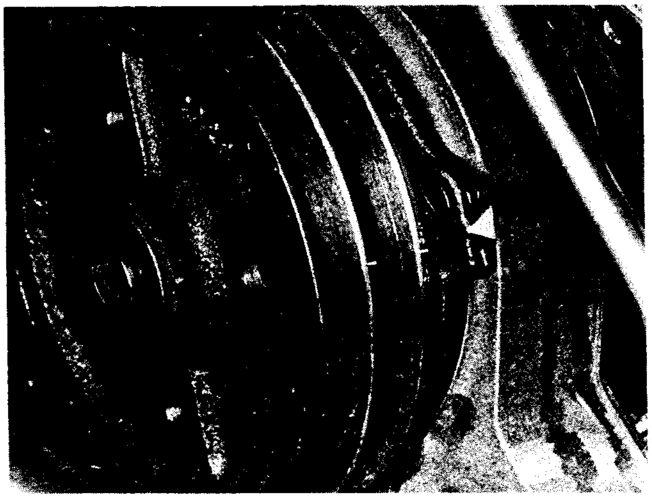


Fig. 2-37, (V514127). Valve set mark on accessory drive — V-903

1. Set up the ST-1270 Indicator Support with the indicator extension atop the injector plunger flange at No. 2 cylinder. Fig. 2-38.

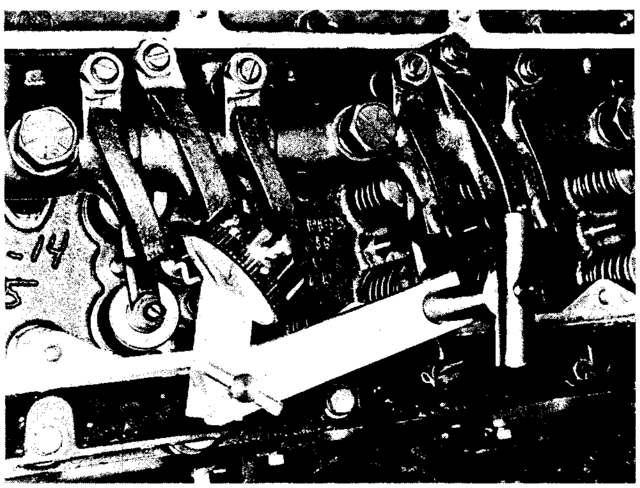


Fig. 2-38, (V514114). Dial indicator in place — V-903

2. Screw injector lever adjusting screw down until plunger is bottomed in cup, back off approximately 1/2 turn then bottom again, set dial indicator at zero (0).

Note: Care must be taken to assure injector plunger is correctly bottomed in cup, without overtightening adjusting screw, before setting dial indicator.

3. Back adjusting screw out until a reading of 0.187 inch [4.75 mm],. reference Table 2-8, is obtained on dial indicator. Snug tighten locknut.

4. Using ST-1251 Rocker Lever Actuator, bottom injector plunger, check zero (0) setting. Fig. 2-39. Allow plunger to rise slowly, indicator must show plunger travel to be within range specified in Table 2-8.

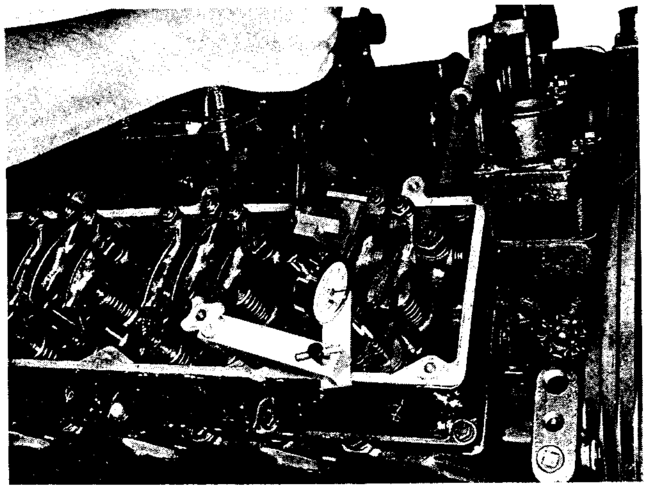


Fig. 2-39, (V514128). Bottoming injector plunger in cup — V-903

5. Using ST-669 Torque Wrench Adapter to hold adjusting screw in position, torque locknut 30 to 35 ft-lbs [41 to 47 N • m]. If torque wrench adapter is not used, hold adjusting screw with a screwdriver, torque locknuts 40 to 45 ft-lbs [54 to 61 N • m].
6. Actuate injector plunger several times as a check of adjustment. Remove dial indicator assembly.
7. Adjust valves on appropriate cylinder as determined in Step 1 and Table 2-8. Tighten locknuts same as injector locknut.

Crosshead Adjustment

Crossheads are used to operate two valves with one rocker lever. The crosshead adjustment is provided to assure equal operation of each pair of valves and prevent strain from misalignment.

1. Loosen valve crosshead adjusting screw locknut and back off screw one turn.
2. Use light finger pressure at rocker lever contact surface to hold crosshead in contact with valve stem (without adjusting screw). Fig. 2-40.
3. Turn down crosshead adjusting screw until it touches valve stem.
4. Hold adjusting screw in position and torque locknut

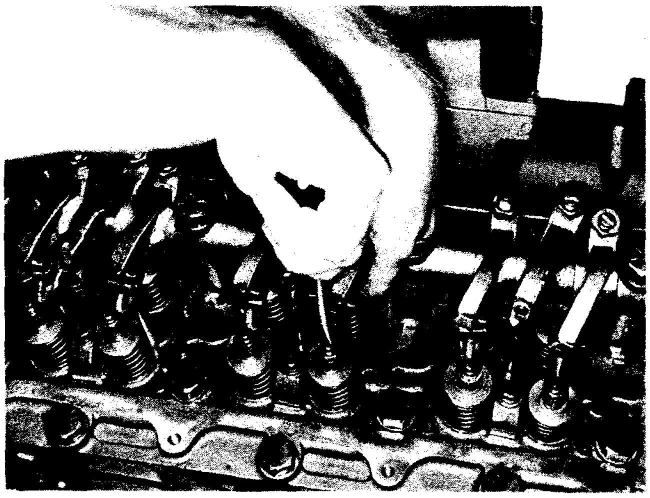


Fig. 2-40, (V51490). Adjusting crossheads — V-903

to values listed in Table 2-6.

Note: Be sure that crosshead retainers on exhaust valves, if used, are positioned equally on both sides of spring over crossheads and valve springs properly.

5. Check clearance between crosshead and valve spring retainer with wire gauge. There must be a minimum of 0.025 inch [0.64 mm] clearance at this point.

Valve Adjustment

The same engine position used in adjusting injectors is used for setting intake and exhaust valves.

1. Loosen locknut and back off adjusting screw. Insert feeler gauge between rocker lever and top of cross-head. Fig. 2-41. Valve clearances are shown in Table 2-8. Turn screw down until lever just touches gauge,

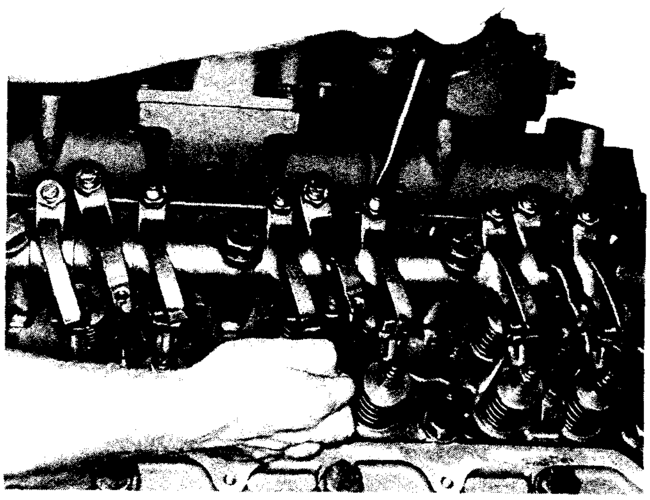


Fig. 2-41, (V51492). Adjusting valves — V-903

and lock adjusting screw in position with locknut. Torque adjusting screw locknuts to 40 to 45 ft-lb [54 to 61 N • m] or 30 to 35 ft-lb [41 to 47 N • m] when using an ST-669 Adapter.

2. Always make final valve adjustment after injectors are adjusted.

NH-743, N-855, C.I.D. Engines, Injector and Valve Adjustment (Dial Indicator Method)

Note: Before adjusting injectors and valves be sure to determine if rocker housings are cast iron or aluminum and use appropriate setting.

