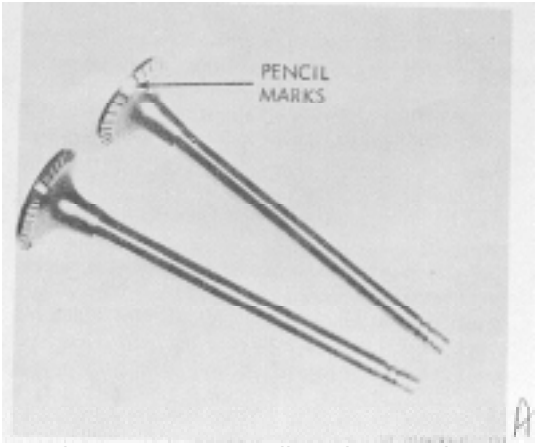


Figure 3-155. Pencil marks on valves.

(b) Ream valve guides with proper reamer to dimensions shown in table 2-2.

Caution: Special care must be used to avoid breaking carbide tips. Sharpen tipped tools on a diamond-impregnated wheel.

d. Replacement.

(1) Install new guides with arbor press and ST 740 valve guide drive, figure 3-157.

(2) If proper valve guide mandrels are not available, press guides into head to obtain protrusion above head surface as listed in table 2-2.

(3) Most valve guides will not require reaming. Insert valve into guide and check for freedom of movement, or check guide with small bore gage to determine if guide bore is too small.

Caution: Guides which have been specially treated, identified by a dull grey appearance, are not to be reamed.

(4) Insert valves.

(5) Place cylinder head face down on a wooden bench or protective surface to prevent marring milled surface.

(6) Assemble lower valve spring guides on valve guides.

(7) Assemble springs.

Note. Use same part number spring with mating spring under crosshead.

Note. Reground valve heads seat deeper in cylinder head causing valve stem to protrude further above the guide. This allows valve spring to extend beyond length limits and causes weak spring action. Therefore, up to 1/16 in. of spacers may be used to reduce valve spring length.

Caution: Too many spacers will cause the compressed spring to become a solid sleeve, see table 2-2, "Valve Spring Data".

(8) Assemble upper valve spring guide.

(9) Use ST448 Valve Spring Compressor to compress valve spring. Insert new half-collets.

(10) Insert new locks.

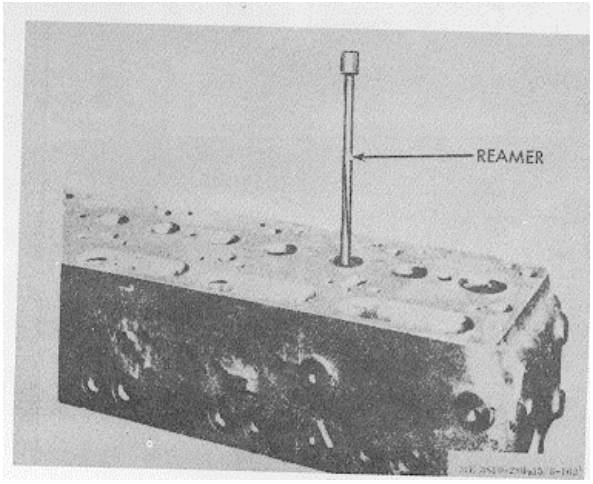


Figure 3-156. Reaming valve guide.

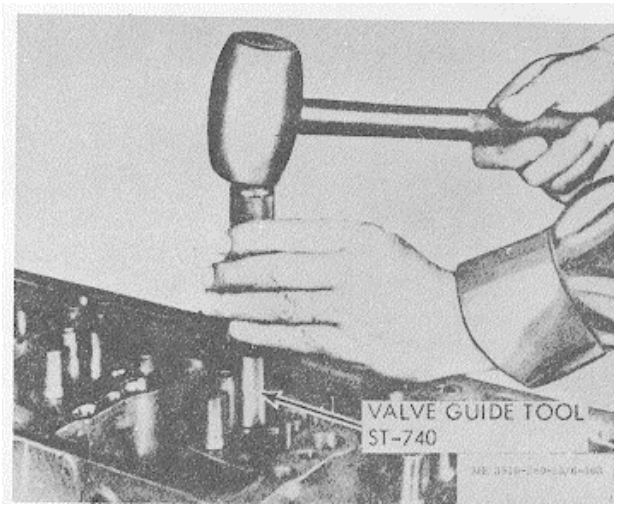


Figure 3-157. Valve

3-32. Tappets and Tappet Guides

a. General. Tappets are used to transmit movement from the engine camshaft to the push tubes and rocker levers to actuate the injectors and valves. Tappet assembly is made up of a body containing a push tube seat, a roller and pin; the roller rides on the camshaft lobe.

b. Removal.

(2) Using a wire with a hook on one end, hook wire into tappet guide slot tappet
nearest the outside wall of block) and lift tappets
former engine.

c. Disassembly.

(1) Refer to figure 3-159 and disassemble the tappet assembly.

(2) Place 0.006 in. shim between tappet and side of roller to prevent spring for k when removing roller: press on end of pin that is not lock-wired
(pinned)..

(3) Discard pin and lockwire.

d. Inspection.

(1) Check for scored, flaked or chipped rollers; discard damaged parts.

Note. If any of the conditions above exist, camshaft should be checked very closely for damage.

(2) Measure tappet body outside diameter for wear; measure roller outside diameter and inside diameter for wear. Discard if worn beyond limits shown in table 2-2.

(3) Check tappet push tube seat by "bluing" corresponding new push tube on ball end and rotating in tappet; a full seat should be indicated. For best results keep push tube with mating tappet, especially if they are to be reused.

(4) Check body pin holes and inspect hole for burrs before reassembly.

(5) Check force required to move guide sleeve inside tappet; if less than 15 in.-lb., install new sleeve.

e. Assembly.

Figure 3-158. Tappet guide screw removal and installation.

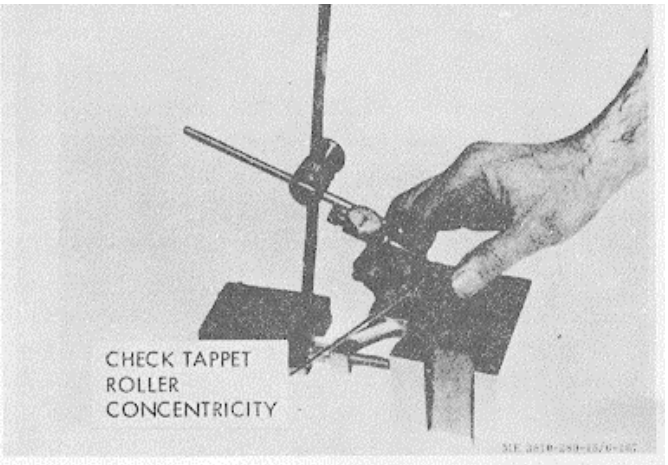


Figure 3-161. Tappet roller concentricity inspection.

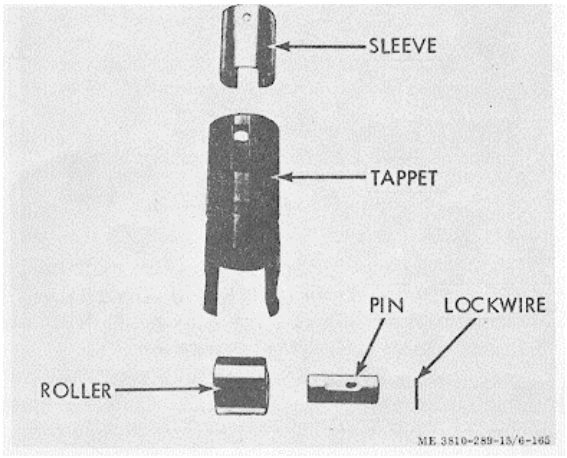


Figure 3-159. Tappet assembly.

(1) Refer to figure 3-159 and reassemble tappet assembly.

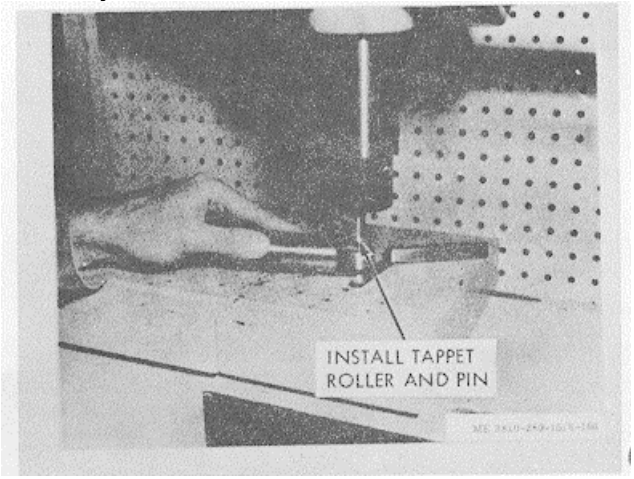


Figure 3-160. Roller and pin installation.

(2) Insert 0.006 in. shim between side of roller and tappet; press pin through tappet and roller with lockwire in pin. Make sure lockwire seats in groove of tappet. (fig. 3-160)

Caution: Lubricating oil passage in pin and tappet must index for adequate lubrication.

(3) Install steel sleeve in tappet by compressing and aligning guide slot in sleeve with slot in tappet body.

Caution: Make certain that any roller pins removed are replaced with identical pins. Use of incorrect pin and tappet combination will seal off lubricating oil drillings and lead to parts failure.

f. Inspection of Assembled Tappet. Inspection of tappet assembly requires a surface plate, small V-block with clamp to hold tappet in position and an indicator calibrated in tenths of a thousandth in. or attached to a surface gage.

(1) Using a small wire inspect indexing of pin and body lubricating oil passage.

(2) Check freeness of roller by rotating two or three turns. If a "drag" is felt the plating on pin has probably picked up during assembly, due to burs of pin not being held square during assembly.

(3) Stand small V-block on surface plate.

Note. Tools and parts must be clean to obtain a true check.

(4) Stand tappet assembly on surface plate with roller up. Secure tappet in V-block with clamp.

(5) Using an indicator calibrated in tenths of a thousandth in. or (mm) check concentricity by rotating roller, figure 3-161. Move indicator stand slightly and recheck. Refer to table 2-2 for dimensions.

Caution: Injector and valve tappet dimensions are not the same. Use correct dimensions when checking wear. Any part that do not pass the checks must be disassembled. (Perform inspection during disassembly to determine the reason for rejection.) Reassemble tappets following "Assembly" and "Inspection of Tappet Assembly".

(6) Using same indicator as in (5) above, check squareness of roller by sweeping indicator across diameter on one end of roller, then sweeping the other end. Rotate tappet roller 180° and check again at roller ends by sweeping across the diameter. See table 2-2 for dimensions. It is permissible and recommended to exert some downward pressure against roller when gaging to assure firm contact against roller pin.

g. Installation.

(1) Install tappets in block; injector tappets slightly larger than valve tappets and are installed between each pair of valve tappets (fig. 3-162).

(2) Aline slots in tappet walls with tappet guide screw holes in block.

(3) Install tappet guide screws (with nylon inserts), figure 3-168; tighten to 95/115 in.-lb.

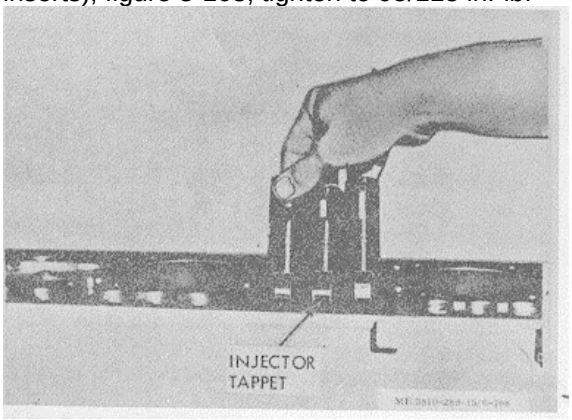


Figure 3-162. Tappet installation.

3-33. Flywheel Assembly

a. Removal.

(1) Remove clutch assembly (para 3-15).

(2) Remove all but two capscrews and washers securing flywheel to crankshaft; insert one or two guide studs in vacant capscrew holes.

Note. Guide studs can be made by using a short length of threaded rod.

(3) Remove remaining capscrews and washers and pull flywheel from crankshaft, figure 3-163.

Note. If necessary, insert two capscrews into threaded holes in flywheel and tighten equally to free flywheel from crankshaft.

b. Inspection

(1) Inspect flywheel for cracks or defects.

(2) Inspect ring gear for broken or cracked teeth. Replace if damaged.

c. Repair.

(1) If replacement is necessary, drive gear from flywheel with blunt chisel.

(2) If an oven is available, heat new ring gear to 600 degrees F. (315.6 degrees C.).

Caution: Overheating to temperatures above 660°F. (348.90C.) will soften gear.

(3) Place ring gear on flywheel and quickly drive onto flywheel until gear is firmly seated.

(4) If an oven is not available, heat gear with a heating torch-not a cutting torch-from inside diameter so heat travels outward to teeth.

Note. The flywheel is 2.65/2.85 inches thick when new. Machining is not recommended for an out of balance wheel; however, ½ inch holes can be drilled in the outer edge as required.

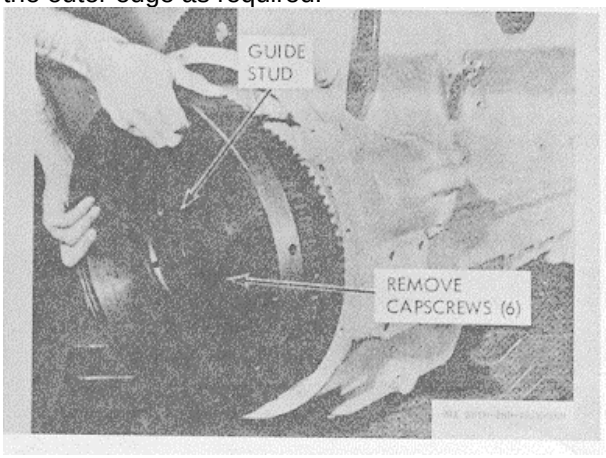


Figure 3-163. Flywheel removal.

d. Installation.

(1) Install two guide studs in crankshaft flange. Assemble flywheel over studs to crankshaft flange.

Note. When installing a new flywheel with MO" marks, match '". indexing marks on flywheel and crankshaft.

(2) Insert flywheel washers and capscrews and tighten alternately to 50/60 ft. lbs. Using same sequence, tighten flywheel capscrews to final torque of 100/110 ft. lbs.

Note. If self-locking capscrews are not used, lockwires must be installed in capscrew heads.

(3) Attach indicator gage to flywheel housing as shown in figure 3-164.

(4) Check clutch pilot bearing bore. Total run out must not exceed 0.005 in.

(5) Shift gage to indicate flywheel face (fig 3-165).

(6) Draw four equidistant chalk marks on flywheel circumference.

(7) Turn crankshaft, taking up crankshaft end clearance as chalk marks align with indicator. Run out must not exceed 0.0005 inch per inch of diameter. If runout exceeds 0.0005 inch per inch of diameter. remove flywheel and clean flywheel and crankshaft flange mating surfaces.

(8) Reinstall flywheel; check bore at face.

Note. Crankshaft must be kept at front or rear limit of thrust clearance while check is being made.

(9) Torque capscrews to 100/110 ft. lbs. If capscrews have holes in head for safety wire, install by crosswiring between pairs of capscrews.

(10) Install clutch assembly (para 3-15.

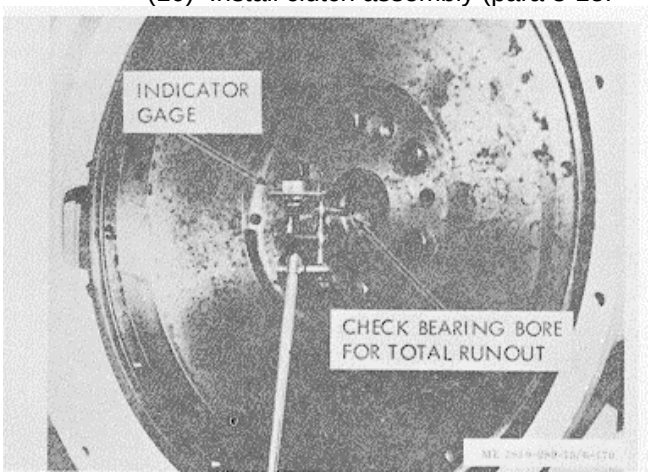


Figure 3-164. Flywheel indicator gage installation.

3-34. Flywheel Housing

a. Removal

(1) Remove clutch assembly (para 3-15).

(2) Remove flywheel assembly (para 343).

(3) Remove capscrews, lockwashers and flatwashers securing flywheel housing to oil pan; remove capscrews, lockwashers and flatwashers securing housing to block, figure 3-166.

(4) Using a soft hammer, tap housing away from engine.

b. Cleaning and Inspection.

(1) Clean dirt and burs from flywheel housing, cylinder block, and oil pan mating surfaces.

(2) Inspect flywheel housing for cracks or defects.

(3) If dowels are worn, sheared or loose, replace them with new dowels.

c. Installation.

(1) Position (with adhesive) new gasket in camshaft counterbore of flywheel housing, figure 3-167. Be sure gasket is set firmly in place.

(2) If engine is to be subjected to dusty conditions, install neoprene sponge rubber seal between flywheel housing and oil pan. Seal is equipped with a fabric pull tape or cotter key to facilitate removal of seal (to allow removal of oil pan).

(3) Mount flywheel housing to cylinder block and oil pan with lockwashers, flatwashers and capscrews; snug-tighten capscrews.

d. Inspecting Flywheel Housing Bore.

(1) Attach indicator gage to crankshaft flange as illustrated in figure 3-168.

(2) Draw chalk marks at A, Al, B and B'.

(3) Check readings at B and B'. If total runout exceeds 0.010 inch, use a pinch bar to move housing one-half distance of total indicator reading in order to center housing horizontally.

(4) Check readings at A and A'. If total runout exceeds 0.010 inch, use a pinch bar to pry housing

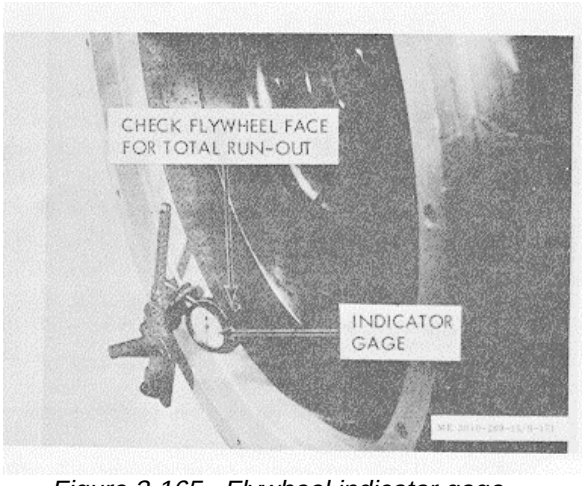


Figure 3-165. Flywheel indicator gage.

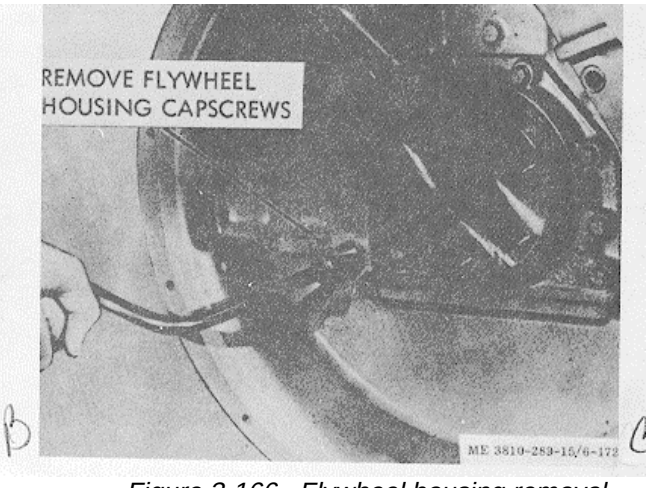


Figure 3-166. Flywheel housing removal.

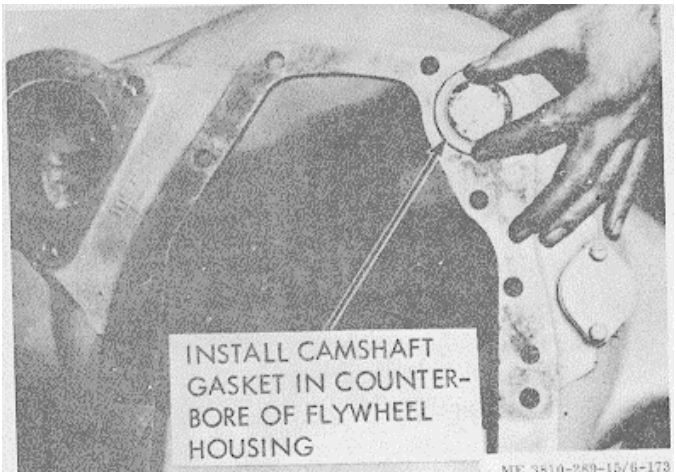


Figure 3-167. Camshaft counterbore gasket installation.

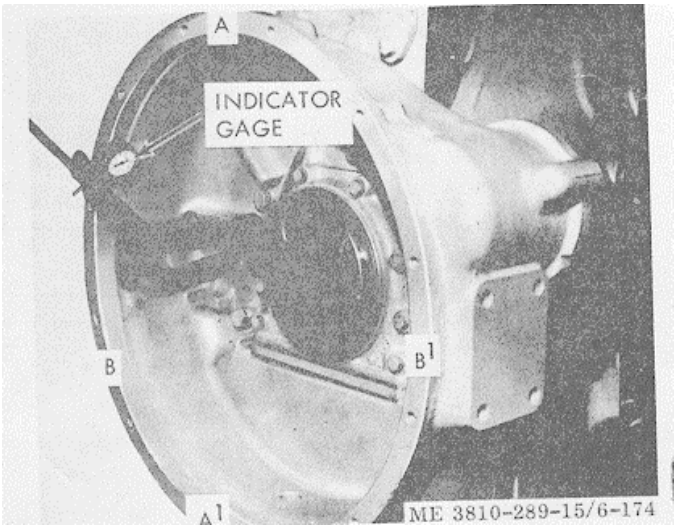


Figure 3-168. Flywheel housing indicator gage installation.

either up or down, whichever is necessary, one-half distance of total indicator reading in order to center vertically.

(5) Check housing bore circumference; total run out must not exceed 0.010 inch.

(6) After readings are within limits, tighten capscrews alternately and evenly to 80/100 ft.-lb. And recheck total runout.

e. Inspecting Flywheel Housing Face.

(1) Attach indicator gage as shown in figure 3-169.

(2) Push crankshaft forward to take up end clearance.

(3) Turn crankshaft to obtain readings on housing face.

Note. Take up crankshaft end clearance in same direction each time.

(4) Total flywheel housing face runout must not exceed 0.008 in.

(5) If both bore and face runout readings are within limits and dowels were removed, ream dowel holes to smallest permissible oversize with ST-406 drill ream fixture as described in (Step 7).

(6) If necessary to correct for housing face runout after the bore has been alined, remove housing and recheck mating surfaces. Then reinstall, realign and insert dowels.

Caution: Be sure all housing capscrews are tight.

(7) To use ST-406.

(a) Attach plate to crankshaft flange, locating tapered plug in former dowel holes.

(b) Remove tapered plug, substitute drill and ream bushings.

(c) Drill new dowel holes. Make sure all metal shavings are removed from dowel holes. Ream holes for oversize dowels.

Caution: If dowel holes are not pilot-reamed or new dowels installed straight, housing will shift and extreme difficulty will be encountered at next engine rebuild.

(d) Clean out dowel holes and install new dowels.

f. Installation of flywheel and clutch assemblies. Refer to paragraphs 3-33 and 3-15.

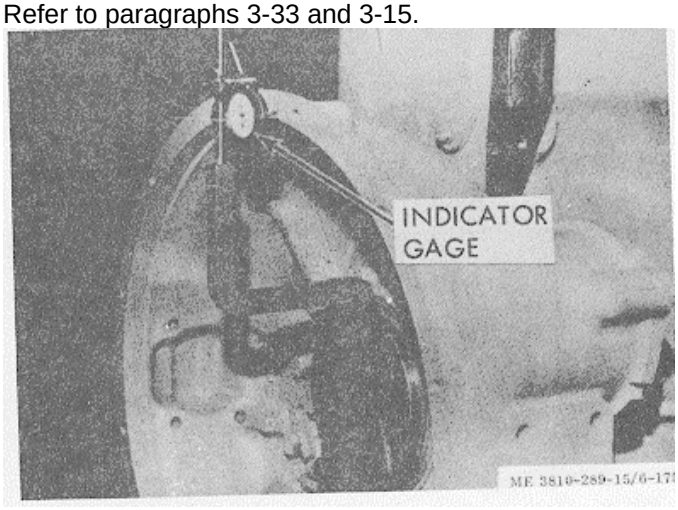


Figure 3-169. Flywheel housing indicator gage.

3-35. Oil Pan

a. General. The oil pan is located beneath the engine block and contains the oil used for lubricating the moving parts of the engine.

b. Removal

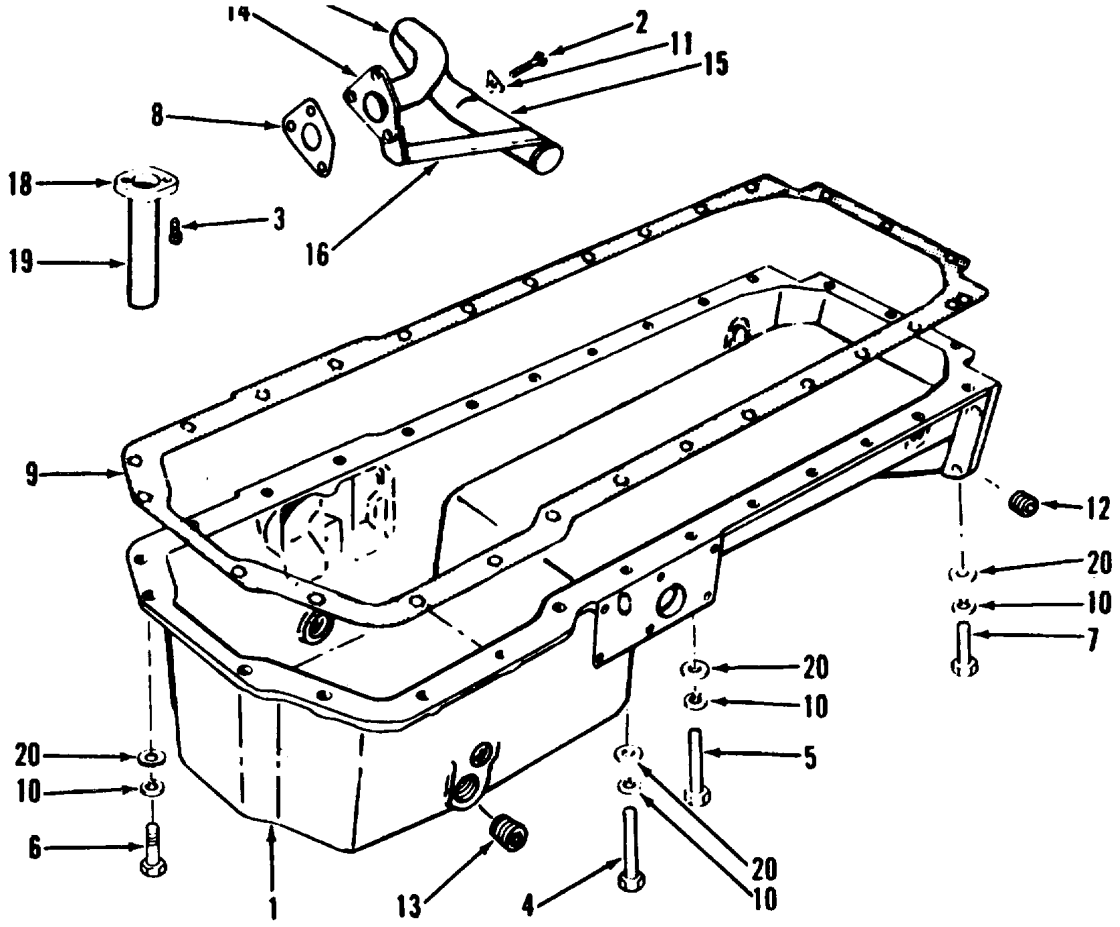
(1) Drain oil from crankcase (see lubrication order).

(2) Remove engine assembly (para 2-9), and flywheel housing (para 3-34).

(3) Turn engine upside down.

(4) Remove all mounting capscrews, lockwashers and flatwashers from oil pan.

(5) Lift oil pan and gasket from block (fig. 3-170); discard gasket.



1 Oil pan
2 Capscrew, suction tube (5/16"—18 x 7/8") (3)
3 Capscrew, drain tube (5/16"—18 x ¾") (2)
4 Capscrew, pan to block (3/8"—16 x 4½") (2)
5 Capscrew, pan to block 3/8"—16 x 4") (2)
6 Capscrew, pan to block (3/8"—16 x ¼") (18)
7 Capscrew, pan to block (3/8"—16 x 2½") (3 rqr)
8 Suction tube gasket
9 Pan to block gasket
10 Lockwasher, pan to block (3/8") (27)
11 Lockplate, suction tube (3)
12 Pipe plug (½") (4)
13 Pipe plug (1")
Suction tube assembly
14 Tube flange
15 Suction screen
16 Screen support
17 Suction tube
Assembly drain tube
18 Tube flange
19 Drain tube
20 Washer, plain (13/32") (27)

Figure 3-170. Oil pan, exploded view.

c. Cleaning and Inspection.

(1) Remove all gasket material from oil pan mating surfaces.

(2) Visually check oil pan for cracks. If a leak, is suspected, check using dye penetrant as follows:

(a) Spray suspected area with dye penetrant.

(b) Allow penetrant to dry for fifteen minutes. Do not "force dry".

(c) Spray area with dye developer, and check for crack indications.

(3) Check all threaded holes for damaged threads.

d. Repair. Repair small cracks in pan by welding. Do not weld finished surfaces.

e. Installation.

(1) Install pipe plugs and drain plugs in oil pan securely. Do not overtighten.

(2) Position (with adhesive) new gasket on oil pan mounting surface. Be sure mating surface is clean of all old gasket material. Check dowels for worn or loose condition.

(3) Position oil pan to block, figure 3-171, and secure with flatwashers, lockwashers and capscrews. Tighten capscrews enough to hold oil pan firmly in place.

(4) Using a straightedge, check rear surface of block and oil pan to be sure these surfaces are flush (fig. 3-172).

Note. Pan must be flush with rear of block to prevent oil leakage and distortion of flywheel housing.

(5) After checking pan-to-block alinement, loosen all capscrews mounting pan to block.

Caution: Oil leakage may occur if oil pan capscrews are tightened before flywheel housing installation.

(6) Install flywheel housing (para 3-34).

(7) Tighten all capscrews securing pan to block.

(8) Install engine assembly (para 2-9).

3-36. Oil Drain Tube

a. Removal Remove capscrews, lockplates and lockwashers securing tube (fig. 3-173) and bracket to block; lift tube and bracket from engine.

b. Installation.

(1) Install oil drain tube and bracket on bottom of cylinder block on camshaft side of engine; secure tube and bracket with lockplates and capscrews.

(2) Tighten drain tube flange to cylinder block first; then tighten bracket capscrew to block. This eliminates the possibility of the drain tube binding between bracket and tube flange.

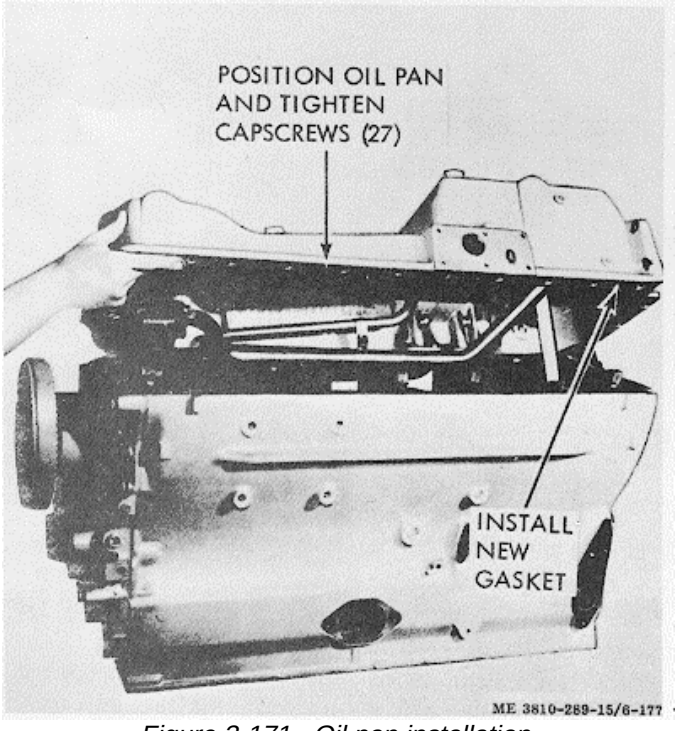


Figure 3-171. Oil pan installation.

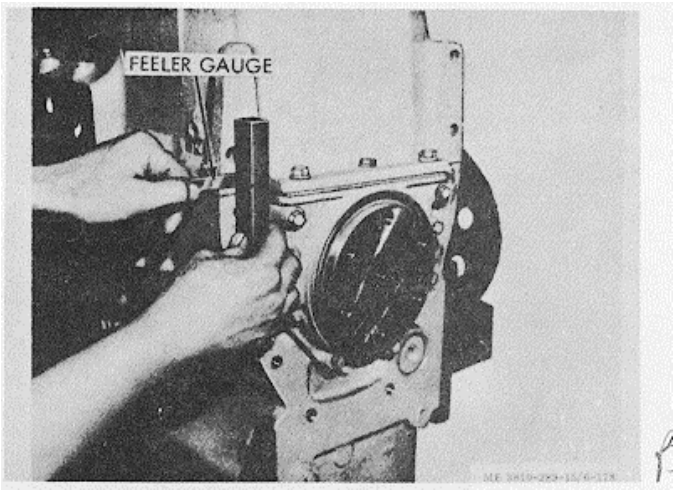


Figure 3-172. Pan-to-block alinement check.

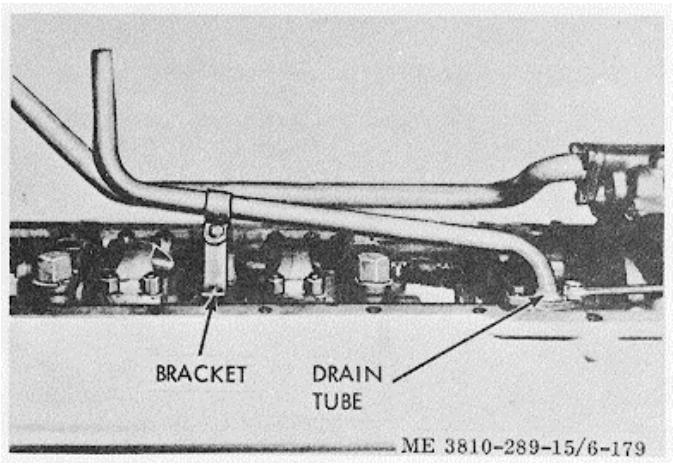


Figure 3-173. Drain tub capscrews removal.

3-37. Oil Pump Replacement

a. Removal.

(1) Remove oil pan (para 3-35).

(2) Remove capscrews and lockplates securing oil pump, figure 3-174, and suction tube strap to block.

(3) Lift pump and tube assembly from block.

b. Installation.

(1) Assemble suction tube to oil pump with lockplates, capscrews and new gasket; tighten capscrews finger tight.

(2) Attach hanger straps to suction tube bell; screw locknuts to within one turn of being tight.

(3) Position oil pump, suction tube and hanger straps to block, figure 3-175; install mounting capscrews and lockplates; tighten oil pump capscrews securely and lock lockplates.

(4) Tighten strap-to-block capscrews finger tight.

(5) Tighten suction tube-to-pump capscrews; tighten locknuts securing hanger straps to suction tube bell. Tighten hanger straps-to-block capscrews.

(6) Check all capscrews and locknuts; lock all lockplates.

(7) Install oil pan (para 3-35).

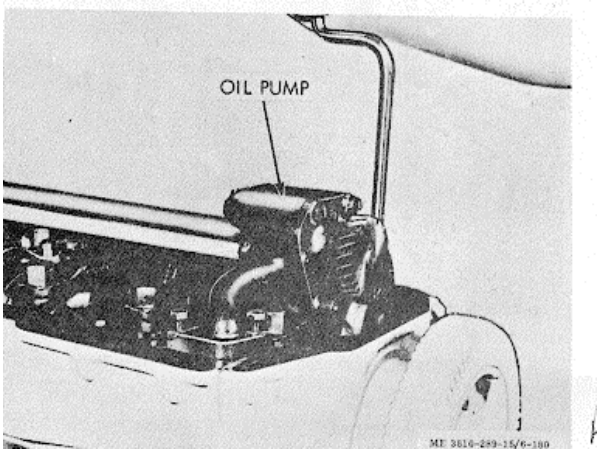


Figure 3-174. Oil pump capscrews removal.

d. Inspection and Repair.

Note. Dampers are not subject to field repair, therefore, if inspection shows them to be defective, install a new damper.

(1) Spray damper with dye penetrant.

(2) Place damper in oven heated to 200° F. (930C.) Allow damper to reach oven temperature.

(3) Remove damper from oven and inspect for oil smudges or fluid leakage.

(4) If oil smudges appear, discard vibration damper.

(5) An alternate but less effective method for inspecting viscous dampers is by shaking damper. Movement of loose pieces will be felt or heard if fluid has been lost. Tap front face at outside and inside seal. If seal is broken, a hollow sound is heard at break.

(6) Inspect for wear at oil seal contact surface; replace if flange is grooved deeper than 0.005 in.

(7) Check damper mounting capscrew hole threads.

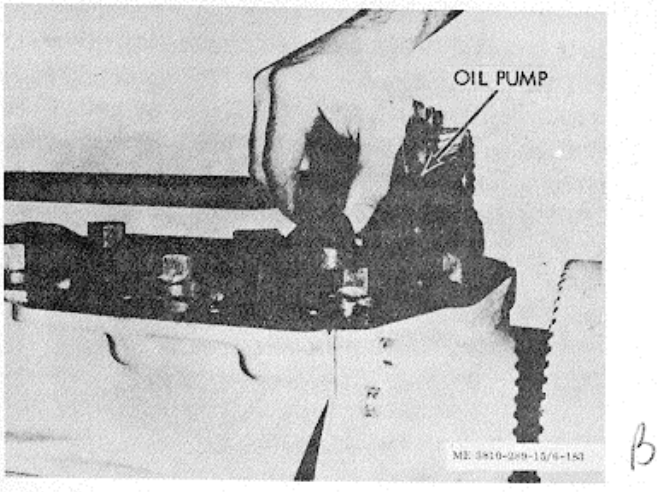


Figure 3-175. Oil pump and suction tube installation.

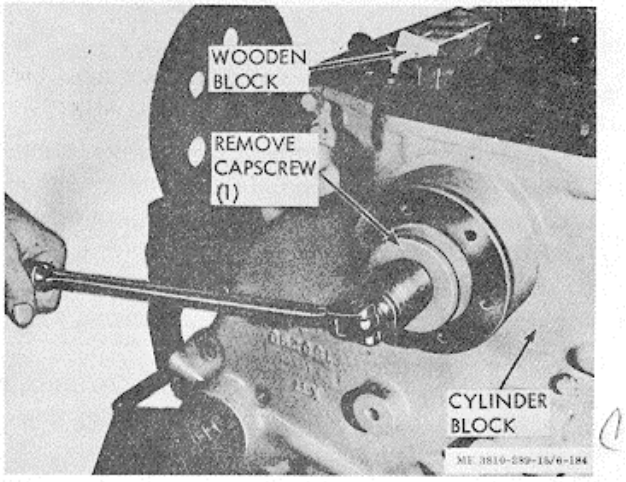


Figure 3-176. Crankshaft hub capscrew removal.

3-38. Vibration Damper and Crankshaft Hub

a. General. The vibration damper prevents damage to the engine due to vibrating forces. The type used is a viscous damper, which allows operation over a greater variation in load and mass than other types, due to design.

b. Removal.

(1) Place a wooden block between a crankshaft counterweight and cylinder block wall to prevent crankshaft from turning (fig. 3-176).

(2) Disengage lockplates and remove capscrews securing damper to hub, figure 3-177; remove damper.

(3) Remove capscrew and flatwasher securing hub to crankshaft, figure 3-176.

(4) Using ST-887 flange puller, pull hub from crankshaft, figure 3-178.

c. Cleaning. Viscous dampers should be cleaned of rust, dirt or grease with a suitable solvent cleaner.

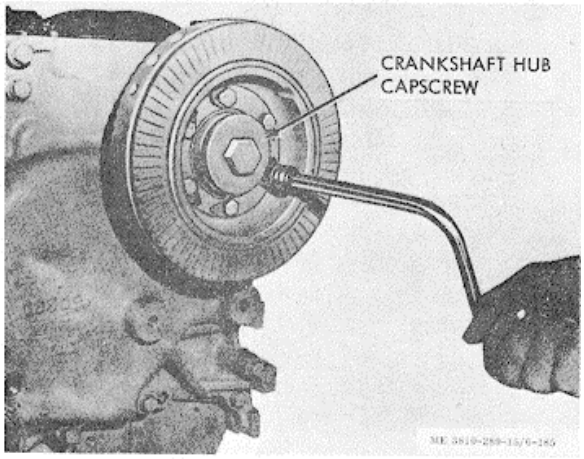


Figure 3-177. Vibration damper removal and installation.

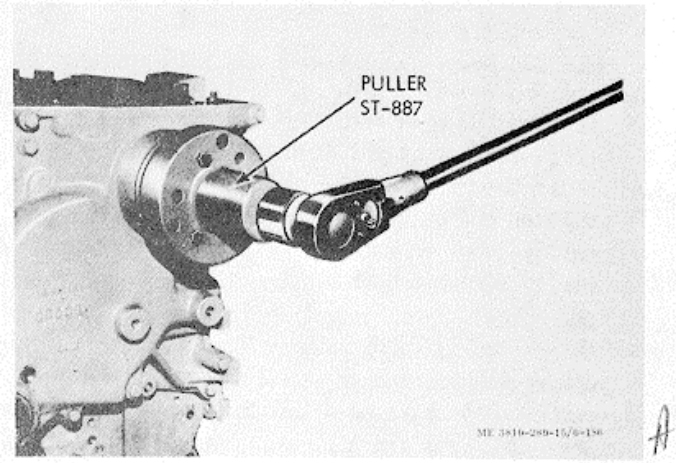


Figure 3-178. Crankshaft hub removal.