Before adjusting injectors, torque cylindrical injector, hold-down capscrews in alternate steps to 10 to 12 ft-lbs [14 to 16 N • m]. With flange injectors torque hold-down capscrews in alternate steps to 12 to 14 ft-lbs [14 6 to 18 N • m]. Tighten fuel inlet and drain connections to 20 to 25 ft-lbs [27 to 34 N • m] in flange injectors.

Maintenance Adjustment

1. Bar engine until "A" or 1-6 "VS" mark on pulley, Fig. 2-42, is aligned with pointer on gear case cover. In this position, both valve rocker levers for cylinder No. 5 must be free (valves closed). Injector plunger for cylinder No. 3 must be at top of travel; if not, bar engine 360 degrees, realign mark with pointer.

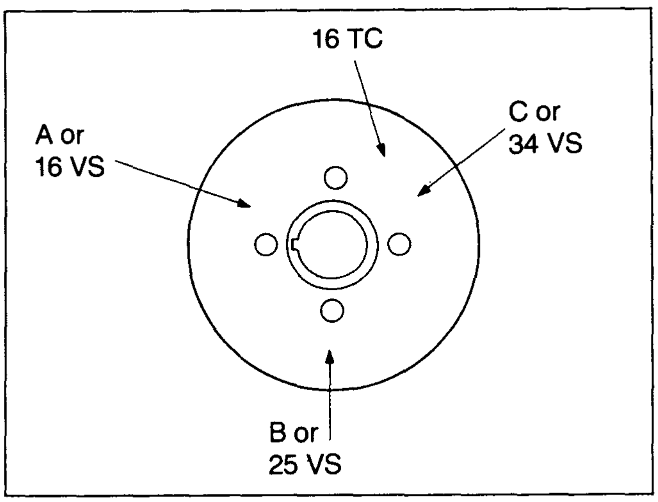


Fig. 2-42, (N114230). Accessory drive pulley marking — N-855

2. Set up ST-1170 Indicator Support with indicator extension on injector plunger top at No. 3 cylinder, Fig. 2-43. Make sure indicator extension is secure in

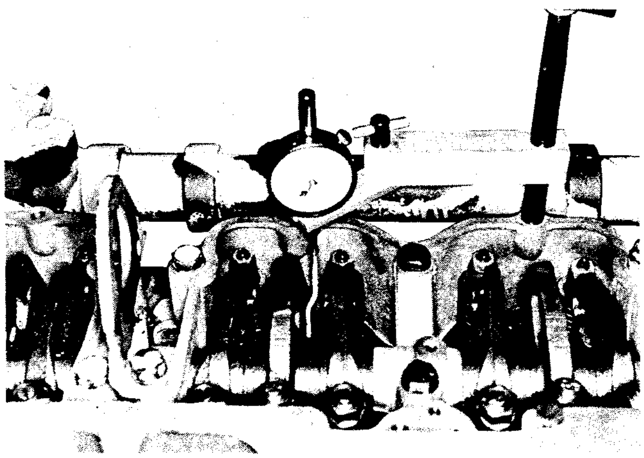


Fig. 2-43, (N114231). Dial indicator in place — extension in contact with polunger — N-855

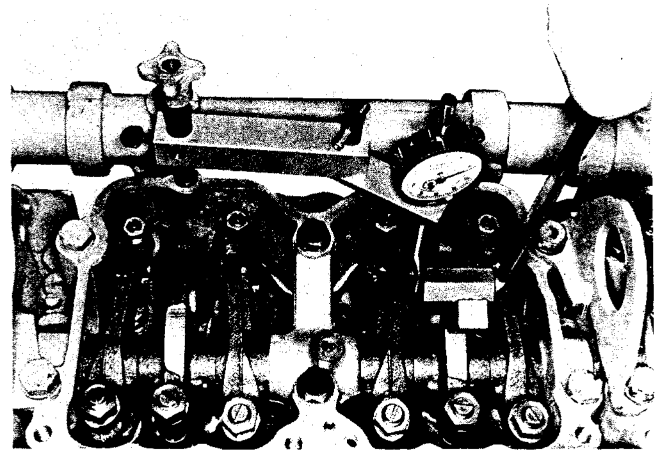


Fig. 2-44, (N114232). Bottoming injector plunger in cup — N-855

indicator stem and not against rocker lever.

Note: Cylinder No. 3 for injector setting and cylinder No. 5 for valve setting are selected for illustration purposes only. Any cylinder combination may be used as a starting point. See Table 2-9.

Table 2-9: Injector and Valve Set Position N-855 Engines

Bar in Direction	Pulley Position	Set Cylinder Injector	Valve
Start	A or 1-6VS	3	5
Adv. To	B or 2-5VS	6	3
Adv. To	C or 3-4VS	2	6
Adv. To	A or 1-6VS	4	2
Adv. To	B or 2-5VS	1	4
Adv. To	C or 3-4VS	5	1

3. Using ST-1193 Rocker Lever Actuator, Fig. 2-44, or equivalent, bar lever toward injector until plunger is bottomed to squeeze oil film from cup. Allow injector plunger to rise, bottom again, set indicator at zero (0). Check extension contact with plunger top.
4. Bottom plunger again, release lever; indicator must show travel as indicated in Table 2-10. Adjust as necessary.
5. If loosened, tighten locknut to 40 to 45 ft-lbs [54 to 61 N • m] and actuate injector plunger several times as a check of adjustment. Tighten to 30 to 35 ft-lbs [41 to 47 N • m] when using ST-669 Adapter.

Table 2-10: Adjustment Limits Using Dial Indicator Method Inch [mm] N-855 Engines

Oil Temp.	Injector Plunger Travel	Valve Clearance Intake	Exhaust
Aluminum Rocker Housing			
Cold	0.170 ± 0.001 [4.32 ± 0.03]	0.011 [0.28]	0.023 [0.58]
Hot	0.170 ± 0.001 [4.32 ± 0.03]	0.008 [0.20]	0.023 [0.58]
Cast Iron Rocker Housing			
Cold	0.175 ± 0.001 [4.45 ± 0.03]	0.011 [0.28]	0.023 [0.58]
Hot	0.175 ± 0.001 [4.45 ± 0.03]	0.008 [0.20]	0.023 [0.58]

Adjust Injectors and Valves (Torque Method) V-1710, NH-743, N-855 C.I.D. Engines

Timing Mark Alignment

1. If used, pull compression release lever back and block in open position only while barring engine.
2. Loosen injector rocker lever adjusting nut on all cylinders. This will aid in distinguishing between cylinders adjusted and not adjusted.

Note: Before adjusting injectors and valves be sure to determine if rocker housings are cast iron or aluminum and use appropriate setting.

3. Bar engine in direction of rotation until a valve set mark (Fig's. 2-45, 2-46 and 2-47) aligns with the mark or pointer on the gear case cover. Example: A or 1-6 "VS" on Inline Engines or 1-6R "VS" on V-1710 Engines.

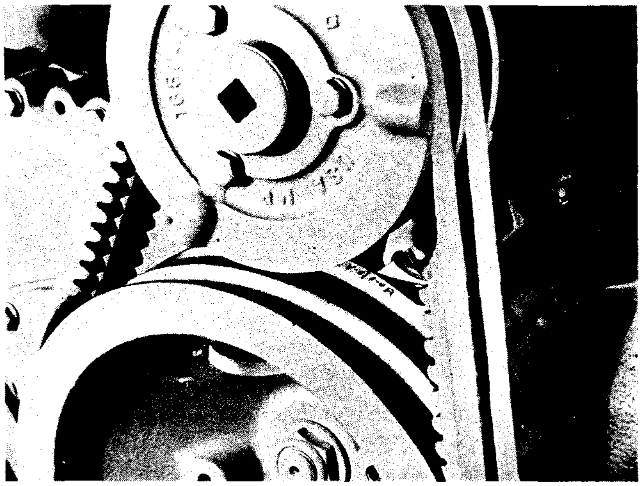


Fig. 2-45, (V41484). Valve set mark — V-1710

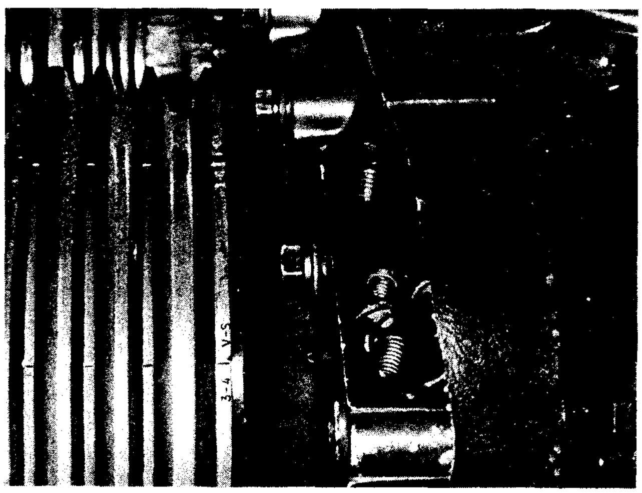


Fig. 2-46, (N114220-A). Valve set mark — N-855

4. Check the valve rocker levers on the two cylinders aligned as indicated on pulley. On one cylinder of the pair, both rocker levers will be free and valves closed; this is cylinder to be adjusted.
5. Adjust injector plunger first, then crossheads and valves to clearances indicated in the following paragraphs.
6. For firing order see Table 2-11 for Inline Engines and Table 2-12 and Fig. 2-47 for V-1710 Engines.

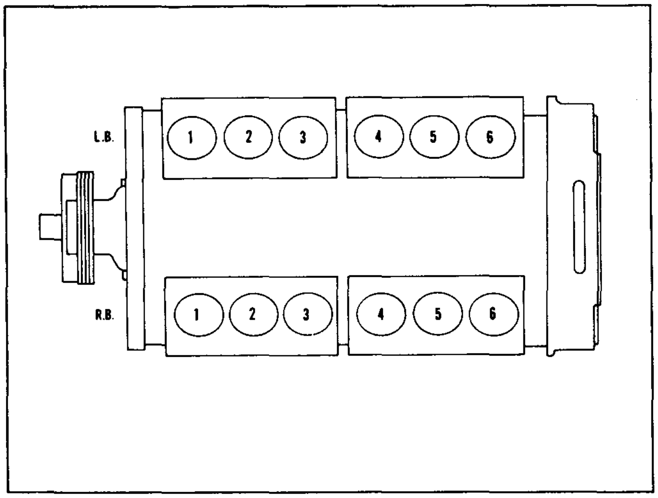


Fig. 2-47, (V414231). V-1710 piston position

Table 2-11: Engine Firing Order N-855 Engines

Right Hand Rotation	Left Hand Rotation
1-5-3-6-2-4	1-4-2-6-3-5

Table 2-12: Firing Order V-1710 Engine

Right Hand —
1L-6R-2L-5R-4L-3R-6L-1R-5L-2R-3L-4R

Left Hand —
1L-4R-3L-2R-5L-1R-6L-3R-4L-5R-2L-6R

7. Continue to bar engine to next "VS" mark and adjust each cylinder in firing order.

Note: Only one cylinder is aligned at each mark. Two complete revolutions of the crankshaft are required to adjust all cylinders.

Injector Plunger Adjustment

The injector plungers must be adjusted with an inch-pound torque wrench to a definite torque setting. Snap-On Model TE-12 or equivalent torque wrench and a screwdriver adapter can be used for this adjustment. See Fig's. 2-48 and 2-49.

1. Turn adjusting screw down until plunger contacts cup and advance an additional 15 degrees to squeeze oil from cup.

Note: Number one L and one R cylinders on V-1710 Engines are at gear case end of engine.

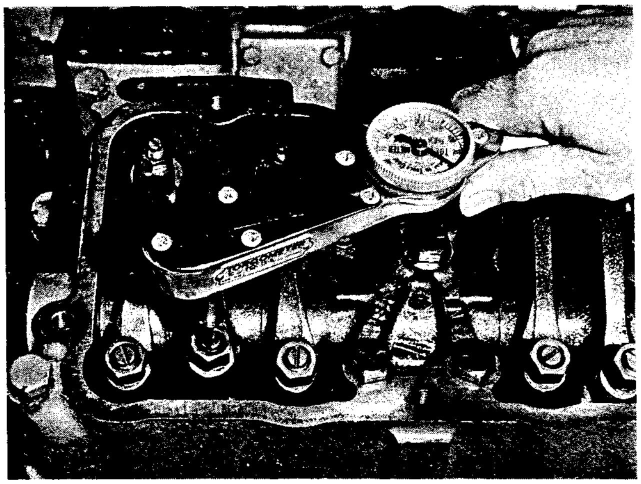


Fig. 2-48, (V414190). Adjusting injector plunger — V-1710

Table 2-13: Injector Plunger Adjustment — Inch-lbs [N • m]

Cold Set	Hot Set
V-1710 Engines	
50 [0.6]	
NH-NT-743 and 855 Engines Cast Iron Rocker Housing	
48 [5.4]	72 [8.1]
Aluminum Rocker Housing	
71 [8.1]	72 [8.1]

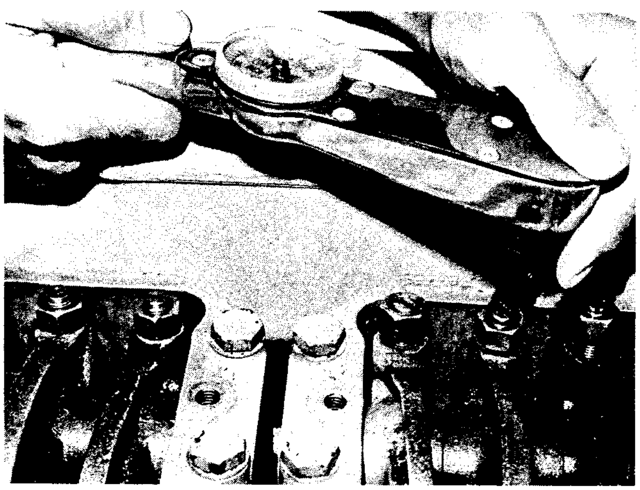


Fig. 2-49, (N11466). Adjusting injector plunger — N-855

2. Loosen adjusting screw one turn; then using a torque wrench calibrated in inch-pounds and a screwdriver adapter tighten the adjusting screw to value shown in Table 2-13 and tighten locknut to 40 to 45 ft-lbs [54 to 61 N • m] torque. If ST-669 Torque Wrench Adapter is used, torque to 30 to 35 ft-lbs [41 to 47 N • m].

Crosshead Adjustment

Crossheads are used to operate two valves with one rocker lever. The crosshead adjustment is provided to assure equal operation of each pair of valves and prevent strain from misalignment.

1. Loosen valve crosshead adjusting screw locknut and back off screw (4, Fig. 2-50) one turn.

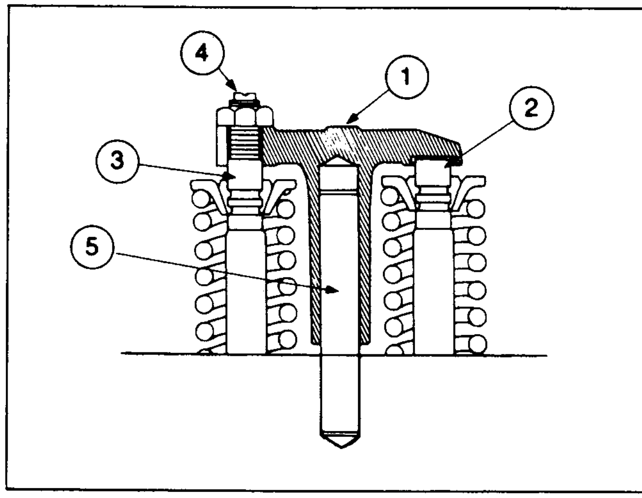


Fig. 2-50, (N21461). Valve crosshead

2. Use light finger pressure at rocker lever contact surface (1) to hold crosshead in contact with valve stem (2).
3. Turn down crosshead adjusting screw until it touches valve stem (3).
4. Using ST-669 Torque Wrench Adapter, tighten locknut to 22 to 26 ft-lbs [30 to 35 N • m]. If ST-669 is not available, hold screws with screwdriver and tighten locknuts to 25 to 30 ft-lbs [34 to 41 N • m].
5. Check clearance between crosshead and valve spring retainer with wire gauge. There must be a minimum of 0.020 inch [0.51 mm] clearance at this point.

Valve Adjustment

The same engine position used in adjusting injectors is used for setting intake and exhaust valves.

1. While adjusting valves, make sure that the compression release, on those engines so equipped, is in running position.
2. Loosen locknut and back off the adjusting screw. Insert feeler gauge between rocker lever and crosshead. Turn the screw down until the lever just touches the gauge and lock the adjusting screw in this position with the locknut. Tighten locknut to 40 to 45 ft-lbs [54 to 61 N • m] torque. When using ST-669 torque to 30 to 35 ft-lbs [41 to 47 N • m].
3. Always make final valve adjustment at stabilized engine lubricating oil temperature. See Table 2-14 for appropriate valve clearances.