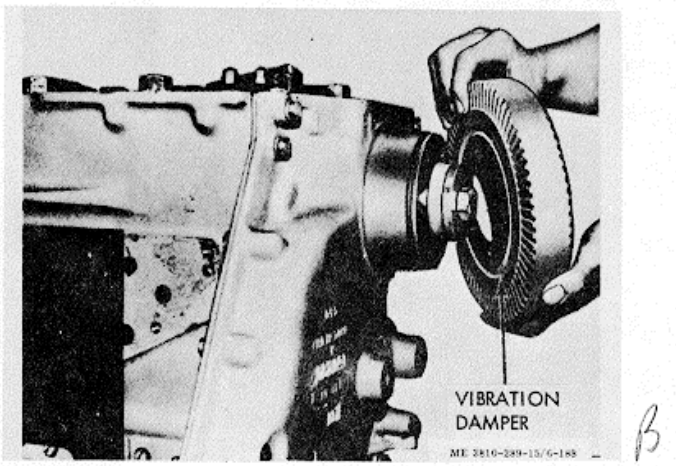


Figure 3-180. Vibration damper installation.

e. Installation.

(1) Slide flange over crankshaft end; secure with large retainer washer and Nylon capscrew. Torque capscrew to 120/140 ft.-lbs., figure 3-179.

(2) Place vibration damper over flange, figure 3-180. Secure with lockwashers and capscrews.

(3) Torque capscrews to 85/45 ft.-lbs.

(4) Eccentricity of vibration damper mounting fange measured on the outside diameter of the pilot must not exceed 0.004 in. total indicator reading, (A, fig. 3-181).

(5) Wobble in the vibration damper mounting flange must not exceed 0.003 in. measured at 23/4 in. radius (B, fig. 3-181).

(6) After assembly, vibration damper maximum allowable runout (total indicator reading) must not exceed values shown in table 2-2.

Note. Make checks with dial indicator measured on smooth inner ledge of inertia member. Keep crankshaft thrust clearance to front or rear limit while checking wobble.

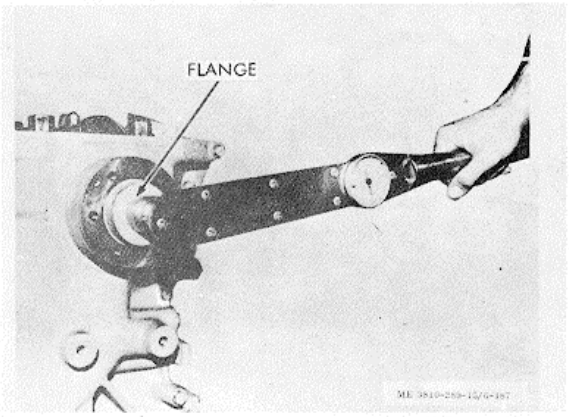


Figure 3-179. Crankshaft hub installation.

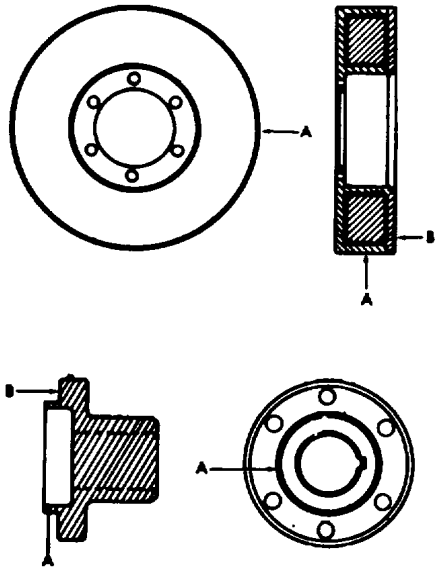


Figure 3-181. Vibration and crankshaft hub eccentricity and wobble measurements.

3-39. Gear Cover

a. General.

(1) Remove accessory drive pulley (para 3-23).

(2) Remove vibration damper and crankshaft hub (para 3-38).

(3) Remove all capscrews and lockwashers securing cover to block (including two capscrews behind mounting plate) (fig. 3-182).

(4) Lift gear cover from engine.

(5) Remove and discard gasket.

b. Inspection.

(1) Inspect gear cover for cracks or other defects.

(2) Remove all oil seal and bearings. (8) Inspect gear trunnion outside diameter (fig. 3-183) for wear. If excessive, install a bushing as described in subparagraph c.

(4) Inspect accessory drive bushing. Replace if inside diameter exceeds 1.322 inches.

c. Repair.

(1) Press new bushing into cover as required.

(2) Do not install oil seals until gear cover is to be assembled to engine; this prevents collection of dirt.

(3) Gear cover trunnion bushing replacement.

(a) Machine gear case trunnion to 4. 747/4.750 in. outer diameter, figure 3-183.

(b) Press bushing over machined trunnion with chamfered side of bushing toward gear case.

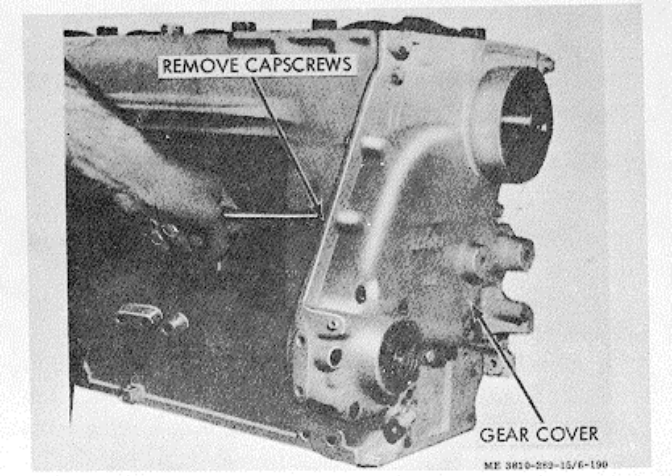


Figure 3-182. Gear cover removal and installation.

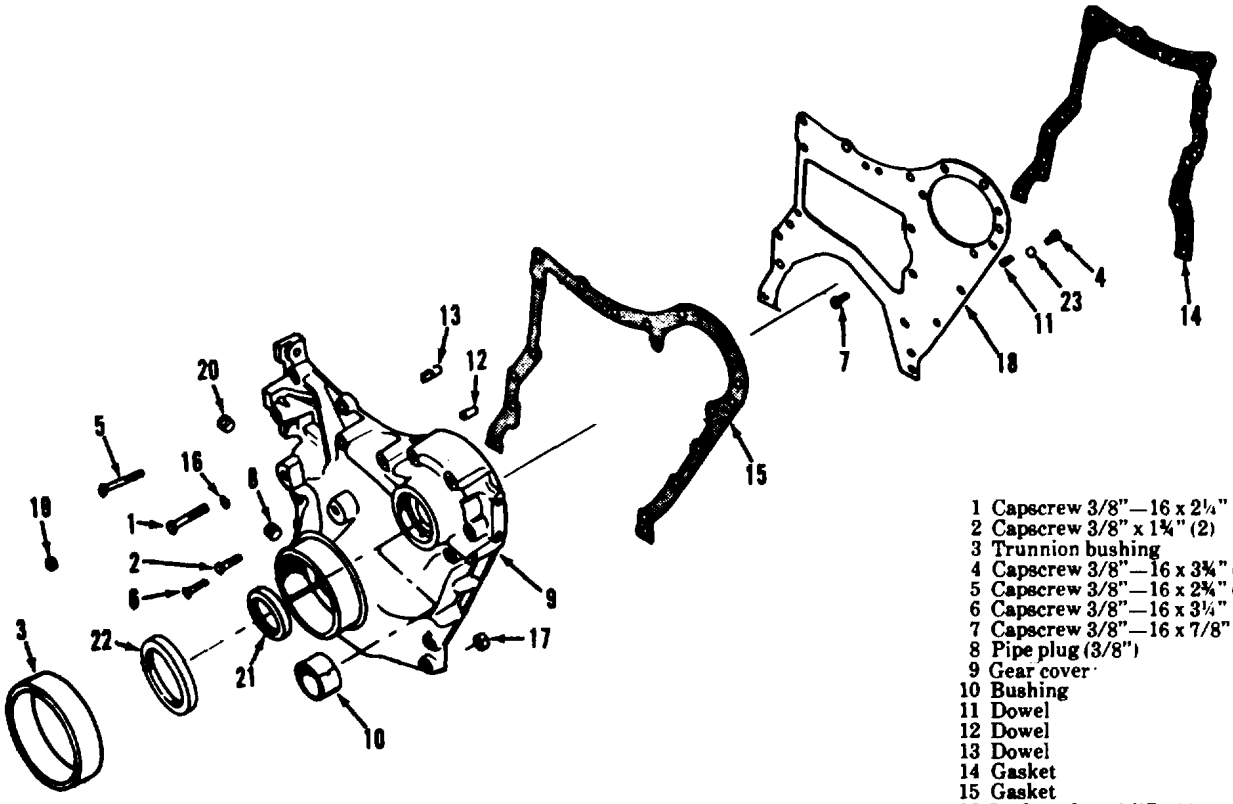


Figure 3-183.

(a) Inspect bushing for wear, install new bushing if worn larger than 1, 322 in. Be sure oil hole is indexed.

(b) See table 2-2. Shaft to bushing clearance should be maintained between 0.002/0.0075 in.

e. Installation.

(1) Position new gasket to gear cover with gasket

adhesive.

(2) Secure gear cover to mounting plate and block with lockwashers and capscrews, figure 3-182. Tighten to 30/35 ft.-lbs torque.

3-40. Gear Cover Mounting Plate

a. Removal. Remove capscrews and lockwashers securing plate to block (fig. 3-184). Tap plate from block with lead or plastic hammer. Discard gasket.

b. Inspection. Inspect mounting plate for any cracks or defects.

c. Installation.

(1) Be sure old gasket material is removed from mounting plate; position a new plate-to-block gasket on back of plate with gasket adhesive.

(2) Mount plate over dowels, figure 3-185, and secure with lockwashers and capscrews; tighten to 30/35 ft.-lb.

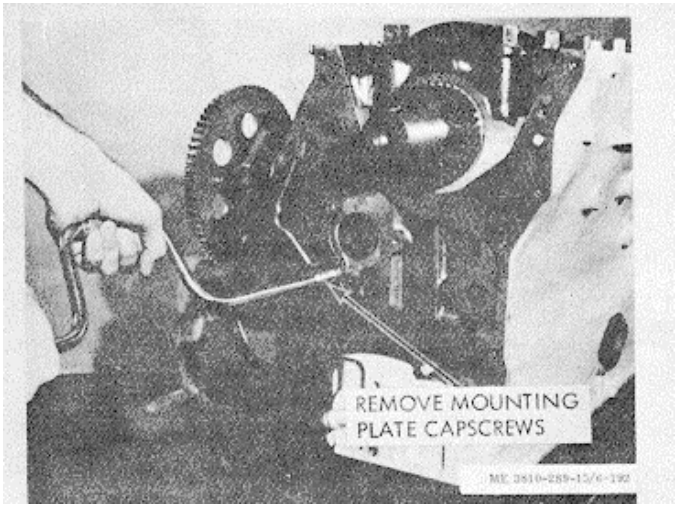


Figure 3-184. Gear cover mounting plate removal.

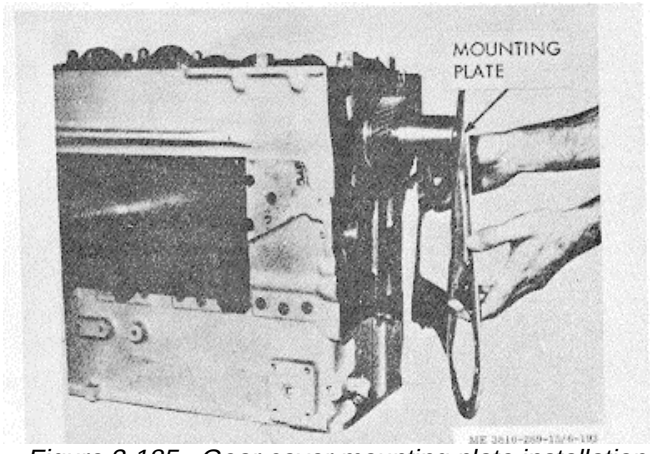


Figure 3-185. Gear cover mounting plate installation.

3-41. Bushings, Camshaft, Gears

a. General. The camshaft is located on the upper left side of the cylinder block and is driven by the camshaft gear. It is supported in the block by three bearings and is positioned by a thrust plate secured to the cylinder block. The cams which actuate the inlet and exhaust valves are forged integrally with the shaft. The camshaft and camshaft gear can be removed as a unit if desired after the timing gear cover has been removed.

b. Removal of Camshaft.

(1) Since the crankshaft oil slinger partially covers the camshaft gear, remove slinger mounting capscrews and lockplates, (fig. 3-186 and remove slinger from crankshaft; discard lockplates.

(2) Remove capscrews and lockwashers (accessible through openings in camshaft gear) securing camshaft retainer bearing to block.

(3) Rotate camshaft gear slightly to disengage gear teeth while carefully pulling camshaft, camshaft gear and bearing plate from block. Refer to figure 3-187.

c. Cleaning and Inspection of Camshaft.

(1) Steam clean camshaft assembly.

(2) Check camshaft journals with micrometers. Refer to figure 3-188.

(3) Replace camshaft if journals are worn beyond limits given in table 2-2.

(4) Replace camshafts that have scuffed, scored, or cracked injector or valve lobes. Check by magnetic inspection for possible cracks.

(5) Regrinding of camshaft lobes is not recommended.

(6) Magnetic inspection.

(a) These instructions apply to the magnetic particle inspection using "Magnaflux" or equivalent. The camshafts should be tested by the active or continuous method. That is, the whole surface must be wetted with the magnetic particle suspension before the magnetizing current is applied. Shafts must be magnetized by a single "shot" of current.

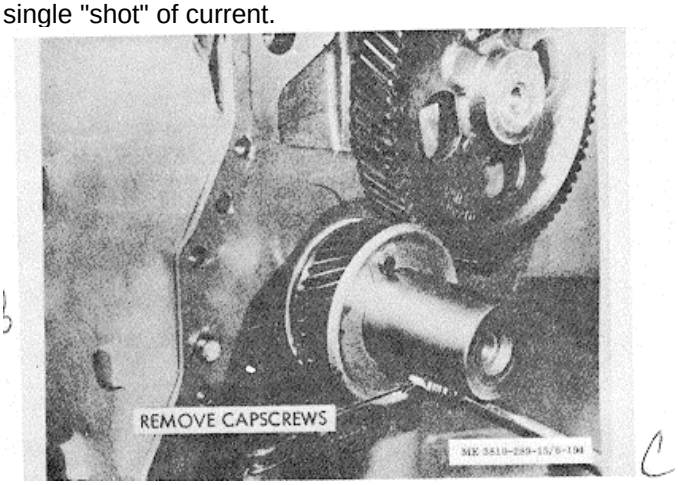


Figure 3-186. Oil slinger capscrews removal.

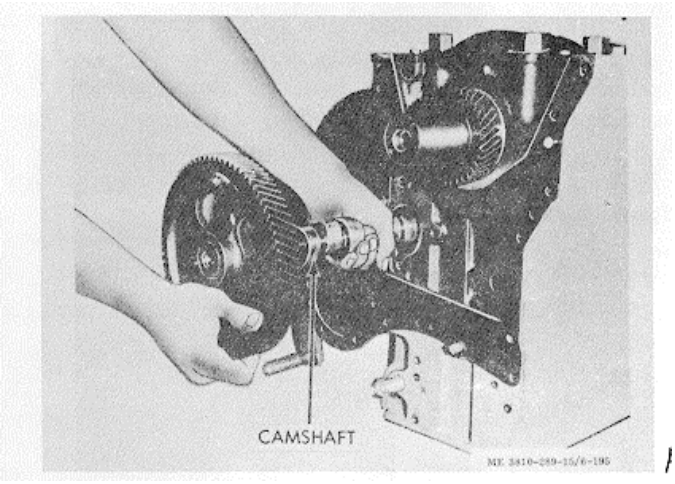


Figure 3-187. Camshaft removal.

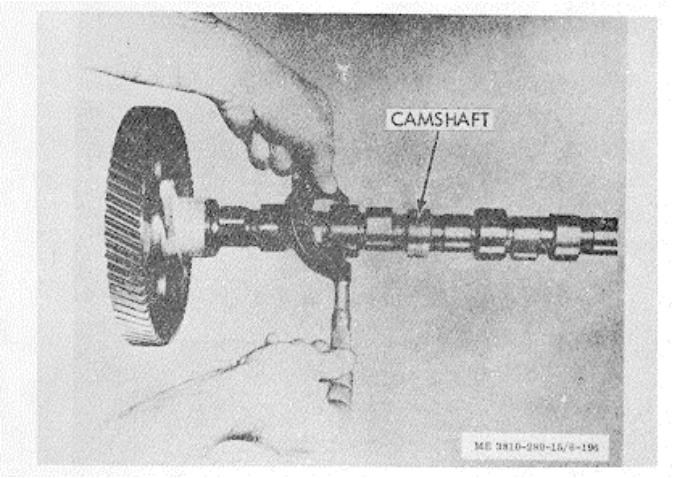


Figure 3-188. Camshaft journals measurement.

(b) 1500 amperes DC longitudinal magnetizing currents must be used for locating open seams and the presence of non-metallic inclusions; for detecting grinding checks a circular (coil) magnetizing current of 2000 amperes DC must be used. Limits of accept ability for injector cam:

(c) Subsurface longitudinal indications:

1. None acceptable on nose.

2. Short longitudinal indications up to 5/8 inch long are acceptable in the critical region on the cam surface, 2 inch before nose, and 3/8 inch after nose.

3. Not more than two indications allowable in the critical region of any one cam.

4. Light longitudinal indications not exceeding two in number are allowable outside of the critical regions.

5. Parallel indications must be separated by at least 1/16 in. of metal.

(d) Open longitudinal indications; Open indications are not allowable except on the base circle. A maximum of two longitudinal open indications ¼ inch long or less will be allowed on the base circle provided they are not closer together than 'A inch and are visible only as a tightly closed line when the surface is wiped clean. Open indications shall not be closer than 3/16 inch to the edge of the cam.

(e) Circumferential indications (lying at an angle greater than 15 degrees with the longitudinal centerline) are not allowable.

(7) Limits of acceptability for valve cams.

(a) Subsurface longitudinal indications:

1. 1/8 inch indications are allowable on the nose.

2. Light longitudinal indications up to ½2 of the cam width are allowable on the ramp.

3. Not more than two indications are allowable on the ramp or nose of any one cam.

4. Light longitudinal indications not exceeding two in number are allowable on the base circle of any one cam.

5. Parallel indications must be separated by at least 'A in. on the ramp and nose by 1/16 inch on the base circle.

(b) Open longitudinal indications: Open indications are not allowable except on the base circle. A maximum of two longitudinal open indications 1/4 inch long or less will be allowed on the base circle provided they are not closer together than 1/4 inch and are visible only as a tightly closed line when the surface is wiped clean. Open indications should not extend closer than 3/16 inch to the edge of the cam.

(c) Circumferential indications (lying at an angle greater than 15 degrees with the longitudinal centerline) are not allowable.

(8) Limits of acceptability for bearing surfaces.

(a) Subsurface indications are acceptable.

(b) Open indications: Four open longitudinal indications are permitted in each section of bearing provided not more than half of them extend the full width of the bearing. Edges of such indications are to be stoned, not to exceed 0.0005 inch deep.

d. Removal of Gear.

(1) Remove gear if chipped, cracked or visibly worn.

(2) Gears with three capscrews mounted thrust bearing must be pulled from the camshaft.

(a) Slide two steel bars, 4 inch by 1 inch behind gear and thrust bearing.

(b) Insert gear puller jaws through access holes in gear.

(c) Tighten puller bolt until gear is free of camshaft.

(3) Camshafts with two capscrew mounted thrust bearing.

(a) Place camshaft and gear in press. Support gear as near hub as possible by using short bars lying parallel with thrust bearing.

(b) Press camshaft from gear.

Note. Care must be taken to prevent gear breakage due to improper use of press and support bars.

(4) Note type of key used. See figure 3-189 "B"-straight, as viewed from gear case of engine.

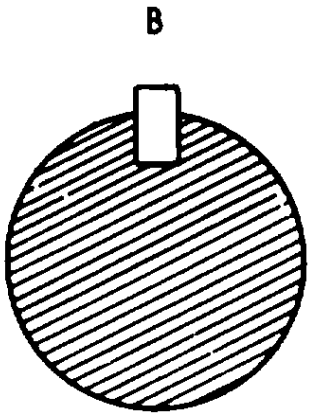


Figure 3-189. Camshaft gear key from gear case end.

e. Installation of Gear

(1) Coat gear hub area of camshaft with lubricant.

(2) Install camshaft thrust bushing on camshaft with grooves in bushing toward gear.

(3) Heat gear evenly to 4000F. (204.400 C) with heating torch (not a cutting torch).

(4) Press on new camshaft gear, aligning gear keyway with camshaft key.

(5) Check between thrust bearing and camshaft gear for 0.007 to 0.011 in. clearance for new thrust bearing.

f. Installation of Camshaft.

(1) Lubricate all camshaft bushings (in block) with high pressure grease.

(2) Rotate camshaft during installation to allow lobes to pass through bushings easily.

(3) Index "O" on camshaft gear with 'O' on crankshaft gear; this is Number One topcenter firing position.

(4) Slide camshaft completely into block; align bearing retainer mounting holes with those in block and secure with lockwashers and capscrews through openings in camshaft gear. Refer to figure 3-190.

(5) Tighten capscrews to 30/35 ft. lb.

g. Camshaft Checks After Installation.

(1) Gear backlash. Bear backlash is the amount of play between intermeshed gears. Excessive back lash is a good indication that gear (s) is/are worn and should be replaced.

(a) Backlash of all gears in gear train may be checked with a dial indicator gage or narrow feeler gage.

(b) When dial indicator gage is used, locate gage so contact point contacts gear tooth; move gear counterclockwise against indicator point and set indicator at "O".

(c) Move gear clockwise against indicator (fig. 3-191) note reading. Repeat checks on four equidistant points on gear.

(d) Normal gear backlash for J six-cylinder engines with new gears is 0.004/0.007 in. between mating gears.

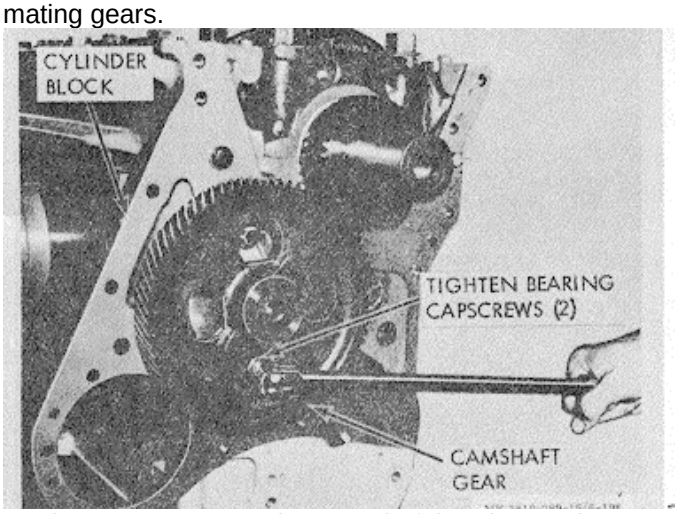


Figure 3-190. Securing camshaft bearing retainer to block.

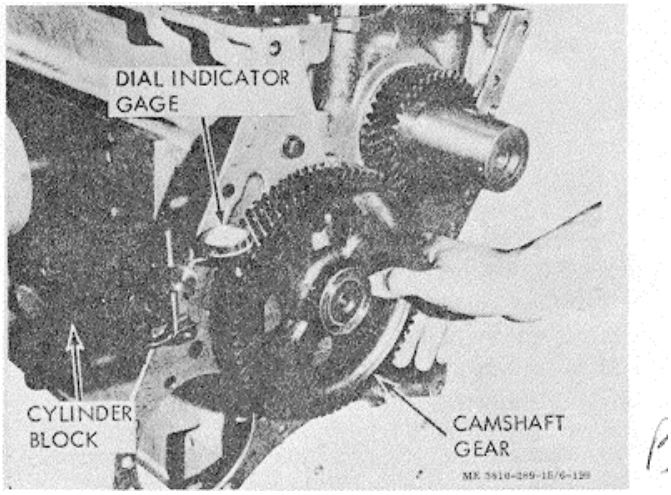


Figure 3-191. Checking camshaft gear backlash.

(e) Worn gears will naturally have more backlash than new gears and will rattle if backlash exceeds 0.012/0.020 in. If noise is not objectionable, do not replace gear(s) unless backlash exceeds 0.020 in. or unless gear(s) is/are visibly worn.

Caution: Insufficient gear lash or improperly mated gears cause quick gear failure.

(2) Camshaft end play.

(a) Secure dial indicator gage clamp to gear cover plate.

(b) Locate indicator pin against front of engine as far as possible Set gage at "O".

(c) Push camshaft and gear toward rear of engine as far as possible; read gage, figure 3-192.

(d) Proper camshaft end play is 0.007/0.0.011in.; if clearance exceeds 0.015 in., replace bearing retainer and/or camshaft.

(7) Position a new cover-to-cylinder block gasket onto cylinder block with gasket adhesive.

(8) Attach ST-558 seal tool assembly (fig. 3-195) to crankshaft; slide rear cover and seal assembly into position over tool.

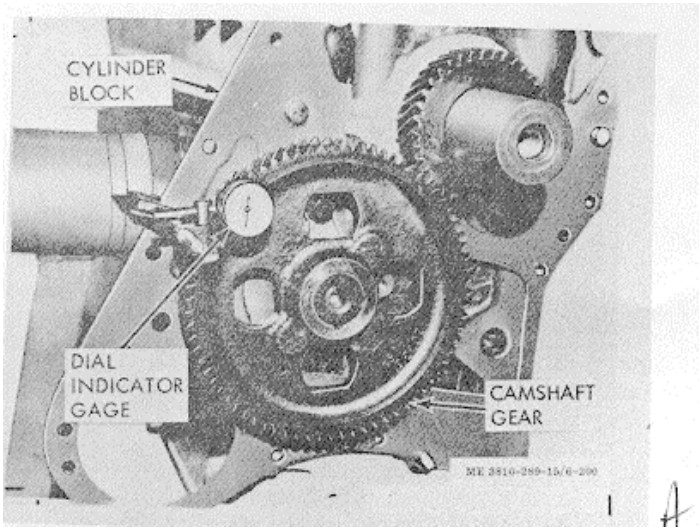


Figure 3-192. Checking camshaft end play.

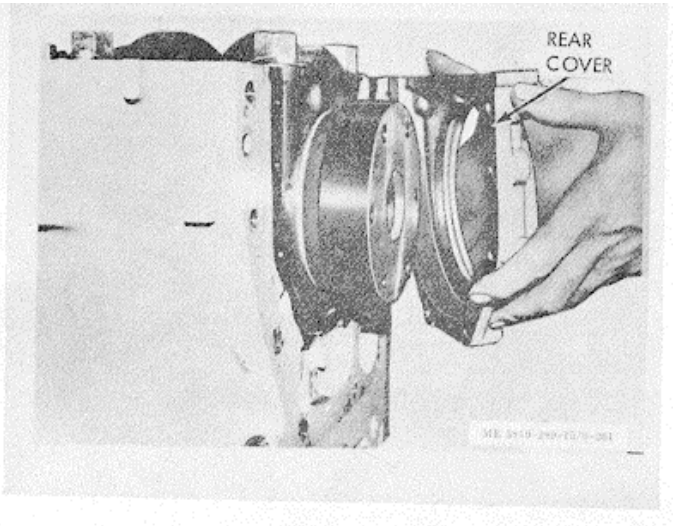


Figure 3-193. Rear cover removal.

3-42. Rear Cover and Seal

a. Removal.

(1) Remove capscrews and lockwasher securing cover to block.

(2) Slide rear cover, seal and gasket off the crankshaft (fig. 3-193).

(3) Discard seal and gasket.

b. Inspection. Inspect rear cover for cracks or defects. If damaged, replace the rear cover.

c. Installation.

(1) Alinement during engine assembly is the biggest factor to proper performance of the rear cover unit. The outer machined surface, indicate by arrows in figure 3-194 is provided so the rear cover may be properly centered around the crankshaft. Attach indicator to crankshaft with point resting on machined surface and maintain within a maximum of 0.005 inch runout.

(2) Coat new rear cover 3eal with clean Lubricating oil.

(3) Lay rear cover on arbor press table with mounting surface face down.

(4) Use a flat plate, larger than outside diameter of seal and press seal ("open" side down) into cover until rear of seal is flush with rear of cover.

(5) Lubricate cavity between oil seal lips with clean lubricating oil.

(6) Clean the crankshaft chamfer outside diameter. A burr on the chamfer would cut the seal and cause a leak.

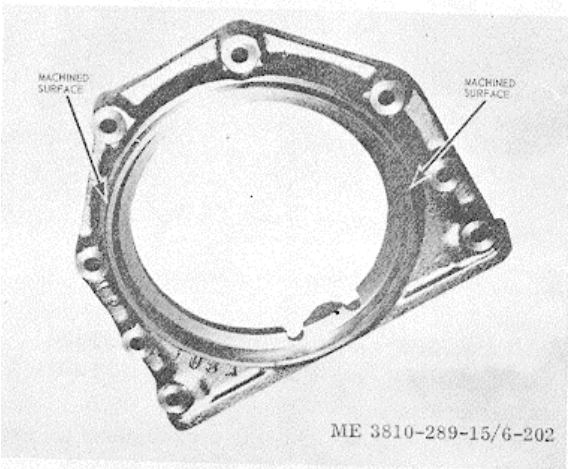


Figure 3-194. Rear cover locating surface.

(9) Install lockwashers and capscrews to secure cover to cylinder block; screw in until finger tight.

(10) Shift cover until oil pan surface of cover is flush with oil pan surface of cylinder block, figure 3-196. Use a piece of metal with a straight edge to check alinement.

(11) To check rear cover alinement, mount indicator on crankshaft end with point of indicator on machined surface of rear cover trunnion as illustrated in figure 3-196. Rotate crankshaft and check alinement; total indicator runout must not exceed 0.005in.

(12) Tighten mounting capscrews to 20/25 ft.-lb.

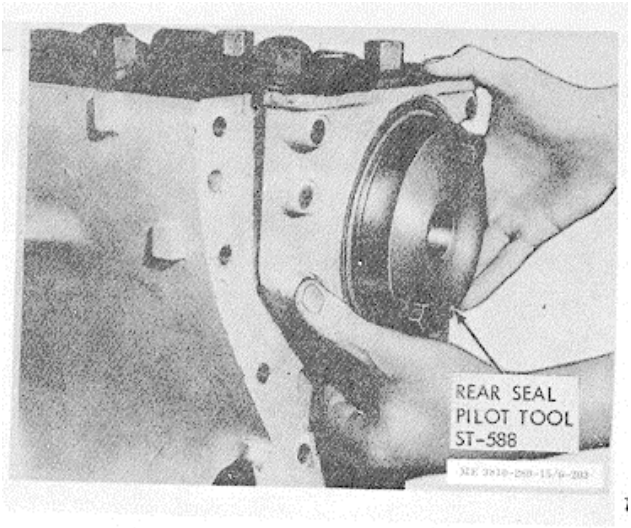


Figure 3-195. Rear cover installation.

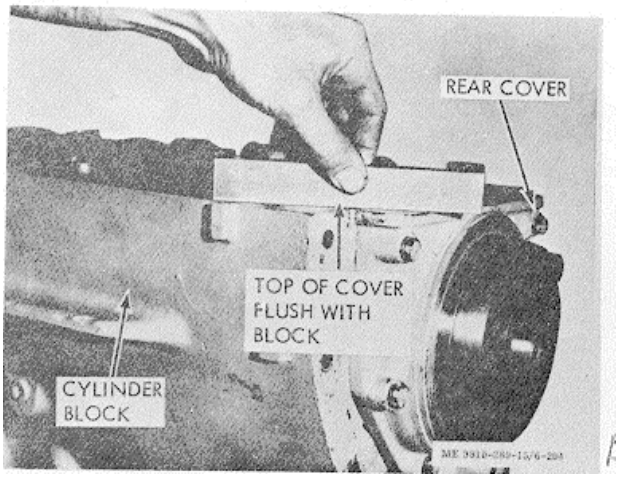


Figure 3-196. Rear cover alinement check.

3-43. Pistons; Connecting Rods; Piston Rings; Replacement and Repair

a. Removal.

(1) Turn engine right-side-up and clean all car bon from upper inside wall of each cylinder liner with ridge reamer and fine emery cloth or equivalent, figure 3-197.

(2) To facilitate removal of rod and piston assemblies, turn engine until crankshaft is in vertical position.

(3) Remove connecting rod U-bolt nuts and lock plates; pull caps and bearing shells from connecting rods, figure 3-198.

(4) Push connecting rod and piston assemblies from cylinder liners with wooden stick, holding pistons so they will not be dropped and damaged.

Caution: Do not mutilate inner walls of cylinder liners.

(5) Reassemble each connecting rod cap to assembly as it is removed, figure 3-199; the rod caps are not interchangeable. Label each assembly by cylinder number; tape mating bearing shells together and label each pair by cylinder number for later reference.

Note. Check each rod and cap as removed to make sure it is stamped, in case of mixing, so all parts are reassembled correctly. Likewise, if a new assembly is to be used be sure to stamp before assembly to engine.

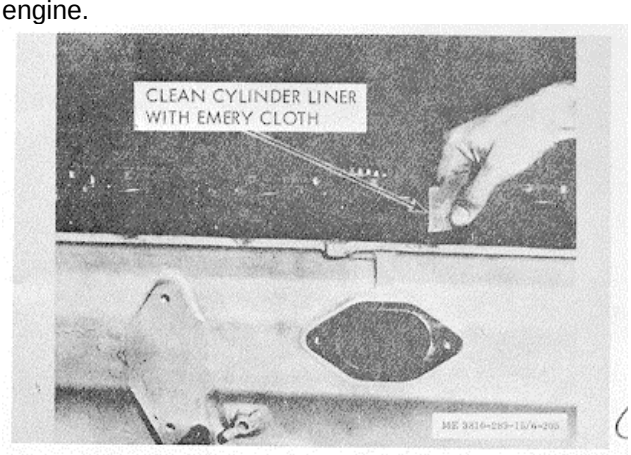


Figure 3-197. Cleaning cylinder liner with emery cloth.

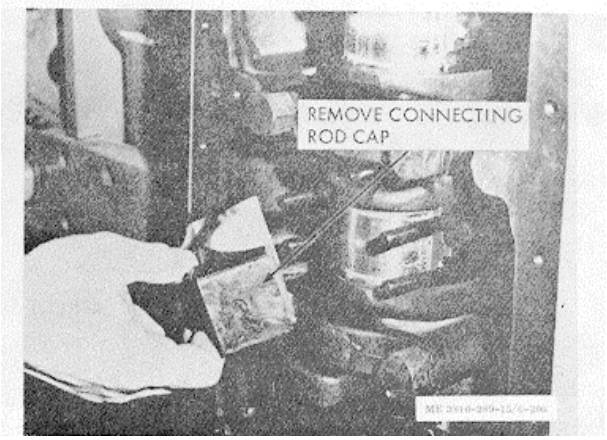


Figure 3-198. Connecting rod cap removal.

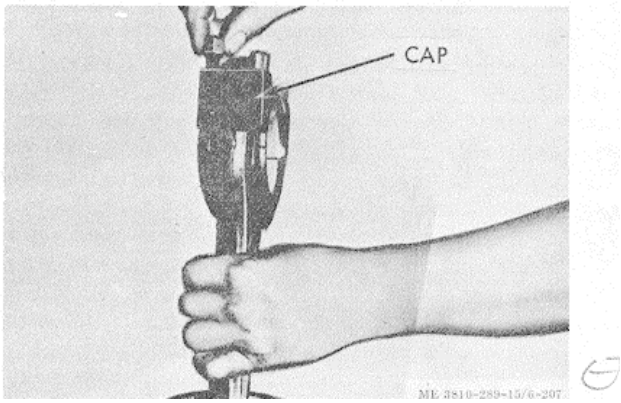


Figure 3-199. Reassembling cap to connecting rod.

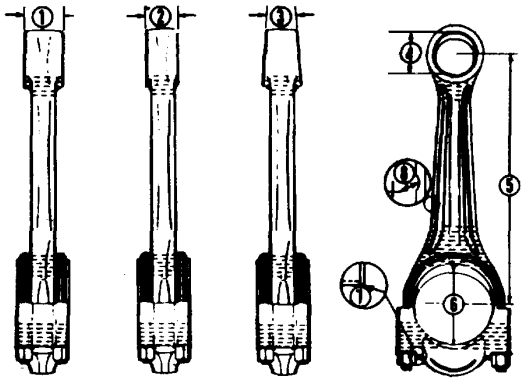


Figure 3-200. Connecting rod specifications.

(6) Remove piston pin snap rings.

(7) To facilitate the removal of piston pins, first heat pistons in hot water; then push pin from piston, using an arbor press or other suitable method. Do not drive or otherwise force pin from piston.

b. Inspection.

(1) Connecting rods.

(a) Magnaflux all connecting rods, caps and bolts; discard if cracks are detected.

Note. Be sure rod and cap are kept mated at all times. Check rods for cracks with 1800 ampere current AC equipment or 1500 ampere current DC or rectified AC equipment longitudinally between plates. Check rods for cracks with 3400 ampere-turns with AC equipment or 2600 to 2800 ampere-turns with DC or rectified AC equipment in a coil. Pay particular attention to shaded critical areas shown in figure 3-200.

Note. Ampere-turns is defined as the amperage flowing through the coil, multiplied by the number of turns in the coil. Most coils contain four turns and therefore only 700 amperes need to be applied with DC equipment, or 850 amperes with AC equipment. Apply one and one half percent wet solution while current is on. Make visual inspection after each application of current.

(b) Assemble cap to rod and alternately tighten nuts to operating tension by Template method as described in table 2-2.

(c) Check crankpin bore with a dial bore gage or inside micrometers. Correct size is important to provide correct bearing crush. See table 2-2, figure 3-201 and (6, fig 3-200).

(d) Check piston pin bushing diameter with ST-504 plug gage or with inside micrometers. See table 2-2, figure 3-202 and (4, fig. 3-200).

(e) Use ST-561 Checking Fixture and Locating Mandrel to check rod alinement.

(f) Calibrate checking fixture for rod size as follows:

1. Select a new rod that has been checked for correct absolute center to center length. C and J rods are 9.500 in. between centers. (Production rods may vary from 9.498 in. to 9.500 in. (5, fig. 3-200).

2. Assemble cap to rod as described in table 2-2.

3. Insert piston pin, furnished in ST-562 mandrel set, in crankpin bore.

4. Insert and tighten ("snug" only) expanding arbor, furnished with Locating Mandrels, in crankpin bore.

5. Set rod in fixture. (fig. 3-203).

6. Move dial holder so dials indicate on piston pin.

7. Zero dial indicators.

8. Lift rod, arbor and pin assembly from fixture; turn horizontally 180 degrees; set back in fixture.

9. Readjust dial indicators to divide difference between first and second readings, fixture is now calibrated.

(g) Check rod alinement as follows:

1. Measurements read directly from dial indicator indicate comparative length and misalignment of bores. Measurements apply with or without bushing installed.

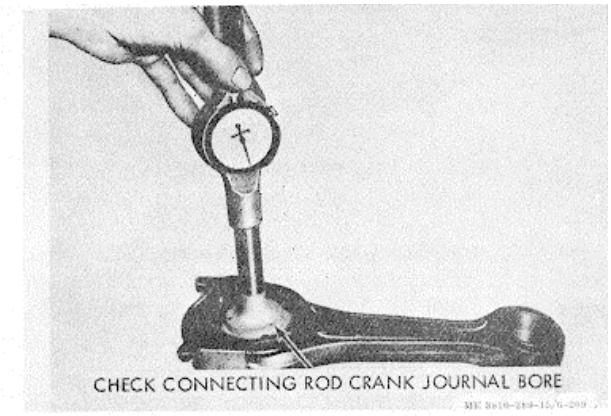


Figure 3-201. Connecting rod crank journal bore check.

2. Assemble ST-562 Mandrel in rod to be checked.

3. Set rod in fixture.

4. Take readings for length and misalignment of bores.

5. Turn rod 180 degrees. Total reading must not exceed 0.008 in. when connecting rod does not contain bushing or 0.004 in. with bushing installed and bored to size. This is combined plus and minus readings of indicator. Length must read ± 0.001 in. on gages.

6. Measure rod twist with a feeler gage between piston pin and dial holding plate. (fig. 3-204.). When measuring connecting rod twist in ST-562 and rod does not contain piston pin bushing, twist must

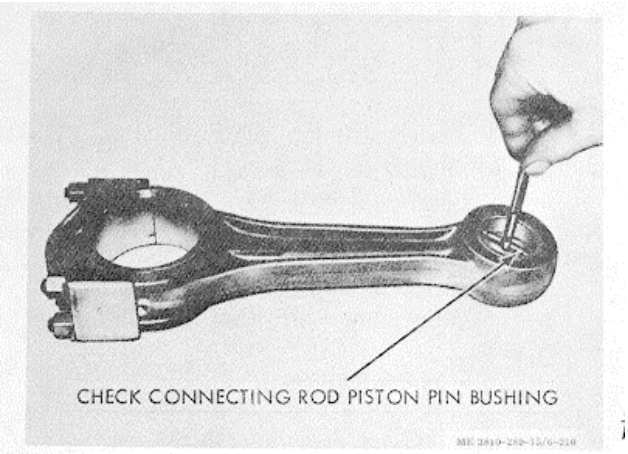


Figure 3-202. Connecting rod piston pin bushing check.

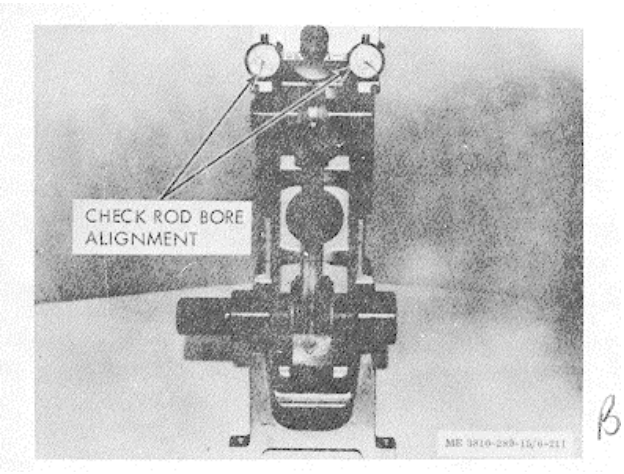


Figure 3-203. Rod bore alinement check.

not exceed 0.020 in. Twist must not exceed 0.010 in. with bushing in place and bored to size.