Table 2-14: Valve Clearance — Inch [mm]

Intake Valves		Exhaust Valves	
Cold Set	**Hot Set**	**Cold Set**	**Hot Set**
V-1710 Engines			
0.014 [0.36]		0.027 [0.69]	
NH-NT-743 and 855 Engines			
Cast Iron Rocker Housing			
0.016 [0.41]	0.014 [0.36]	0.029 [0.74]	0.027 [0.69]
Aluminum Rocker Housing			
0.014 [0.36]	0.014 [0.36]	0.027 [0.69]	0.027 [0.69]

Injector and Valve Adjustment Using 3375004 Dial Indicator Kit KT(A)-1150 Engines

This method involves adjusting injector plunger travel with accurate dial indicator. A check can be made of the adjustment without disturbing the locknut or screw setting. The valves can also be checked or set while adjusting the injectors by this method. See Table 2-15.

3375004 Injector Adjustment Kit is used to adjust the injectors with or without Jacobs Brake units installed.

It is essential that injectors and valves be in correct adjustment at all times for the engine to operate properly.

Table 2-15: Injector and Valve Set Position KT(A)-1150

Bar in Direction	Pulley Position	Set Cylinder Injector	Valve
Start	A	3	5
Adv. To	B	6	3
Adv. To	C	2	6
Adv. To	A	4	2
Adv. To	B	1	4
Adv. To	C	5	1

Firing Order 1-5-3-6-2-4

One controls engine breathing; the other controls fuel delivery to the cylinders.

Operating adjustments must be made using correct values as stated.

Injector and Valve Adjustment

Note: Do not use fan to rotate engine. Remove shaft retainer key. Fig. 2-51, and press shaft inward until barring gear engages drive gear; then advance. After adjustments are completed retract shaft and install retainer key into safety lock groove.

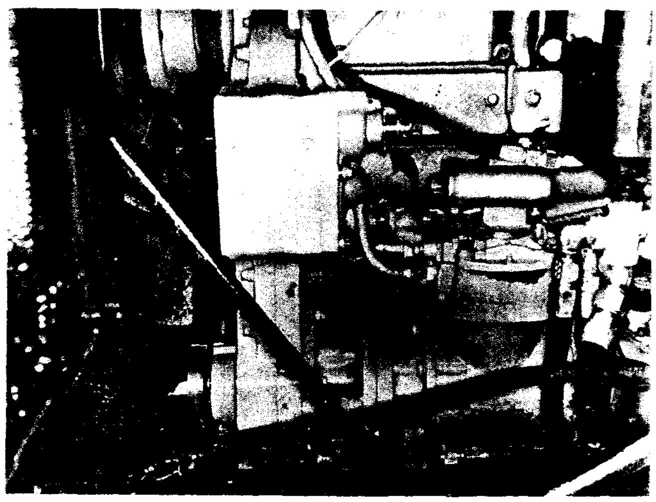


Fig. 2-51, (K11919). Engine barring arrangement — KT(A)-1150

Caution: Barring mechanism gear must be completely engaged when barring engine to avoid damage to teeth of gear.

1. Bar engine in direction of rotation until "B" mark on

pulley, Fig. 2-52, is aligned with pointer on gear case cover. In this position, both valve rocker levers for cylinder No. 3 must be free (valves closed). Injector plunger for cylinder No. 6 must be at top of travel; if not, bar engine 360 degrees, realign marks with pointer.

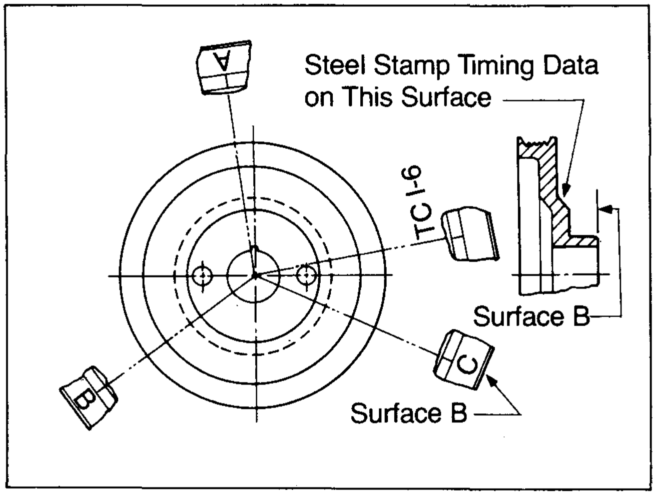


Fig. 2-52, (K11920). Accessory drive pulley marking — KT(A)-1150

Note: The injector and valves on any one (1) cylinder can not be set at the same valve set position. Example: If the rocker levers on No. 3 cylinder are free (valves closed) the injector plunger travel on No. 6 cylinder is to be adjusted. Any valve set position may be used as a starting point. See Table 2-15.

2. Install 3375004 Dial Indicator Assembly to rocker housing, extension (3375005) must go through opening in Jacobs Brake housing and contact injector plunger top. Fig. 2-53.

3. Screw injector lever adjusting screw down until plunger is bottomed in cup, back off approximately 1/2 turn then bottom again, set dial indicator at zero (0).

Note: Care must be taken to assure injector plunger is correctly bottomed in cup, without overtightening adjusting screw, before setting dial indicator.

4. Back adjusting screw out until a reading of 0.304 inch [7.72 mm], reference Table 2-16, is obtained on dial indicator. Snug tighten locknut.

5. Using 3375009 Rocker Lever Actuator Assembly and Support Plate, bottom injector plunger, check zero (0) setting. Fig. 2-54. Allow plunger to rise slowly; indicator must show plunger travel to be within range specified in Table 2-16.

6. Using ST-669 Torque Wrench Adapter to hold adjusting screw in position, torque locknut 30 to 35

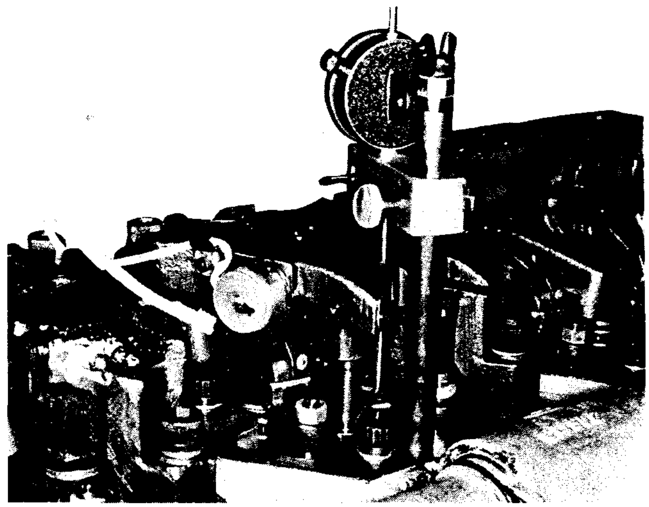


Fig. 2-53, (K114130). Dial indicator in place — extension in contact with plunger — KT(A)-1150

Table 2-16: Adjustment Limits Using Dial Indicator Method Inch [mm] KT(A)-1150 Engines

Injector Plunger Travel	Valve Clearance Intake	Exhaust
0.304 ± 0.001 [7.72 ± 0.03]	0.014 [0.36]	0.027 [0.69]

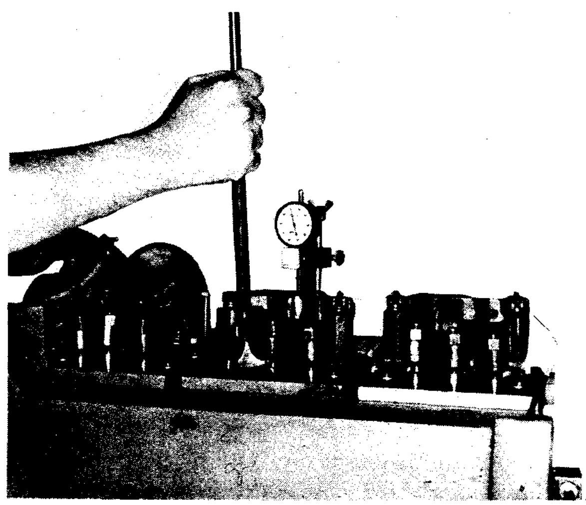


Fig. 2-54, (K114104). Actuating rocker lever ft-lbs [41 to 47 N • m]. If torque wrench adapter is not used, hold adjusting screw with a screwdriver, torque locknuts to 40 to 45 ft-lbs [54 to 61 N • m].

7. Actuate injector plunger several times as a check of adjustment. Remove dial indicator assembly.

Caution: If Jacobs Brake is not used, be sure crossheads are adjusted before setting valves. See Crosshead Adjustment following.

8. Adjust valves on appropriate cylinder as determined in Step 1 and Table 2-16. Tighten locknuts same as injector locknut.
9. If Jacobs Brake is used, use 3375012 (0.018 inch [0.46 mm] thick) Feeler Gauge and 3375008 Torque Wrench Adapter, set exhaust valve crosshead to Jacobs Brake slave piston clearance. Fig. 2-55.

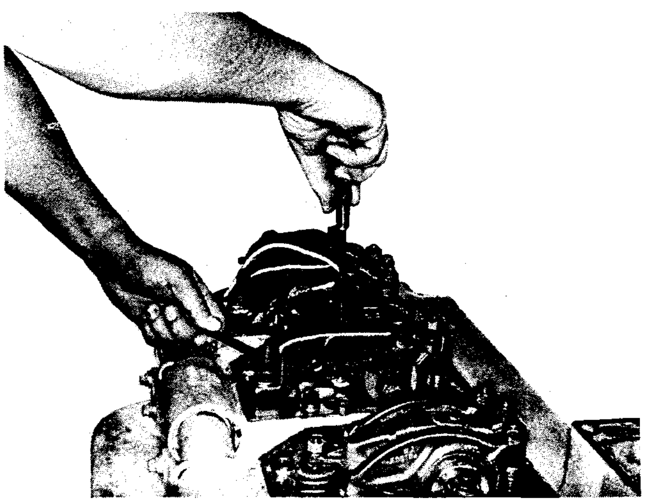


Fig. 2-55, (K114105). Adjusting crosshead to slave piston clearance

Note: Turn both adjusting screws alternately and evenly until crosshead and feeler gauge contact slave piston and adjusting screws are bottomed on valve stem. Back adjusting screws out one-fourth (1/4) to one-half (1/2) turn. Starting with outer adjusting screw (next to water manifold), then moving to screw under rocker lever, retighten gradually until crosshead and feeler gauge contact slave piston. Snug tighten locknuts.

10. Hold crosshead adjusting screws with a screwdriver, torque locknuts 22 to 26 ft-lb [20 to 35 N • m] using 3375008 Adapter and torque wrench.
11. See Table 2-16 for valve clearance values.
12. Repeat adjustment procedure for each cylinder.

See Table 2-15 for firing order and injector and valve set positions.

Crosshead Adjustment

Crossheads are used to operate two valves with one rocker lever. The crosshead adjustment is provided to assure equal operation of each pair of valves and prevent strain from misalignment.

1. Loosen valve crosshead adjusting screw locknut and back off screw (4, Fig. 2-56) one turn.

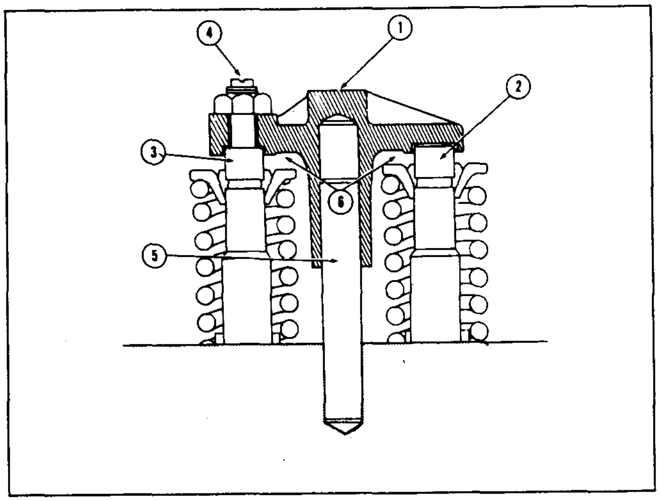


Fig. 2-56, (K21924). Valve crosshead

2. Use light finger pressure at rocker lever contact surface (1) to hold crosshead in contact with valve stem (2) (without adjusting screw).
3. Turn down crosshead adjusting screw until it touches valve stem (3).
4. Using ST-669 Torque Wrench Adapter, tighten locknuts to 22 to 26 ft-lbs [30 to 35 N • m]. If ST-669 is not available, hold screws with screwdriver and tighten locknuts to 25 to 30 ft-lbs [34 to 41 N • m].
5. Check clearance (6) between crosshead and valve spring retainer with wire gauge. There must be a minimum of 0.025 inch [0.64 mm] clearance at this point.

Injector and Valve Adjustment Using 3375004 Dial Indicator Kit KT(A)-2300 and KTA-3067 Engines

Valve Set Mark Alignment

Note: KT(A)-2300 and KTA-3067 injectors, crossheads and valves are adjusted to same values. Refer to Fig's. 2-57 and 2-58 for specific cylinder arrangement and engine firing order.

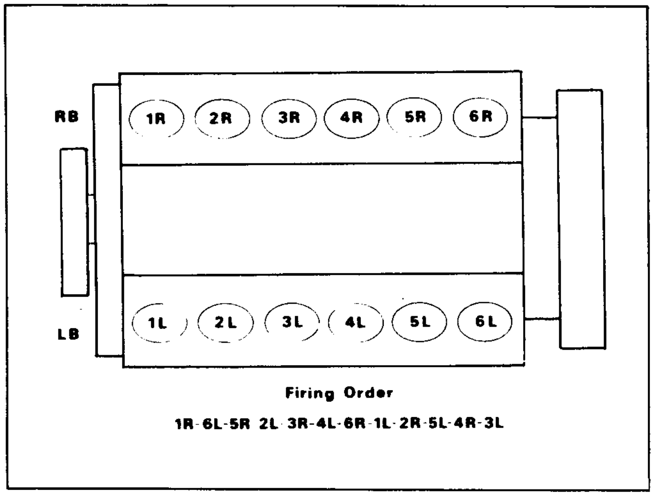


Fig. 2-57, (K21916). Cylinder arrangement and firing order — KT(A)-2300

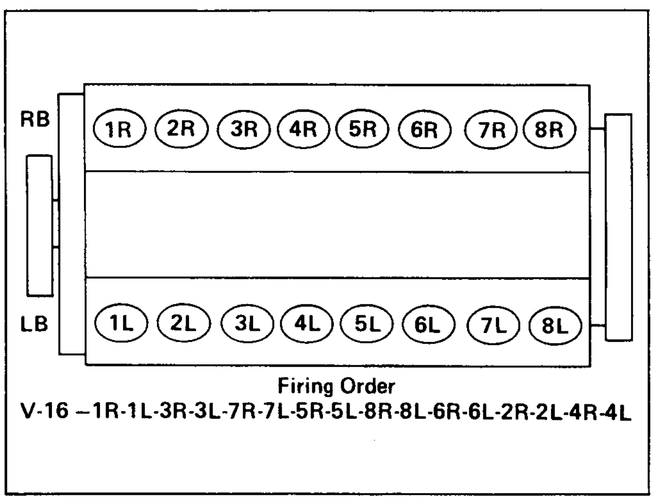


Fig. 2-58, (OM204). Cylinder arrangement and firing order — KTA-3067

Three locations are provided where valve and injector alignment marks may be viewed. Injector plunger travel and valves both may be set on one cylinder at the same valve set location. The crankshaft must be turned through two (2) complete revolutions to properly set all injector plunger travel and valves.

Note: Barring mechanism may be located on either left bank or right bank at the flywheel housing. Cover plate on opening "A" or "C" directly above barring mechanism must be removed when viewing timing marks at flywheel housing.

1. When viewing engine at vibration damper, Fig. 2-59, align timing marks on damper with pointer on gear case cover.

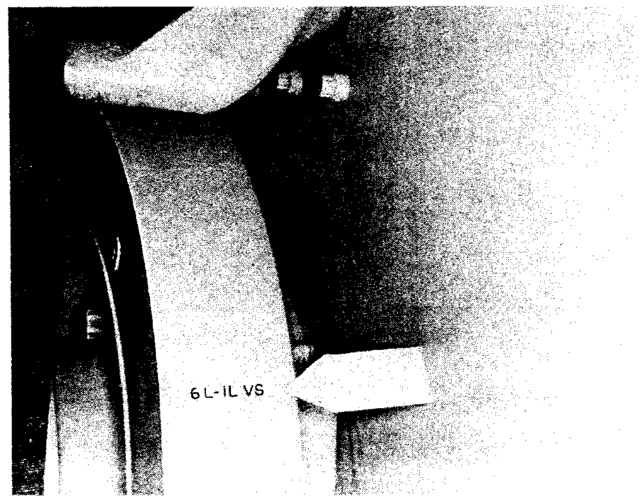


Fig. 2-59, (K21917). Valve set marks on vibration damper — KT(A)-2300

2. When barring engine from right bank at flywheel housing "A" VS timing marks on flywheel (1, Fig. 2-60) must align with scribe mark (2) when viewed through opening marked "A" on flywheel housing.