(h) Check centerline of rod as follows:

1. Attach a dial indicator so it will contact the side milled surface of piston pin end of rod.

2. Slide crankshaft end of connecting rod sideways to contact ST-561 on same side as indictor gage. See Step 1.

3. Zero indicator gage on milled surface.

4. Turn rod 180 degrees; repeat all above checks.

Note. Difference in reading should not exceed 0.015 in.

(2) Pistons.

(a) Clean pistons in a solvent cleaning bath that will not attack aluminum or blast with a material that will not imbed in or remove metal (ground seed, etc.).

Caution: Piston skirts are coated with a plating that may blister if overheated. Recommended that water boiling point not be exceeded.

(b) After cleaning, check top and second ring grooves with ST-560 Wear Checker, figure 3-205.

(c) Shoulders of gage must not touch ring groove lands if piston is to be reused. If shoulders touch, discard piston or mark piston for regrooving to the top groove.

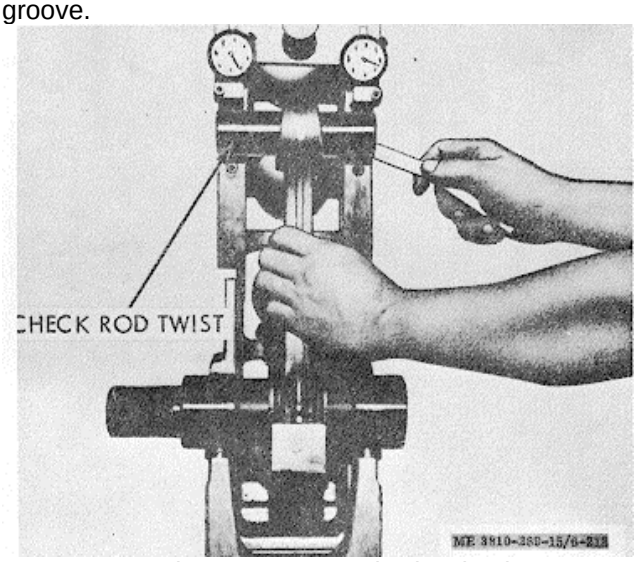


Figure 3-204. Rod twist check.

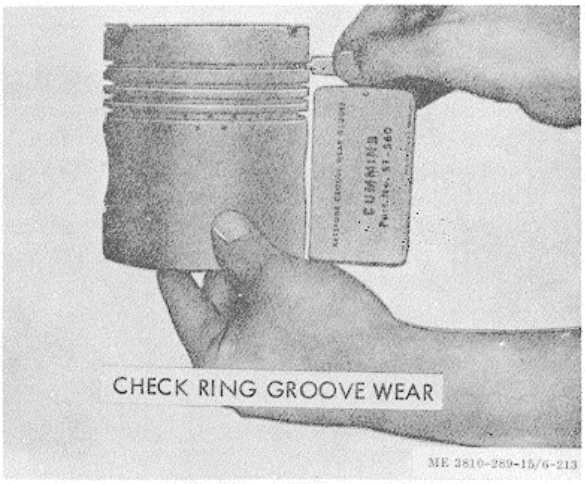


Figure 3-205. Ring groove wear check.

(d) If ST-560 is not available, check wear with a segment of a new ring and a feeler gage.

1. Hold ring in groove, flush with land.

2. Insert 0.006 in. feeler gage.

3. If gage enters groove without forcing or disengaging ring, wear is excessive and piston should not be used or should be marked for regrooving.

(e) Measure piston skirt diameter with micrometer at right angle to piston pin bore (2, fig. 3-206 for barrel-ground pistons), measure straight or tapered ground pistons at point 1 and 3. Pistons should not be reused if worn more than indicated in table 2-2 on this diameter.

(f) Pistons should be checked at temperature of 70/90 F.; see table 2-2.

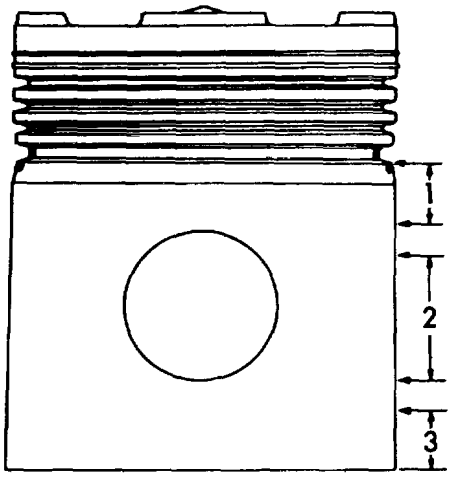


Figure 3-206. Piston check points.

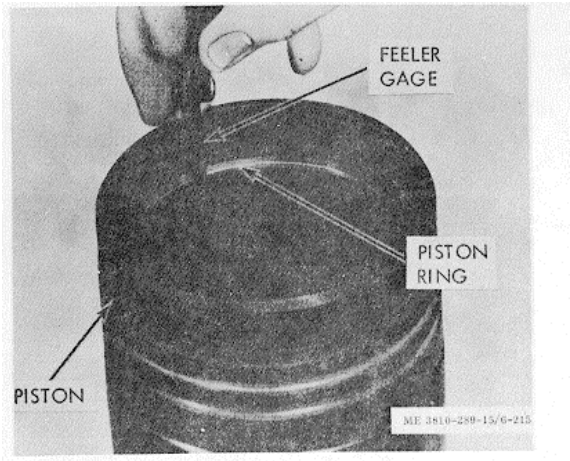


Figure 3-207. Piston ring gap check.

Note. After measuring piston and comparing with liner inside diameter, piston-to-liner clearance may be computed if desired.

Piston pin bore checked at 700 F. (21.1' C.) should fall within limits shown in table 2-2; add 0.005 in. per 10 F. (-12.2' C.) up to 900 F. (32.2° C.). Check piston pin outside diameter with micrometers. Pins should not be reused if out-of-round more than 0.001 in. or worn smaller than indicated in table 2-2.

Caution: Reboring of piston pin bores and use of oversize pins is not practical because the misalinement that results from such practice will cause seizure of piston or failure of connecting rod bearings.

(3) Piston rings.

Note. Normally, new piston rings are used at the rebuild period. New rings should be checked in the cylinder liner in which they worn to be used to make sure the gaps are correct.

(a) Insert each ring in mating cylinder liner; position with head of a piston so it is seated squarely.

(b) Seat ring in an unworn area of the liner.

(c) Measure ring gap with a feeler gage. (fig. 3-207). Gap should fall within limits given in table 2-2.

(d) If necessary, file or stone the ends of the rings to obtain the minimum gap.

Caution: Never file or stone chromeplated rings and never use chrome-plated rings in chrome-plated cylinder liners.

(e) Check current parts catalogs to make sure you use proper ring/piston combination.

Note. When used, chrome-plated compression ring is always installed in top piston ring groove.

(f) Pistons and rings are available in standard 0.020, 0.030 and 0.040 in. oversizes.

c. Repair.

(1) Connecting rods.

(a) Restore filet.

1. Minimum 0.070 in. fillet radius at all corners, (7, fig. 3-200). Maximum 1/16 in. metal may be milled off to restore radius.

2. Remove nicks and dents which are less than 1/16 inch deep by grinding or filling with a half round file. Radius must be /2 inch or more. Blend radii at ends of cut. Scrap rod if dents are deeper than 1/16 inch, (8, fig. 3-200).

(b) Chamfer piston pin bore.

1. ST-861 Chamfering Tool is used to chamfer tapered piston pin bushing bore, if not chamfered.

2. Install proper bushing tool detail by use of flat-head screw.

3. Set the guide screw holder in position; there are three notches, so guide screw will follow on face of bore.

4. Adjust tool fit until point just clears guide screw and tighten in position with two setscrews.

5. Install unit into bore.

6. Adjust the guide screw (up or down) until tool bit just engages bore.

Note. A slight pressure is required against guide screw. To obtain this pressure, tighten setscrew in end of holder against guide screw.

7. Insert drive ratchet and turn tool one complete turn to clean up edge of bore.

8. Loosen guide screw and again turn tool one or more complete turns to give a clean cut.

Note. Repeat until a uniform chamfer of 0.040 to 0.060 in. depth is reached.

9. Remove tool from bore, turn rod over and chamfer other side of bore.

10. With both sides chamfered, remove tool.

11. Use emery cloth to remove any sharp edges which may have been left on chamfer.

12. Wash rod which is ready for bushing installation.

(c) Replace piston pin bushing.

1. Use ST-605 Mandrel and Block in an arbor press to press out old piston pin bushing. Figure 3-208.

2. Use a straight or tapered sleeve from ST-605 depending upon type of connecting rod.

3. Aline oil hole and use ST-605 Mandrel to press in new bushings to a point flush with milled side surfaces.

4. Aline tapered bushing half on tapered sleeve and press flush with milled side surface. Turn rod over to install second bushing.

5. Fill lubrication holes with soap to keep shavings out.

6. Mount connecting rod in ST-526 Boring Machine, figure 3-209.

7. See instruction booklet furnished with the machine for operating procedures.

8. Check rebushed rods in ST-561 as described in previous paragraphs.

9. When reworking wide connecting rods for use with new pistons:

(a) Machine piston pin end of connecting rod an equal amount on both sides until it measures 1.150/1.160 in. wide.

(b) Chamber pin hole 15 degrees by 0.200/0.040 in. deep to allow installation of bushing.

(c) Install bushings.

(d) Bore new bushing to 1.500/1.5 in. (4, fig. 3-200).

(e) Use ST-561 to check rebushed rods.

(2) Pistons.

Note. This applies only to aluminum pistons without top ring groove inserts. Observe following precautions when regrooving.

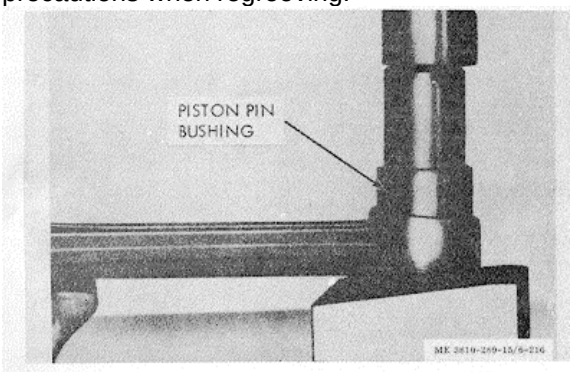


Figure 3-208. Piston pin bushing installation.

(a) Set up piston in lathe or similar device. Make certain piston is held securely without dam aging or distorting machined surfaces. Install ST 483 (15 degree grooves) Grooving Tool in lathe.

(b) Set tool to only clean up bottom face of

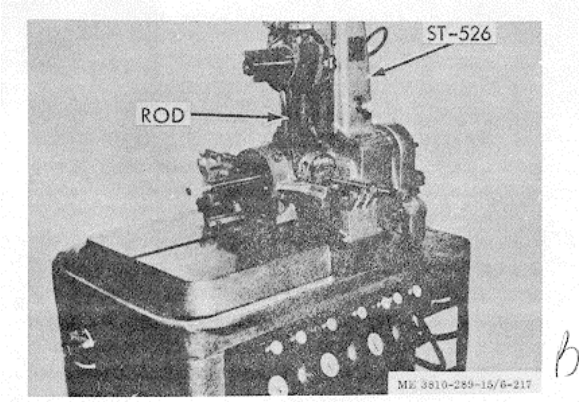


Figure 3-209. Boring piston pin bushing on ST-526.

groove, removing as small amount of material as possible.

(c) The tool is a formed tool so balance of cut will come from top of groove.

(d) Hold machined surfaces within 0.0015 in. total indicated runout.

Caution: Limits must be held accurately for satisfactory ring performance.

(e) Stand letters "OW" (over-width ring) after part number on piston crown.

d. Assembly. Piston-to-Connecting Rod Assembly.

(1) Pistons are machined to a very close weight tolerance; therefore, as long as the same part number piston is used throughout the engine weight does not affect engine operation.

Note. Be sure rod and cap are stamped before disassembly to prevent mixing parts.

(2) Connecting rods have the weight (720, etc.) stamped on the rod cap and must be matched with other rods by weight. Total weight between rod assemblies in any one engine should not vary more than 0.03 lb. Weight includes piston pin bushing, bolts, lockplates and bearing shells.

(3) Install one piston pin snap ring in piston pin bore.

(4) Heat aluminum pistons in boiling water or, not exceeding water boil temperature, in an oven and install pin through piston and connecting rod pin bores before piston cools; at 70 o F. the pin fit is 0.0001 to -0.0003 in. which prevents pin assembly unless piston is heated.

Caution: Never drive piston pins in pistons. Driving may cause distortion of the piston, causing piston seizure in the cylinder liner.

(5) Secure pin with second snap ring at opposite end-of pin bore.

e. Installation.

(1) Check all pistons (for any one engine) to make sure they are the same part number.

(2) Check all connecting rods and caps to be cer-

tain they are properly stamped and mated.

(3) Check weight of all connecting rods. Actual weight of each rod assembly (which includes bushings, bearing shells, bolts, nuts and lockplates) must not vary more than 0.03 lb. among all assemblies in any one engine.

(4) Heat aluminum piston in boiling water and push piston pin through piston and connecting rod before piston cools, figure 3-210.

Caution: Never drive piston pin into piston, as this may distort piston enough to cause seizure in liner. Do not over heat pistons (220°F. (104°C.) maximum).

(5) Secure piston pin at each end with snap rings; snap rings must be seated in grooves of piston.

(6) Check side clearance of rod (piston pin end) to piston boss with feeler gage; clearance must be 0.040/0.050 in.

(7) Before installing rings on pistons, lubricate rings and pistons with clean lubricating oil.

(8) Install piston rings, using ST-760 Ring Expander, figure 3-211.

(9) All rings must be installed with the word “Top" toward top of piston. Compression rings are placed in upper grooves, usually the top ring is chrome plated; oil rings (which may be multiple piece assemblies) are placed in lower groove.

(10) Stagger ring gaps so they are not in line with each other or with piston pin holes in pistons.

Caution: Never use chrome-plated rings in chrome-plated cylinder liners.

(11) Remove U-bolts and cap from one connecting rod assembly.

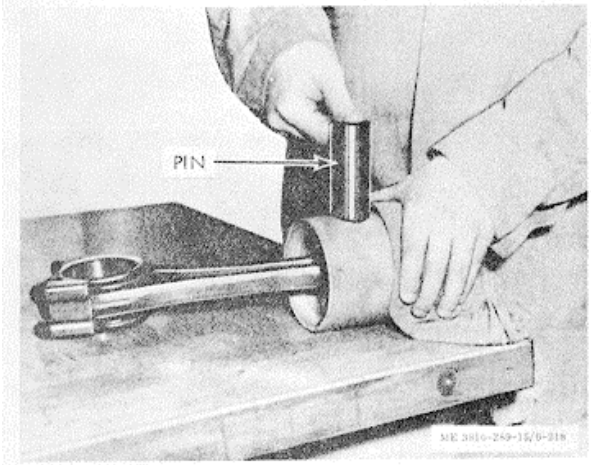


Figure 3-210. Installing pin in piston and rod.

Caution: These parts are not interchange able.

(12) Turn engine to vertical position on engine stand; rotate crankshaft until any two crank throws are at bottom-center position.

(13) Compress piston rings with ST-755

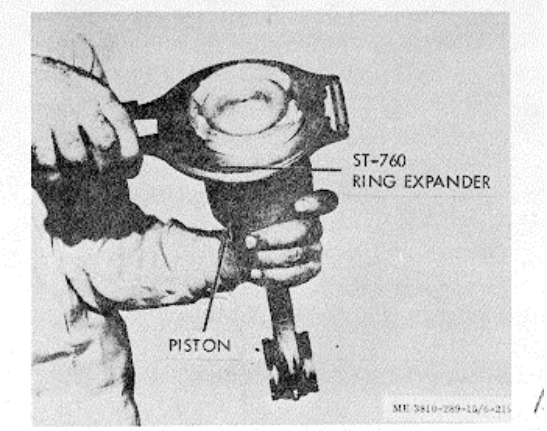


Figure 3-211. Piston rings installation.

Ring Compressor.

(14) Match cylinder number stamped on rod with cylinder in block; locate stamped number on rod toward camshaft side of engine. Install rod and piston assembly into liner by tapping top of piston with wooden hammer handle until piston rings have cleared ring compressor, figure 3-212.

Caution: Do not turn piston in liner. Support connecting rod to prevent scratching or marring liner bore. If ring breakage is suspected, remove assembly from liner and check rings carefully.

(15) Moving to bottom of block, grasp connecting rod and pull to within a short distance of crankshaft (for bearing shell clearance).

(16) Lubricate crankshaft contact surface of upper bearing shell with a thin coat of graphite grease such as Lubriplate.

(17) Slide shell into position between crankshaft journal and rod; be sure that shell locking tang makes firm contact with recess in connecting rod.

(18) Place lower bearing shell in connecting rod cap and lubricate shell with graphite grease such as Lubriplate. Be sure that the shell locking tang is seated in milled recess in cap. Cylinder numbers on rod and cap must be on same side and must match (1 to 1, 2 to 2, etc.). Install U bolts on rod; install cap to rod over crankshaft journal, figure 3-213; lubricate bolts, nuts and lockplates and assemble.

(19) Tighten front (of engine) U-bolt nuts, then rear U-bolt nuts to 15/20 ft. lbs figure 3-214.

(20) Bar crankshaft around after each piston and rod assembly is installed to see if assembly is binding. After each piston and rod assembly is installed, a little more effort will be required to turn crankshaft; however, if one assembly causes an unusual binding, it indicates an out-of-round liner (probably caused by a misplaced liner packing ring) or an incorrect or misplaced piston ring.

(21) Assemble and install each piston and rod

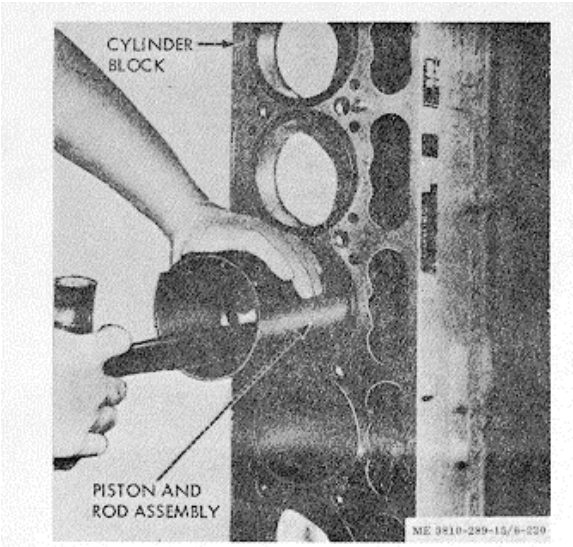


Figure 3-212. Piston and rod assemblies installation.

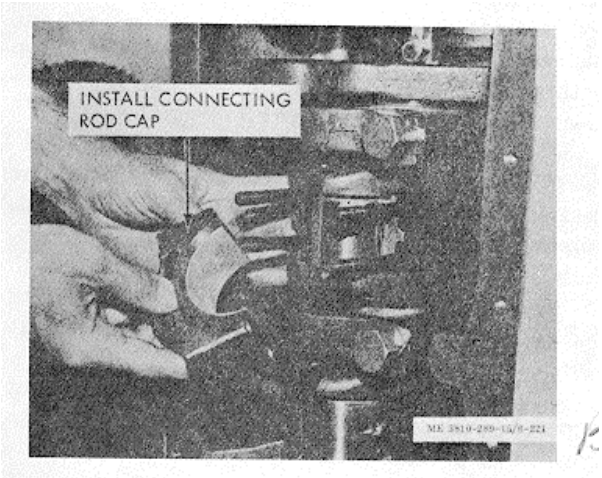


Figure 3-213. Connecting rod cap installation.

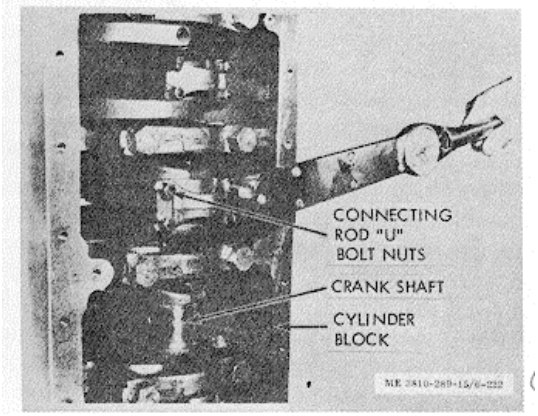


Figure 3-214. Torquing connecting rod U-bolt nuts.

assembly in foregoing manner; then:

(a) Tighten each nut (first front, then rear) to 30 ft. lbs.

(b) Loosen all nuts and repeat steps 19 and 21a.

(c) Advance each nut one-half hex (30 degrees).

(d) Finish tightening by advancing each nut an additional one-half hex (30 degrees).

(e) Check torque in clockwise direction; if less than 38 ft lbs. is required to turn nut after tightening sequence is completed, remove U-bolt(s) and replace with new one(s).

(22) Tightened rod should be free to move sideways on crankshaft journal. Check with hand pressure first; tap lightly with soft hammer only if necessary. Check side clearance (between crankshaft journal and side of connecting rod), figure 3-215; a minimum of 0.008 in. clearance should be present in this area.

Note. If rod is not free, remove cap and check for improper bearing shell size, bur, dirt, tang misengagement, etc. before proceeding with engine assembly.

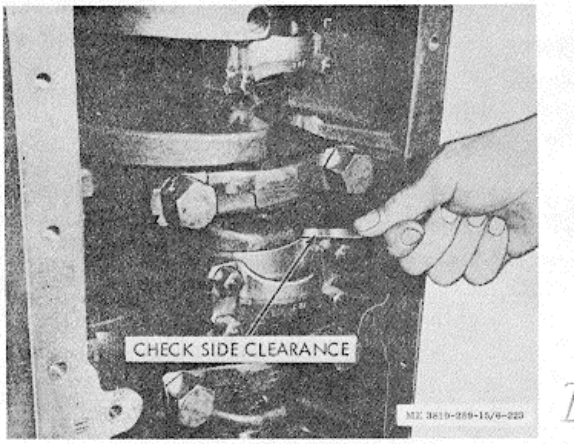


Figure 3-215. Rod-to-crankshaft side clearance check.

3-44. Crankshaft Assembly; Bearings; Seals

a. Removal.

(1) Refer to paragraph 3-43 and remove the connecting rods.

(2) Turn engine so bottom side is up; loosen capscrews securing caps to block, leaving two or three threads engaged in block to pilot caps as they are removed.

(3) Pry each cap loose with pry bar (fig. 3-216): remove capscrews and lockplates and lift caps from block (fig. 3-217).

Note. Lower thrust rings are held in place with dowels on No. 7 main bearing cap. Upper thrust rings rest in chamfer on No. 7 main bearing bore in block. Be careful not to drop thrust rings; remove before lifting crankshaft.

(4) Remove main bearing shells from crankshaft (if they did not adhere to caps).

(5) Lift crankshaft from cylinder block, using hooks covered with rubber hose, or a rope, to prevent bearing surface damage, figure 3-218. Remove upper main bearing shells.

(6) Tape lower and upper main bearing shells together and identify according to cylinder number for future reference.

b. Main Bearing Caps.

(1) Main bearing caps have an interference fit to block of 0.002/0.004 in.

(2) Caps must fit in block with no perceptible clearance or "shake". Milled faces of cap must always rest on mating portion of block to prevent distortion during tightening.

(3) Replacement caps, must be machined to fit.

c. Main Bearing Cap Replacement.

(1) Semi-finished replacement main bearing caps are available for limited use in rebuild shops.

Note. The responsibility for use of semi-finished caps must be assumed by the engine owner or by the shop which performs the work.

(2) Replacement main bearing caps have 0.003 in. material in bore and 0.005 in. excess in length (pilot dimension). Other dimensions are the same as finished main bearing caps.

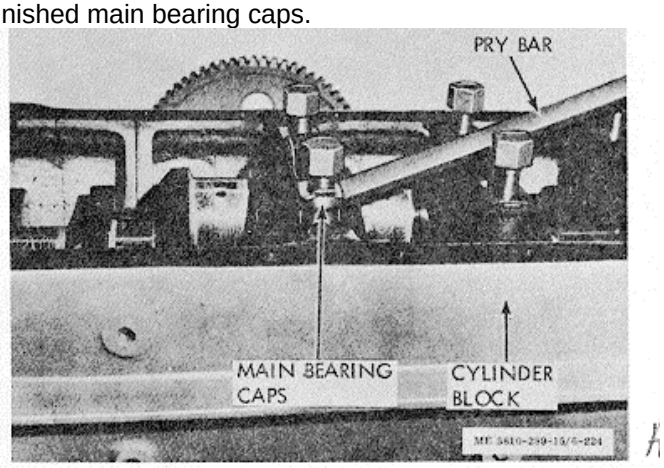


Figure 3-216. Prying main bearing caps loose.

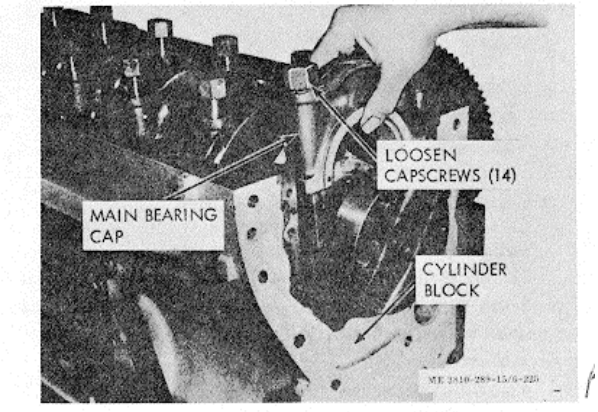


Figure 3-217. Removal of main bearing caps from block.

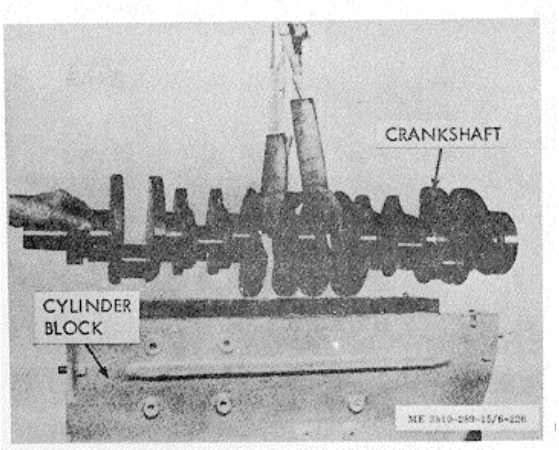


Figure 3-218. Lift crankshaft from block.

(3) A No. 7 new replacement cap does not have cap-to-block dowel holes and must be machined to block width.

(4) Machine an equal amount of material from each end of semi-finished cap to provide 0.002/0.004 in. interference fit in block.

(5) If the cap is a rear cap (No. 7):

(a) Remove locating dowels from block.

(b) Locate and machine cap so thrust faces of cap and block are flush. Use Prussion Blue on block surface to locate dowel holes in cap.

(c) Remove cap.

(d) Drill dowel holes. Refer to figure 3-219.

(e) Reinstall cap and ream dowel holes to the smallest permissible oversize.

(f) Install dowels in block.

(6) Install all caps on block and ream bore as described in following paragraphs.

d. Inspection of Bearing Shells.

(1) Gage shell with ball point micrometer, dial indicator thickness gage, or comparator. Refer to figure 3-220.

(2) Discard shells that are worn more than 0.002 in. or if chipped, flaked, or scored. See table 2-2 for thickness of standard shells.

(3) Total worn maximum oil clearance should not vary more than 0.002 in. between adjacent main bearings. See table 2-2.

Caution: Under no circumstances should an attempt be made to scrape bearing shells, or should they be lapped or filed to increase oil clear(4) A properly fitted bearing will appear dull gray after a reasonable period of service, indicating it is running on an oil film. Bright spots indicate metal to-metal contact and black spots indicate excessive clearance.

e. Crankshaft Thrust Rings.

(1) The best measurement of wear on crankshaft thrust rings (half-rings) is the crankshaft end clear-

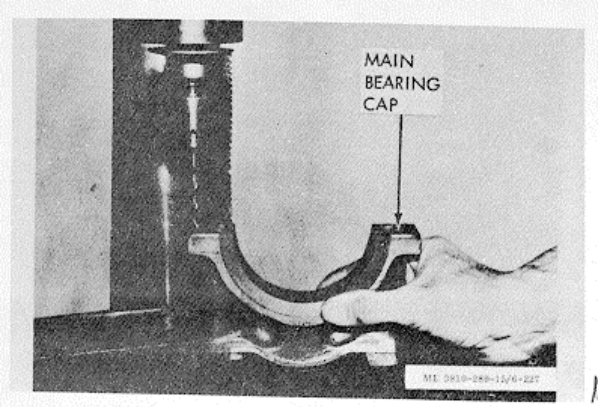


Figure 3-219. Drilling dowel hole in rear main bearing cap.

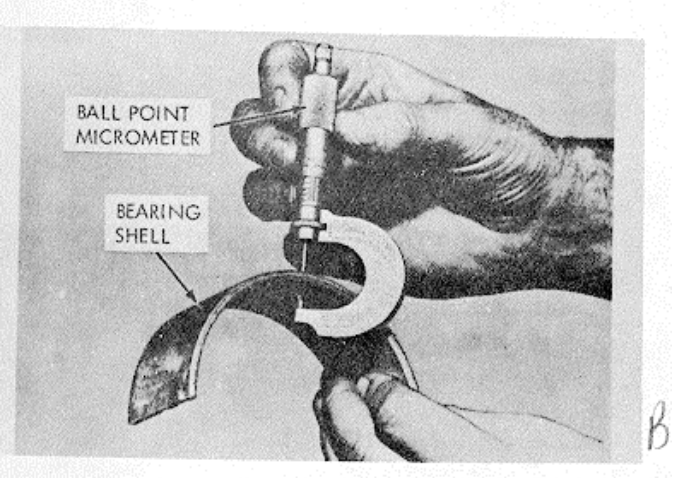


Figure 3-220. Measuring thickness of bearing shell.

(2) Oversize thrust rings are available as indicated in table 2-2.

(3) At any time oversize thrust rings are used, be sure to use the same size (thickness) half-ring on both the upper and lower positions. Stamp crankshaft rear web indicating size used. See paragraph f, below.

f. Disassembly of Cranksh4ft.

(1) If crankshaft gear is chipped, cracked, broken or worn remove capscrew and washer.

(2) Attach a circular-type puller, as illustrated in figure 3-221, behind the crankshaft gear.

(3) Apply 75 to 100 ft. lbs. on puller screw.

(4) Heat gear with heating torch-not a cutting torch-to 300°/400° F. (148.90/204.40 C.). The gear will expand, making it easier to pull.

(5) Remove gear key.

(6) If crankshaft gear condition is satisfactory, do not remove.

g. Cleaning and Inspection of Crankshaft.

(1) Inspect crankshaft visually for scratches, nicks, cracks and obvious wear pattern.

(2) Measure crankshaft journals with micrometers. See figure 3-222 or 3-223 and table 2-2.

(3) Check crankshaft for out-of-round condition. Crankshafts should be reground if main bearing or crankpin journals are worn out-of-round more than 0.002 inch. Refer to figure 3-223.

h. Clean Drillings in Crankshaft.

(1) Remove all pipe plugs.

(2) Clean all drilled oil passages in crankshaft with a rod and rag as if cleaning a rifle barrel. Refer to figure 3-224.

(3) Install and tighten plugs to 5 ft. lbs. torque.

(4) Stake pipe plugs by making a 1/64 inch indentation at outside diameter of threads with center punch.

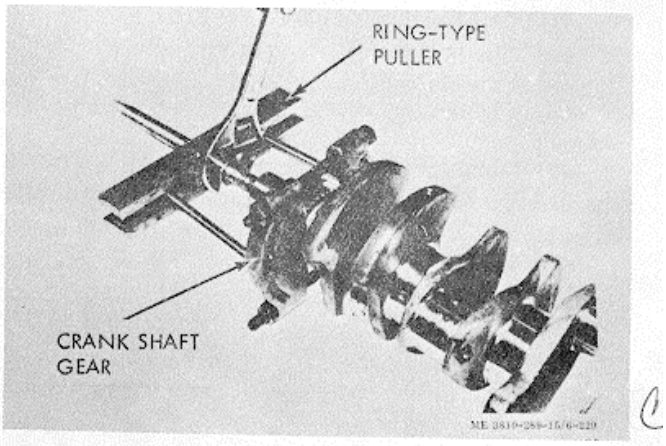


Figure 3-221. Crankshaft gear removal with ring-type puller.

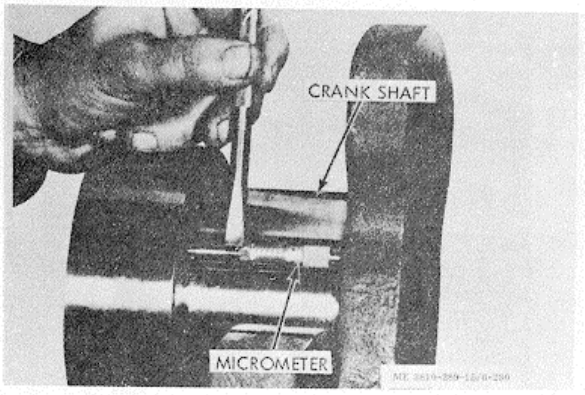


Figure 3-222. Checking thrust flange for wear.

i. Inspect Crankshaft Thrust Flange..

(1) Carefully examine crankshaft thrust flange at No. 7 main bearing. Refer to figure 3-222. If surface is scored or scratched, flange should be reground for oversize thrust rings.

(2) Reground crankshafts or those used with oversized thrust rings should be marked so the

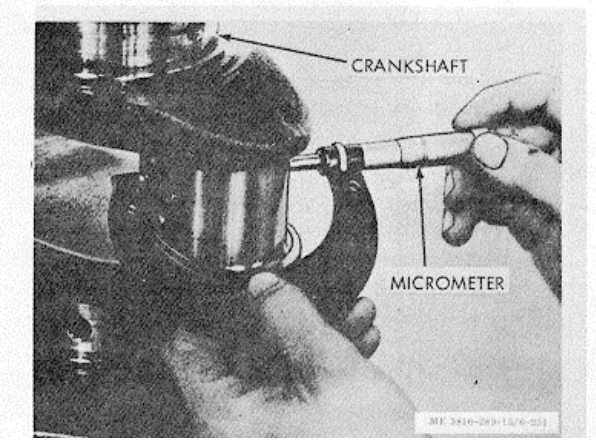


Figure 3-223. Crank pin journal measurement.

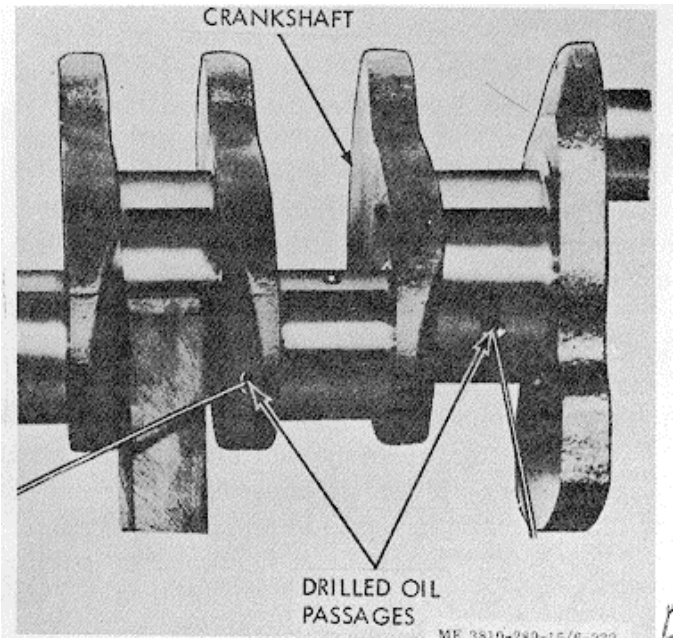


Figure 3-224. Cleaning drilled oil passages.

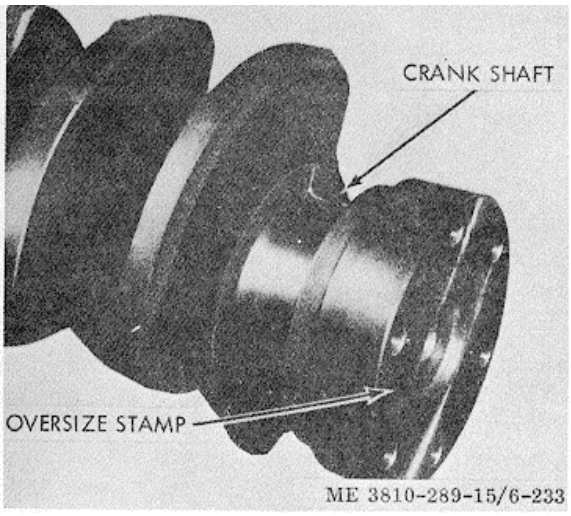


Figure 3-225. Oversize thrust bearing size mark on crankshaft.

correct thrust rings will be installed in their proper position. Refer to figure 3-225.

(a) The marking should be stamped on the rear crankshaft web.

(b) Both the thrust ring size and ring location must be included in the stamping as shown in figure 3-225. For example: front- 0.010 in. and rear--0.020 in.

(c) Measure for flange wear by checking K dimension (fig. 3-226).

(d) If wear does not exceed 0.003 in. at any one point, flange condition is acceptable.

(e) If wear is 0.003 in. or more, regrind flange to restore flatness. If total wear and regrinding does not exceed 0.005 in., standard thrust rings may be used.

(f) If worn more than 0.007 in., flange should be ground for 0.010 or 0.020 in. oversize thrust rings or built up by electric arc welding and reground to specifications. Mark as noted in (a), (b), and (c) above.

(g) Regrind must clean up a minimum of 90 percent of the thrust surface.

(h) The regrind or resurfacing must result in maintaining installed crankshaft end clearance below 0.015 in.

j. Magnetic Inspection

(1) Wet complete surface with magnetic particle suspension before applying current.

(2) Table 2-2 lists magnetizing currents that should be used.

(3) Flow magnetic particle suspension over part in advance' of placing part through coil. Turn current on coil and move coil full length of part.

(4) If shaft parts are within 2 or 3 inches of coil I.D., ample magnetism will be obtained if 3 shots of current are passed through coil while it is at each end and center of part length.

(5) Limits of acceptability.

(a) Unless otherwise stated, limits of acceptability apply only to light slag or oxide stringers usually defined as inherent inclusions. Obvious cracks and Circumferential or transverse defects are not acceptable.

(b) Limits listed in following steps must be maintained within region "C" (Critical Region) shown in figure 3-227. Dimensional value of "C' is vertical distance measured downward from crankpin centerline and extending longitudinally for all crank webs between region "X" on crankpin and region "X" on main journal.

(c) Indications located less than 1 in. from major axis or centerline of adjacent web (measured circumferentially) must not exceed the following limits:

1. Light indications in or entering fillets are acceptable if not more than 1/8 inch long (open) or 1/4

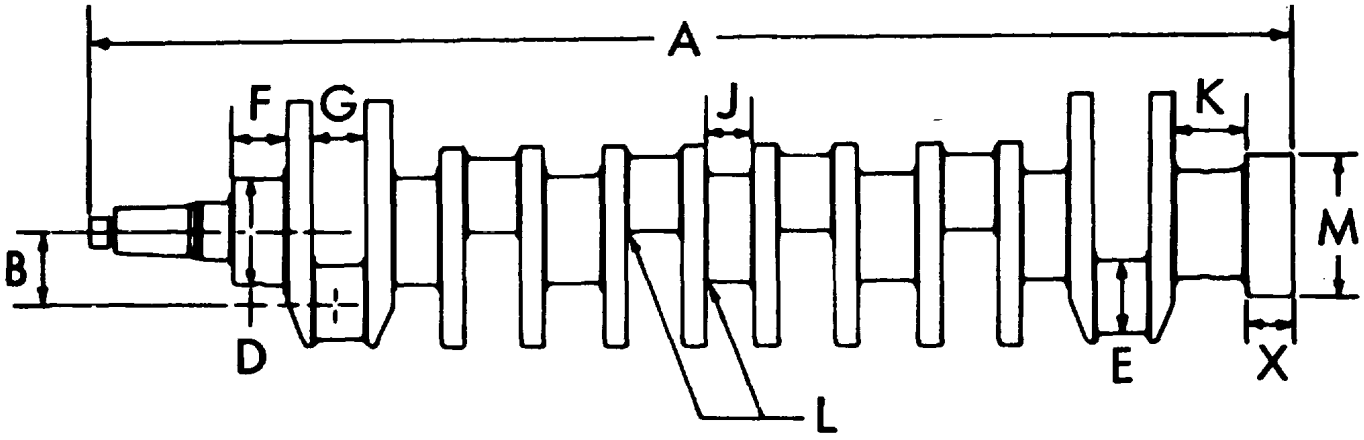


Figure 3-226. Crankshaft dimension points.

inch long (subsurface).

2. Light open indications on crankpin and main journal walls or bearing surface that extend closer than 1/8 inch to fillets, but do not enter fillets are acceptable if 3/16 inch long or less. Light subsurface indications are acceptable.

(d) Indications located more than 1 inch from major axis or centerline of adjacent web (measure circumferentially) must not exceed following limits:

1. Light open indication in or entering fillet are acceptable if 3/16 inch long or less. Light subsurface indications are acceptable.

2. Light open indications on crankpin and main journal walls or bearing surfaces that extend closer than 1/8 inch to fillet, but do not enter fillet, are acceptable if /4 inch or less. Light subsurface indications are acceptable.

a. Nicks on corners of webs are not accept able. The part will be acceptable if nick can be removed by grinding a 1/8 inch radius on corner.

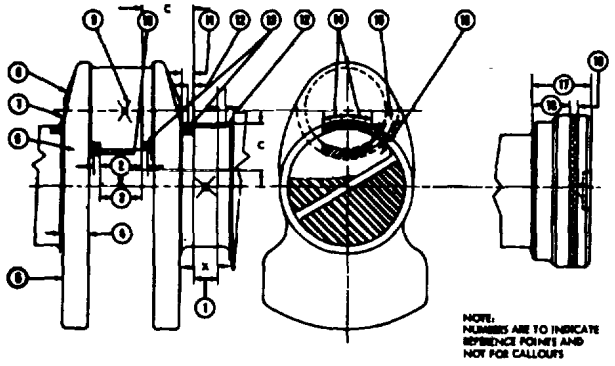


Figure 3-227. Crankshaft magnetic inspection.