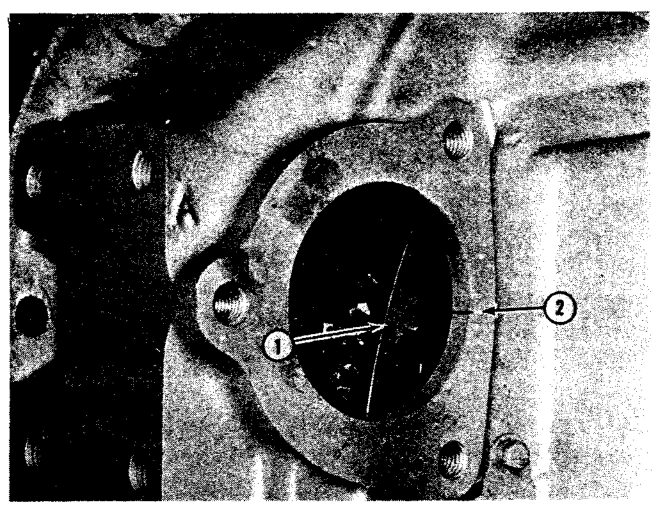


Fig. 2-60, (K21918). Valve set marks on right bank flywheel and housing — KT(A)-2300

3. When barring engine from left bank at flywheel housing "C" VS timing marks on flywheel (1, Fig.

2-61) must align with scribe mark (2) when viewed through opening marked "C" on flywheel housing.

Caution: When aligning valve set marks at either flywheel housing location, care must be taken to assure that "A" or "C" valve set marks on flywheel match "A" or "C" marks on flywheel housing opening.

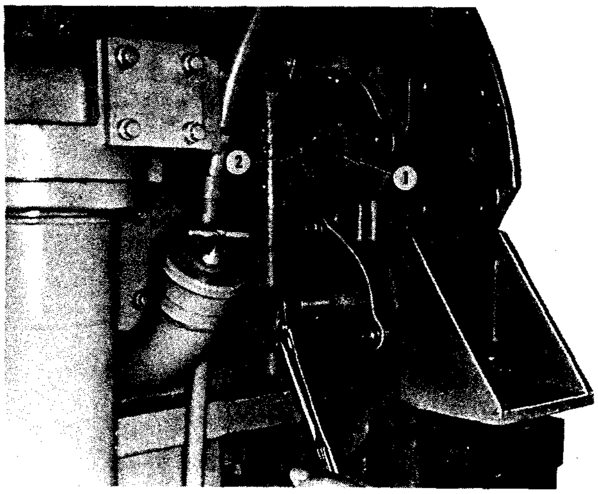


Fig. 2-61, (K21919). Engine barring device

Injector Plunger Adjustment

1. Bar engine in direction of rotation until appropriate valve set mark is aligned with scribe mark on flywheel housing or until a valve set mark on vibration damper is aligned with pointer on gear case cover.

Note: Any valve set position may be used as a starting point when adjusting injectors, crossheads and valves. Determine which of the two (2) cylinders indicated have both valves closed (rocker levers free). This cylinder is in position for injector plunger travel, crosshead and valve adjustment.

2. Set up 3375007 Indicator Support on rocker lever housing, of cylinder selected, with indicator extension 3375005 on injector plunger top. Fig. 2-62.

Note: Make sure indicator extension is secure in indicator stem and is not touching rocker lever.

3. Using rocker lever actuator, Fig. 2-63, depress lever toward injector until plunger is bottomed in cup to squeeze oil film from cup. Allow injector plunger to rise, bottom again, hold in bottom position and set indicator at zero (0). Check extension contact with plunger top.
4. Allow plunger to rise then bottom plunger again, release lever, indicator must show travel as indicated in Table 2-17. Adjust as necessary.

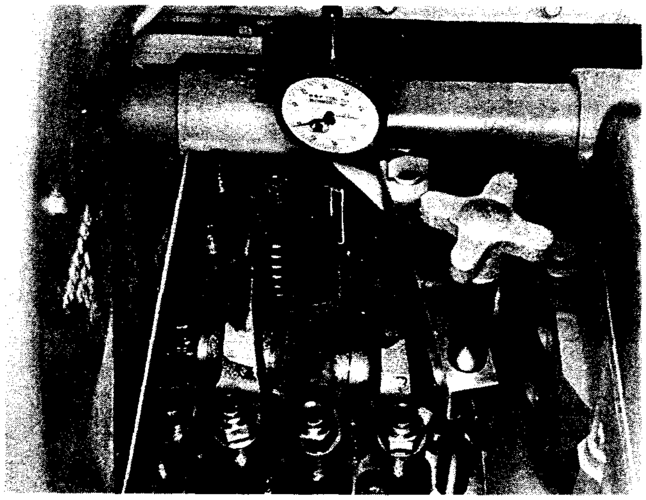


Fig. 2-62, (K21920). Dial indicator in place — extension in contact with plunger

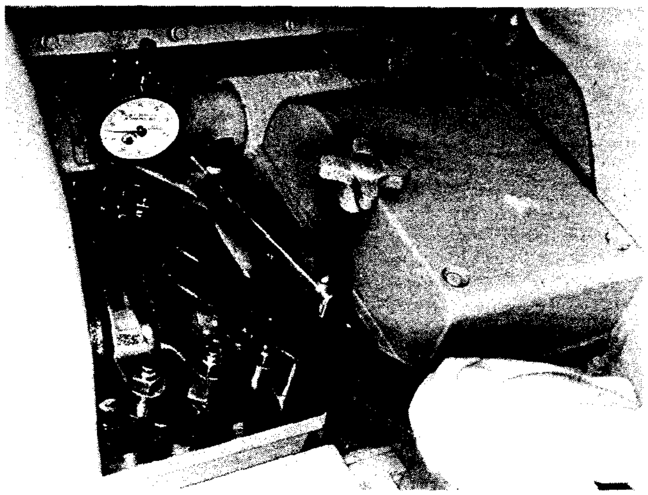


Fig. 2-63, (K21921). Bottoming injector plunger in cup

5. If adjusting screw locknuts were loosened for adjustment, tighten to 40 to 45 ft-lb [54 to 61 N • m]

Table 2-17: Adjustment Limits Using Dial Indicator Method Inch [mm] KT(A)-2300 and KTA-3067 Engines

Injector Plunger Travel	Valve Clearance Intake	Exhaust
0.308 ± 0.001 [7.82 ± 0.03]	0.014 [0.36]	0.027 [0.69]

6. Remove 3375004 Kit.

torque and actuate plunger several times as a check of adjustment. Tighten locknuts to 30 to 35 ft-lb [41 to 47 N • m] torque when using ST-669 Torque Wrench Adapter.

6. Remove 3375004 Kit.

Crosshead Adjustment

Crossheads are used to operate two valves with one rocker lever, an adjusting screw is provided to assure equal operation of each pair of valves and prevent strain from misalignment. Crosshead adjustment changes as a result of valve and seat wear during engine operation.

1. Loosen adjusting screw locknut, back off screw (4, Fig. 2-56) one turn.
2. Use light finger pressure at rocker lever contact surface (1) to hold crosshead in contact with valve stem (2). Adjusting screw should not touch valve stem (3) at this point.
3. Turn down adjusting screw until it touches valve stem (3).
4. Using 3375008 Torque Wrench Adapter to hold adjusting screw in position, tighten locknut to 22 to 26 ft-lb [30 to 35 N • m] torque. If torque wrench adapter is not used, hold adjusting screw with a screwdriver, tighten locknut to 25 to 30 ft-lb [34 to 41 N • m] torque.
5. Check clearance (6) between crosshead and valve spring retainer with wire gauge. There must be a minimum of 0.025 inch [0.64 mm] clearance at this point.

Valve Adjustment

1. Insert correct thickness feeler gauge between rocker lever and crosshead for valves being adjusted. See Table 2-17 for valve clearances.

Note: Exhaust valves are toward front of engine in each cylinder head on LB side and are toward rear of engine in each cylinder head on RB side.