4. Imperfections on web periphery may be ground out to a depth of 1/8 inch maximum using a 1% inch minimum radius grinding wheel, provided balance limits are maintained.

5. Light open indications that pass within 3/16 inch of a crankpin hole are acceptable if 12 inch long or less and do not enter the oil hole chamfer or interest the 450 ± 100 diagonal. Only those subsurface indications that lie closer than 1/16 inch to surface (measured at chamfer at a 45°D 100 diagonal) are not acceptable. All other subsurface indications are acceptable.

(e) Light open indications that enter the chamfer of any main bearing oil hole are acceptable if they are 3/8 inch or less. Subsurface indications ending in a main bearing oil hole are acceptable.

(f) Fine subsurface, salt and pepper type indications are permitted on upper and lower side of crankpins on trimming line.

(g) Open longitudinal indications within region "X" which are less than 1 1/8 inch on the main journals and 7/8 inch long on crankpins, are acceptable after sharp edges have been stoned 0.002/0.004 in. below the journal surface.

(h) Longitudinal subsurface indications within the area "X" are acceptable.

(i) Parallel open indications that meet the requirements of (s) and other requirements on length and frequency are acceptable.

(j) Parallel subsurface indications are acceptable.

(k) Indications that contain loose or foreign particles or voids left by such particles are not acceptable.

(l) Not more than three open indications are to appear on any one journal or crankpin. Scattered small, open, or subsurface indications, four per crankpin, and six per main bearing 1/8 inch long or less, if not forming part of a long intermittent indication or entering an oil hole or fillet, will not be counted as indications in arriving at total number permitted. However, if in addition to showing maximum number of acceptable indications for the whole crank-

shaft the part also shows many widely scattered short indications, it will be rejected.

(m) An inclusion which is intermittently open and subsurface shall be considered and measured as an open indication after the original indication is wiped off. The entire indication must first meet requirements for subsurface limits.

(n) Open and subsurface indications on counterweights and crankthrow bevel outside the critical region are acceptable.

(o) Seams or indications outside critical region that extend over crank web periphery but are not visible on crankpin wall are acceptable.

(p) Open seams on web periphery that show visual depth on crankpin wall may be removed from web periphery with a 1/8 inch radius wheel, provided at least 1/16 inch wall remains above crankpin fillet after repair and balance limits are maintained.

(q) Indications due to weld defects are not acceptable in counterweight welds. Indications at corner may be ground out and blended to depth not exceeding /4 inch long.

(r) Open longitudinal indications in flywheel and thrust flange fillets longer than 3/8 inch are not acceptable.

(s) For limits of indications on oil seal surface refer to figure 3-227. Open Magnaflux indication, or machining defects that are within specification limits are acceptable in unshaded areas around circumference of flange. Open light indications which, when wiped clean, do not show sharp edges, are acceptable in the 3/16 inch shaded area.

(6) After inspection where coil shot is used, give crankshaft head shot to put magnetic poles at ends of crank, not throws. The residual magnetic field should not exceed two units on the Magaflux Field Indicator or equal.

k. Assembly of Crankshaft.

(1) Install crankshaft gear, if removed.

(a) Install key in shaft.

(b) Heat gear with heating torch-not cutting torch-to 400 F. 204.4 C.

(c) Lubricate flange with graphite grease such as Lubriplate and drive gear onto shaft with piece of tubing.

(2) Install lockplate and nut (if used).

I. Installation.

(1) Turn cylinder block upside down.

(2) Make sure that crankshaft, main bearing shells, main bearing bores, oil passages, etc., have been cleaned and inspected and that pipe plugs are installed tightly in crankshaft.

(3) If not previously performed, check main bearing bore and alinement. See Cylinder Block, paragraph 3-45.

(4) Clean main bearing caps and capscrew holes; be sure all liquid and foreign particles are removed.

(5) Lay upper main bearing shells in block bores, engaging locking tangs with recesses in block bores (fig. 3-228). Index drilled oil passage holes in block and shells.

(6) Coat crankshaft surface of upper main bearing shells thoroughly with graphite grease such as Lubriplate, or equivalent high-pressure grease.

Note. The use of clean lubricant throughout the engine cannot be over-emphasized; built-in dirt soon causes engine failure.

(7) Lift crankshaft over cylinder block, using a rope sling or hooks protected with rubber hose; lower crankshaft carefully into place (fig. 3-229).

(8) Roll upper thrust rings onto position, being certain that babbit or grooved sides are facing crankshaft flanges.

Note. Upper thrust rings are not doweled to block; doweled lower rings (to main bearing cap; prevent upper rings from turning.

(9) Coat lower main bearing shells (crankshaft surface) with graphite grease such as Lubriplate, or equivalent high pressure grease; snap lower main bearing shells into place over crankshaft. Lower main bearing shells are plain with no grooves or oil passage holes.

Caution: Solid lower shells should not be used where continuous-groove shells have been used and crankshaft has not been reground.

(10) Position lower thrust rings over dowels on No. 7 main bearing cap (fig. 3-230); install main bearing caps with numbers (corresponding to upper main bearings) toward camshaft (fuel pump) side of block.

Note. Main bearing caps are not interchangeable.

Figure 3-228. Upper main bearing shells installation.

(11) Lubricate main bearing capscrew threads with clean lubricating oil; install new lockplates on capscrews.

(12) Place main bearing capscrews in position; tighten alternately and slowly to seat caps in position.

Caution: Driving main bearing caps into position may jar lower main bearing shells out of position.

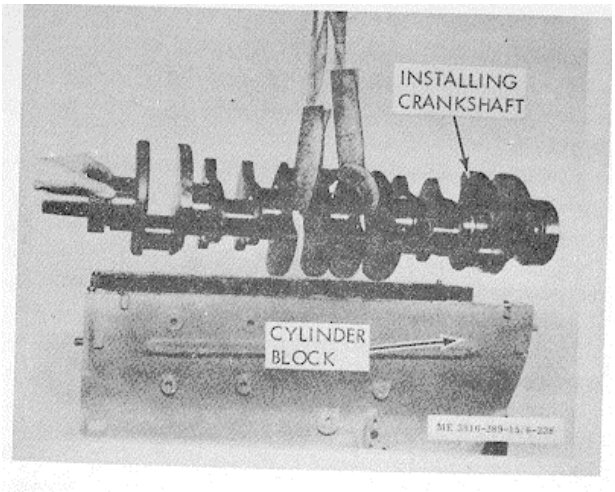


Figure 3-229. Crankshaft installation.

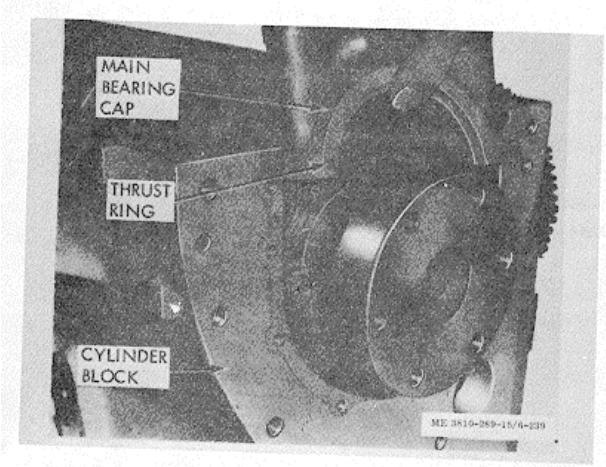


Figure 3-230. Main bearing cap with thrust ring in place.

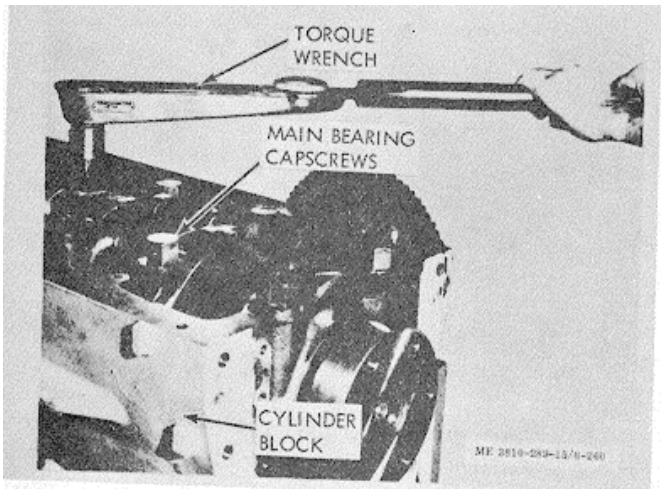


Figure 3-231. Torquing main bearing capscrews.

m. Template Method of Tightening Main Bearing Capscrews.

(1) Tighten main bearing capscrews alternately to 65/75 ft. lbs. to set shells, caps and lockplates; then advance to 140/150 ft. Ibs., figure 3-231.

(2) Loosen all capscrews completely; tighten to 45/50 ft. lbs. and scribe each capscrew head to coincide with permanent mark on cap, or scribe each cap in line with capscrew hex corner.

(3) Advance each capscrew 600 (one hex) from position described in Step 2, this will align scribed mark (or next corner of capscrew with mark on main bearing cap.

Caution: Tighten capscrews on each side of cap a little at a time and as evenly as possible until proper positions are reached. Never use lead ribbon or feeler gage to check main bearing clearance. Doing so may result in unnecessary damage to main bearing shells.

n. Main Bearing Shell Replacement with Crankshaft in Place. If the crankshaft has not been removed from the engine, it is possible to install new main bearing shells in the following manner:

(1) Remove one main bearing cap and lower shell; turn crankshaft until drilled hole in main bearing journal is visible.

(2) Insert a 7/32 inch by /2 inch pin with a head 3/32 inch thick into drilled hole of crankshaft; turn crankshaft so pin pushes against shell on opposite side of locking tang. Shell will turn out as crankshaft is rotated.

(3) Carefully remove all metal and/or foreign material from oil passages in crankshaft and cylinder block.

(4) Lubricate the shell to be installed; then lay shell in proper position on crankshaft journal so turning the crankshaft will seat the shell locking tang into recess in block.

(5) Use pin and turn shell into position; remove pin.

(6) Replace -lower shell, making sure locking tang seats in recess of main bearing cap.

(7) Install new lockplates and position cap against crankshaft; use template method to tighten capscrews. Make sure crankshaft turns freely.

(8) If necessary, replace remaining shells one pair at a time in the same manner. If bearing shells have had considerable service, it is recommended that all shells be replaced to assure that the 0.002 inch maximum variation in oil clearance between adjacent main bearing shells and journals is not exceeded.

o. Check Crankshaft End Clearance.

(1) Attach dial indicator securely to rear of block with contact point of gage resting against crankshaft flange end face.

(2) Using a small bar (or equivalent), pry crank-

shaft toward front of block; remove bar and set gage at zero.

(3) Pry crankshaft toward rear of block (fig. 3-232); remove pry bar and read gage. Total gage reading should be 0.004/0.015 in. with new (or rebuilt) crankshaft and new thrust rings.

(4) If reading is less than 0.004 inch:

(a) Shift gage away from crankshaft.

(b) Loosen main bearing capscrews slightly.

(c) Shift crankshaft first toward front and then toward rear of block in order to properly position main bearing caps.

(d) Tighten capscrews, using template method.

(e) Recheck end clearance (Steps 1, 2 and 3).

(5) When end clearance exceeds 0.022 inch, new thrust rings and/or crankshaft must be installed.

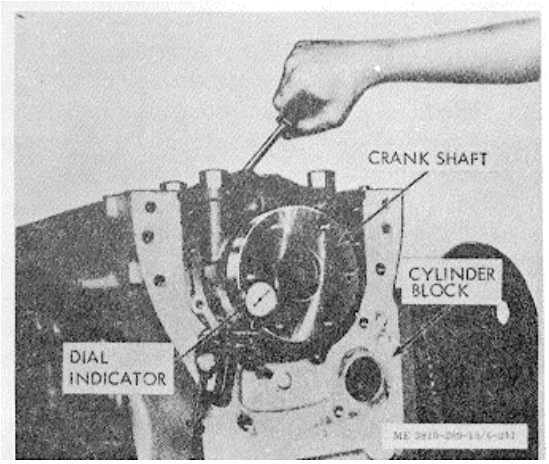


Figure 3-232. Checking crankshaft end play.

(6) Lock main bearing capscrews by bending lock plates against sides of capscrew heads.

(7) Turn crankshaft to be sure it turns freely; if it binds, remove crankshaft and recheck for dirt in shells and bore.

Caution: Never ream or scrape main bearing shells.

p. Crankshaft Oil Sea.

(1) Coat gear cover oil seal bore with clean lubricating oil.

(2) Coat sealing lips and outer diameter of oil seal with clean lubricating oil.

(3) Install oil seal in bore with ST-480 Mandrel and soft hammer (fig. 3-233). Steel spring side of seal must go into bore first. Drive seal into bore until outer edge of seal is at least 0.030 inch inside of bore shoulder.

3-45. Cylinder Block

a. General The cylinder block is a one piece casting with mounting surface for cylinder head, lifter guides, timing gear housing, oil filter base, oil cooler, and oil pan. It houses the crankshaft, pistons, connecting rods, cylinder liners and camshaft. Drilled passages carry pressurized oil to various moving parts.

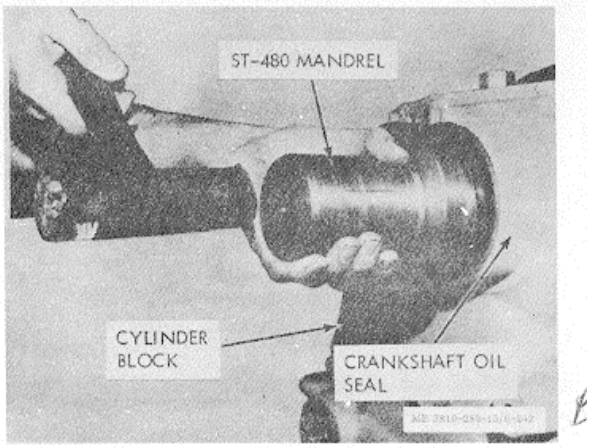


Figure 3-233. Installing crankshaft oil seal with ST-480.

b. Removal.

(1) Refer to paragraph 2-10 and remove the engine assembly.

(2) Refer to paragraph 3-28 and remove the cylinder head.

(3) Remove all internal and external assemblies from the cylinder block. Refer to the applicable paragraphs for instructions.

(4) Remove all pipe plugs from oil and water passages.

c. Cleaning.

(1) Clean block in approved solvent and dry thoroughly.

(2) Clean all gasket residue from mating surfaces.

(3) Clean all corrosion and scale from water jacket and ports.

(4) Run rods with brushes or swabs through all oil passages. Blow out passages with air (fig. 3-234).

(5) Replace all pipe plugs. Use sealing tape or lead sealer, on plugs to prevent leakage. Tighten plugs to values listed in table 2-2.

Note. If additional machining is to be performed, oil gage cleaning and replacement of plugs should be done after all machining is completed.

(6) Clean hole at front (No. 1 cylinder) that opens into water header (fig. 3-235).

(7) Blow all dirt or cleaning fluid from capscrew holes with an air (fig. 3-236).

Note. Cylinder head capscrew holes in block are counterbored to prevent distorting and forcing liners out-of-round, when cylinder head capscrews are tightened. All dirt and oil must be removed from holes to prevent damaging block when capscrews are tightened.

(8) Scrape counterbore lightly to remove any scale.

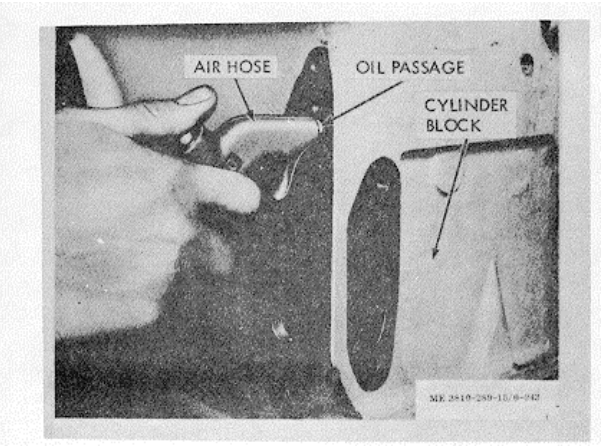


Figure 3-234. Cleaning block oil passages.

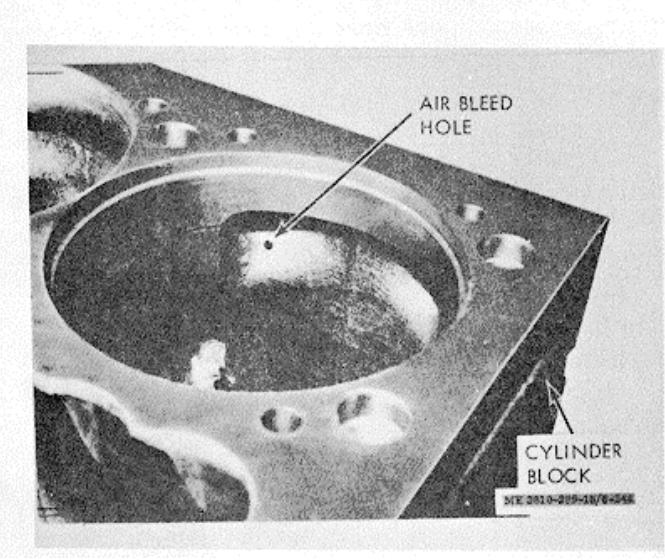


Figure 3-235. Air bleed hole.

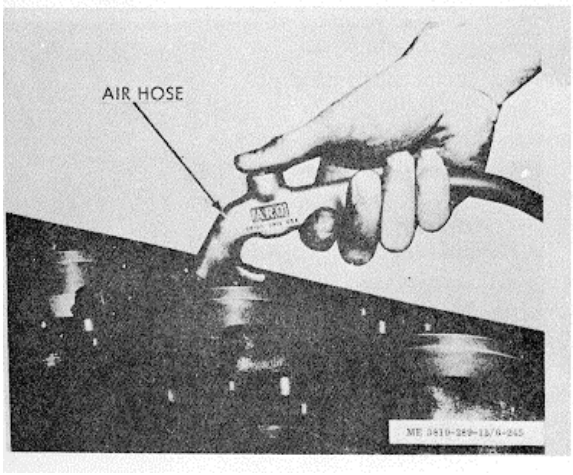


Figure 3-236. Cleaning cylinder head capscrew holes.

(9) Clean lower liner bore with sandpaper or sanding drum powered by an electric drill. Emery cloth may be used if bore contains ridges. Be sure to remove nicks or burs that would damage liner packing rings as liner is installed.

d. Inspection. Before any part is discarded or used again a careful inspection must be performed. The inspection should include wearing surfaces and general over-all conditions.

(1) Inspect for corrosion on portions of block nearest cylinder liners as evidenced by pitting. Discard block if area cannot be cleaned, or if area is distorted.

(2) Inspect water passages for erosion within 1/32 to 3/32 inches from liner counterbore; if not too deep block may be resurfaced.

(3) Inspect all water passages to make sure they are open.

(4) Inspect for eroded water holes which may prevent proper seating of head gasket or grommet retainers. Water holes not eroded more than 1/16 inch from edge of hole can be reamed and bushings inserted.

(5) Use inside micrometer or dial bore gage to gage camshaft bushing inside diameter as illustrated in figure 3237. Replace bushings if worn larger than limit shown in table 2-2. If bushings have been badly chipped, scored or scratched, mark for replacement. If bushings have turned in block bore, check block size; see table 2-2.

(6) Check upper cylinder liner counterbore diameter A, at four equidistant points around the circumference of the liner as illustrated in figure 3-238.
If counterbore exceeds limits shown in table 2-2 for the top 0.250 inch depth, the block will have to be machined for oversize flange liners (e.(4)). The counterbore ledge must be smooth and perpendicular to the cylinder liner bore.

(7) Check counterbore depth B so installed liner will be assembled to correct protrusion and to determine if refinish of counterbore surface is necessary. Depth of counterbore on a new block is listed in table 2-2. If worn to or beyond worn limit the cylinder block must be replaced.

(8) Installed cylinder liners must protrude 0.004/0.006 in. above block. To check for proper protrusion without installing a liner:

(a) Measure liner flange outside bead with micrometer (fig. 3239).

Note. Do not include bead on top of liner flanog in taking measurement.

(b) Measure block counterbore depth with dial indicator depth gage or ST-547 Gage Block (fig. 3-240). If ST-547 is used, "zero" indicator before taking measurement.

(c) Inspect depth at four equidistant locations.

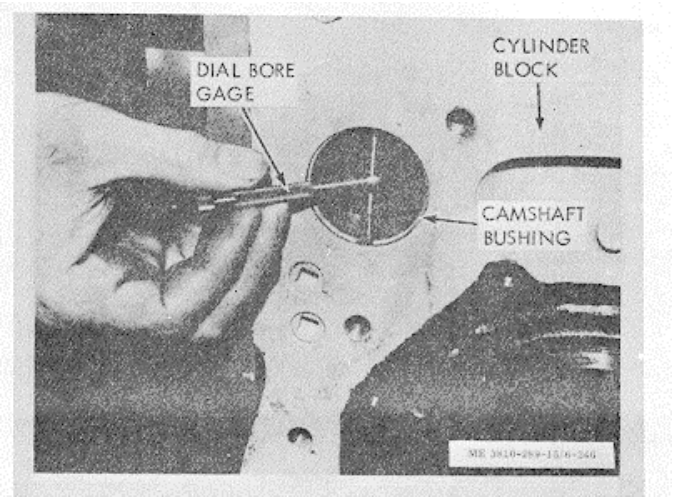


Figure 3-237. Checking camshaft bushing inside diameter.

Ledge must not be "cupped" more than 0.0007 in. Depth must not vary more than 0.001 in. throughout counterbore circumference.

(d) If dimensions do not meet standards of Step (c) above, counterbore must be resurfaced (e.(3)).

(e) Subtract counterbore depth from liner flange thickness to determine amount of shims and depth of counterbore cut that must be used to provide desired liner protrusion ((B) above), 0.007 in. shims are thinnest available.

Note. If material to be removed will result in a counterbore depth exceeding worn limit in table 2-2 block cannot be reused.

(9) Install a new cylinder liner in the block without packing rings or crevice seal.

Note. Liner contact is permissible as long as it does not cause liner out-of-bound.

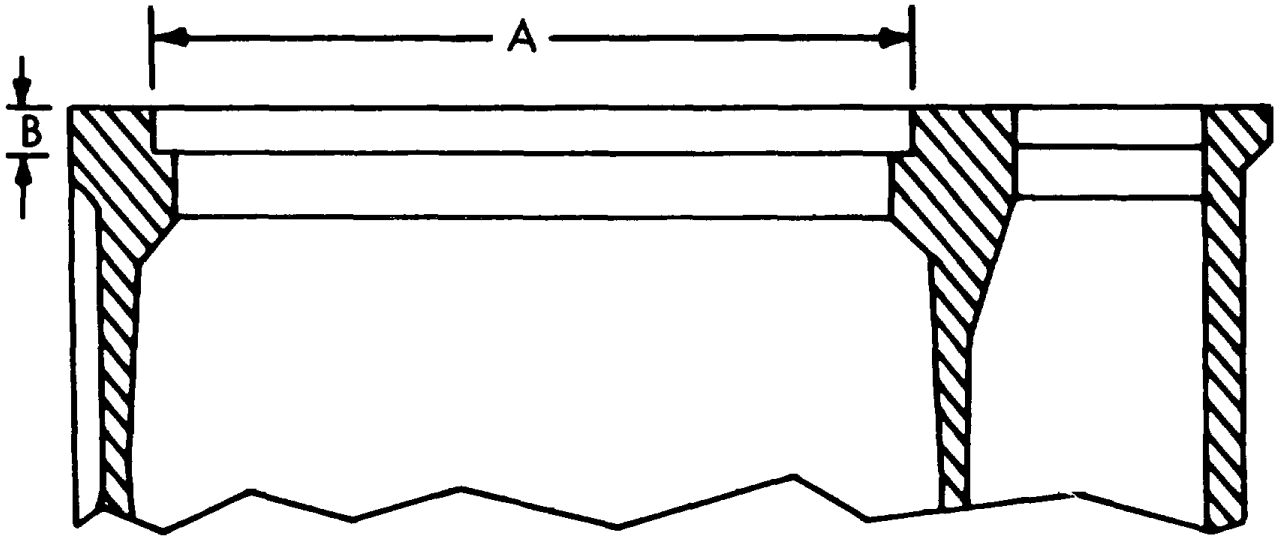


Figure 3-238. Cylinder liner counterbore dimensions.

Clearance between liner and block should be as shown in figure 3-241 and listed in table 2-2. If clearances do not fall within these limits, reinspect after counter boring.

Note. These limits do not apply with cylinder head installed and tightened to operating torque. If clearance is not correct, check lower block packing ring bore inside diameter. See table 2-2.

(10) Inspect bore alinement with special tool, ST 409. This closely ground bar will pass through all bores and turn freely unless caps are not tightened to proper tension, burs, etc., have not been removed, or caps are distorted, figure 3-242.

(11) Assemble main bearing caps, lockplates or flatwashers and capscrews to block in operating position, (fig. 3-243). Tighten capscrews to operating tension.

(12) Gage main bearing bores horizontally, vertically and diagonally with dial bore gage or inside micrometers properly adjusted to standards, figure 3-244, see table 2-2.

(13) Inspect tappet bore diameter with a dial bore gage as illustrated in figure 3-245. If wear exceeds the limit indicated in table 2-2 or they are out of round by more than 0.0015 inch, replace block.

e. Repair. Refer to figure 3-246 for disassembly of cylinder block components.

(1) Camshaft bushing.

(a) To replace the camshaft bushing, (1, fig. 3-246) locate the bushing on the ST-783 Camshaft Bushing Mandrel.

(b) Aline oil holes in bushing with the oil holes in the block.

(c) Drive bushing into position (oil alined) using the ST-782 Bushing Driver (fig. 3-24

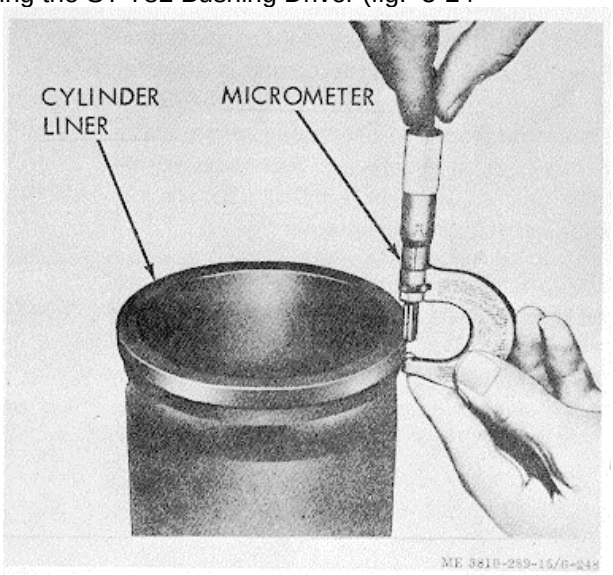


Figure 3-239. Inspecting liner flange height- outside bead.

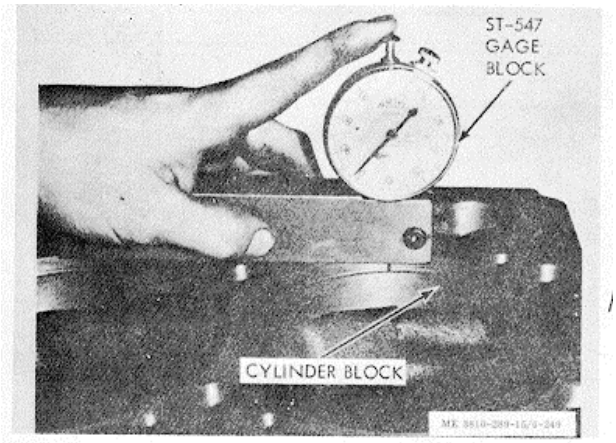


Figure 3-240. Inspecting liner counterbore depth in block.

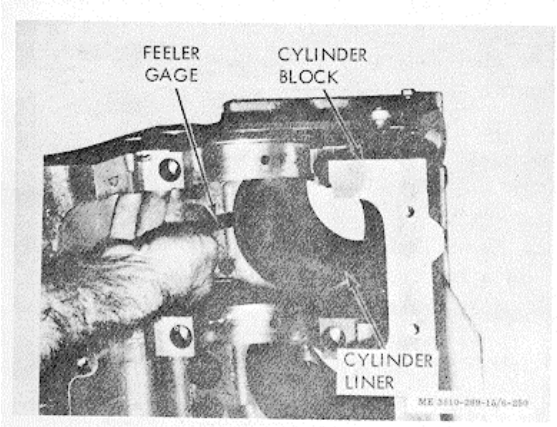


Figure 3-241. Inspecting cylinder liner clearance.

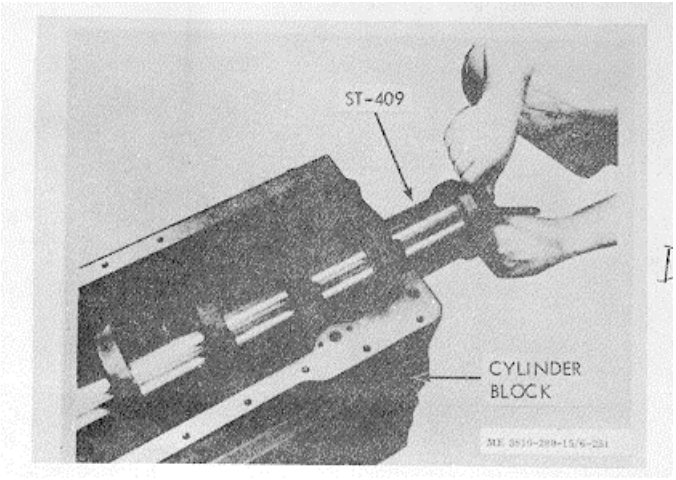


Figure 3-242. Checking main hearing bore alinement.

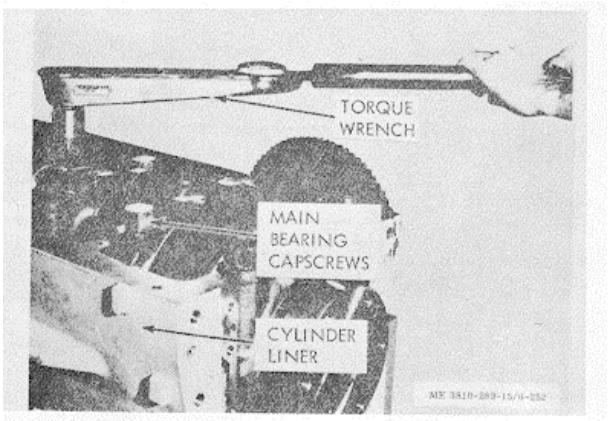


Figure 3-243. Torquing main bearing capscrews.

(2) Top surface refinishing.

(a) Under certain conditions, a cylinder block may be salvaged by removing a maximum of 0.010 in. of material from the top surface.

(b) Use either a milling machine or large surface grinder; locate block on main bearing pads, not on pan ledge.

(c) Make light cuts of 0.001/0.003 in. deep, removing only enough material to make block usable.

(d) Check distance from centerline of main bearing bore to top of block (fig. 3-248 and 3-249). Find this dimension by placing block, top down, on a flat surface plate and measuring from main bearing bore centerline to plate, table 2-2.

(e) An alternate method is to check distance from installed main bearing bore alinement bar to top surface of block, table 2-2. Distance from head surface to main bearing bore centerline must not vary more than 0.002 in. throughout length of block. Head surface flatness must not vary over 0.002 in.

(f) Finish surfaces to 125 R.M.S.

(g) Resurface counterbore to obtain proper liner protrusion.

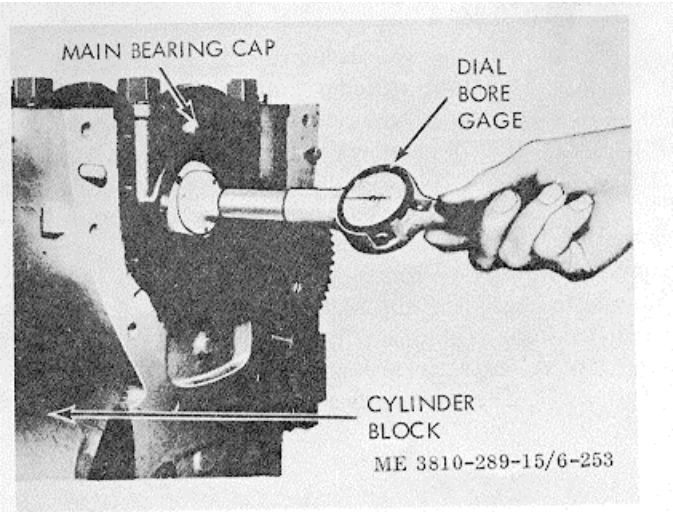


Figure 3-244. Checking main bearing bore for out-of round.

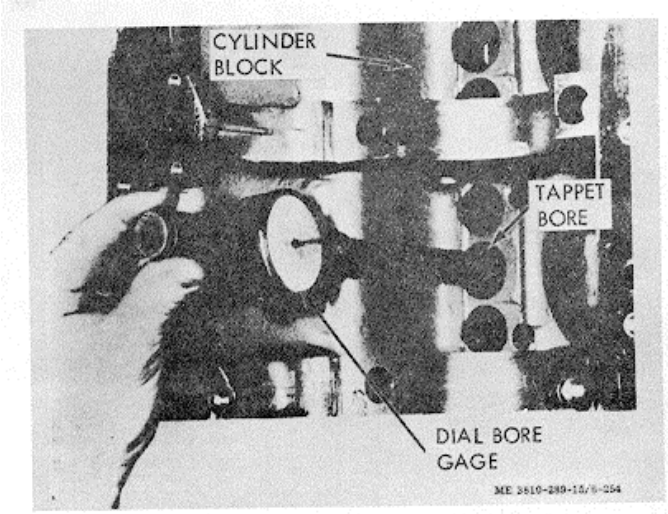


Figure 3-245. Tappet bore inside diameter check.

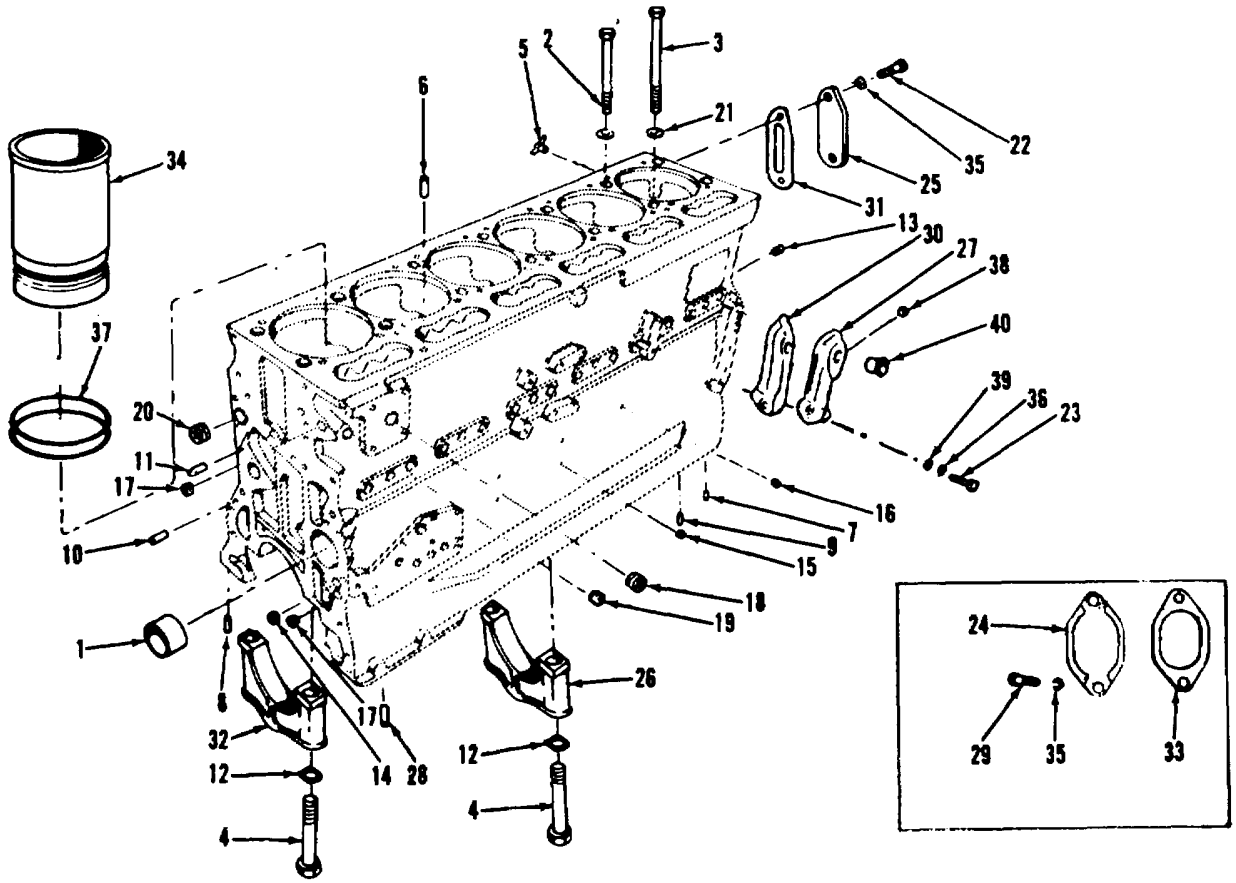


Figure 3-246.

2 Capscrew, cylinder head (7)
3 Capscrew, cylinder head (7)
4 Capscrew, main bearing (14)
5 Drain cock
6 Dowel (2)
7 Dowel (2
8 Dowel
9 Dowel
10 Dowel
11 Dowel
12 Lockplate (14)
13 Pipe plug
14 Pipe plug
15 Pipe plug (3)
16 Pipe plug (9)
17 Pipe plug (2)
18 Pipe plug
19 Pipe plug
20 Pipe plug
21 Washer (14)
22 Capscrew (2)
23 Capscrew (4)
24 Side cover
25c End cover
26c Main bearing cap(6)
27c Connector
28 Dowel(2)
29 Capscrew(2)
30 Gasket
31 Cover gasket
32 Main bearing cap
33 Cover gasket
34 Cylinder liner (6)
35 Lockwasher
36 Lockwasher(4)
37 Liner Packing (12)
38 Pipe plug
39 Washer (4)
40 Bushing

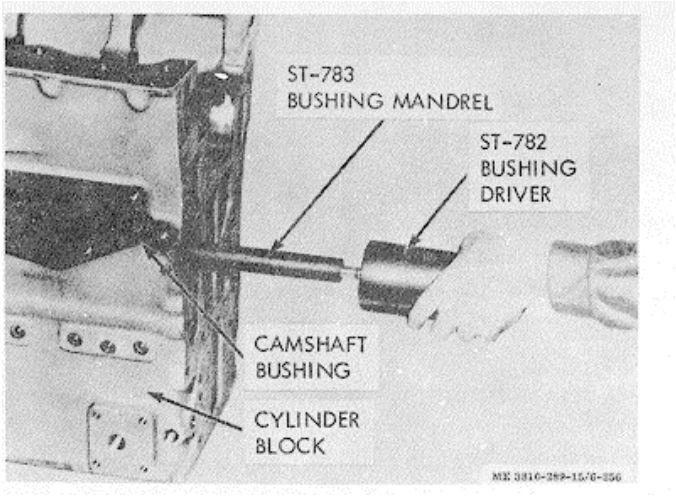


Figure 3-247. Camshaft bushing installation

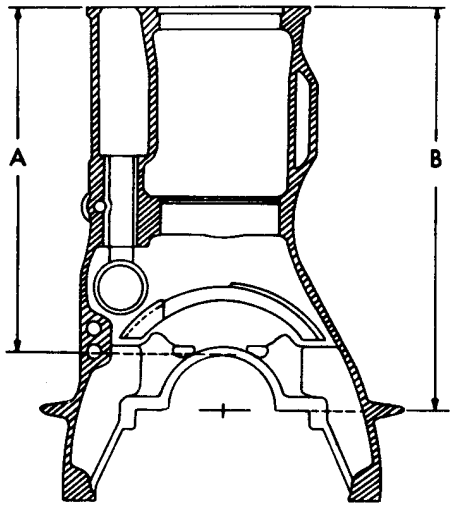


Figure 3-248. Cylinder block height.

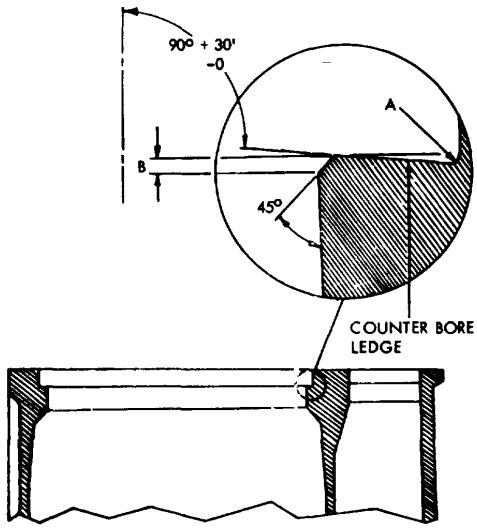


Figure 3-249. Cylinder liner counterbore cross-section.

(3) *Cylinder liner counterbore.*

(a) Resurface cylinder liner counterbore if block has been resurfaced, ledge is uneven or where liner protrusion is incorrect. ST-676 liner bore Tool with adapter plate ST-679 is used for this operation.

(b) Check counterbore tool bit before boring operation. A correctly ground tool bit will leave counterbore surface completely flat or cupped to a 30-minute angle (the cup is preferred) with a 0.005/0.015 in. radius as shown in fig. 3-249, A).

(c) A correctly ground tool bit is shown in figure 3-250. The side surface must be ground flat to sharpen.

(d) Position tool adapter in liner bore.

(e) Tighten top and bottom locating pins by turning in sockethead screws.

(f) Set tool adjustable sleeve so blade just touches bottom of counterbore ledge. Use lubricating oil on cutter blades.

(g) Turn tool in clockwise rotation with even pressure.

Caution: **Never turn tool counterclockwise. Doing so will damage cutter blade.**

(h) Use a series of light cuts to clean up entire circumference of seat.

(i) Check seat to determine if additional cuts are required.

Caution**: Under no circumstances may inside diameter of ledge be lower than outside diameter. A ledge that droops toward center could contribute to cylinder liner breakage. Maximum counterbore depth after boring must not exceed limit given in table 2-3.**

(j) Chamfer edge of counterbore ledge 45 degrees after counterboring, figure 3-249 B. Do not chamfer deeper than 0.013/0.019 in. to avoid reducing liner seating area.

(k) Use shims to compensate for metal removed and to restore liner protrusion to 0.004/0.006 in. Shims are available as shown in table 2-2.

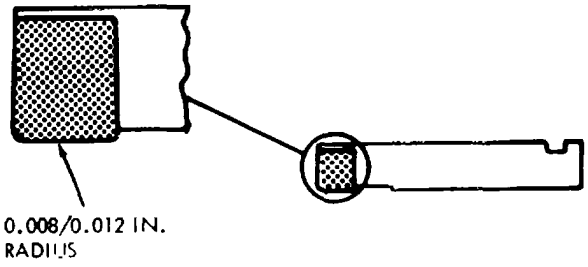


Figure 3-250. Counterboring tool bit

Note. **Use as few shims as possible, i.e., use one thick shim in preference to two or more thinner shims. Never use shims thinner than those listed.**

(4) Oversize cylinder liner counterbore.

(a) Cylinder blocks that were

equipped with non-press-fit liners may be reworked to accept special (0.020 inch oversize flange) press-fit liners.

(b) Enlarge block counterbore diameter to 4.894/4.896 in. (fig. 3-249 B) with a vertical boring bar or equivalent. Non-press-fit liner bore (fig. 3-251 A) was 4.874/4.876 in.

(c) Extend cut to only 0.200/0.250 in. (fig. 3-251 C) below surface of block.

Caution: **Do not extend cut full depth of counterbore or liner shims will not locate correctly.**

(d) Remove sharp corners and burs.

(e) Use shims as listed in table 2-2, necessary during liner assembly.

(5) *Cylinder head capscrew threads.* Check cylinder head capscrew hole threads in block. If threads are damaged, block may be repaired by installing Helicoil inserts.

(a) 11/16 inch cylinder head capscrews.

1. Drill out old threads with 13/16 inch drill to 1 15/16 inch.

2. Tap drilled hole with tap from ST-476 to 1 ½ inches depth.

3. Install insert with inserting tool. Break off notched lead tang of insert.

(b) 34 inch cylinder head capscrews.

1. Drill out old threads with 13/16 inch drill to 115/ 16 inches depth.

2. Rough and finish tap drilled hole with tap from ST-595 to 1 19/32 in. depth.

3. Install insert with inserting tool. Break off notched lead tang of insert.

(6) *Main bearing bore reaming.*

(a) If main bearing bore was out of alinement or if replacement cap has been installed ream bore as follows.

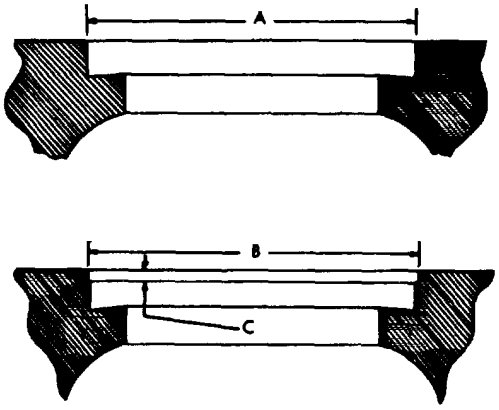


Figure 3-251. Standard and oversize counterbore diameters.

Caution: **Do not ream the main bearing bore indiscriminately. It should never be necessary to ream the main bore unless a cap has been distorted or replaced. Use of the reamer must never replace use of the checking bar.**

(b) If bore must be reamed, first remove 0.002/ 0.003 in. stock from bottom milled surface of main bearing caps which are out of alinement. Remove stock by lapping or surface grinding.

Note. **Omit this step if replacement caps are being used.**

(c) Main Bearing Bore Reamer ST-401 in block so rear of bar is piloted in two good main bearing bores.

(d) Install all main bearing caps in block and tighten capscrews to operating tension, following steps shown in table 2-2, in alternating steps from one capscrew to another on same journal.

(e) Lubricate reamer cutters and bores in block with engine lubricating oil. This will prevent reaming oversize and will allow a better finish (fig. 3-252).

(f) Use ST-219 Reamer Driver to turn the reamer, (fig. 3-253). This driver is loosely pinned to prevent up and down or side thrust of reamer while it is being turned.

(g) Run reamer through remaining main bearing bores without "backing up" or reversing.

(h) Check bore with Checking Bar and measure bore diameter once again with dial bore gage. Refer to figures 3-242 and 3-244 and d. (10), (12) above.

(i) Clean block thoroughly.

(7) *Sleeve eroded water holes.*

(a) The cylinder block surfaces around the water holes must be free of any erosion, pits, scratches or blemishes which are more than 0.003 in. (0.0762 mm) deep in the area 1/16-to 5/32-in. from edge of water holes. Repair as follows:

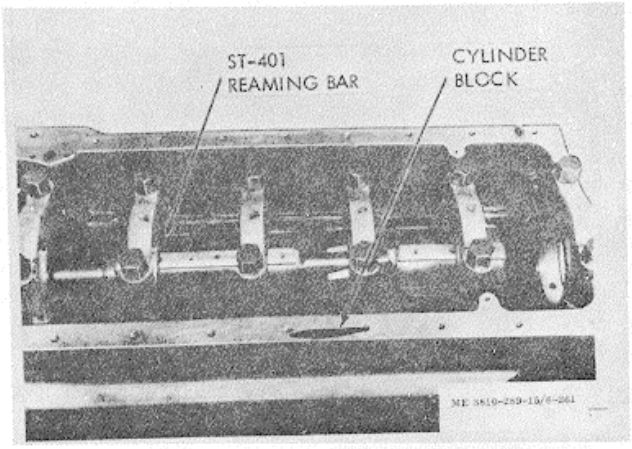
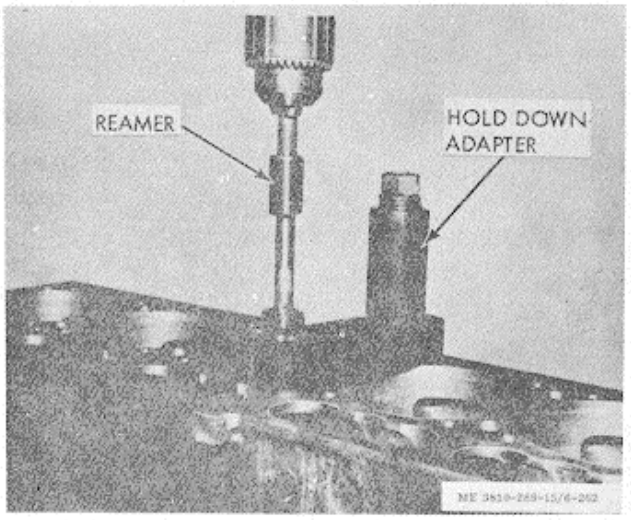


Figure 3-252. Reamning main bearing bore.

(b) Insert holddown adapter of ST-1010 into cylinder head capscrew hole as illustrated in figure 3-253.

(c) Position tool on head with reamer guide hole over water hole to be repaired.

(d) Insert tool holddown knob into holder assembly and tighten down finger tight.



Figtre 3-253. Reaming eroded water hole.

(e) Insert locating pin into eroded hole and tighten holddown knob.

(f) To set depth of reamer assembly, insert assembly in guide. Place bushing between holder assembly and reamer adjustable stop collar. Insert 0.005 inch feeler gage between bushing and adjustable collar; tighten setscrew.

***Caution*: Take care not to use too large a reamer, avoid getting head gasket grommet over liner flange.**

(g) Attach drive adapter to half-inch drill chuck and place grooved end of drive adapter into reamer assembly.

(h) Ream out eroded water hole until collar bottoms against tool.

(i) Remove drill, reamer assembly, holder assembly and holddown adapter.

(j) Drive bushing into reamed hole with driver. Bushing should protrude about 0.003-to 0.005-in.

(k) If block is to be resurfaced, refer to e.(2). If not to be resurfaced, file bushing flush with head, using a wide, flat mill file.

3-46. Valve Seats and Inserts Repair and Replacement

a. General. The valve seat insert is used to provide a greater wear-resistant surface than the cylinder head material and to provide a new seat where an insert was not used before.

b. Removal. Remove loose or excessively worn valve seat inserts, which were previously marked for replacement during cylinder head inspection, with an insert extracting tool or by striking insert sharply with a chisel, causing it to crack and release the press fit. Remove all inserts if head has been resurfaced (fig. 3-254).

***Caution:* Cover the valve seat with a shop rag to avoid injury from broken pieces of the seat.**

c. Inspection.

(1) Check for loose valve seat inserts by lightly 3-0 tapping head near inserts. A slight looseness, which can be found only by tapping, when head is cold and covered with film of oil is n-o objectionable.

(2) If valve seat insert is loose enough to bounce or cannot be reground, mark for replacement.

(3) If seat area width (2, fig. 3-255) exceeds 0.125 in. at any point (see A to B), and cannot be narrowed (1) sufficiently it is unlikely that seat can be successfully reground.

d. Repair.

(1) Enlarge counterbore to next oversize. Most inserts are available in standard and oversizes as shown in table 2-2.

***Note.* If head was resurfaced and inserts are to be reused, deepen counterbore only.**

(2) ST-257 Valve Seat Insert Tool must be used to hold and drive cutters. ST-257 must be driven by an electric motor, figure 3-256.

(3) Cut counterbore 0.006/0.010 in. deeper than insert thickness to permit peening of head to hold insert.

***Caution:* Be sure to measure insert before machining head or installing insert in head.**

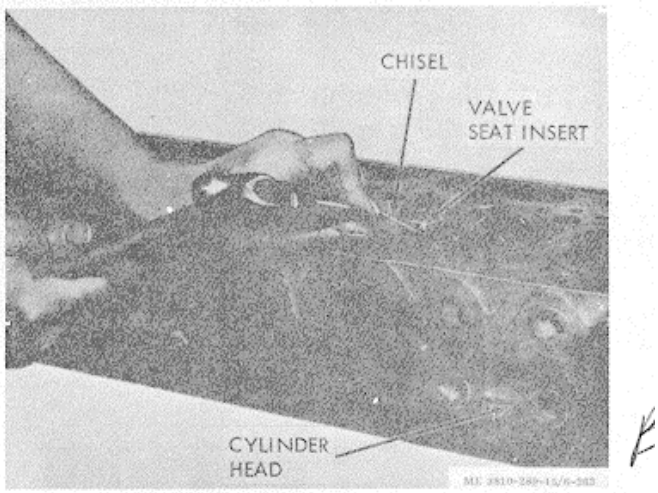


Figure 3-254. Valve seat insert removal

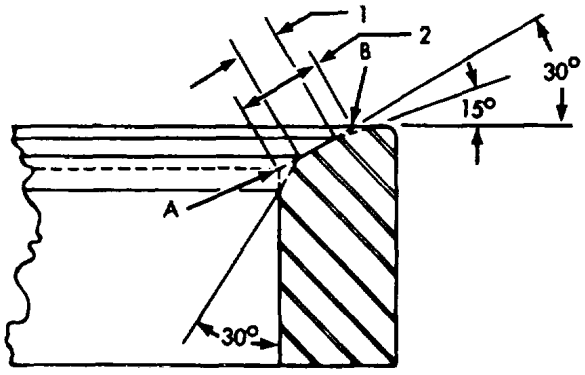


Figure 3-255. Valve seat insert cross-section.

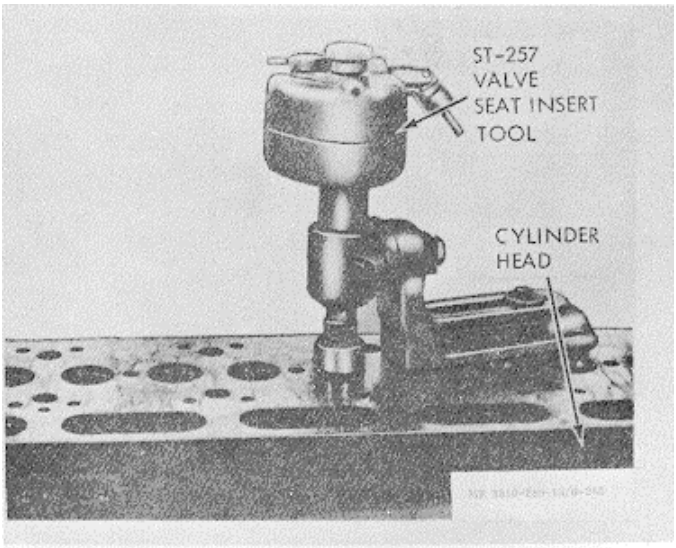


Figure 3-256. Coutnterbore for valve seat insert.

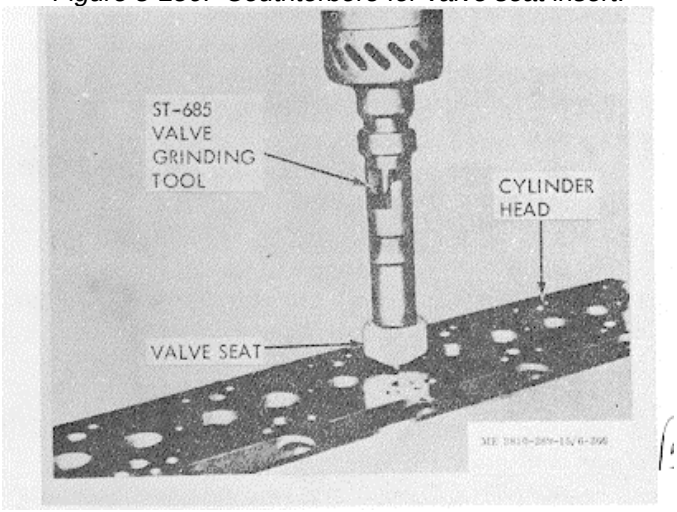


Figure 3-257. Refacing valve seat.

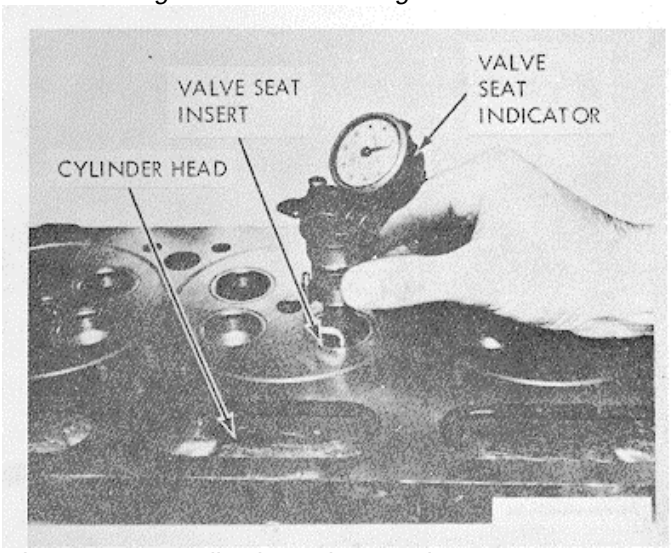


Figure 3-258. Indicating valve seat insert.

(4) Grind valve seats as follows: (a) Use ST-685 Valve Grinding Machine or machine of equal standard.

(b) Check condition of grinding equipment.

1. Mandrels must be straight and of proper size to fit in guides.

2. Bushings in grinder must be clean and must fit improperly in guide mandrel.

3. Drive unit bearings must be in good condition.

(c) Dress stone to 30 degrees from horizontal.

(d) Grind valve seats, holding seating motor as nearly vertical as possible, figure 3-257. A severe angle will cause seat to be out-of-true depending upon amount of wear in grinder bearings, mandrel, bushings, etc., even though grinder has a universal joint. iCheck valve seat width which should be 1/16 to 1/8 inch. See figure 3-258.

1. If seating area is wider than 1/8 inch maximum, stock can be removed with specially dressed valve seat grinder stones.

2. Narrowing should not extend beyond chamfer on seat insert. Chamfer provides for peen metal.

(f) Dress wheel for final finish.

(g) Finish grind with light touches of stone against face.

(h) Check valve seat concentricity with valve seat indicator as shown in figure 3-258.

1. Use valve guide as a center.

2. Total run out should not exceed 0.002 in.

3. The gage must be a perfect fit on pilot mandrel.

(i) Check seat with mating valve as described in paragraph 3-31 to insure proper sealing.

e. Installation. Install valve seat and peen around insert in at least 4 or 5 places with the peening tool available as extra equipment in ST-257. A A/ inch diameter round end punch may also be used.

3-47. alve Crossheads and Guides Replacement

Caution: Over-swagging around insert may crack cylinder head.

a. General Valve crossheads are used on engines with dual intake and exhaust valves to insure that both valves under the crosshead are opened and closed at the same time.

b. Remova.

(1) Lift valve crossheads from crosshead guides, figure 3-259. In some cases these may be left in cylinder head and the complete unit sent to the head repair section.

(2) Remove crosshead guides to be replaced,

using ST-667 Guide Puller which contains different-size collets for the various guides, figure 3-260.

c. Inspection.

(1) Valve crossheads.

(a) Clean crossheads.

(b) Check for cracks with Magnaflux process.

(c) With accurate micrometers, set a small bore gage 0.0002 in. above worn replacement limit. Use as a "No-Go" gage in crosshead bore to check if bore is worn beyond wear limits as shown in table 2-2. Check for out-of-round holes.

(d) Gage hole at several points 90 apart.

(e) Check reamed depth of crosshead bore; it should be a minimum of 1.370 inch in depth.

(f) Check valve stem counterbore depth in underside of crosshead; it should be a minimum of 0.090 in. deep.

(g) Mark crossheads for replacement that are not within worn replacement limits.

(h) Check for excessive wear on rocker lever and valve contact surfaces.

(2) *Crosshead guides.*

(a) Check guide Outside Diameter with micrometers. See table 2-2 for worn replacement limits.

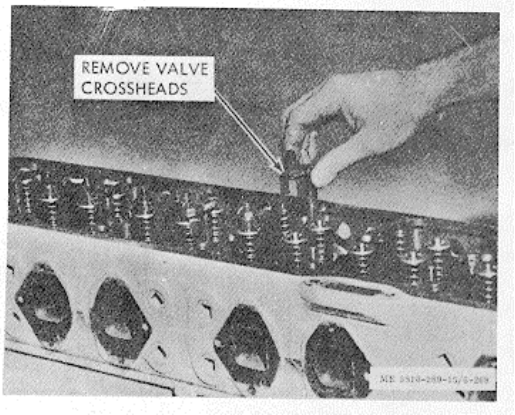


Figure 3-259. Valve crossheads removal.

(b) Check guide for straightness. It should be at right angles with milled surface of head. Replace if not straight or if worn beyond replacement limit.

(c) Check crosshead guide protrusion above cylinder head (d below).

d. Installation.

(1) *Cross head guides.*

(a) Press in new solid guides with ST-707 to 1.540/1.559 in. assembled height, figure 3-261.

(b) If mandrels are not available, press guides into head to obtain above protrusion.

(2) *Valve crossheads.*

(a) Install proper (right or left) crossheads on crosshead guides with adjusting screws resting on valves farthest from push tubes (3, fig. 3-262).

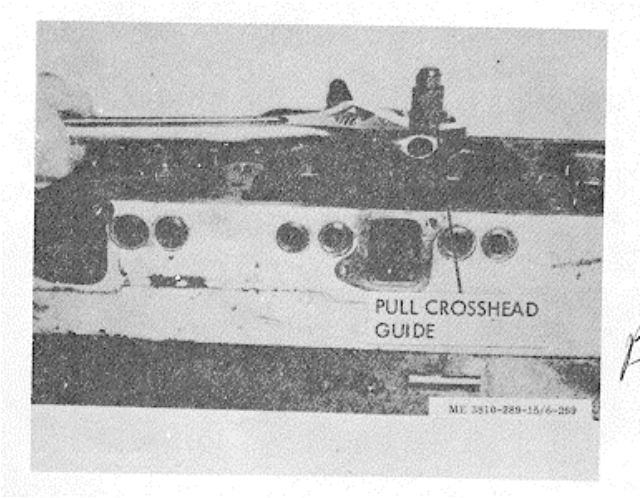


Figure 3-260. Pulling crosshead guides.

(b) If not already done, install valve crosshead retainer under adjusting screw nuts on crossheads; these retainers keep crossheads from jumping off valve stems during engine operation.

(c) Use light finger pressure on rocker lever contact surface (1) to hold crosshead in contact with valve stem nearest push tubes (2); turn crosshead adjusting screw (4) down until it contacts valve stem beneath it.

(d) If new crossheads and guides (5) are used, advance adjusting screws one-third of one hex (20 degrees) to straighten valve stems on their guides and to compensate for slack in threads. When worn crossheads and guides are used, it may be necessary to advance adjusting screws approximately one-half of one hex.

(e) Using ST-669 Wrench Adapter, locknuts to 22/26 ft-lbs., figure 3-263. If ST-669 is not available, hold screws with screwdriver and tighten locknuts to 25/30 ft-lbs.

(f) Check clearance between each crosshead and valve spring retainer with wire gage; a minimum of 0.030 in. clearance is required at this point.

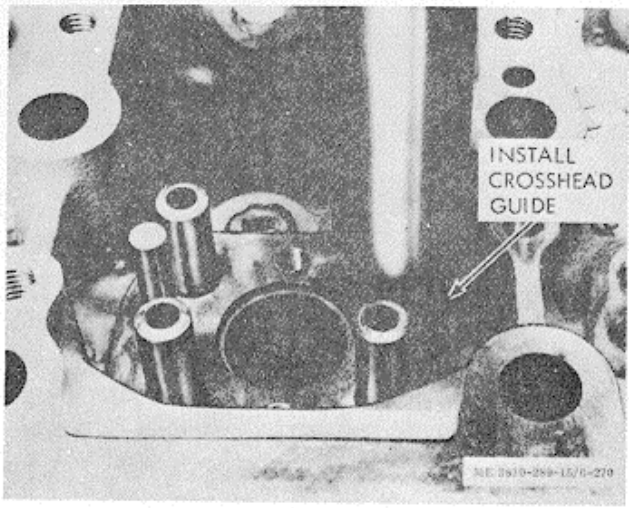
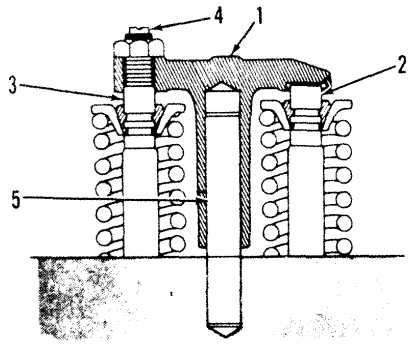


Figure 3-261. Crosshead guide installation.



ALIGN CROSSHEAD STEM AND GUIDE

1 Lever contact surface
2 Push tubes
3 Push tubes
4 Adjusting screw
5 Crosshead guides

Figure 3-262. Crosshead stem and guide alinement, cutaway view.

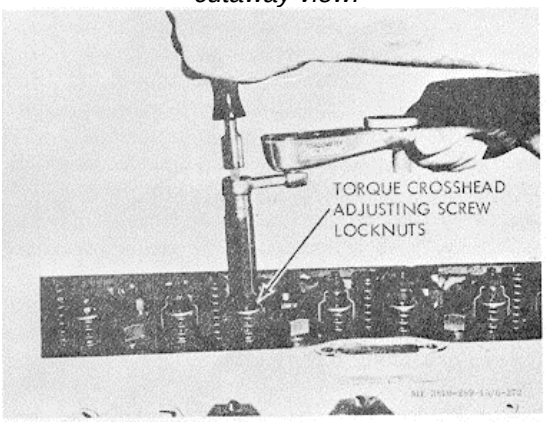


Figure 3-263. Torquing crosshead adjusting screw locknuts

3-48. Cylinder Liners

a. Removal

(1) Pull cylinder liners from block with ST-777 Liner Puller, using ST-778 Plate Puller.

***Caution*: The elevated top plate straddles the cylinder liner, figure 3-264; the plate puller, figure 3-265, is placed on bottom of cylinder liner and held in place with a nut. When using the cylinder liner puller, be careful not to mutilate machined surface of cylinder block.**

(2) Adjust shaft screw and pull down on cam lever to loosen liner. If liner sticks in block, turn lever in clockwise direction until liner is loose.

(3) Remove liner puller and lift liner from block; remove and discard O-rings and crevice seal (if used) from liner.

b. Cleaning and Inspection.

(1) Remove rust and scale from liner exterior with wire brush or by similar cleaning operation.

(2) Inspect for cracks in cylinder liners just under top flange, at bottom of liner, or above top seal ring groove. Check by:

(a) Magnetize liner if magnetic equipment is available.

(b) Pour magnetic solution over liner while it is still magnetized.

***Note.* Cast iron will not hold magnetism permanently.**

(c) If magnetic inspection cannot be performed, clean liner thoroughly.

(d) Spray suspected area with dye penetrant.

(e) Allow penetrant to dry for fifteen minutes. Do not "force" dry; remove excess dye.

(f) Spray with developer and check for crack indications.

(3) Discard any liner with excessive corrosion or erosion and pits 1/16 inch deep or more.

(4) Inspect underside of liner flange for dents, pitting or fretting. Discard liner if any unevenness cannot be removed by lapping.

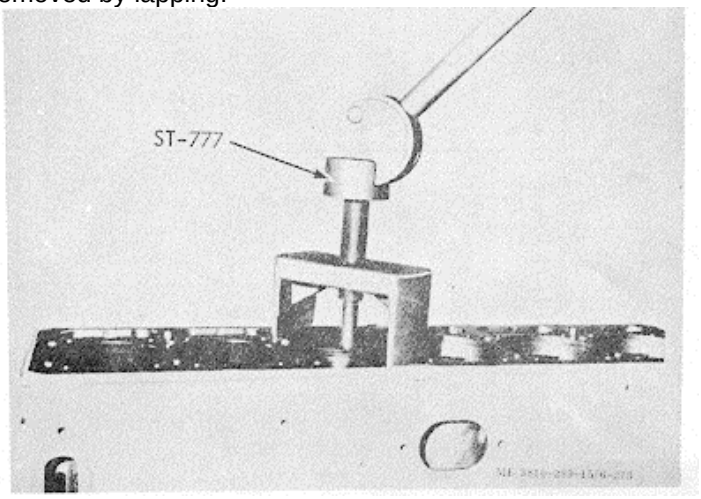


Figure 3-264. Pulling cylinder liner with ST-777 puller.

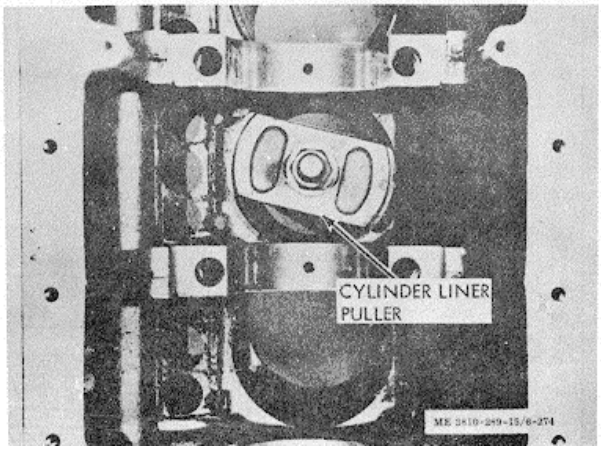


Figure 3-265. Cylinder liner puller adapter plate.

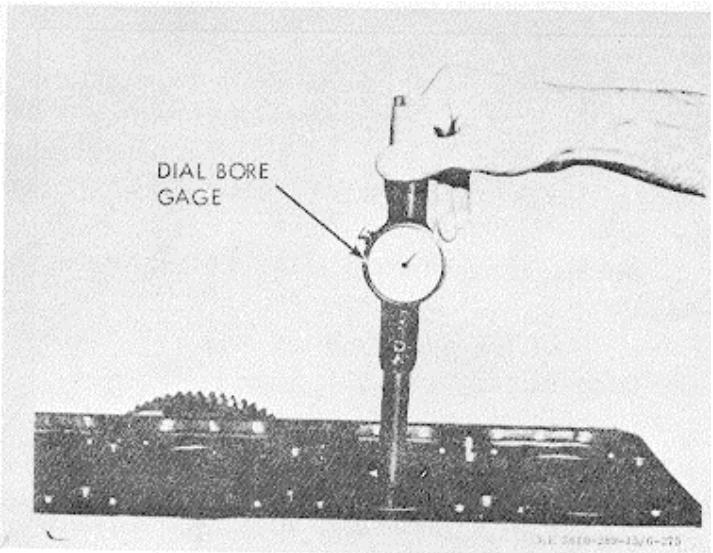


Figure 3-266. Cylinder liner bore inspection.

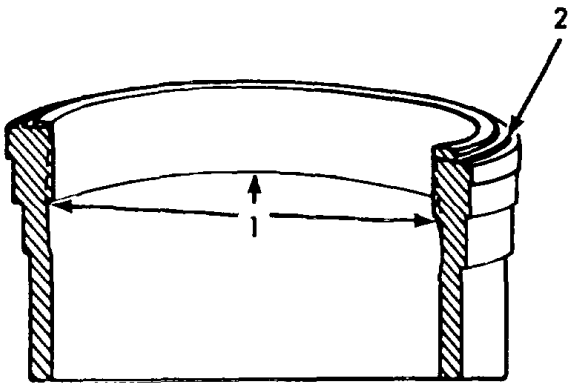


Figure 3-267. Cylinder liner cross section.

(5) Inspect worn liners with dial bore gage (fig. 3-266). If liners are worn more than 0.004 in. in excess of new liner maximum diameter, replace or hone to next oversize. See table 2-2 for new liner dimensions. Pistons for oversize liners are available in 0.020, 0.030 and 0.040 in. oversizes.

(6) Mark liners to be reused for ridge cutting, boring or grinding and honing if worn less than above limits and otherwise undamaged in areas 1 and 2 (fig. 3-267).

c. Repair. Cylinder liners should not be reused without reboring or regrinding if they exceed worn limits. Pistons and rings are available in 0.020, 0.030, 0.040 in. oversizes. Add oversize increments to standard dimensions to determine final oversize dimension desired.

(1) Remove ridge at top of worn liners with a ridge cutter, or other means, to prevent damage to new rings.

(2) Grind or bore liners to next standard oversize.

(3) Finish hone liners to proper finish.

(a) *Liner honing.* Honing operation described below is not designed to enlarge cylinder bore several thousandths for oversize pistons and rings. When 3-94 honing oversize, both roughing and finishing stones are used. Recommendations given are specifically designed to put proper finish and geometric design in cylinder liner with a minimum of stock removal. For this reason, only one grit size is used and stones are used wet.

(b) *Cylinder walls.* Walls can be straightened with 4 or 5 final passes through bore. Proper finish will be on walls due to fine grading of stone recommended. Visual inspection of liner honed, according to recommendations, will indicate importance of using equipment and procedures which give the operator maximum control of operation.

1. Place cylinder liner in cylinder bore of a scrap block without packing rings or crevice seal. Upper liner bore in block should be relieved so liner will drop into place very easily.

2. Tap two water holes and assemble capscrews and soft washers to holes making sure soft washers are over liner flange, but do not extend into bore of liner. Tighten finger tight.

3. Place dial gage in cylinder liner about 1 l/ inches from top.

4. Watch gage for movement while capscrews are tightened to secure liner.

5. Loosen capscrews and move dial bore gage to another position in liner bore and repeat check while tightening capscrews.

6. If distortion is noted, remove liner and check for dirt between flange and counterbore ledge. Also, check flatness of counterbore ledge. If liner is seating evenly on ledge, distortion will be less than 0.0003 in. and barely noticeable.

7. Assemble a honing stand to cylinder block. Use wooden blocks to adapt base to bore size; then use expanding foot to tighten base to stand in bore.

8. Assemble upper support arm to stand and attach drill handle to canvas loop.

9. Place a quick coupler securely in drill chuck (fig. 3-268).

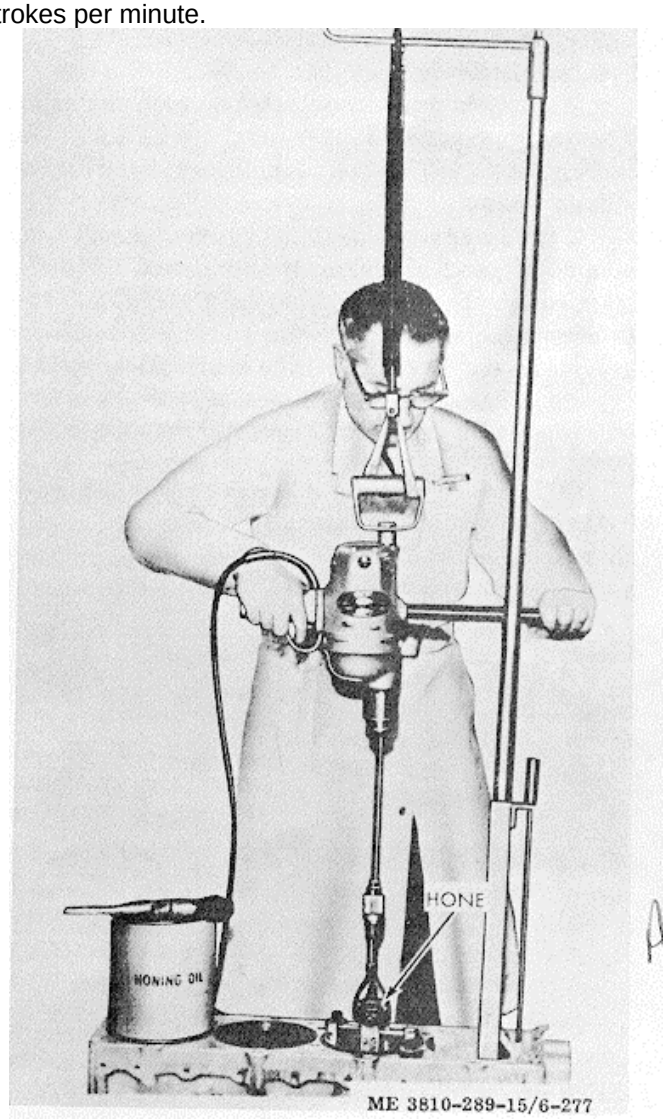
10. Insert hone assembly into top of cylinder liner. Raise center pinion assembly /4 in. and turn counterclockwise (left) to expand stones to approximate bore size, figure 3-269. Push center pinion down until its inside gear engages outside gear on hone body. Attach hone to quick coupler.

11. Swing upper support arm so drill and hone are approximately over center of liner bore. Adjust length of canvas strap attached to drill so hone hangs with ends of stones extending out of liner bore approximately 1 inch.

12. Adjust stroking stop (collar and wing screw) so stones will not extend more than 1 inch from bottom of cylinder liner at end of down stroke. Put enough down pressure on hone to make sure they will not hit obstructions beneath liner during honing.

Secure stop collar when setting is correct to clear stones.

13. Do not start drill motor. Practice stroke a few times for "feel" with stones expanded loosely in liner and not in actual contact with walls. Down stroke hits stop, but operator must stop stroke at top allowing stones to extend out top of bore 1/2 inch. Stroking speed required to produce a 35 ° to 45 ° crosshatch is approximately 50 strokes per minute.



Note. **It is very important to have a 450 crosshatch pattern to enable the piston rings to shear or peel the sharp ridge points during break-in. If pattern is nearly horizontal some pattern engagement and tearing may occur. If pattern is vertical, this forms a path for blow-by.**

14. Disconnect hone and remove Figure 3-268. Honing Liner.

15. The edges and corners of new stones are very sharp. Take a hand hone and slightly round all corners and edges to reduce tendency to crumble when stones are first used.

16. Recheck set-up and become familiar with hone mechanism and stroke. Check manufacturer's instructions packaged with components.

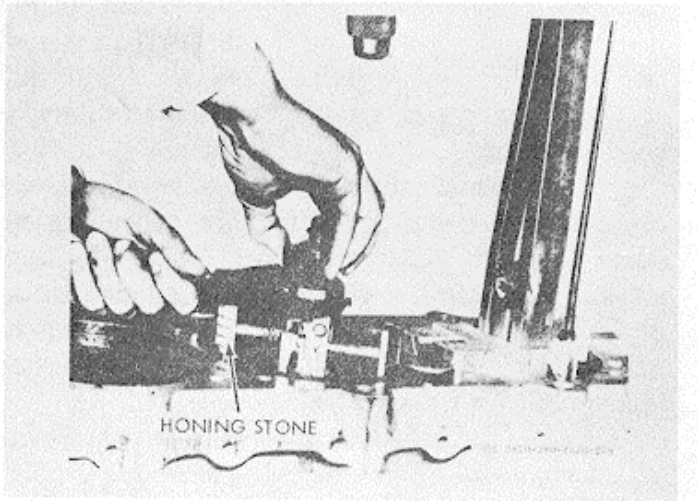


Figure 3-269. Initial honing stone expansion.

Check liner in honing fixture to make sure it is secure.

18. Check liner with dial bore gage to determine how wear pattern must be removed. In this case, assume that liner has a slight ring at top, 0.002 inch wear and out-of-roundness in ring travel area.
It tapers in at bottom of bore due to lack of wear in that area.

19. Assemble hone to liner bore. Expand stones to diameter of cylinder bore.

20. Expand stones and guides firmly against cylinder walls by turning winged collar clockwise on top of pinion assembly. Do not tighten too tight.

21. Apply honing oil freely to stones, guides and cylinder walls with brush or oil can after attaching hone to quick coupler.

22. Grasp drill handles of a heavy duty drill with a 300 rpm no-load speed firmly and turn on motor. Let extension handle contact vertical stand to absorb torque of motor. Use hand or. handle (with switch) to keep drill and hone over center of liner.

23. Stroke as follows: Move to bottom of bore and bring hone up half-way in bore. Then go back to bottom of bore. On next upstroke come all the way to top (let stones extend more than 1/2 inch out top of bore) and return to bottom repeating double stroke in bottom of bore. After 6 to 8 strokes have been made to top of bore, double stroke both top and bottom of bore. This action removes stock faster at opposite ends of bore removing tapered condition of liner. The first honing cycle should last only 10/15 seconds; then shut off drill and check for results. At first it may be wise to remove hone and check with dial bore gage to become familiar with cutting speed of stones. Make a visual inspection of bore frequently and add oil to keep stones clean and rutting freely.

24. Apply honing oil and operate for another 10/15-second cycle, if needed, double stroking either end that is smaller in diameter than ring area. This

operation is designed to straighten wall of bore and remove carbon ring at top. Keep stones cutting by adjusting pressure with winged collar. A slight reduction in drill speed will be noted when stones are cutting. Torque action felt on drill handles also is a good indicator.

25. Thirty to forty seconds honing time can remove 0.001/0.002 in. from bore depending upon stone pressure. Straighten bore quickly by double stroking, then full stroke bore only enough to lay a uniform finish on the walls. The total honing time will usually run about 20/40 seconds to perform what is commonly called a deglazing operation.

26. After pattern is uniform, stop hone; adjust stones to a firm but light pressure. Apply oil and make 4 or 5 full-length strokes and shut drill off while continuing stroke. Double stroke in bottom if necessary to time actual stopping of hone rotation when hone is at top of bore. This preserves crosshatch pattern, and puts true stone pattern (20/30 rms finish) on cylinder walls. This slightly irregular surface on the cylinders liners is required so new piston rings and reworked liners will break in (or wear in) together. It is also necessary to have basic honed pattern in liners to retain some oil in valleys as piston rings scrape away oil on liner walls. If walls were smooth, they would quickly run dry and score.

27. Remove hone from liner and remove liner from fixture.

28. Make a final check of bore size and make sure that carbon ring at top and thrust wear pattern are removed. Note angle of cross-hatch to check stroke speed. Refer to table 2-2 for specifications concerning maximum bore size. Out-of-roundness should not exceed 0.0015 in. except at assembly. If stones have been kept wet, walls will show a uniform satin finish and will be of proper 20/30 rms finish. If a smooth, shiny finish is noted, it is probably due to lack of oil or motoring hone too long in final honing cycle. As oil disappears from walls, stones tend to load and become dull. Honing oil keeps stones sharp and promotes true cutting action.

d. Cleaning.

(1) After liners are honed, they must be cleaned thoroughly with solvent, steam cleaner or hot soap and water. It is recommended that cleaning operation be ended by scrubbing bore with a bristle brush to remove as much honing debris as possible. Blow liners dry with compressed air.

(2) Coat bore of liners generously with clean lubricating oil. If possible, let liners stand 5-or 10minutes before next step.

(3) Use white paper towels to wipe lubricating oil from liner bores. Note gray and even black residue that appears with oil on white towels. This is honing debris that remained on liner walls. Repeat application of lubricating oil and wipe off with white paper towels. If honing debris is still present, repeat lubricating oil treatment. Usually liners will appear clean on second application. Liners must be completely cleaned after honing. After soap and hot water treatment, liners will appear clean when a paper towel is wiped through dry bore. This is a false indication since lubricating oil treatment will remove additional abrasive material.

Note. **The importance of proper cleaning of the liner cannot be overemphasized. Dirt or grit remaining in the liner will cause improper break-in of the liners and piston rings.**

e. Installation.

(1) Inspect liner counterbore depth in cylinder block at four equidistant points, using ST-547 Gage Block, figure 3-270: "zero" indicator before taking measurements.

(2) Measure thickness of cylinder liner flange, outside of bead as illustrated in figure 3-271. Subtract counterbore depth from liner flange thickness to determine amount of shim thickness required to provide correct liner protrusion above block.

Note. **Another method of determining liner protrusion is to install liner in block and measure amount of protrusion (outside of bead) with ST-547 Gage Block.**

(3) Installed cylinder liners must protrude 0.004/ 0.006 in. above block; refer to table 2-2 for required shim(s). Check as follows:

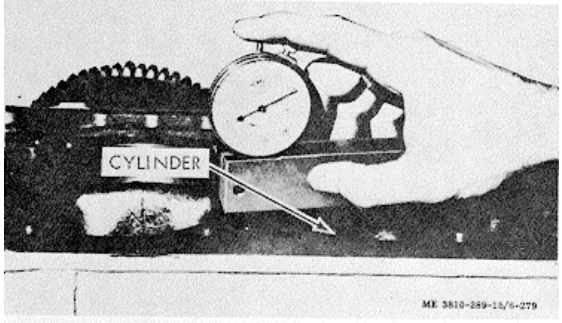


Figure 3-270. Cylinder liner counterbore inspection.

(a) Install liners without packing rings.

(b) Pass a 0.0015 in. feeler gage around the entire circumference between liner flange and block. If 0.0015 in. clearance is not present, mark binding spot with chalk, remove liner and scrape counterbore at points of binding until proper clearance is attained.

(4) After determining number and thickness of shims, install them on liner so they seat at liner flange.

(5) Using clean lubricating oil, lubricate surface of cylinder block where packing rings and crevice seals will seat; wipe off excess oil with clean cloth.

(6) Lubricate, with clean lubricating oil, those surfaces on the cylinder liner where packing rings and crevice seal will be located; wipe off excess oil with clean cloth.