2. If adjustment is required, loosen locknut and turn adjusting screw down until rocker lever just touches feeler gauge; lock adjusting screw in this position with locknut.
3. Tighten locknut to 40 to 45 ft-lb [54 to 61 N • m] torque. When using ST-669 Torque Wrench Adapter tighten locknuts to 30 to 35 ft-lbs [41 to 47 N • m] torque.

After completing the injector plunger travel, crosshead and valve adjustment on this cylinder bar engine in direction of rotation until next valve set mark is aligned with scribe mark at flywheel housing or pointer on gear case cover; repeat procedure. See Fig's. 2-57 and 2-58 for cylinder arrangement and engine firing order.

Change Oil

Change Aneroid Oil

1. Remove fill plug (1, Fig. 2-64) from hole marked "Lub Oil".

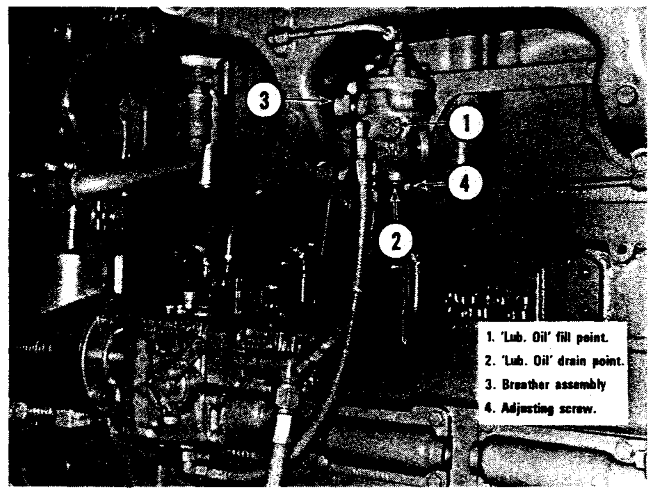


Fig. 2-64, (N10503). Aneroid

2. Remove drain plug (2) from bottom of aneroid.
3. Replace drain plug (2), fill aneroid with clean engine lubricating oil. Replace fill plug (1).

Replace Aneroid Breather

Remove and replace aneroid breather (3, Fig. 2-64).

Change Hydraulic Governor Oil

Change oil in the hydraulic governor sump at each "C" Check.

Use the same grade of oil as used in the engine. See "Lubricating Oil Specifications".

Note: When temperature is extremely low, it may be necessary to dilute the lubricating oil with enough fuel oil or other special fluid to insure free flow for satisfactory governor action.

Backside Idler Fan Drive

1. Inspect idler assembly to be sure pivot arm is not

binding. Grasp pulley, pull back on idler assembly and release; pivot arm should move freely toward belt without binding.

2. If idler assembly does not move freely, remove and disassemble idler assembly. Inspect teflon bushings, replace if worn. Repack bushings with Aeroshell No. 5, Lubriplate (type 130AA), or Moly-disulfide grease, reassemble and install idler assembly.

Clean Complete Oil Bath Air Cleaner

Steam

Steam clean the oil bath cleaner main body screens. Direct the stream jet from the air outlet side of the cleaner to wash dirt out in the opposite direction of air flow.

Solvent-Air Cleaning

1. Steam clean exterior of cleaner.
2. Remove air cleaner oil cup.
3. Clamp hose with air line adapter to air cleaner outlet.
4. Submerge air cleaner in solvent.
5. Introduce air into unit at 3 to 5 psi [21 to 34 kPa] and leave in washer 10 to 20 minutes.
6. Remove cleaner from solvent and steam clean thoroughly to remove all traces of solvent. Dry with compressed air.

Caution: Failure to remove solvent may cause engine to overspeed until all solvent is sucked from cleaner.

7. If air cleaner is to be stored, dip in lubricating oil to prevent rusting of screens.

Note: If screens cannot be thoroughly cleaned by either method, or if body is pierced or otherwise damaged, replace with new air cleaner.

"D" Maintenance Checks

At each "D" Maintenance Check, perform all "A", "B" and "C" Checks in addition to those following. Most of these checks should be performed by a Cummins Distributor or Dealer and where Cummins Shop Manuals are available for complete instructions.

Clean and Calibrate Injectors

Clean and calibrate injectors regularly to prevent restriction of fuel delivery to combustion chambers. Because of the special tools required for calibration, most owners and fleets find it more economical to let a Cummins Distributor do the cleaning and calibration operations.

To clean and calibrate injectors, refer to Bulletin No. 3379071 and revisions thereto.

After removing injectors from KT(A)-1150, KT(A)-2300 or KTA-3067 Engines for cleaning the seal seat should be removed from the injector (1, Fig. 2-65) or injector "well" for cleaning, examination and/or replacement as necessary.

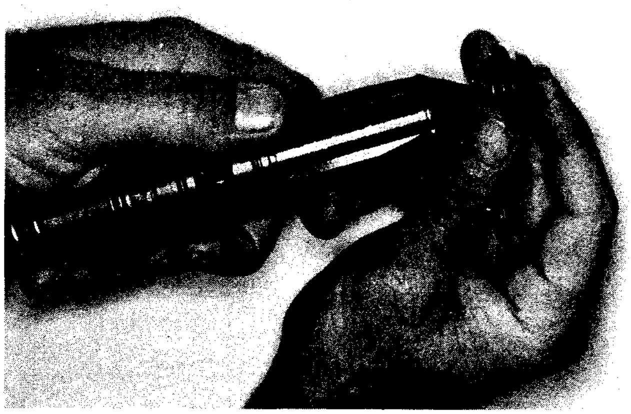


Fig. 2-65, (K11918). Injector seal seat — all KT Engines

Caution: There must be only one (1) seal seat used in each injector "well". Use of more than one seal seat per injector will change injector protrusion and cause combustion inefficiency.

Clean and Calibrate Fuel Pump

Check fuel pump calibration on engine if required. See the nearest Cummins Distributor of Dealer for values.

Clean and Calibrate Aneroid

1. Remove flexible hose or tube from aneroid cover to intake manifold.
2. Remove lead seal (if used), screws and aneroid cover.
3. Remove bellows, piston, upper portion of two piece shaft and spring from aneroid body.

Note: Count and record amount of thread turns required to remove upper shaft, piston and bellows from lower shaft.

4. Place hex portion of shaft in vise, snug tighten vise, remove self-locking nut, retaining washer and bellows.
5. Clean parts in approved cleaning solvent.
6. Position new bellows over shaft to piston, secure with retaining washer and self-locking nut. Tighten self-locking nut to 20 to 25 ft-lb [2.3 to 2.8 N • m] torque.
7. Install spring, shaft, piston and bellows assembly into aneroid body. As two piece shaft is re-assembled, turn upper portion of shaft same amount of thread turns recorded during disassembly.

Caution: Amount of thread turns during installation must correspond with turns during removal to avoid changing aneroid setting.

8. Align holes in bellows with corresponding capscrew holes in aneroid body.
9. Position cover to body; secure with flatwashers, lockwashers and fillister head screws.
10. Install new seal. Refer to Bulletin No. 3379084 for sealing instructions and calibration procedure. Calibration, if required, must be performed by a Cummins Distributor on a fuel pump test stand.
11. Reinstall flexible hose or tube from aneroid cover to intake manifold.

Inspect/Install Rebuilt Unit as Necessary

The following assemblies should be inspected at this time. The options are: inspect and reuse, rebuild per shop manual instructions, replace with new or Distributor/Dealer exchange units or Cummins Diesel ReCon Inc. units.

Inspect Water Pump and Fan Hub

Inspect water pump and fan hub for wobble and evidence of grease leakage. Replace with rebuilt pre-lubricated units as necessary.

Idler Pulley

Inspect, rebuild and repack idler pulley with correct grease. Refer to Engine Shop Manual for rebuild and lubricating procedure for idler pulley.

Inspect Turbocharger

Check Turbocharger Bearing Clearance

Check bearing clearances. This can be done without removing the turbocharger from the engine, by using a dial indicator to indicate end-play of the rotor shaft and a feeler gauge to indicate radial clearance. Fig. 2-66.