(7) Assemble liner packing rings and crevice seal on cylinder liner in the following manner:

(a) Lubricate all packing rings and crevice seals (if used) with clean lubricating oil; wipe off excess oil with clean cloth.

(b) Roll packing rings into position on liner; using mold marks on rings as guides, straighten as required if rings are twisted.

(c) Lower the liner into block bore; when packing rings contact ring-seating bore in block, work liner carefully in a downward, circular motion until liner is seated snugly.

(d) Using ST-594 Cylinder Liner Driver, figure 3-272, and light hammer, drive liner remainder of distance; when liner is seated firmly, tap driver tool lightly to prevent liner from bouncing up again.

(e) Check liner bore for roundness at several points within range of piston travel.

(f) Check with a precision dial bore gage as illustrated in figure 3-273.

(g) If liner is more than 0.0015 in. out-of-round in packing ring area, remove liner and check for binding condition which would cause distortion of liner bore.

(h) A total of 0.003 inch out-of-round at the top one inch of liner bore is permissible if liner is press-fit type.

(i) If more than 0.004 in. out-of-round and liner contacts block at packing ring bore, counterbore is out of flat (para 3-45).

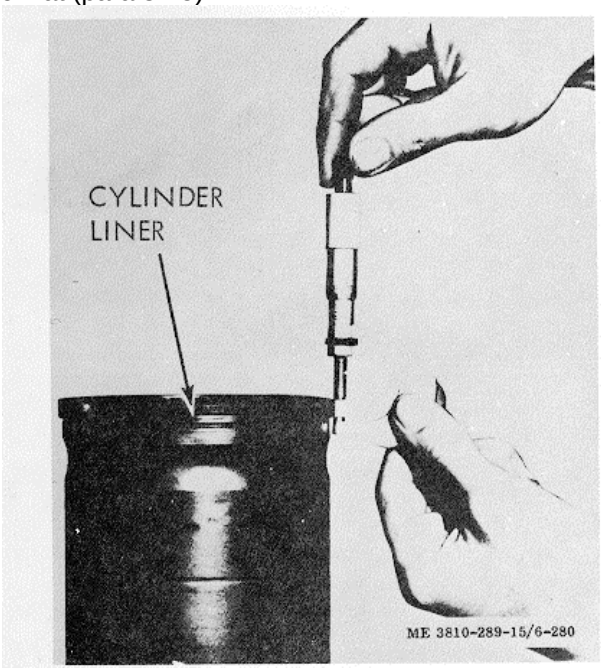


Figure 3-271. Cylinder liner flange inspection.

(j) Check liner protrusion at four equidistant points with ST-547 Gage Block, (Fig. 3-274) to be certain that liner protrusion is within 0.004/0.006 in. Measure outside of bead.

Note. **On new liners, lubrite finish may increase readings slightly. Take readings at 60 /75 F. (16 /29 C).**

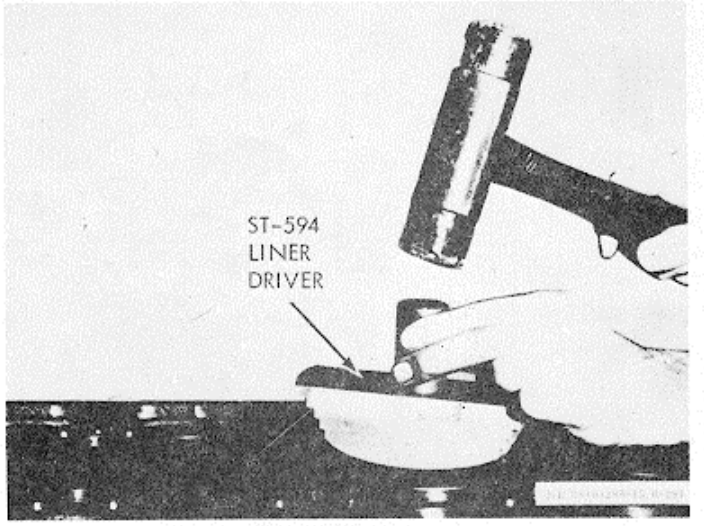


Figure 3-272. Cylinder liner installation.

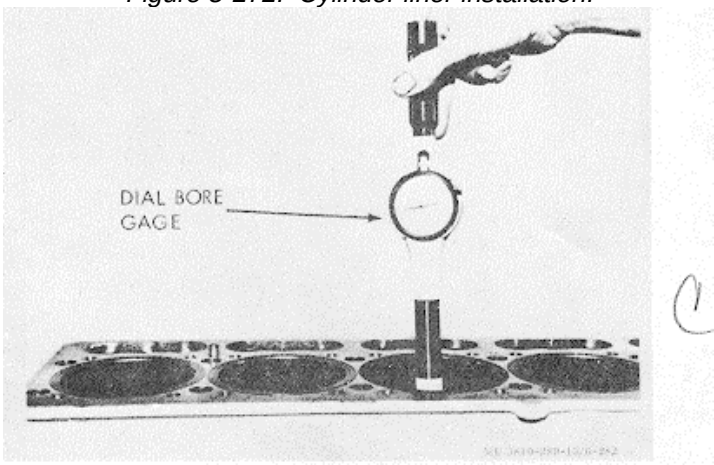


Figure 3-273. Cylinder liner bore inspection.

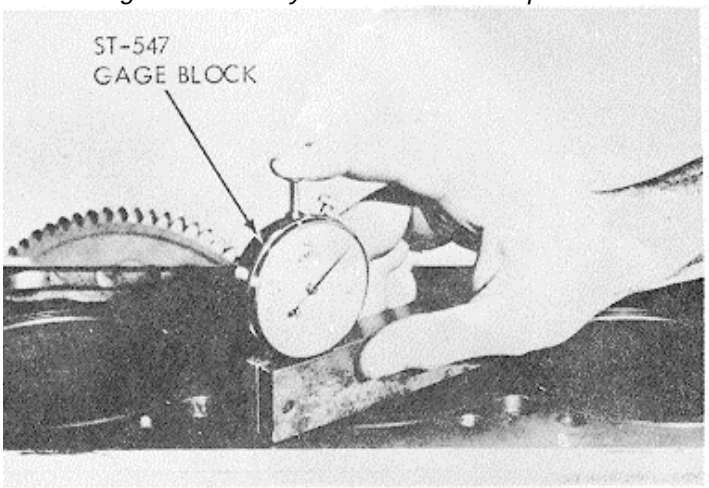


Figure 3-274. Inspecting cylinder liner protrusion.

CHAPTER 4
REPAIR OF CRANE-SHOVEL UPPER WORKS AND LOWER WORKS

Section I. UPPER WORKS

4-1. General.

The upper works consists of the revolving frame, main machinery, engine, operating controls, and the operator's cab. This section contains instructions for repair and replacement of major components on the upper works.

4-2. Transmission

a. General The transmission is a fully enclosed multiple-strand chain drive running in oil. The shaft has a 2' inch diameter, is alloy steel, and splined at both ends to accept driven sprocket and pinion. It is mounted on anti-friction bearings.

b. Removal and Disassembly.

(1) Drain oil out of both transmission chain case and gear case. Remove chain case cover (20, fig. 4-1). Remove gasket seal (74) of revolving frame at left of chain case (36). Remove chain case.

(2) Remove transmission chain (24) by splitting at connecting link.

(3) Remove sump pan (58) from gear case (75).

(4) Remove hoist clutch yoke fulcrum pin (53) from right bearing cover on right side of gear case.

(5) Remove right bearing cover.

(a) Take out four capscrews and their lock plates.

(b) Remove cover and gasket.

(c) If gasket is loose, put it away where it will not be damaged.

(6) Remove right retainer plate by removing lockwire (28) and two capscrews (27). Leave the left retainer plate on for pulling shaft.

(7) Place a block of wood inside the gear case at the left of the hoist pinion so shaft can be pulled and force off the "tap-fit" right bearing with the pinion. Block of wood should be well located to distribute the load against the inside of the gear case and prevent springing the case.

(8) Pull shaft using sprocket spokes to assist in applying traction. Shaft should come free with relative ease but it may be necessary to tap it lightly to work it free from the right bearing. After it clears the bearing it should come out freely. Catch hoist pinion under gear case before it drops free. Remove the right bearing from its seat in the side of the case.

(9) Sprocket and left bearing are still on the shaft. If disassembly is desired:

(a) Remove lockwire (6) and two capscrews (5) and retainer plate (7) from left end of shaft.

(b) Remove sprocket (25).

(c) Remove bearing. Bearing is a "tap-fit" and it may be necessary to tap it lightly (through a wood block) to free it from shaft.

c. Inspection and Repair. Clean all parts thoroughly and inspect for damage and excessive wear. For gear and bearing inspection and repair procedures, see paragraph 2-8. Replace damaged gasket or hardware.

d. Reassembly and Installation

(1) Mount left bearing from left end of shaft tapping lightly into place with soft babbitt hammer or through a wooden block. Shield on bearing must face sprocket.

(2) Put key in place and press sprocket on shaft. This requires a press of 20-to 30-tons capacity.

(3) Install gear and retainer plate on end of shaft, fasten securely with two capscrews and lock with wire.

(4) Insert shaft in revolving frame and push it through until the right end enters the gear enclosure.

Note. **Check oil seal in gear case. Replace if necessary.**

(5) Put the hoist pinion in place and push shaft through it.

(6) Push pinion back against shoulder and start right bearing on end of shaft.

(7) Insert wood block between bearing and side of gear case. Drive shaft into bearing until it seats against shoulder of shaft.

(8) Remove block and insert bearing on end of shaft in housing inside of gear case.

(9) Install right bearing retainer, insert two capscrews and lock with wire.

(10) Install right bearing cover with gasket, and fasten in place with four capscrews and lock plates.

(11) Install hoist clutch yoke and insert and lock clutch yoke fulcrum pin.

(12) Wash out and replace oil sump pan on gear case.

(13) Replace transmission chain by inserting pins and plates and locking with cotter pins.

(14) Install chain case. Install gasket seal of

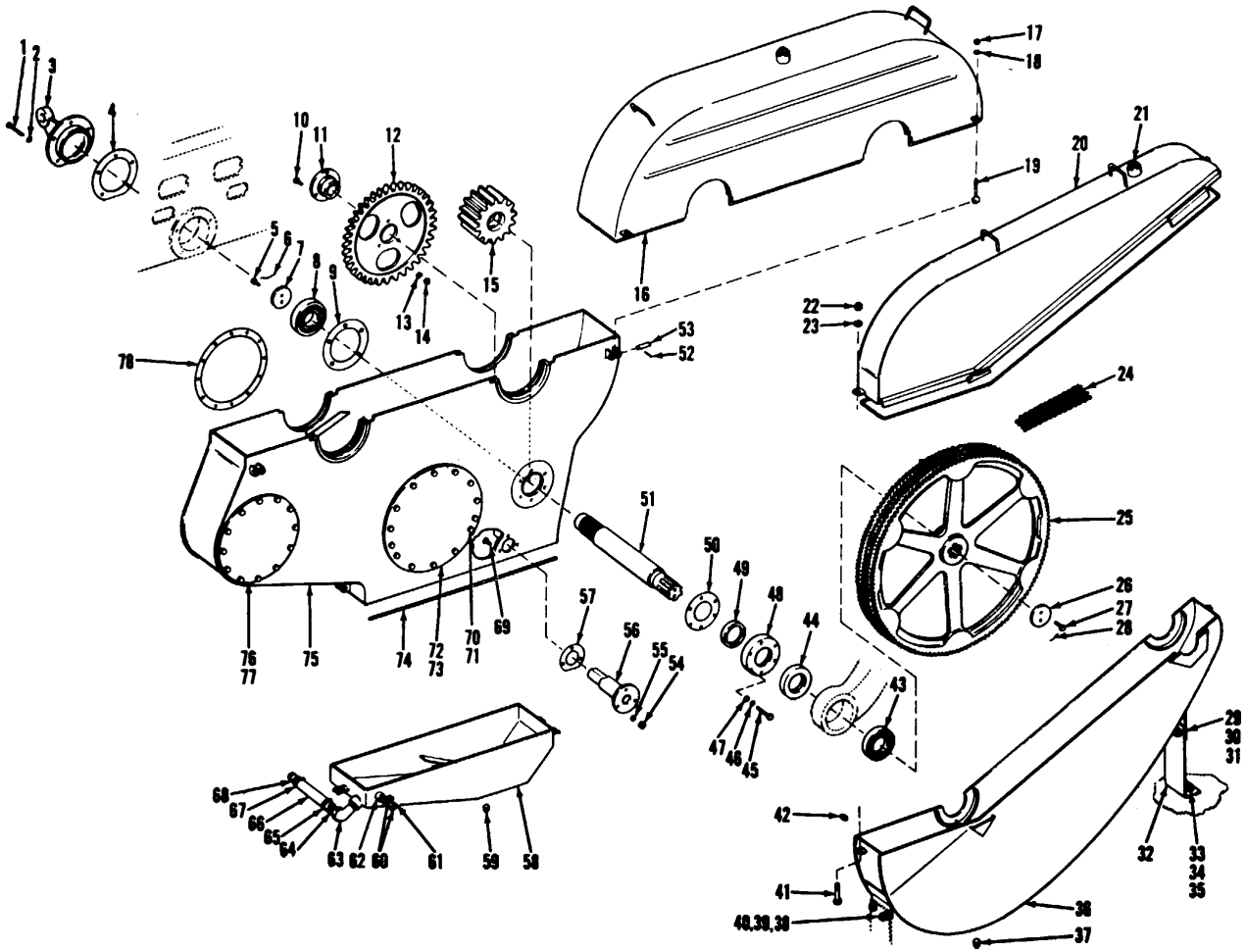


Figure 4-1. Transmission shaft, exploded view.

1 Screw cap 3/8” x3 ¼” UNC Gr. 2
2 Washer, lock 3/8"
3 Bearing retainer
4 Gasket
5 Screw, cap 3/8"x 1 UNC Gr. 2
6 Lock wire
7 Retainer
8 Bearing
9 Gasket
10 Screw, cap 3/8"x1 1/2" UNC Gr. 2
11 Hub
12. Oil Gear
13 Washer, lock 3/8"
14 Nut, full 3/8” UNC
15 Pinion
16 Gear case over
17 Nut, full 3/8" UNC
18 Washer, plain 3/8"
19 Bolt, eye
20 Chain case cover
21 Plug
22 Nut, full 1/2" UNC
23 Washer, lock ½”
24 Chain
25 Sprocket
26 Retainer
27 Screw, cap 3/8" x 1" UNC Gr. 2
28 Wire lock #12 x 5
29 Washer, lock 3/8"
30 Screw, cap3/8"x1"UNC Gr. 2
31 Nut, full 3/8" UNC
32 Chain case support
33 Washer, plain 3/8"
34 Screw, cap 3/8" x 1" UNC Gr. 2
35 Nut, full 3/8" UNC
36 Chain case
37 Pipe plug ½” std. sq. hd.
38 Screw, cap 1/2"x 1/4" UNC Gr. 2
39 Nut, full 1/2" UNC
40 Washer, lock 1/2"
41 Screw cap 1/2" x 2" UNC Gr. 2
42 Pipe plug 1/4" std, sq. hd.
43 Bearing
44 Seal ring
45 Screw, cap
46 Washer, lock 5/16"
47 Washer, plain 5/16"
48 Retainer
49 Seal
50 Gasket
51 Shaft
52 Pin, cotter 1/8" x 3/4"
53 Lever pin
54 Nut, full 3/8" UNC
55 Washer, lock
56 Shaft
57 Gasket
58 Oil sump
59 Pipe plug " std. sq. hd.
60 Pipe plug 1/8" std. sq. hd.
61 Tee 1/8"
62 Nipple 1/8"
63 Elbow
64 Pipe nipple 1" x 21/2"
65 Clamp
66 Hose
67 Clamp
68 Pipe nipple 1l" x 2 1/2"
69 Screw, cap 3/8" x 1" UNC Gr. 2
70 Screw, cap 1, " x ½" UNC
71 Washer, lock 1/4"
72 Cover
73 Gasket
74 Gasket seal
75 Gear case
76 Cover
77 Clamp
78 Gasket

revolving frame and chain case cover.

(15) Fill gear case with lubricant in accordance with lubrication order.

(16) Fill chain case in accordance with lubrication order.

4-3. Upper Structure Assembly

a. Disconnect

(1) Position boom and machine as required for method used.

(2) Release swing lock after blocking machine to prevent swing.

(3) Remove front cover from swing and propel gear case (fig. 4-2).

(a) Clean swing and propel gear case front cover.

(b) Take out capscrews along front edge of cover and slide forward.

(4) Remove two plugs from oil sump of main gear case and drain oil (fig. 4-3).

(5) Free upper ends of digging lock control rod and hollow steering control rod (or sleeve) operating through vertical swing shaft (fig. 4-4).

(a) Remove lever pins connecting steering clutch lever with vertical control rod.

(b) Loosen capscrews holding steering clutch and digging lock levers to horizontal control shaft and control sleeve leading across deck.

(c) Remove reach rod pins attaching to levers on the outer (right) end of this horizontal shaft and sleeve.

(d) Slide shaft and sleeve to right until steering and digging lock levers can be removed from left end. *(e)* If upper works are to be lifted by crane, the vertical control rod and sleeve can remain in place as can also the vertical swing shaft. If the upper works are removed by jacking, about six inches of lift can be saved by disconnecting the vertical digging lock control rod and steering control sleeve at their lower ends and pulling them up out of the vertical swing shaft. A further saving of about 15 inches of lift can be made by removing the vertical swing shaft. (para 4-16).

b. Remove Cone Rollers (fig. 4-5).

(1) Lift upper works (weight, 25, 000 pounds) just enough so cone rollers are free in their path. Lift can be made by:

(a) Crane, with sling fastened to lifting eyes provided on A-frame yoke and lugs near boom foot pins.

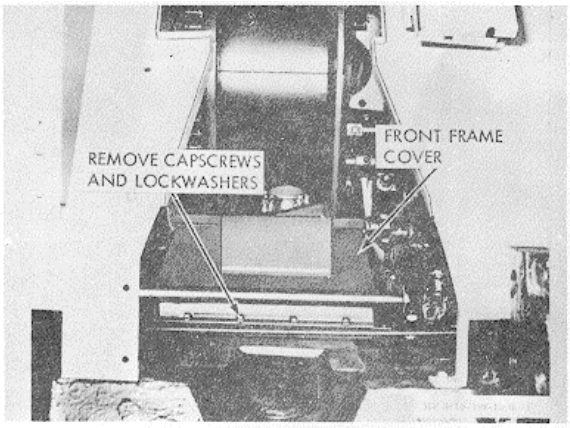


Figure 4 -2. Front frame cover.

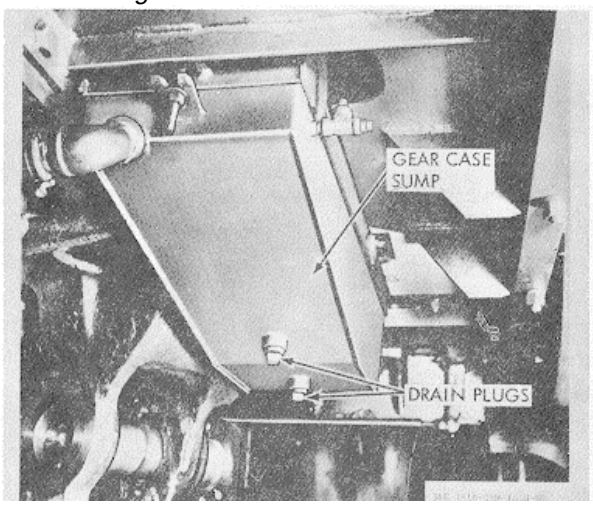


Figure 4-3. Gear case sump.

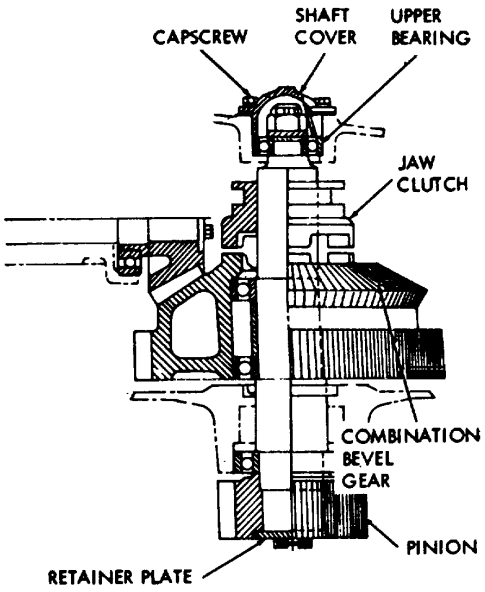
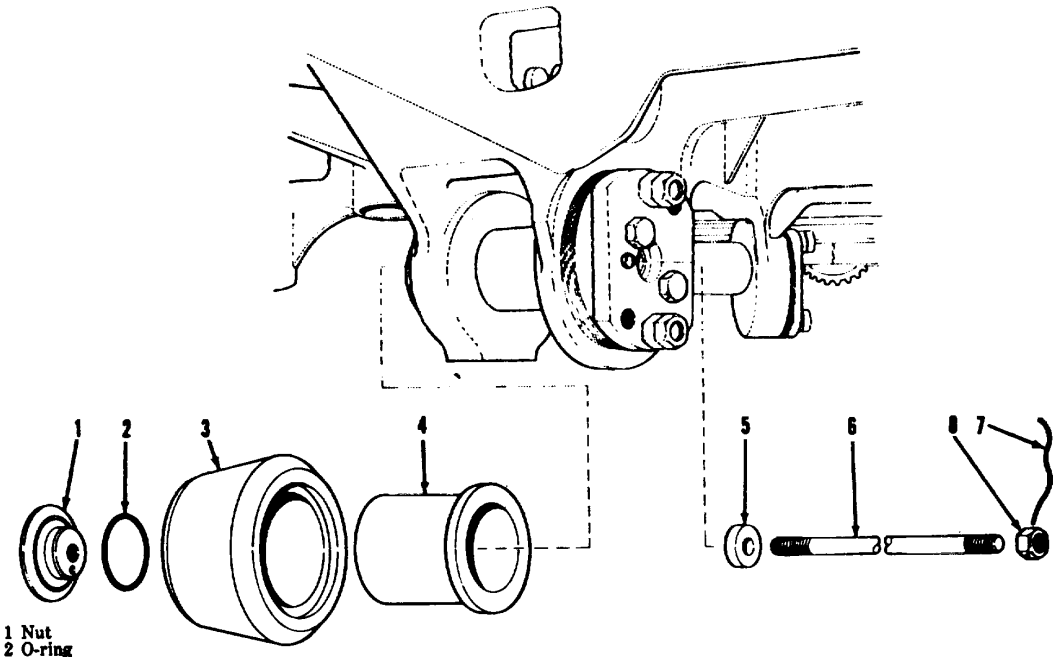


Figure 4-4. Vertical swing shaft.



1 Nut
2 O-ring
3 Cone roller
4 Bushing
5 Washer
6 Bolt
7 Lock wire
8 Nut

(b) Jacking up revolving frame and building cribbing to support it. Four jacks should be used, one under each corner of revolving frame (do not jack against light side decks).

(2) Remove adjusting rod.

(3) Pry off retainer with shaft attached.

(4) Roll cone roller aside and remove cone unit nut with O-ring seal attached.

c. Lift Off the Upper Works.

(1) Lifting may be accomplished with a crane (capable of lifting 25, 000 pounds). An overhead shop type crane is preferred if convenient. Lift can be made with a larger sized crawler crane or with two 22-B cranes. If crane is not available, lift can be made by jacks and blocking. General instructions follow for each method.

(2) *Crane lift.*

(a) If this machine is carrying crane type boom, lower boom to about 20 degree angle.

(b) Attach a wire rope sling to lifting eyes at boom foot pins.

(c) Attach a second wire rope sling to lifting eyes at A-frame yoke.

(d) Attach slings to crane hook and adjust slings so machine is balanced evenly. Check by roller clearances while lifting slightly to take load off cone rollers.

(e) Having completed the disconnecting of upper and lower works, lift upper works off from lower works and set it aside on blocking. It should rest bn two forward roller lugs and on corners of rear end casting (gear case side is heaviest.) Do not support under the larger (outer) counterweight casting.

(3) Jack lift.

(a) Position upper works crossways on lower works for convenience in pulling lower works out after jacking and blocking upper works.

(b) Lower crane boom point to ground on shovel boom to rest on a block placed on extended dipper handle between handle and boom ("scissors" fashion), and at rest on the dipper.

(c) Use square timbers or sound railroad ties for blocking. Have plenty of good blocking material on hand.

(d) Use four hydraulic jacks for lifting. (Screw jacks may be used but are not as convenient. Do not use ratchet jacks.)

(e) Position jacks to jack against the corners of central revolving frame being sure to jack against substantial frame members.

(f) Jack and block by turns until upper works clears lower works. Note that about six inches of lift can be saved by removing steering and digging lock controls and another 15 inches by removing vertical swing shaft.

Caution: **Keep blocking solid. Also remember not to block permanently in front opening for rolling out lower works.**

(g) When upper works is clear, drag lower works out from under upper works. It can be hauled out on skids with tractor, but watch to clear blocking at sides. Leave upper works standing on blocking until lower works can be replaced.

d. Prepare Upper Works for Installation.

(1) Remove propel jaw clutch and shifter and propel gear from inside propel and swing gear case. These parts have been left free in the case where upper works was lifted off from lower works and will interfere with free insertion of the vertical swing shaft unless they are removed.

(2) Remove vertical shaft oil seal flange and seal to avoid damage to them in lowering upper works. (fig. 4-6).

(3) Move upper works (or lower works) into place and lower carefully so the vertical swing shaft enters its bushing accurately. Install cone roller frame assemblies, if these have been removed. Lower just far enough so cone rollers can be inserted in roller path.

(4) Block revolving frame at that level for safety.

e. Assembly and Installation.

(1) Insert roll pin on shaft.

(2) Coat pin with white lead at revolving point lugs.

(3) Place cone roller with its cone nut and O-ring in place on roller path and roll in position to permit insertion of pin.

(4) Install adjusting rod in pin bore and thread into cone nut.

(5) Install shims and retainer in place with capscrews.

(6) Refer to table 2-2 and adjust the cone rollers.

f. Connect Control Linkage.

(1) Install vertical shaft oil seal, retainer flange and capscrews.

(2) Install swing gear, swing jaw clutch and shifter.

(3) If vertical control shaft and sleeve running through vertical swing shaft have been removed replace them. (fig. 4-6).

(4) Slide horizontal steering clutch control shaft and digging lock control sleeve to left through control levers.

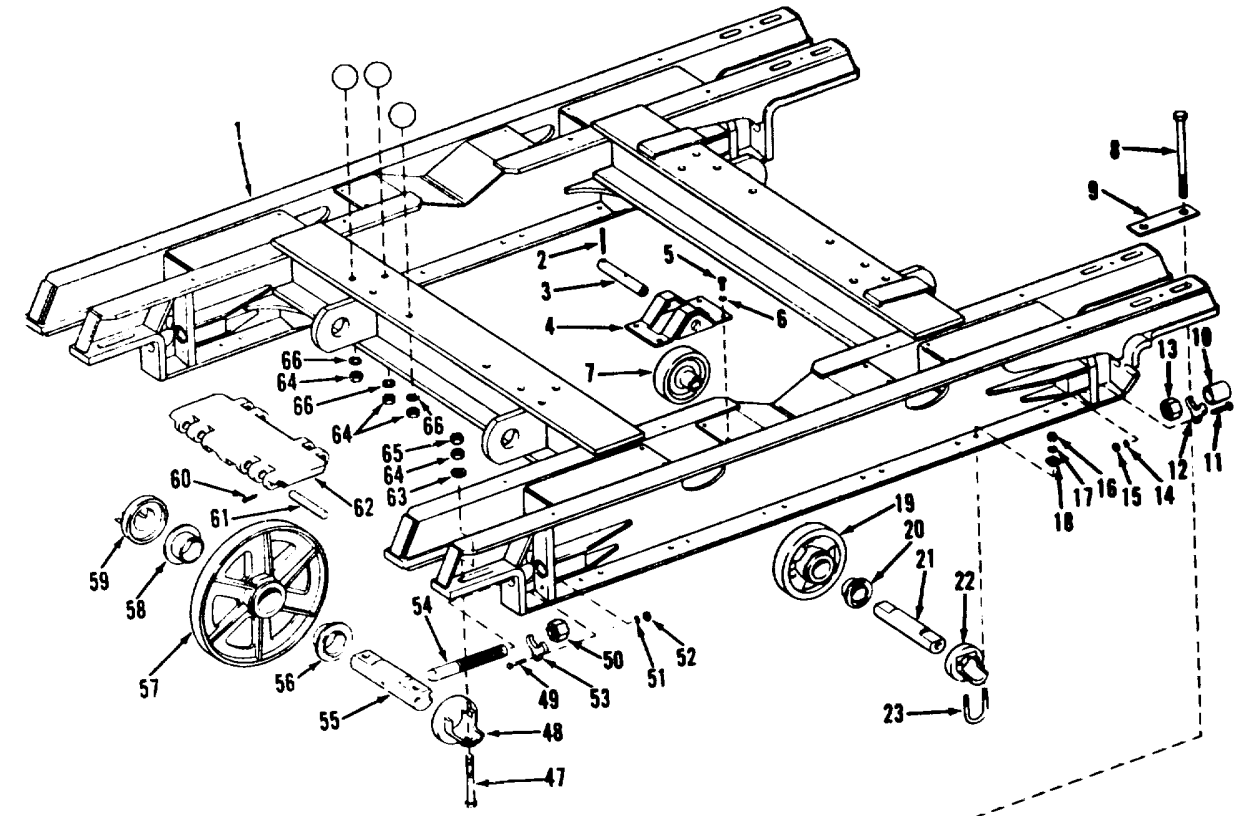
(5) Connect steering clutch lever to vertical control sleeve (running through vertical swing shaft) by inserting lever pins in the holes on each side.

(6) Insert digging lock lever in slot on top of vertical control rod.

(7) Tighten setscrews holding above levers to horizontal control shaft and sleeve and reconnect reach rods to levers.

(8) Install two oil sump plugs.

(9) Replace front cover on swing and propel gear



1 Frame
2 Pin, cotter
3 Upper roller shaft
4 Bearing
5 Screw, cap
6 Washer, lock
7 Upper roller
8 Bolt, hexagon
9 Spanner bar
10 Separator
11 Screw, cap
12, Nut, lock
13 Nut, special
14 Washer, lock
15 Nut, hexagon
17 Nut, hexagon
17 Washer, lock
18 Bevel washer
19 Lower roller
20 Bushing
21 Lower roller shaft
22 Dust shield
23 U-bolt
24 Driving tumbler
25 Bushing
26 Outside bearing
27 Nut, hexagon
28 Nut, jam
29 Pin, cotter
30 Pin
31 Pin, cotter
32 Eye bolt
33 Nut, hexagon
34 Nut, jam
35 Adjusting bolt
36 Tumbler shaft
37 Straight key
28 Bushing
39 Inside bearing
40 Bushing
41 Chain
42 Sprocket
43 Retaining plate
44 Lock bar
45 Screw, cap
46 Washer, lock
47 Bolt
48 Dust shield
49 Screw, cap
50 Nut, special
51 Washer, lock
52 Nut, lock
53 Nut, lock
54 Adjusting bolt
55 Shaft
56 Bushing
57 Takeup tumbler
58 Bushing
59 Dust shield
60 Pin, cotter
61 Link pin
62 Link
63 Washer, plain
64 Nut, hexagon
65 Nut, jam
66 Washer, lock

Figure 4-6. Vertical propel shaft, exploded view (sheet 1 of 3).

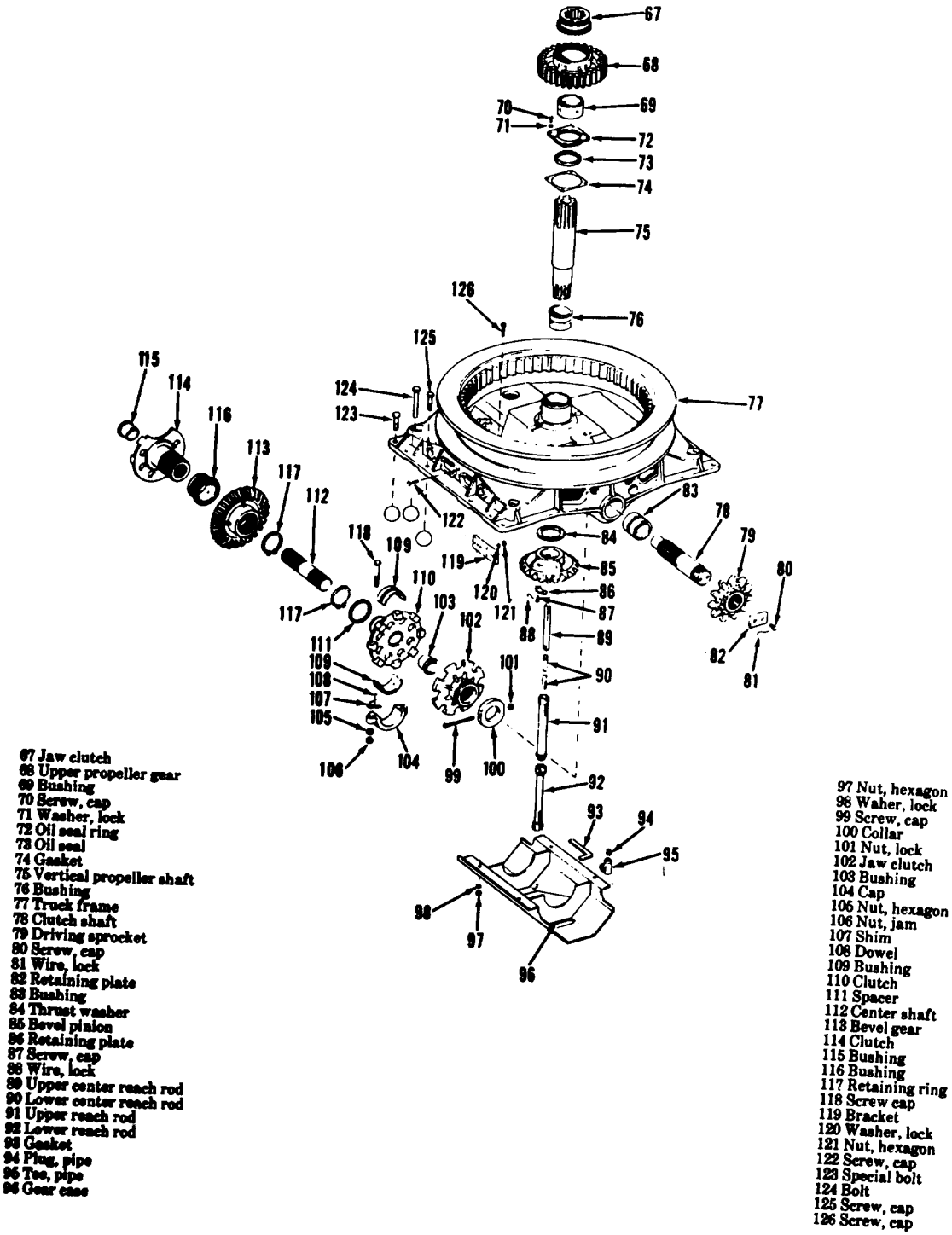


Figure 4-6. Vertical propel shaft, exploded view (sheet 2 of 3).

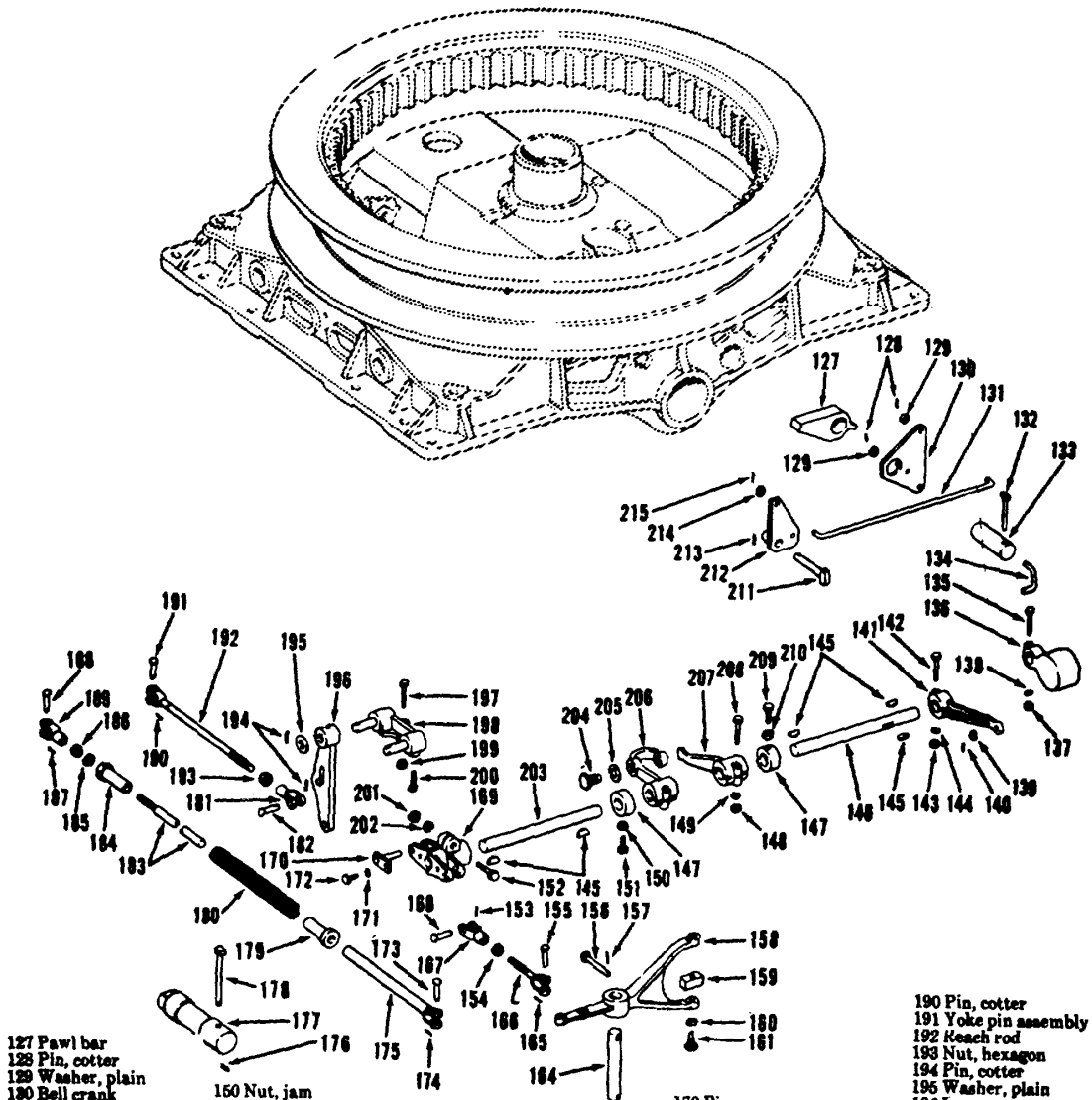


Figure 4-6. Vertical propel shaft, exploded view (sheet 3 of 3)

case.

(10) Refill gear case per lubrication order.

4-4. Revolving Frame

a. General. The revolving frame is a one-piece, heat treated steel casting with integral lugs for boom foot and cone roller mounting brackets. Cast steel machinery side frames are bolted to revolving frame. Shear plugs relieve bolts of shear loads and maintain alignment.

b. Inspection and Repair. Clean up frame and inspect for cracks, broken welds and other defects. Make repair by welding and grinding. For bushing inspection and repair procedure, see paragraph 2-5.

4-5. Chain Case Assembly

a. Removal

(1) Swing revolving frame cross-wise of the tread belts so the case can be taken out between the crawler side frame.

(2) Remove chain case cover (20, fig. 4-1) and gasket.

(3) Drain chain case by removing plug (27).

(4) Remove level gage plug on right side under revolving frame.

(5) Remove nuts, screws and washers from forward and rear support brackets; remove rear support bracket and drop case into hole in revolving frame.

(6) Slide case to rear and drop out through revolving frame.

***Note.* Side member of revolving frame to left of case is removable if desired by removing three bolt at rear, two bolts t front and four bolts that come up through sill.**

b. Installation

(1) Installation is the reverse of removal procedure, a above.

(2) Refer to the lubrication order and service the chain case assembly.

4-6. Vertical Swing Shaft (fig. 4-4 and 4-7)

a. Disassembly.

(1) Swing machine so that shaft can be dropped down clear of the truck frame.

(2) Remove swing and propel gear case cover (fig. 4-2).

(3) Drain oil from sump of main gear case through two drain plugs (fig. 4-3).

(4) Loosen bolt at split hub of swing jaw clutch shifter and at the hand lever and pull hand lever shaft out taking care not to lose key.

(5) Remove propel jaw clutch shifter shoe pins and shoes.

(6) Take out clutch shifter.

(7) Remove vertical shaft cover and gasket by taking out four capscrews.

(8) Prepare blocking and extended jack under vertical swing shaft to provide for lowering it safely (pinion weight 50 pounds and shaft 80 pounds).

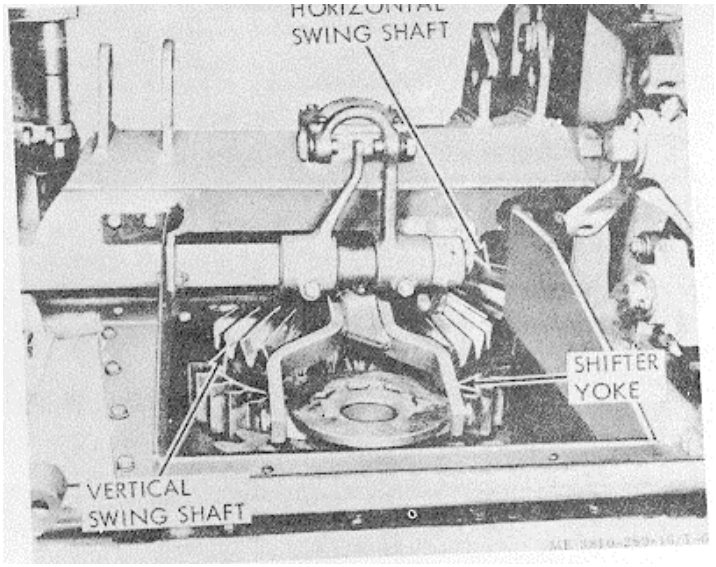


Figure 4-7. Vertical swing shaft repair and replacement.

(9) Remove cotter pin and nut at upper end of shaft and tap down lightly with babbitt hammer just enough to force through upper bearing.

(10) Pinion drops with the shaft and may be removed from shaft by taking out the two capscrews, lock plate, and removing the retainer plate.

(11) The upper bearing can be lifted out. The lower bearing can be tapped off from the shaft if necessary.

***Note.* If repair involves only the replacement of the pinion this an easily be removed without any of the above steps except paragraph 20.**

(12) Jaw clutch and combination bevel gear can be tilted and lifted out, after removing steering and digging lock horizontal shafts.

(13) There are still two ball bearings mounted in the combination gear. If it is necessary to remove these, tap down from bevel pinion end. The spacer between bearings will come out with bearings.

b. Inspection and Repair. Clean all parts thoroughly and inspect for damage and excessive wear. For gear and bearing inspection and repair, see paragraph 2-8. Replace defective gaskets and hardware. Rebuild broken or worn jaw clutch splines or jaws by welding and grinding. Replace worn or damaged oil retainer.

c. Reassembly.

(1) Replace top bearing, spacer, and lower bearing in combination gear if they have been removed. Place shield on upper side of top bearing.

(2) If oil seal at bottom of case is damaged, replace in revolving frame.

(3) Assemble pinion gearing with shield towards pinion, and pinion on lower end of shaft securing in place with retainer, two capscrews and lock plate.

(4) Place combination gear and jaw clutch in place in case and insert shaft from below.

Note. **Combination gear and jaw clutch must be held down by blocking under upper bearing housing, to prevent cocking as shaft is pushed up through with jack and blocking.**

(5) Replace upper bearing, washer and nut. Tighten nut until shaft runs tight and then back off one flat on hexagon nut to line up with cotter hole. Check to be sure of a free running fit and insert cotter to lock. Pack cavity half full GAA, wheel bearing grease, and replace gasket and shaft cover.

(6) Replace clutch shifter, shifter shoes, shaft and hand lever, also steering and digging lock controls, if previously removed.

(7) Replace main gear case cover and drain plugs in sump pan.

(8) Replace crown chain, or rope guard.

(9) Refill case with transmission case lubricant to high level in accordance with lubrication order.

4-7. Horizontal Swing Shaft (fig. 4-7 and 4-8)

a. Disassembly.

(1) Position upper works crossways with tracks to provide clearance needed to drop gear from gear case.

(2) Remove cover over swing and propel gear case (fig. 4-2).

(a) Clean cover.

(b) Take out capscrews along front edge of cover and slide cover forward.

(3) Drain oil from main gear case by removing two plugs in bottom of oil sump (fig. 4-3).

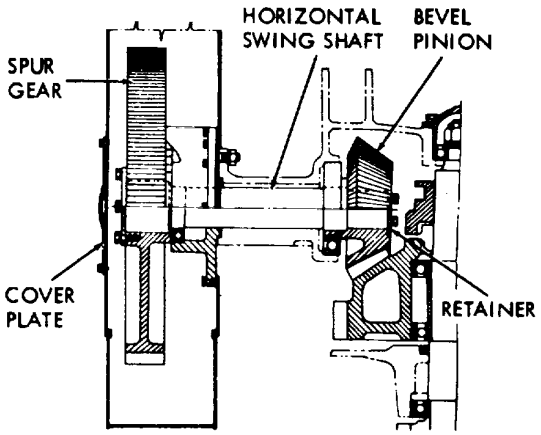


Figure 4-8. Horizontal swing shift, cutaway view.

(4) Remove sump pan from main gear case.

(5) Remove swing friction clutch shifter assembly unit.

(6) Remove hand hole cover on outer side of gear case.

(7) Remove the two capscrews and retaining plate on shaft at bevel pinion end.

Note. **Before removing bevel, mark the meshing of its teeth with its mating bevel so that its position can be duplicated to allow ready insertion of shaft in spline. The spline in the bevel pinion has six keyways, that in the spur gear has eight. Matching is difficult once relative positions are lost. If new pinion is to be installed match splines and duplicate the marks on old pinion. If shaft is to be removed (or position disturbed) mark case, end of shift and hub of spur gear to show relationship so splines can be meshed readily.**

(8) The shaft is now free to be pulled out partially. Leave the retaining plate on the spur gear side on the shaft to aid in pulling shaft.

(9) The bevel pinion will stay in its place. If it is to be removed, the combination bevel gear must be shifted out of the way by dropping the vertical swing shaft as described in paragraph 4-6. The bevel pinion can then be removed. The right ball bearing is a light tap fit on the hub of the bevel pinion and will come out with it, but it can be readily removed by prying it off.

(10) Support the spur gear, then remove the two outer capscrews in retainer, leaving the center one in place to aid in pulling shaft.

Caution: **Use a suitable lifting device when removing the shaft from the 160 pound spur gear. Take care not to bend the oil trough, located above the gear.**

(11) Pull the shaft all the way out. Catch the left ball bearing as it drops off shaft, and lower the spur gear down through the bottom of the gear case.

b. Inspection and Repair. Clean all parts thoroughly and inspect for damage and excessive wear. For gear and bearing inspection and repair, see paragraph 2-8. Replace damaged hardware.

c. Reassemblv.

(1) Insert left bearing in casting, with the shielded side inward.

(2) Raise up and support spur gear in gear case.

(3) Replace bevel pinion with right bearing on it, if it was removed.

Caution: **Both bearings must be replaced so that the shields are towards each other.**

(4) Insert shaft through hand hole at left of gear case, and thread through spur gear, left bearing, and bevel pinion.

(5) Replace the retainers at both ends of shaft with two capscrews with lockwashers on the bevel pinion end, and three capscrews with lockwashers on the spur gear end.

Note. Reassembly of shaft through spur and Into bevel requires simultaneous engagement of two sets of splines. If adequate marks were not made in disassembly, this process can be simplified by lining up a spline keyway in gears and noting into which position shaft must be rotated to similarly line up its spline. Two position line (note marking" notes in disassembly).

(6) Replace hand hold gasket and cover.

(7) Replace swing friction clutch shifter assembly unit.

(8) Replace sump pan and gasket checking to insure seal.

(9) Replace swing and propel gear case front

(10) Fill gear case to proper level with lubricant in accordance with the lubrication orders d. Adjustment. Remove or add shims under spur gear retainer to secure correct end play.

4-8. Rear Drum Shaft Assembly

a. General.

(1) The shaft is alloy steel mounted on ball bearings, with a 4" major diameter. Shaft speed is 37.6 R.P.M. with diesel engine direct drive at full load speed.

(2) Hoist and swing gears are heat treated steel castings with machine cut teeth. Hoist gear is keyed to the shaft. Swing gear is keyed to the swing clutch housing.

(3) Swing clutch housing is mounted on ball bearings.

(4) There is a plain tapered rope drum with integral clutch and brake housing mounted on ball bearings.

(5) The drum brake is an external contracting band type, 27"' diameter; 3" wide-and mechanically operated.

(6) The drum clutch is an internal expanding band type, 24" diameter; 3" wide and mechanically operated.

(7) The clutch on right side of rear shaft is used to power controlled load lowering of crane hoist line. Housing is grooved on outer surface for cooling. The clutch is mounted on ball bearings.

b. Removal (fig. 4-9 and 4-10).

(1) Lower boom to rest securely and slacken suspension ropes.

(2) Remove hoist rope from drum.

(3) Remove left front A-frame leg, first removing left front and center cab sections (fig. 2-2') if shaft is to be lifted out with crane. If removal is to be handled manually, shaft can be partially stripped and skidded out through left door without removing A frame leg or cab sections.

(4) Remove retract clutch guard.

(5) Remove hoist brake band. (fig. 4-9.)

(6) Remove retract and swing clutch shifter yokes and hoist clutch shifter screws (fig. 4-10).

(7) Remove shifter lever bridge.

(8) Remove right and left bearing housings, which are attached by two bolts in each.

Note. **Be careful not to mix right and left bearing bolts m right bolts are drilled to receive clutch guards.**

(9) Remove gear case cover.

(10) The entire assembly, weighing about 1200 pounds can now be lifted out if crane is available.

***Caution*: Do not move the assembly horizontally until the gears are clear of the cue.**

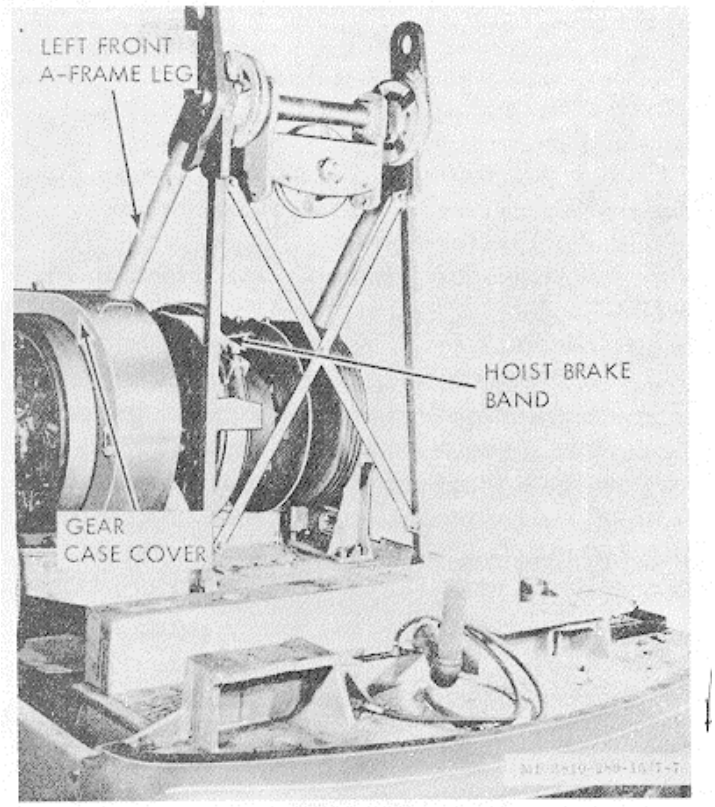


Figure 4-9. Rear drum shaft removal.

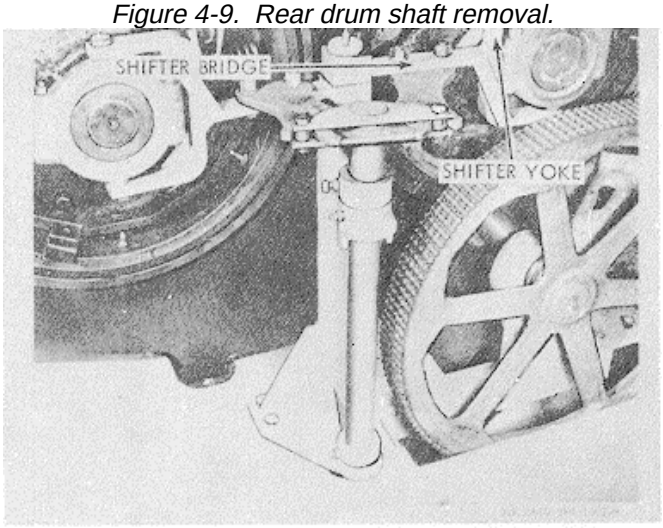


Figure 4-10. Re drum shift shifter bridge and yoke.

(11) If no crane is available and shaft must be removed manually, further dismantling in Race is advisable in order to reduce weight. See shaft disassembly instructions in following paragraphs.

c. Disassembly After Disconnecting and Removing Shaft From Machine. The following subassemblies remain on the shaft after carrying out the instructions in paragraph a. If shaft is to be removed manually, these should be disassembled as far as possible before and during raising of shaft following stripping directions as given below and in following paragraph. If a crane is used, these assemblies can be removed with the shaft and later disassembled as required.

(1) Rear swing-and-propel clutch.

***Note*. This swing-and-propel clutch can be removed as a unit by disconnecting the shifter yokes as described in previous paragraph, loosening the driver bolt, wedging open the split hub and sliding the entire assembly to the left off the shaft**

(2) Gears and left bearing

(3) Rear drum clutch.

***Note.* This clutch can alos be removed from housing as a unit on ground or after raising shaft so clutch clears frame.**

(4) Right shaft bearing.

d. Stripping After Removal From Machine (fig. 4-11).

(1) *General.*

(a) These stripping operations are after maximum disassembly of units as described in preceding paragraphs. In other words the shaft is now free and carrying only those parts which must be pulled off from the ends of the shaft itself. Where shaft is being removed manually, it is usually more convenient to remove these units from the left and right as described below as the elevation of the shaft permits sufficient clearance. When the shaft is finally removed through the left door, it then carries only the hoist gear and left bearing.

(b) Disassembly instructions are presented is two sections: Disassembly to the right, dissasembly to the left.

(c) Either sequence may be taken first. For instance to replace the swing gear, start with the second section and leave the assemblies to the right on the shaft, disassembling only to the point necessary for removal of the swing clutch housing with gear mounted on its hub from the machine.

(2) *Disassembly operations to the right.*

(a) Pull off right shaft bearing housing and bearing which is a light tap fit. Take care to protect bearing shield from damage. Remove bearing housing by tapping lightly.

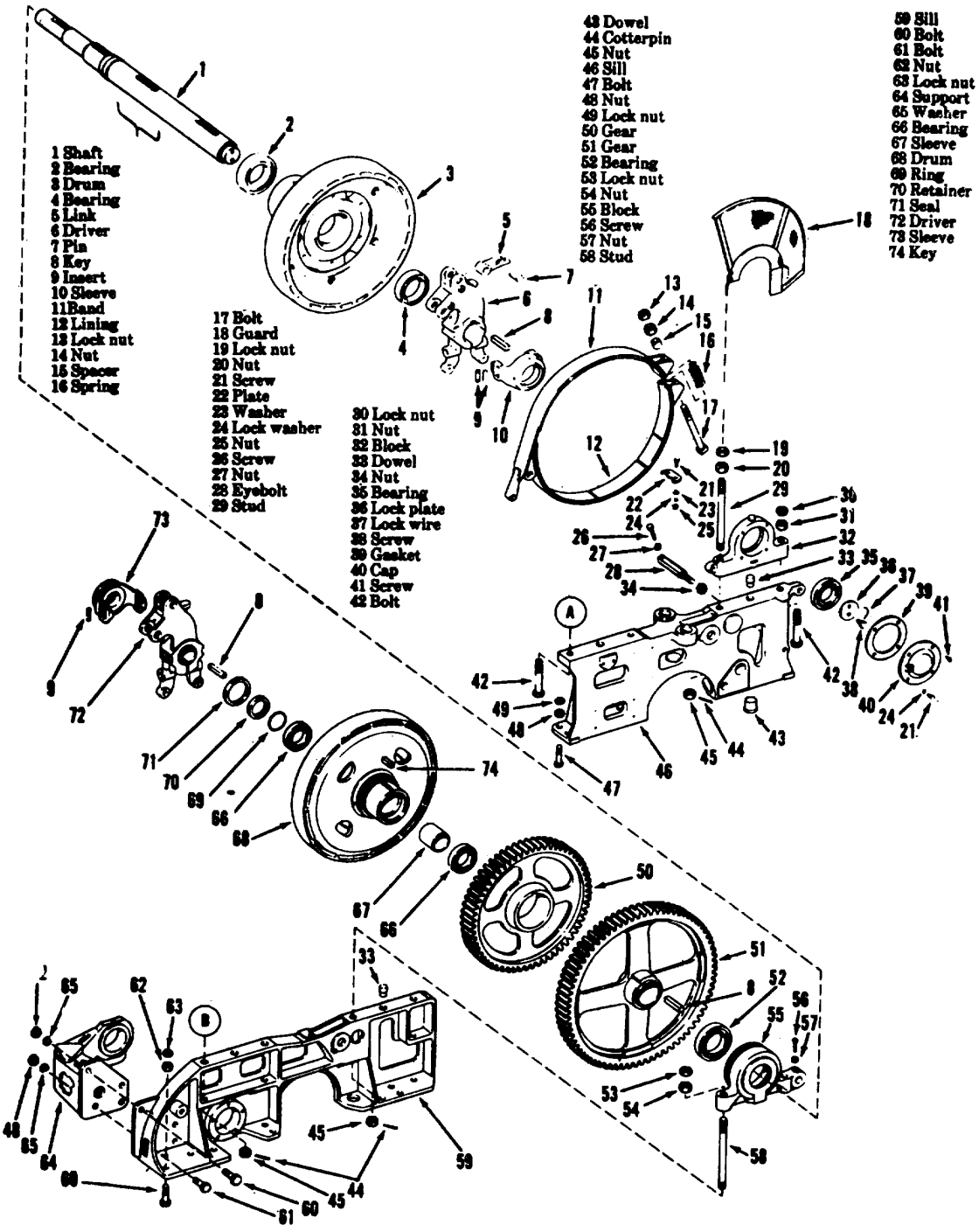
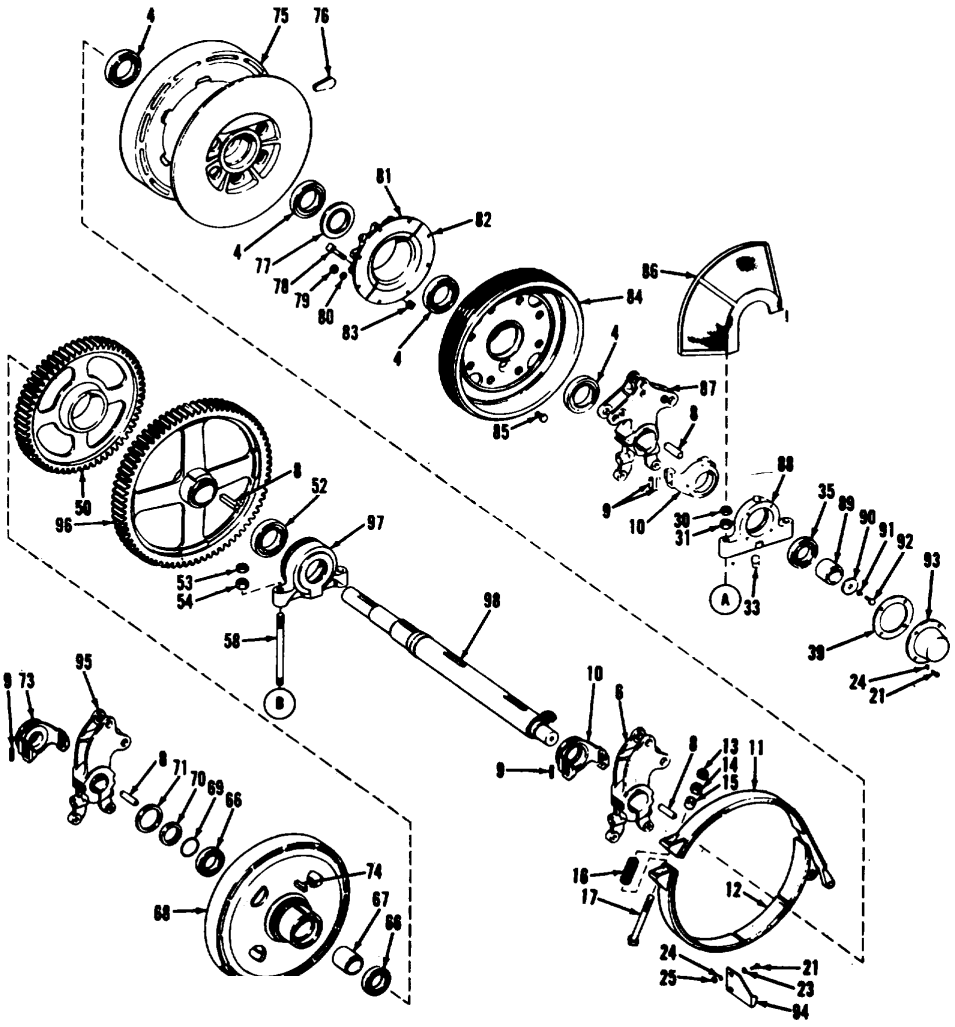


Figure 4-11. Rear and front drum shaft assembly exploded view (sheet 1 of 3).



4 Bearing
6 Driver
8 Key
9 Insert
10 Sleeve
11 Band
12 Lining
13 Locknut
14 Nut
15 Spacer
16 Spring
17 Bolt
21 Screw
23 Washer
24 Lock washer
25 Nut
30 Lock nut
31 Nut
33 Dowel
35 Bearing
39 Gasket
50 Gear
52 Bearing
53 Lock nut
54 Nut
58 Stud
66 Bearing
67 Sleeve
68 Drum
69 Ring
70 Retainer
71 Seal
73 Sleeve
74 Key
75 Drum
76 Wdge
77 Collar
78 Bolt
79 Nut
80 Washer
81 Sprocket
82 Sprocket
83 Nut
84 Drum
85 Screw
86 Guard
87 Driver
88 Block
89 Sleeve
90 Lockplate
91 Washer
92 Screw
93 End cap
94 Shield
95 Driver
96 Gear
97 Block
98 Shaft

Figure 4-11. Rear end front drum shaft assembly exploded view (sheet 2 of 3)

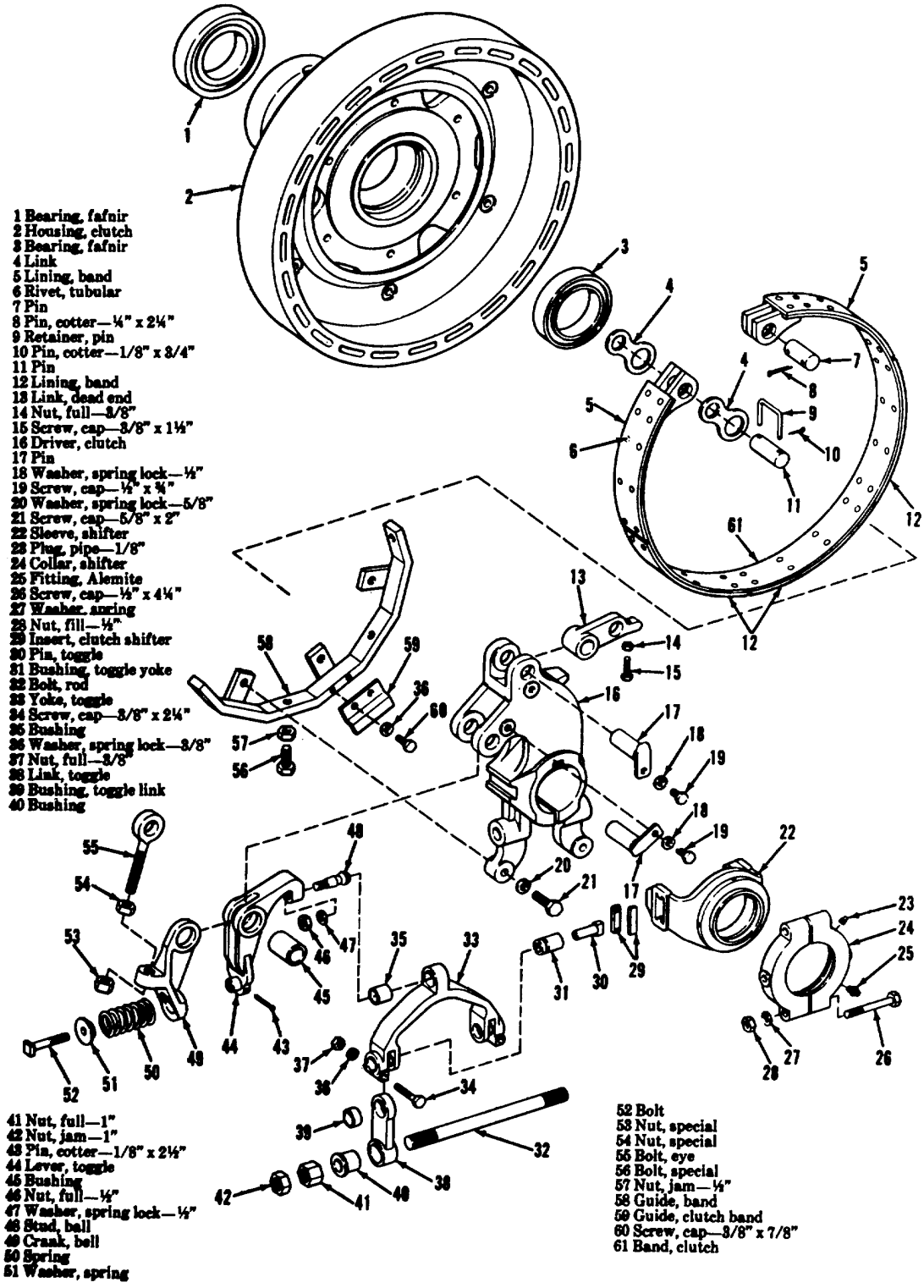


Figure 4-11. Rear and front drum shaft assembly, exploded view (sheet 3 of 3).

(b) Loosen bolt through split hub of secondary hoist clutch driver wedge open, and remove entire clutch assembly and key.

Note. **The entire secondary hoist clutch comes out from housing m a unit on the driver and may be dissembled later.**

(c) Smooth shaft with fine emery cloth around keyway, use fine file on heavy burrs, clean, oil, and inspect entire shaft to right.

(d) Pull secondary hoist friction clutch housing and sprocket. Right bearing comes along in place. Use pinch bar and block of wood to bump unit along from left of sprocket. Take care to avoid damage to left bearing shield.

(e) After unit is off from the shaft, remove outer (right) bearing by tapping out from left through hub of housing.

(f) Sprocket may be pulled off from sleeve end of housing by using 20-to 30-ton press.

(g) Tap off inner (left) clutch bearing and spacer.

(h) Remove rear drum by driving from left; left drum bearing usually remains in place.

(i) Tap right bearing out of drum after drum is off from shaft; swing round wood handle or bar.

(j) Tap left drum bearing off from shaft.

(k) Slide off clutch assembly by loosening hub bolt and wedging hub open. If driver comes hard, remove pins from toggle links and slide shafter collar and sleeve to left. Bump and pry directly against driver hub.

(l) Remove key. Smooth shaft with emery paper and fine file as in (c) above.

(m) Tap left bearing housing free of bearing and slide off to right, leaving bearing to be removed to left.

(n) This completes disassembly operations to the right.

(3) *Disassembly operation to the left.*

(a) Remove clutch driver and entire clutch assembly from housing by loosening driver bolt and wedging split hub open. Remove driver key.

(b) Smooth shaft around keyway with emery cloth and fine file, inspect, clean, and oil entire left shaft.

(c) Pull swing-and-propel friction clutch housing with the swing gear in place using a pinch bar and wood block to bump it along. Left bearing will come with housing.

(d) Remove right bearing.

(e) If desired, the swing gear may be removed from housing but a 20-to 30-ton capacity press required.

(f) The hoist gear and left shaft bearing are now the only remaining parts on the shaft. The hoist gear is a press fit on the shaft and a 20-to 30-ton press is required to pull it.

(g) The left bearing can now be removed d to the left with the press.

(h) This completes disassembly to the,

e. Inspection and Repair. See front drum shaft inspection and repair, paragraph 4-10. For bearing and gear inspection and repair, see paragraph 2-8.

f. Assembly, Preparatory to Installations on the Machine.

(1) General Assembly instructions are presented in two sections: Assembly from the left, assembly from the right. Either sequence may be taken first.

(2) Assembly operation from the left (fig. 4-12).

(a) Press on left shaft bearing and set its shield side solidly against shoulder on shaft. Bearing housing is assembled later from right.

(b) Place the key for the hoist gear in keyway. Press the hoist gear in place (long hub next to bearing) on the shaft using a 20 to 30 ton press.

(c) Replace right swing clutch bearing.

(d) Replace swing gear on housing using a 20to 30-ton press (long hub away from housing).

(e) Place housing on shaft and tap into position over right bearing.

(f) Insert left swing clutch bearing and tap into place with shield outermost.

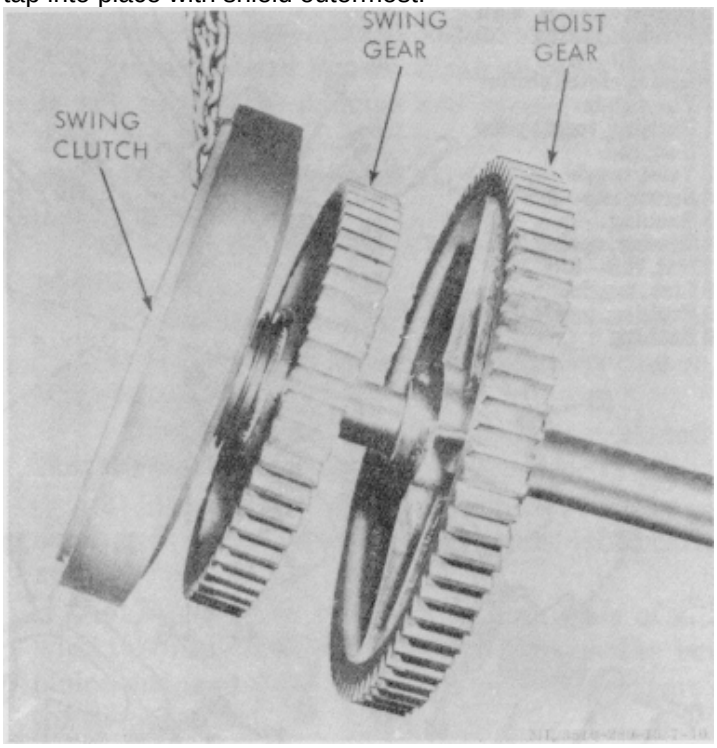


Figure 4-12. Rear drum shaft assembly (left side).

Note. **The three bearings mentioned in (a), (d), and (g) are oil lubricated from the gear cue and should NOT be peeked with grease. Dip each in OE, oil engine before assembly.**

(g) Place driver key and replace clutch assembly using wedge to hold split hub open. Remove wedge and tighten driver bolt (driver key must not protrude from driver hub).

(h) This completes assembly operations from the left.

(8) *Assembly operations from the right.*

(a) Tap left bearing housing over left bearing.

(b) Remove clutch driver from hoist clutch assembly and slide on shaft. Insert key in keyway mad slide on clutch assembly by wedging split hub to give free movement. Remove wedge and lock in position by tightening driver bolt. See figure 4-18.

(c) Check distance between bearing facing lip and uppermost part of clutch. Allowable tolerance is 257/16" ± 1/32" (fig. 4-14).

(d) Tap left drum bearing into position with shield side against driver.

(e) Put combination drum and clutch housing on shaft and drive it into place on left bearing. Pack cavity half-full with GAA wheel bearing grease.

(f) Tap right bearing into position in right end of drum with shield outermost.

(g) Slide spacer into place.

(h) Tap on the inner bearing of the secondary hoist clutch housing and sprocket with shield side next to spacer.

(i) If sprocket has been removed from hub of housing replace it using 20-to 30-ton press.

(j) Slide housing with sprocket into place and tap into position on inner bearing. Pack cavity halffull with GAA wheel bearing grease.

(k) Insert outer bearing and tap it into place in hub with shield side outermost.

(l) Insert driver key in keyway and slide clutch assembly into place wedging split hub to permit free movement. Driver key must not protrude from driver hub.

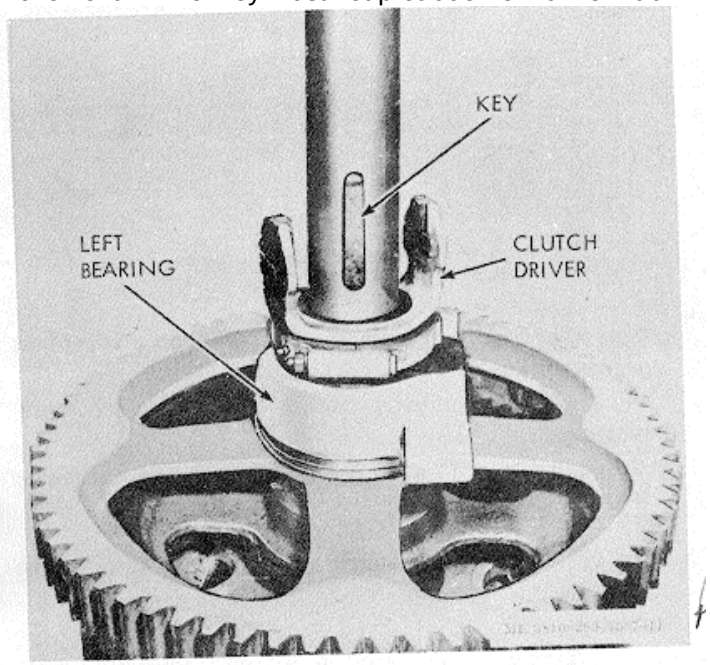


Figure 4-13. Rear drum shaft assembly (right side).

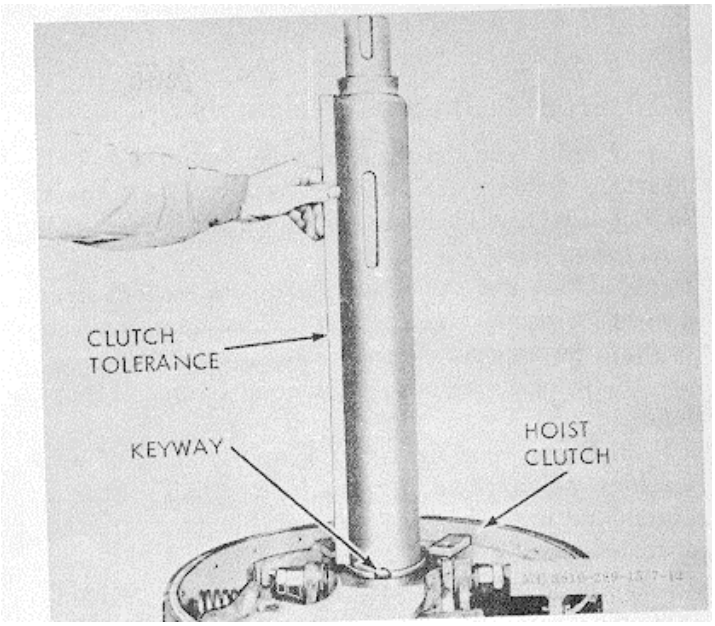


Figure 4-14. Rear drum shaft assembly.

lock into place.

Note. **In assembling part all across the shaft from the main drum clutch driver to secondary hoist clutch driver, seat each part solidly against the part ahead of it. When the secondary hoist friction clutch driver has been thus seated, back it off 1/32 inch before clamping in place on shaft to provide a free running fit for all parts across right side of shaft.**

(n) Tap right shaft bearing into right bearing housing (shield side inside) solidly against shoulder.

(o) Tap assembly of bearing and housing on shaft, open side (on cover side) of housing outermost.

(p) This completes assembly operations from the right.

g. Installation.

(1) Lower shaft into place, carefully matching bearing housing and their shear pins.

(2) Bolt housings in place.

(3) Install gear case cover.

(4) Assemble three main clutch shifter yokes.

(5) Install rear drum brake band and connect brake lever.

(6) Install clutch guard and left front A-frame leg.

(7) Reeve hoist rope on drum.

(8) Replace cab section. (fig. 2-2).

(9) Drain and replace transmission case lubricant in accordance with lubrication order.

h. Complete Shaft Installation and Connections.

(1) Replace left side and front corner of cab. (fig. 2-2).

(2) Reassemble secondary hoist clutch band.

(3) Reassemble rear hoist drum clutch.

(4) Reassemble swing-and-propel clutch.

4-9. Hoist Clutch

For disassembly procedure of the hoist clutch refer

to figure 4-11 and disassemble shaft as required to remove the hoist clutch.

4-10. Front Drum Shaft Assembly

a. General. The shaft is alloy steel mounted on ball bearings with a 4 1/8" major diameter. Shaft speed is 37.1 R.P.M. with diesel engine direct drive at full load speed.

(1) Hoist and swing gears are heat treated steel castings with machine cut teeth. Hoist gear is keyed to shaft. Swing gear is keyed to swing clutch housing.

(2) Swing clutch housing is mounted on ball bearings.

(3) Boom hoist drum is located inboard of left machinery side frame. It is mounted on ball bearings. Clutch and brake housing are cast integral with the drum.

(4) Boom hoist brake is external contracting band type, spring set and released with boom hoist control lever. It has 24" diameter and is 2 1/2" wide.

(5) Boom hoist clutch is internal expanding band type, set by a booster clutch band. It is mechanically controlled, 20" in diameter and 2" wide.

(6) Boom hoist clutch driver is keyed to the shaft.

(7) Front rope drum clutch housing is cast integral with brake and clutch housing. It is mounted on ball bearings.

(8) Drum brake is external contracting band type, 27 1/2" in diameter, 3" wide and mechanically operated.

(9) Drum clutch is internal expanding band type, 24" in diameter, 3" wide and mechanically controlled.

(10) Forward and below the front drum shaft is a countershaft which contains the mechanism for power controlled lowering of the boom hoist.

b. Removal. Refer to figure 4-15.

(1) Lower boom to rest securely, slacken suspension ropes, and remove rope from boom hoist drum.

(2) Remove left front A-frame leg.

(3) Remove left front cab sections (fig. 2-2) if lifting shaft with crane. If handling manually, shaft can be partially stripped and skidded out through left door.

(4) Remove clutch and boom hoist guards.

(5) Remove boom hoist speed control chain (disconnect at any link) and safety pawl control rod.

(6) Remove boom hoist brake and booster bands.

(7) If front rope lagging is on, remove rope guard at the drum flange.

(8) Remove retract brake band. (fig. 4-16).

(9) Remove clutch shifter yokes by first removing integral head plate and yoke pin and the two yoke screws on each at the collar ends.

(10) Remove two long horizontal bolts supporting lever bracket on right hand bearing housing. Disconnect controls and remove bracket for convenient access to shaft.

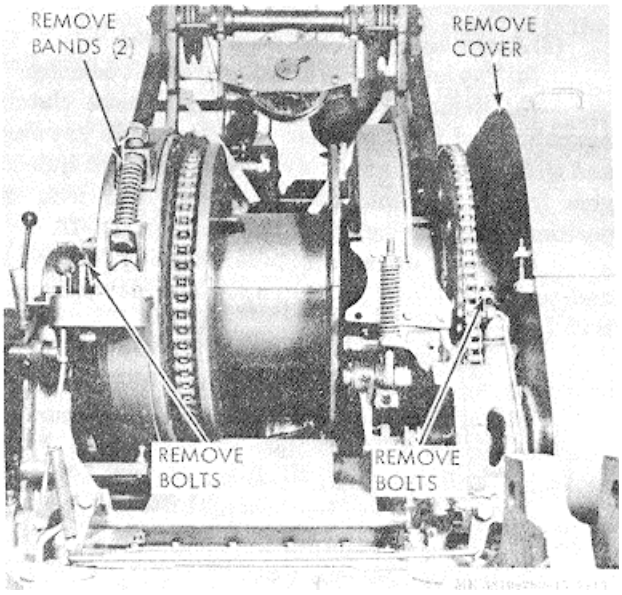


Figure 4-15. Front drum shaft removal.

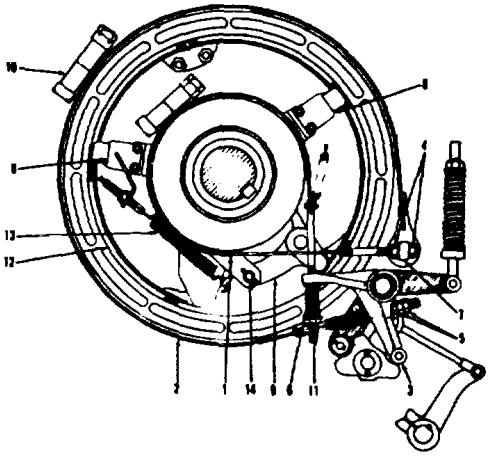


Figure 4-16. Boom hoist clutch and brake band removal and installations.

1 Booster band
2 Brake band
3 Booster band cam roller
4 Booster band clutch adjusting nuts
5 Brake band adjusting nuts
6 Cushion spring
7 Dead end pin
8 Band guides
9 Main clutch bell crank
10 Booster bond joint bolt
11 Cushion spring nut
12 Main clutch band
13 Clutch release spring
14 Cotter pins

nect controls and remove bracket for convenient access to shaft.

(11) Remove bolts from right and left bearing housings.

Note. **Be careful not to mix up right and left bearing housing bolts as right bolts are drilled to receive clutch guards.**

(12) Remove gear case cover.

(13) The entire shaft assembly, weight about 1200 pounds, can now be lifted out if crane is available.

Caution**: Do not move the assembly horizontally until it has been lifted far enough so the gears are out of the case.**

(14) Further dismantling in place is advisable to reduce weight if no crane is available and shaft is to be removed manually. Refer to shaft disassembly instructions.

c. Disassembly. After Disconnecting and Removing Shaft From Machine. See figure 4-11.

(1) General The following subassemblies remain on the shaft after carrying out the instructions in paragraph b. If shaft is to be removed manually, these should be disassembled as far as possible before raising shaft for stripping operations. If a crane is used these assemblies can be removed with the shaft and later disassembled as required.

(2) Swing-and-propel clutch. The swing-and propel clutch can be removed as a unit after disconnecting the shifter yoke as described in paragraph a. by loosening the driver bolt, wedging open the split hub and sliding the entire assembly to the left off from the shaft.

(3) Gears and left bearing. Refer to stripping shaft, d below.

(4) Boom hoist, clutch and booster. Refer to paragraph 4-12.

(5) Drum lagging. Remove drum lagging.

(6) Front drum clutch Refer to paragraph 4-11.

Note. This clutch can also be removed as a unit from housing on ground or after raising to clear frame.

(7) Right shaft bearing. Refer to stripping front shaft, d below.

d. Stripping After Removal From the Machine.

(1) General.

(a) These stripping operations are after maximum disassembly of units as described in sections referred to in previous paragraph. In other words the shaft is now stripped down to those parts which must be pulled off from the ends of the shaft itself. Where shaft is being removed manually it is usually more convenient to remove these units from the left and right as the elevation of the shaft permits sufficient clearance of the shaft. When the shaft is finally removed through the left door, it carries only the hoist gear and left bearing.

(b) Disassembly instructions are presented in two sections. Disassembly to the right or disassembly to the left.

(c) Either sequence may be taken first. For instance, to replace the left shaft bearing, start with the second section and leave the assemblies to the right on the shaft, disassembling only to the point necessary for removal of the complete shaft assembly from the machine.

(2) Disassembly operations to the right (fig. 4-11).

(a) Remove right hand bearing cover and gasket from right end of shaft. Cover is attached with four screws.

(b) Take out two retainer capscrews and remove the shaft retainer (5).

(c) The bearing housing, which is a light tapping fit, with the bearing can now he pulled off. Take care not to damage bearing shield. The bearing can be removed from the housing by lightly tapping it.

(d) Loosen clutch driver bolt through the split hub, wedge split hub open and remove driver assembly. Remove driver key.

Note. The entire clutch comes out from housing as a unit on the driver and may be disassembled later. Refer to figure 4-11 and disassemble in numerical sequence.

(e) Smooth the shaft with a fine emery cloth around the keyway, clean carefully and drop on some engine oil to insure free movement of the tap fit bearings that list slide off over the shaft. Before starting each bearing off inspect the section of the shaft over which it must slide carefully for any scratches or mars that may have left upset steel on the surface. Remove heavy burrs with a fine file.

(f) Now pull the primary hoist friction clutch housing which is integral with the drum sleeve. The right bearing comes with it, in place. Use a pinch bar and a wood block behind the left end of the drum sleeve to bump it off. Take care to protect shield of bearing at left end of sleeve. Left bearing will usually stay in place on shaft.

(g) After the housing is removed from shaft, the outer (or right) bearing may be tapped out of housing by inserting a bar or hammer handle from the left and tapping it lightly.

(h) Tap the left (or inner).bearing and spacer off from the shaft.

(i) The boom hoist driver with the booster housing on it now slides off.

(j) Remove the key and use emery cloth to smooth off rough edges of keyway. Use fine file to remove any heavy burs. Clean, oil, and inspect entire shaft.

(k) Slide off boom hoist drum, carrying the right bearing along and leaving its left bearing in place. Right bearing can be removed after drum is off the shaft.

(1) Remove left boom hoist drum bearing.

(m) Slide off left shaft bearing housing. The ball bearing will remain in place, and must be removed to left.

(n) This completes disassembly operations to the right.

(3) Disassembly operations to the left. (a) Loosen clutch driver bolt, wedge driver hub open, remove entire clutch assembly as a unit or disassemble in place as may be most convenient. (b) Smooth shaft around keyway with emery cloth. Clean and oil. Use fine file on heavy burrs if

necessary.

(c) Pull swing and propel friction clutch housing with the swing gear in place, using a pinch bar and wood block to bump it along. The left hand bearing will come with housing.

(d) Remove right hand bearing which is a light tapping fit, .

(e) If desired, the swing gear may be removed from housing but a 20- to 30-ton capacity press is required.

(j) The hoist gear and left shaft bearing are now the only remaining parts on the shaft. The hoist gear is a press fit on the shaft and a 20-to 30-ton press is required to pull it.

(g) The left bearing can now be removed to the left by pulling with the press or tapping off.

Caution: Do not damage oil seal on bearing.

(h) This completes disassembly operation to the left.

e. Inspection and Repair. Clean all parts thoroughly and inspect for damage and excessive wear. For bearing and gear inspection and repair procedures, see paragraph 2-8. Replace, or repair by welding, any broken or cracked parts. Place shaft in V-blocks and rotate using dial indicator to detect bent shaft Straighten shaft in press or replace if bent. Check drums for scoring, and if in bad condition, replace Check keys and keyways for good condition and tight fit. Replace damaged keys.

Note. The undercut tolerances for drums, clutches and brakes is .090 inch on the radius.

f. Assembly Preparatory to Installation on Machine.

(1) General Assembly instructions are presented in two sections: Assembly from the left, assembly from the right. Either sequence may be taken first.

(2) Assembly operation from the left.

(a) Refer to figure 4-11 under rear drum shaft assembly and follow the assembly procedure for the left side of the shaft.

(b) Reverse disassembly sequence shown in figure 4-11.

(3) Assembly operations from the right.

(a) Tap left bearing housing over left bearing.

(b) Tap on left boom hoist drum bearing, seating its shield side against shaft shoulder.

(c) Slide boom hoist drum into place and tap it onto its left bearing, pack drum cavity half full with GAA wheel bearing grease.

(d) Tap right bearing with its shield towards outer side of drum and into place in boom hoist drum.

(e) Insert key and slide boom hoist clutch with booster housing on it, into place on key. Booster housing must float free on driver hub. See figure 4-17.

(f) Slide on spacer.

(g) Tap inner crowd clutch housing bearing into housing and slide crowd clutch housing with integral drum onto shaft, seating hearing shield side against spacer; pack sleeve half full with GAA, wheel bearing grease. See figure 4-17.

(h) Tap outer bearing into place with shield outermost.

(i) Replace driver key and slide on clutch assembly with wedge in split hub. Remove wedge and tighten bolt through split hub (driver key must not protrude from hub).

(j) Tap right shaft bearing into right bearing housing, shield side against shoulder.

(k) Tap assembly of housing and bearing on shaft, open (or cover) side of housing outermost.

(1) Replace shaft retainer and lock with two wired capscrews. Pack half full with GAA grease.

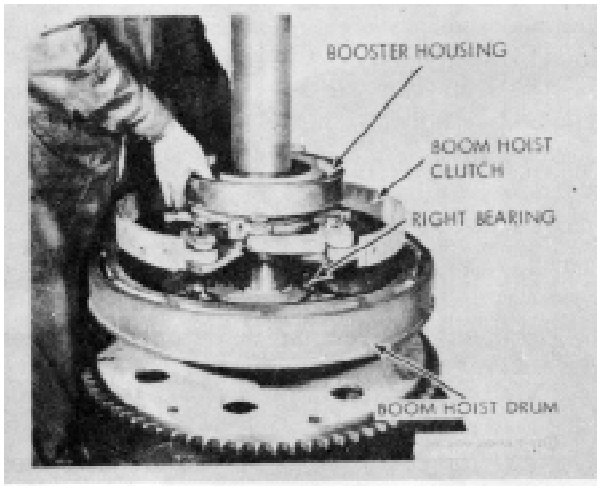


Figure 4-17. Front drum shaft assembly (right side) (sheet 1 of 2).

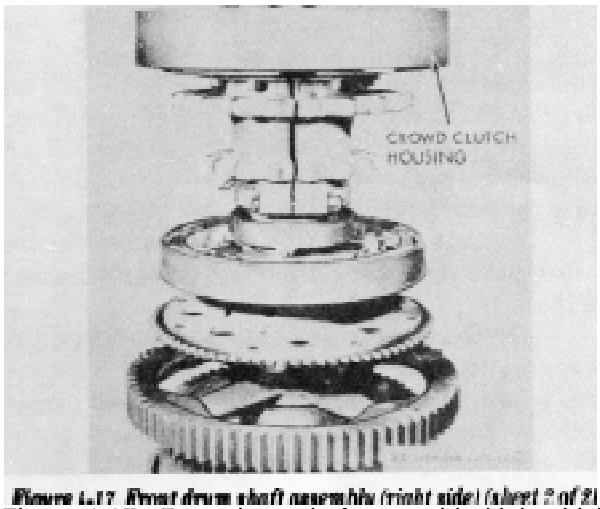


Figure 4-17. Front drum shaft assembly (right side) (sheet 2 of 2).

(m) Replace gasket being sure that it is in good condition.

(n) Replace right hand bearing cover and fasten in place with two capscrews with lockwashers and two countersunk head screws. Cover will only

assemble in one position.

Now In assembling parts all crow the shaft, seat each solidly against part ahead of it. When the primary hoist friction clutch driver has been thus seated, back it off 1/82 inch before clamping in place on shaft.

(o) This completes assembly operations from the right.

g. Installation.

(1) Lower shaft into place, carefully matching bearing housings and their shear pins.

(2) Bolt housings in place.

(3) Replace gear case cover.

(4) Replace clutch shifter yokes (replace both screws and pins).

(5) Replace crowd brake band, boom hoist brake and booster bands.

(6) Replace drum flange rope guard (if rope lagging is on).

(7) Replace boom hoist lowering control chain and safety pawl control rod.

(8) Replace clutch and boom hoist guards.

(9) Replace left front A-frame leg.

(10) Replace cab section (fig. 2-2).

(11) Drain and replace lubricant in gear case in accordance with lubrication order.

h. Complete She installation and Connections.

(1) Install front left corner of cab (fig. 2-2).

(2) Assemble front drum clutch.

(3) Install drum lagging.

(4) Assemble boom hoist clutch and booster.

(5) Assemble swing-and-propel clutch.

4-11. Front Drum Clutch

For disassembly procedure of the front drum clutch refer td figure 4-11 and disassemble shaft as required to remove the front drum clutch.

4-12. Independent Boom Hoist Assembly

a. Safety Pawl Removal (fig. 4-18).

(1) Part the drive chain by removing cotter pins in pin link assembly at any pin link.

(2) Remove the cover plate from left side of gear case.

(3) Remove cotter pins from lowering pawls pin and loosen setscrew.

(4) Remove pawl pins and lift pawls from shaft.

b. Control Shaft Removal.

(1) Remove shaft cap and loosen setscrew.

(2) Slide sprocket from shaft.

(3) Tap out control shaft with housing and ball bearings on shaft.

(4) Ball bearings on sprocket end of shaft should remain in place unless replacement is required.

c. Control Linkage. Refer to figure 4-19 and remove control linkage.

d. Disassembly. Refer to figure 4-20 and dissemble the independent boom hoist assembly in numerical sequence.

e. Inspection and Repair.

(1) Clean all parts in an approved cleaning solvent.

(2) Inspect parts for damage or wear.

(3) Rebuild broken or cracked parts by welding and grinding, or replace them.

(4) Replace all damaged or worn hardware and gaskets.

f. Reassembly.

(1) Ball bearing and seal in bracket must be replaced before shaft is installed, only if removal was necessary because of damage to oil seal during bearing removal.

(2) Assemble on shaft.

(a) Ratchet housing and pinion.

(b) Slide bearings into pinion with right bearing shield against shoulder on shaft.

(c) Slide right and left retainers on shaft.

(d) Slide pawl arm on shaft. Insert key and lock arm in place with setscrew.

(3) Slide control shaft into gear case, being careful not to damage oil seal.

(4) Install sprocket against shoulder of shaft and lock in place with setscrew.

(5) Refer to figure 4-18 and replace pawl.

(6) Replace gasket and cover plate and connect drive chain.

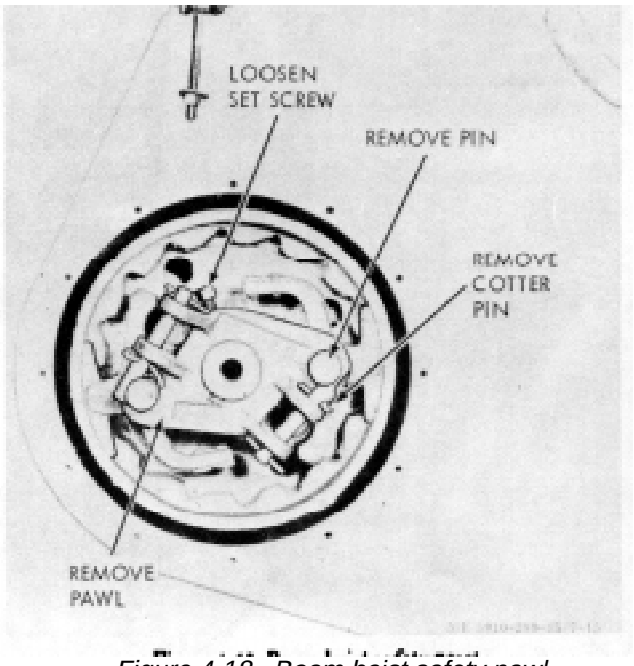


Figure 4-18. Boom hoist safety pawl.

4-13. Hoist Assemblies

Refer to figure 4-11 and follow disassembly of the front and rear drum shafts as required to remove the hoist assembly.

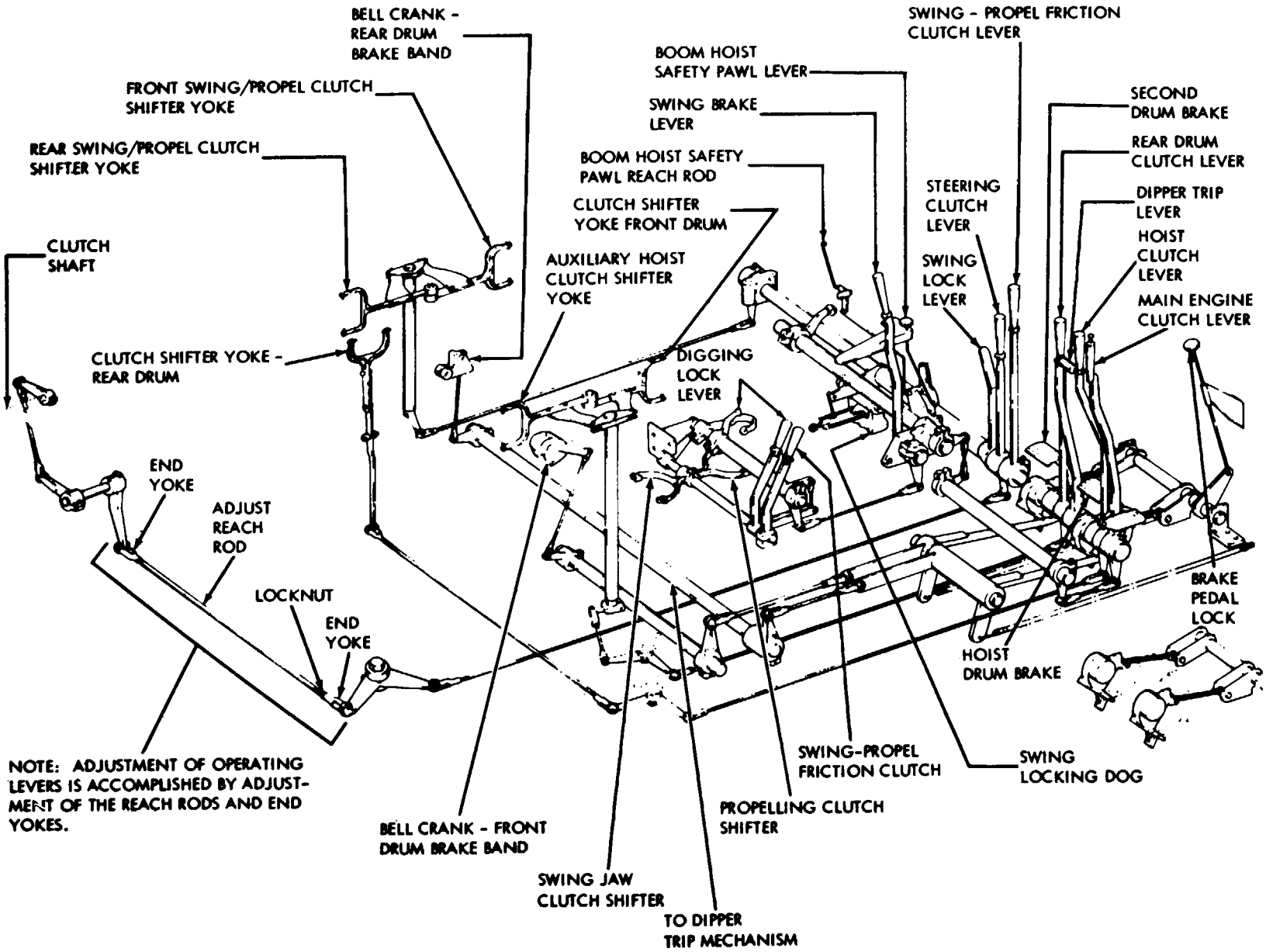


Figure 4-19. Control levers.

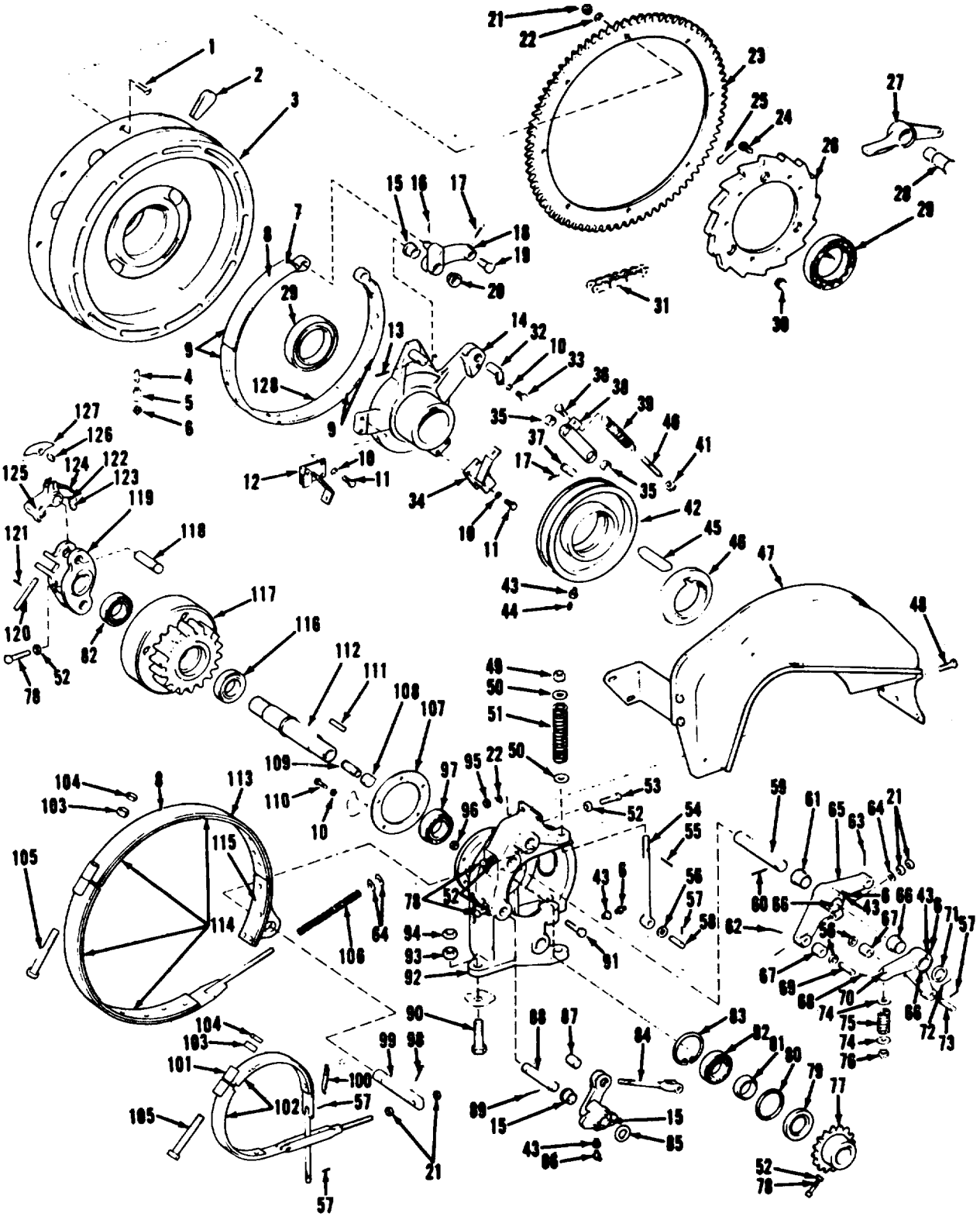


Figure 4-20. Independent boom hoist assembly, exploded view.

1 Screw, cap CTSK—½" x 1½"
2 Wedge
3 Drum
4 Nipple, close—1/8"
5 Coupling, std. pipe—1/8"
6 Fitting, alemite
7 Rivet—#10 x 29/32"
8 Rivet—#10 x 7/16"
9 Lining
10 Washer, spring lock—3/8"
11 Screw, cap—3/8" x 1"
12 Guide, band
13 Pin, cotter—¼" x 1½"
14 Driver, clutch
15 Bushing
16 Pin, cotter
17 Pin, cotter—3/16" x 2"
18 Crank, bell
19 Pin
20 Bushing
21 Nut, full—½"
22 Washer, spring lock—½"
23 Sprocket
24 Screw, cap special—½" x 1"
25 Lockwire—#12 x 26"
26 Ratchet
27 Pawl
28 Pin, pawl
29 Bearing
30 Dowel
31 Chain
32 Pin
33 Screw, cap—3/8" x 5/8"
34 Bracket, band guide and spring
35 Bushing
36 Screw, special cap
37 Pin
38 Link, booster
39 Spring, tension
40 Bolt, takeup
41 Nut
42 Housing, booster
43 Bushing, red—¼" x 1/8"
44 Fitting, hyd. lub.—1/8"
45 Key, special
46 Spacer
47 Guard
48 Screw, cap—½" x 1½"
49 Nut, full—5/8"
50 Washer, spring
51 Spring, compression
52 Nut, jam—½"
53 Screw, set—½" x 1¾"
54 Rod, end
55 Pin, cotter—3/16" x 1¼"
56 Washer
57 Pin, cotter—1/8" x 1"
58 Pin
59 Pin
60 Pin, cotter—5/16" x 1¾"
61 Bushing
62 Pin, cotter—1/8" x 2"
63 Pin, cotter—1/8" x 1¾"
64 Washer, special—½"
65 Lever
66 Bushing
67 Roller, cam
68 Pin, cotter
69 Pin
70 Crank, bell
71 Washer
72 Pin, cotter—1/8" x 1¾"
73 Pin
74 Washer, plain—½"
75 Spring, compression
76 Nut, slotted
77 Sprocket
78 Screw, set
79 Retainer, oil
80 Spacer
81 Collar
82 Bearing
83 Ring, snap
84 Rod, reach
85 Washer
86 Fitting, hyd. lub.—1/8" x 90°
87 Pin
88 Pin
89 Pin, cotter—¼" x 1¾"
90 Bolt
91 Screw, cap—½" x 2¼"
92 Bracket, anchor
93 Nut, full—7/8"
94 Nut, jam—7/8"
95 Nut, full—½"
96 Nut, jam—½"
97 Bearing
98 Pin, cotter—¼" x 2"
99 Pin, brake anchor
100 Spring, ext.
101 Band, booster
102 Lining
103 Nut, full—¾"
104 Nut, jam—¾"
105 Screw, cap—¾" x 4¾"
106 Spring, compression
107 Gasket
108 Cap, pipe—½"
109 Nipple—½" x 2½"
110 Screw, cap—3/8" x 1"
111 Key, straight
112 Shaft
113 Band, brake
114 Lining
115 Lining
116 Bearing
117 Housing
118 Pin
119 Arm, pawl
120 Pin
121 Pin, cotter—3/16" x 1
122 Rivet, but.—¼" x ¾"
123 Washer, plain—#10
124 Spring
125 Pawl
126 Pin, friction shoe
127 Shoe, friction
128 Band, clutch

4-14. Main Clutches

a. Removal and Disassembly. See figure 4-11.

(1) Remove clutch band.

(a) Loosen lock nuts and turn down two band guide screws in the guide, enough to free band.

(b) Remove cotter pin, take out U shaped retainer pin, and remove band live end pin.

(c) Remove band dead end (anchor) pin by removing capscrew in lock plate.

(d) Swing the two live end links away from live end of band and loosen lock nut on adjusting bolt to give maximum clearance.

(e) Rotate band bout 2 inches so that live end approaches dead end anchor position and slide it out of housing.

(2) Remove end nut from adjusting bolt and remove bolt.

(3) Take out the two cotter pins in toggle yoke and pull out the two bushings together with their headed pins.

(4) Pull the toggle yoke off the ball stud and remove it.

(5) Take out the two bolts and remove the band guide.

(6) Two toggle links and their bushings are readily removed by taking off nuts on ends of long clutch driver bolt (nut on one end locked with cotter pin). The bolt itself cannot be removed unless clutch driver is shifted on shaft enough to allow bolt to clear clutch housing (loosen clutch driver bolt and wedge hub open).

(7) Remove sub-assembly of bell crank, toggle lever, toggle lever spring, and live end links:

(a) Remove capscrew locking bell crank fulcrum pin.

(b) Remove bell crank fulcrum pin with lock plate attached and remove the subassembly.

(c) Complete disassembly if necessary by removing cotter pin and spring bolt. Live end links and toggle lever may be separated from bell crank by driving out pin bushing.

Note. This toe lever spring is t at the factory for correct adjustment. Do not disturb by disassembly unless necessary.

(8) There is now left on the shaft: the new clutch housing with bearings, clutch driver and key, and shifter sliding sleeve. On the swing-and-propel clutches these parts can be removed by simply sliding off the shaft (wedge open split hub of driver for easy removal). On the remaining three drum clutches, the above parts can be removed only by disassembling the front and rear shafts to the point where these parts can be removed. (para 4-8 and 4-9).

b. Reassembly.

(1) Insert bearings in clutch housing, pack half full with GAA grease.

(2) Assemble clutch driver bolt, toggle links and bearings to clutch driver. Do not tighten bolt but wedge split hub open.

(3) Insert clutch driver key in shaft and slide on driver.

Note. Driver key must not project beyond drive hub face or it will interfere with necessary travel of shifter sleeve.

(4) Remove wedge and tighten driver bolt securely.

(5) Put on the clutch shifter sleeve.

(6) Make up bell crank subassembly:

(a) Insert live end links and toggle lever in bell crank. Drive in bushing. Turn bushing half way around when replaced to give double life.

(b) Replace spring by inserting bolts; screw down to spring height of 2 5/16-inches and cotter pin to lock.

(c) Insert adjusting bolt and nuts. Thick nut goes on outer end, thin nut inside on eye end.

(7) Insert bell crank in arm of clutch driver insert fulcrum pin and lock with lock plate and cap screw.

(8) Reassemble toggle:

(a) Slide toggle yoke over ball stud.

(b) Attach yoke and links by assembling bushings with pins inserted so heads are inside and lock with cotter pin.

(9) Attach band guide with two capscrew. Adjust guide screws to permit free entry of clutch band.

(10) Insert band.

Note. If old band is to be used, reverse it end-for-end to distribute wear. Bands for five main clutches are interchangeable and reversible end-for-end.

(a) Position band about 2 inches ahead of dead end where it slides in easily and then rotate back into pin position.

(b) Insert dead end pin and lock with lock plate and capcrew.

(c) Insert adjustment bolt eye between live end links and line up with pin holes in band, slide in pin, insert U-lock pin and lock with cotter pin.

(d) Adjust guide screws and lock with position nuts.

(e) Adjust clutch band (TM 5-3810-289-12).

(11) Install shifter collar with clamp bolts and install clutch shifter yoke.

(12) Check adjustment of clutch carefully after several hours operation.

Section II. LOWER WORKS

4-15. Vertical Propel Shaft

a. General.

(1) The vertical propel shaft (fig. 4-6) is machined from alloy steel with splines at both ends of a 4 7/8" diameter shaft. There is a hole through the center of the shaft for steering clutches and digging lock linkage.

(2) The shaft turns on bushing type bearings in centering gudgeon of truck frame and revolving frame. It transmits propelling power only, and takes no shear or tipping loads.

(3) The propel bevel pinion is splined to bottom of shaft and held in place with a retaining plate and capscrews. To remove the vertical propel shaft the upper works must be removed.

b. Disassembly.

(1) If shaft is to be pulled entirely, remove drum lagging from front drum to provide clearance.

(2) Disconnect boom hoist control vertical reach rod and, on shovel, crowd chain to get room for cover removal.

(3) Clean and remove horizontal swing-and-propel gear case cover.

(4) Remove connections to controls in hollow vertical propel shaft (6) as when removing upper works (para 4-3).

(5) Remove swing-and-propel jaw clutch and steer yoke and lift jaw clutch (2) off splines.

(6) Lift out spur gear.

(7) Drain and remove lower gear case and steering clutch guards as complete unit.

(8) Remove bevel pinion split retainer which is attached by four wired capecrews, from lower end of shaft and block bevel pinion in place for reassembly (unless removal is necessary).

(9) Pull out shaft (90 pounds) upward.

(10) If removal is not necessary, leave digging lock and steering control rods in place. If removal of bevel gear is desired, digging lock and steering control rods may be disconnected at the lower end and lifted to clear.

(11) Remove oil seal flange, oil seal, and oil seal gasket by taking out four capscrews.

Note. Always remove flange and gasket to prevent damage to oil seal when replacing shaft.

(12) Remove bevel gear from center gear case.

c. Inspection and Repair. Clean all parts thoroughly and inspect for damage and excessive wear. For gear and bearing inspection and repair procedure, see paragraph 2-8. Rebuild chipped or broken shaft splines by welding and grinding. Replace damaged or worn hardware. Be sure all grease fittings and lubrication ducts are clean and open so lubricant can reach bushings. Replace damaged oil seal or gasket.

d. Reassembly.

(1) If bevel gear has been removed, insert it in lower case above center shaft.

(2) Block bevel pinion in place against top of propelling gear case with washer above it, ready to receive shaft.

(3) Lower shaft into place over steering and digging lock control rods. If rods have beer, removed, assemble them after vertical propel shaft is in place.

(4) Replace the two split retainer plates on bevel pinion and fasten with two capscrews in each. Install safety wire to lock capscrews.

(5) Replace oil seal, gasket and flange securing with four capscrews with lockwashers.

Caution: Check carefully to be sure a tight seal is obtained.

(6) Install spur gear with jaw side upward.

(7) Install jaw clutch and shifter.

(8) Use OE, engine oil, in an oil can freely to lubricate control rods in vertical propel shaft getting oil into swivel joints.

(9) Install cover over horizontal swing-and-propel gear case.

(10) Connect boom hoist control vertical reach rod and, on shovel, connect crowd chain.

(11) Install drain plugs and fill main gear case in accordance with lubrication order.

(12) Install propel case sump-pan.

4-16. Center Propelling Shaft (fig. 4-6)

a. Disassembly.

(1) Drain and remove center gear case and steering clutch guards as a unit. The complete unit is attached by four bolts.

(2) Disconnect one end of spring rod assembly by removing reach rod end pin.

(3) Move both steering jaw clutches out to disengaged positions.

(4) Remove both clutch shaft lock blank bolts.

(5) Pull outer clutch shafts out enough to engage inner ends from center lower propel shaft (about 4 inches; propel chain need not be disconnected).

(6) Remove two bolts holding main bearing cap remove the cap, and lower the shaft.

Note. The main bearing bushing is split in half and held from turning by shims between truck frame and bearing cap. When removing bearing cap keep shims in groups as removed so reassembly can be made with the same bearing fit, or, if necessary adjusted for a snug free-running fit.

(7) The bevel gear and right driving clutch are an integral unit, keyed to the shaft and pressed on. The left driving clutch is pressed on the same shaft. Removal requires a press of 20-30 tons capacity.

Caution: This assembly weights about 200 pounds and should be jacked down for safety.

h. Inspection and Repair. Clean all parts thoroughly and inspect for damage and excessive wear. If clutch teeth are worn or rubbed off, rebuild by welding and grinding. Clutch bushings (one in bevel gear clutch unit, the second in the other driving clutch unit) cannot be removed whole without pressing the bevel gear and clutch off the shaft. If necessary to replace, however, cut and groove, through the bushing with a pointed chisel, and then pull it out without disturbing the gear and clutch. The new bushing can then be driven into place.

c. Reassembly.

(1) Insert keys in shaft keyways, and press gear clutch and driving clutch units on shaft (2030 ton pressure required).

(2) Place top half of the split bushing on shaft.

(3) Put bottom half of split bushing in main bearing cap, and lay shims in place on cap.

(4) Raise assembly into place and bolt on bearing cap, making sure bolts pass through shims properly. Adjust shims if necessary to provide snug but free running fit.

(5) Put gasket in place on bevel gear case cover, raise cover and bolt in place.

(6) Assemble two outer clutch shaft sections.

(7) Fill case with lubricant in accordance with lubrication order.

4-17. Outer Clutch Shaft (fig. 4-6)

a. Disassembly.

(1) Remove steering clutch guard from side to be dismantled by removing five bolts from center gear case.

(2) Remove intermediate steering shaft lever pin.

(3) Remove lock pin at top of shifter yoke fulcrum pins.

(4) Remove both fulcrum pins and subassembly of reach rods and shifter levers as a unit.

(5) Remove propel chain from drive sprocket.

(6) Remove lock wire, capscrews, and sprocket retainer from outer end of clutch shaft.

(7) Pull drive sprocket off from end of clutch shaft.

(8) Remove clutch shaft lock.

(9) Pull clutch shaft out of truck frame and remove sliding section (2) of jaw clutch. Hub in truck frame is now exposed.

b. Inspection and Rear. Clean all parts thoroughly and examine for damage and excessive wear. Inspect truck frame hub bushing and replace if necessary. If. sliding section of jaw clutch or propelling chain sprocket have nubbed- teeth, rebuild them by welding and grinding. Replace other damaged or excessively worn parts.

c. Reassembly.

(1) Insert clutch shaft through hub, and slide on jaw clutch section.

(2) Insert clutch shaft lock pin and cotter pin.

(3) Slide drive sprocket on splined end of shaft.

(4) Put on sprocket retainer and lock with capscrews. Install capscrew lock wire.

(5) Install reach rod and shifter yoke unit. Replace fulcrum pins (8) and lock bolts. Install intermediate shaft lever pin.

(6) Attach steering clutch guard with five bolts.

4-18. Center Gudgeon Bushing

a. Removal.

(1) Refer to paragraph 4-3, and remove the upper works.

(2) Refer to figure 4-3 and remove the vertical propel shaft.

(3) Lift bushing from center of revolving frame.

b. Inspection and Cleaning.

(1) Clean in an approved cleaning solvent and dry thoroughly.

(2) Inspect for wear or damage and replace if necessary.

c. Installation. Refer to figure 446 and install in reverse order of removal.

4-19. Cone Roller

a. General. Cone rollers require repair if flat spots or dents are evident.

b. Removal. Refer to paragraph 4-3b for removal of cone roller.

c. Inspection and Repair.

(1) Inspect cone rollers for dents or flat spots.

(2) Repair defective rollers by welding, and machining until smooth.

d. Installation. Refer to paragraph 44e for installation of cone roller.

4-20. Crawler Frame (fig. 4-6)

a. Removal and Disassembly.

(1) Using a crane lift or jack lift method (para 4-3), raise complete machine just enough so crawler tracks, tumblers, and rollers can be removed from crawler frame.

(2) Remove propelling chains and crawler tracks.

(3) Remove upper and lower rollers and take-up and drive tumblers.

(4) Block under crawler frame and remove bolts attaching truck frame. Remove blocks and lower crawler frame to ground.

(5) Raise upper works with truck frame attached until gear case clears truck frame and drag frame out from under.

b. Inspection and Repair

(1) Clean all parts in an approved solvent.

(2) Lubricate in accordance with Lubrication Order.

(3) Repair cracks or opened welds in the crawler frame by welding and grinding.

c. Reassembly and Installation.

(1) Drag crawler frame under truck frame, block it up and bolt in position.

(2) Reassemble in reverse order of removal.

4-21. Ring Gear (fig. 4-6)

The ring gear is an integral part of the truck frame and can not be replaced. Inspect the ring gear for broken or worn teeth and repair by welding or filing.

4-22. Track Idlers and Brackets

Replacement and Repair

a. Takeup Idler.

(1) Disassembly (fig. 4-6).

(a) Part track, and fold back to expose idler.

(b) Remove takeup shaft bolts.

(c) Roll idler forward and pull off the two dust shields, and shaft.

(2) Inspection and repair. See lower roller procedures.

(3) Reassembly.

(a) Pack bearing with general purpose grease.

(b) Install shaft and two dust shields.

(c) Roll idler into place.

(d) Install shaft bolts.

(e) Connect track.

(4) Track adjustment. Adjust track tension after idler assembly has been completed (TM 5-3810-289-12).

b. Drive Tumbler.

(1) Disassembly.

(a) Part track at drive tumbler end, and fold back upper threads.

(b) Remove four bolts in tumbler shaft bearings.

(c) Part the drive chain at an link.

(d) Remove the two adjusting screw pins and roll tumbler out.

(e) Remove chain sprocket by bending back lock bar and removing capscrews.

(f) Take outer and inner bearings off shaft.

(g) Press idler off shaft (30-50 ton press).

(2) Inspection and repair. Clean all parts thoroughly and inspect for damage or excessive wear. See paragraph 2-8 for bushing inspection and repair procedures. Rebuild by welding any broken or worn sprocket teeth. Replace damaged or worn hardward.

(3) Reassembly.

(a) Press tumbler on shaft (3050 ton press).

(b) Pack bearings with general purpose grease.

(c) Install inner and outer bearings.

(d) Slide chain sprocket on splined shaft and lock in place with two capscrews and lock bar.

(e) Roll tumbler into position and insert two adjusting screw pins.

(f) Replace drive chain.

(g) Replace four tumbler shaft bolts.

(h) Connect track belt.

(4) Adjustment. Adjust track tension according to procedure in TM 5810-289-12.

4-23. Track Drive Sprockets

a. Disassembly (fig. 4-21).

(1) Part track belt at drive tumbler end, and fold back upper links.

(2) Remove four bolts in tumbler shaft bearings.

(3) Part the drive chain at any link.

(4) Remove the two adjusting screw pins and roll tumbler out.

(5) Remove chain sprocket by bending back lock bar and removing capscrews.

(6) Take outer and inner bearings off shaft.

(7) Press tumbler off shaft (30-50 ton press).

b. Inspection and Repair. Clean all parts thoroughly and inspect for damage or excessive wear. See paragraph 2-8 for bushing inspection and repair procedures. Rebuild by welding any broken or worn sprocket teeth. Replace damaged or worn hardware.

c. Reassembly.

(1) Press tumbler on shaft (30-50 ton press).

(2) Pack bearings with general purpose grease.

(3) Install inner and outer bearings.

(4) Slide chain sprocket on splined shaft and lock in place with two capscrews and lock bar.

(5) Roll tumbler into position and insert two adjusting screw pins.

(6) Replace drive chain.

(7) Replace four idler shaft bolts.

(8) Connect track belt.

d. Adjustment. Adjust track tension according to procedure in TM 5-3810-289-12.

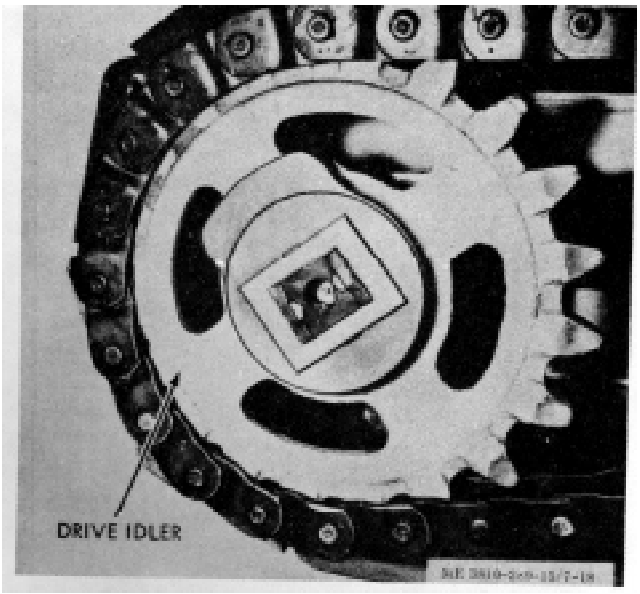


Figure 4-21. Track drive sprocket replacement.

4-24. Track Assembly Replacement

Note. The maximum allowable pitch on track wear is 3/16 inches.

a. Track-link (fig. 4-22).

(1) Propel machine so link to be removed is in contact with takeup idler in vertical position.

(2) Loosen track by backing up the two take-up screws on this idler.

(3) Drive block along the ground against the link just below the link you want to remove to relieve load on pins.

(4) Remove link-pin locks from the four pins attaching the link to be removed.

(5) Remove four link-pins and lift out link (weighs about: 30 pounds).

Note. If possible retain block position for reassembly.

Note. To remove an entire track, part one link as outlined above lay track flat on ground and lift or jack machine up so it clears the track.

b. Track-link Assembly.

(1) Put new link in place.

(2) Insert two link-pins and locks, attaching new link to one end of track.

(3) If necessary, pull ends of track together, (track adjustment as loose as possible).

(4) Insert remaining two pins and locks.

(5) Remove blocking or plank or bar clamped to hold track ends in place.

(6) Readjust track tension.

Note. To replace an entire track, assemble individual links as described below, lay track out on ground, slide it under jacked-up machine, lower truck-frame into place, bring track-ends up over drive-tumbler, propel and lead track over top rollers, hold in place for fastening end-links by blocking as above, or by clamping end-links on a plank or bar. When installing a new track, part track as above, attach new links to end of old, and propel machine on to new track.

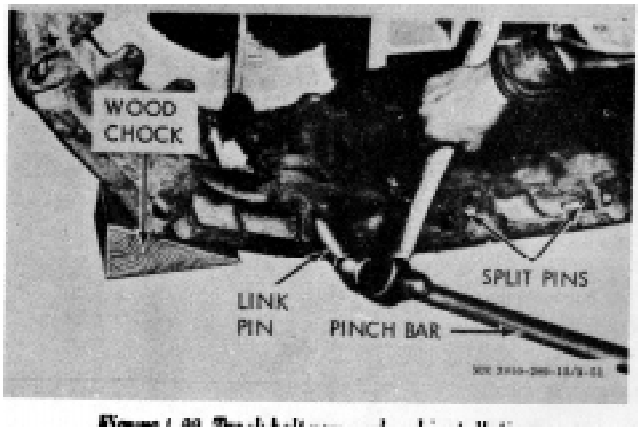


Figure 4-22. Track belt removal and installation.

APPENDIX A
REFERENCES

A-1. Fire Protection

TB 5-200-10	Hand portable fire extinguisher for Army users

A-2. Lubrication

C91001L	Fuel, lubricating, oils and waxes
LO 548810-289-12	Lubrication order

A-3. Maintenance

TB 750-651	Use of antifreeze solution and cleaning compounds in engine cooling systems
TM 38-750	Army equipment record procedures
TM 5-3810-289-12	Operator and organizational maintenance manual
TM 53810-28920P	Organizational maintenance, repair parts and special tool list
TM 53810-289345P	Direct support, general support and depot maintenance, repair parts and special tool list
TM 9-6140-200-15	Operation, organizational, field and depot maintenance storage batteries, lead acid type
TM 5-764	Electric motor generator repair
TB 385101	Safety use of cranes, crane-shovel, drag line, and similar equipment near electric power lines

A-4. Radio Suppression

TM 11-483	Radio interference suppression

INDEX

By Order of the Secretary of the Army:

W. C. WESTMORELAND,
General, United States Army,
Chief of Staff.

Official:

KENNETH G. WICKHAM,
Major General, United States Army,
The Adjutant General

Distribution:
To be distributed in accordance with DA Form 12-25, Section II, (qty rqr block no. 343) direct and general support maintenance requirements for Crane-Shovel, Crawlers: 12% Ton.

*U.S. GOVERNMENT PRINTING OFFICE: 1995 0-461-202/1193C

THEN. . JOT DOWN THE DOPE ABOUT IT ON THIS FORM, CAREFULLY TEAR IT OUT, FOLD IT AND DROP IT IN THE MAIL!

SOMETHING WRONG WITH THIS PUBLICATION?

FROM: (PRINT YOUR UNIT'S COMPLETE ADDRESS)

DATE SENT

TION NUMBER	PUBLICATION DATE	PUBLICATION TITLE

CT. . .PIN-POINT WHERE IT IS

PARA-GRAPH	FIGURE NO	TABLE NO

IN THIS SPACE TELL WHAT IS WRONG AND WHAT SHOULD BE DONE ABOUT IT:

NAME, GRADE OR TITLE, AND TELEPHONE NUMBER

SIGN HERE

PIN: 025257-000