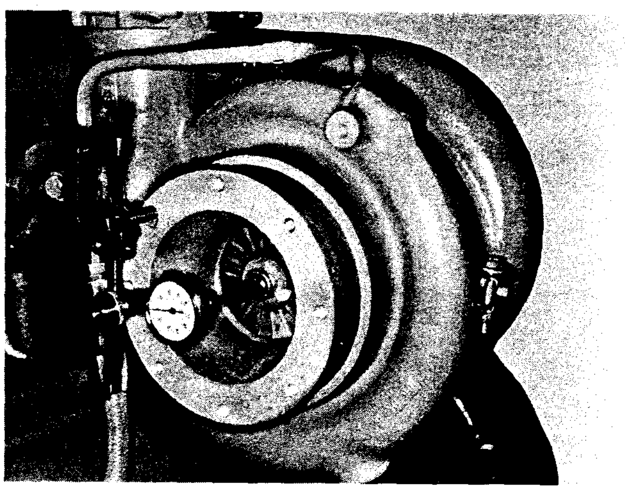


Fig. 2-66, (N11956). Checking turbocharger bearing and clearance

Checking Procedure

1. Remove exhaust and intake piping from the turbocharger to expose ends of rotor assembly.
2. Remove one capscrew from the front plate (compressor wheel end) and replace with a long capscrew. Attach an indicator to the long capscrew and register indicator point on end of rotor shaft. Push shaft from end-to-end making note of total indicator reading. Fig. 2-66. On T-50, ST-50 and VT-50 end clearance should be 0.006 to 0.018 inch [0.15 to 0.46 mm].
   a. Push wheel toward side of bore.
   b. Using feeler gauge, check distance between tip of wheel vanes and bore. On T-50, ST-50 and VT-50 clearance should be 0.003 to 0.033 inch [0.08 to 0.84 mm].
3. Check radial clearance on compressor wheel only.
4. If end clearances exceeds limits, remove turbocharger from engine and replace with a new or rebuilt unit.
5. Check T-18A turbochargers as follows:
   a. For checking procedures refer to Service Manual Bulletin No. 3379055.
   b. End clearance should be 0.004 to 0.009 inch [0.10 to 0.23 mm], radial clearance should be 0.003 to 0.007 inch [0.08 to 0.18 mm]. If clearances exceed these limits, remove turbocharger(s) from engine and replace with new or rebuilt units.
6. Install exhaust and intake piping to turbocharger(s).

Inspect Vibration Damper

Rubber Damper

Damper hub (1, Fig. 2-67) and inertia member (2) are stamped with an index mark (3) to permit detection of movement between the two components.

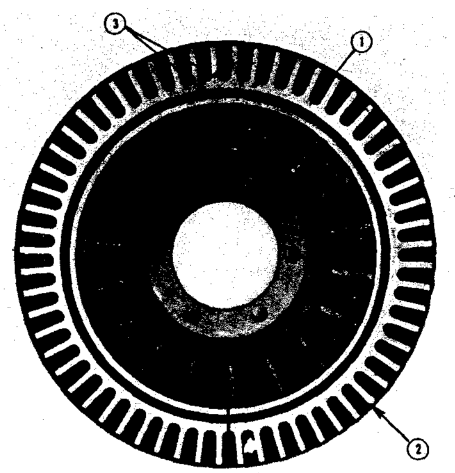


Fig. 2-67, (N10146). Vibration damper alignment marks

There should be no relative rotation between hub and inertia member resulting from engine operation.

Check for extrusion or rubber particles between hub and inertia member.

If there is evidence of inertia member movement and rubber extrusion, replace damper.

Viscous Dampers

Check damper for evidence of fluid loss, dents and wobble. Visually inspect the vibration damper's thickness for any deformation or raising of the damper's front cover plate.

1. If lack of space around damper will not permit a visual inspection, run a finger around inside and outside of front cover plate. If any variations or deformations are detected, remove vibration damper and check as follows.
2. Remove paint, dirt and grime from front and rear surface of damper in four (4) equal spaced areas. Clean surface with paint solvent and fine emery cloth.
3. Using micrometer measure and record thickness of dampers at the four (4) areas cleaned in Step 3. Take reading approximately 0.125 inch [3.18 mm] from outside edge of front cover plate.
4. Replace damper if variation of the four (4) readings exceeds 0.010 inch [0.25 mm].

Air Compressor

Inspect air compressor, check for evidence of oil or coolant leakage. Drain air tank and check for air compressor lubricating oil carry over. Replace with rebuilt unit as necessary.

Backside Idler Fan Drive

Remove pivot arm assembly, disassemble and clean. Replace teflon bushings with new, inspect thrust washers and replace as necessary. Pack teflon bushings with Aeroshell No. 5, Lubriplate (type 130AA) or Moly-disulfide grease, reassemble and install idler assembly.

Clean Crankcase Breathers (KT(A)-2300 and KTA-3067 Engines)

Remove crankcase breathers from right bank front and left bank rear of cylinder block. Clean in approved cleaning solvent, dry with compressed air, install breather.

Seasonal Maintenance Checks

There are some maintenance checks which may or may not fall exactly into suggested maintenance schedule due to miles or hours operation but are performed once or twice each year.

Clean Cooling System (Fall)

The cooling system must be clean to do its work properly. Scale in the system slows down heat absorption from water jackets and heat rejection from radiator. Use clean water that will not clog any of the hundreds of small passages in radiator or water passages in block. Clean radiator cores, heater cores, oil cooler and block passages that have become clogged with scale and sediment by chemical cleaning, neutralizing and flushing.

Chemical Cleaning

If rust and scale have collected, the system must be chemically cleaned. Use a good cooling system cleaner such as sodium bisulphate or oxalic acid followed by neutalizer and flushing.

Pressure Flushing

Flush radiator and block before filling with antifreeze, or installing a water filter on a used or rebuilt engine.

When pressure flushing radiator, open upper and lower hose connections and screw radiator cap on tight. Use hose connection on both upper and lower connections to make the operation easier. Attach flushing gun nozzle to lower hose connection and let water run until radiator is full. When full, apply air pressure gradually to avoid damage to core. Shut off air and allow radiator to refill; then apply air pressure. Repeat until water coming from radiator is clean.

Caution: Do not use excessive air pressure while starting water flow. This could split or damage radiator core.

Sediment and dirt settle into pockets in block as well as radiator core. Remove thermostats from housing and flush block with water. Partially restrict lower opening until block fills. Apply air pressure and force water from lower opening. Repeat process until stream of water coming from block is clean.

Replace Hose (As Required)

Inspect oil filter and cooling system hose and hose connections for leaks and/or deterioration. Particles of deteriorated hose can be carried through cooling system or lubricating system and restrict or clog small passage especially radiator core, and lubricating oil cooler, and partially stop circulation. Replace as necessary.

Check Preheater Cold-Starting Aid (Fall)

Remove 1/8 inch pipe plug from manifold, near glow plug, and check operation of preheater as described in Section 1.

Check Shutterstats and Thermatic Fans (Fall)

Shutterstats and thermatic fans must be set to operate in same range as thermostat with which they are used. Table 2-18 gives settings for shutterstats and thermatic fans as normally used. The 180 to 195° F [82 to 91° C] thermostats are used only with shutterstats that are set to close at 187° F [86° C] and open at 195° F [91° C].

Check Thermostats and Seals (Fall)

Remove thermostats from thermostat housings and check for proper opening and closing temperature.

Most Cummins Engines are equipped with either medium 170 to 185° F [77 to 85° C] or low 160 to 175° F [71 to 79° C] and in a few cases high-range 180 to 195° F [82 to 91° C] thermostats, depending on engine application.

Steam Clean Engine (Spring)

Steam is the most satisfactory method of cleaning a dirty engine or piece of equipment. If steam is not available, use an approved solvent to wash the engine.

All electrical components and wiring should be protected from the full force of the cleaner spray nozzle.

Checking Mountings (Spring)

Tighten Mounting Bolts and Nuts (As Required)

Engine mounting bolts will occasionally work loose and cause the engine supports and brackets to wear

Table 2-18: Thermal Control Settings

Control	Setting With 160 to 175°F [71 to 79°C]		Setting With 170 to 185°F [77 to 85°C]		Setting With 180 to 195°F [82 to 91°C]	
	Open	Close	Open	Close	Open	Close
Thermatic Fan	185°F [85°C]	170°F [77°C]	190°F [88°C]	182°F [83°C]		
Shutterstat	180°F [82°C]	172°F [78°C]	185°F [85°C]	177°F [81°C]	195°F [91°C]	187°F [86°C]
Modulating Shutters open	175°F [79°C]		185°F [85°C]		[91°C]	

rapidly. Tighten all mounting bolts or nuts and replace any broken or lost bolts or capscrews.

Tighten Turbocharger Mounting Nuts (As Required)

Tighten all turbocharger mounting capscrews and nuts to be sure that they are holding securely. Tighten mounting bolts and supports so that vibration will be at a minimum. Fig. 2-68.

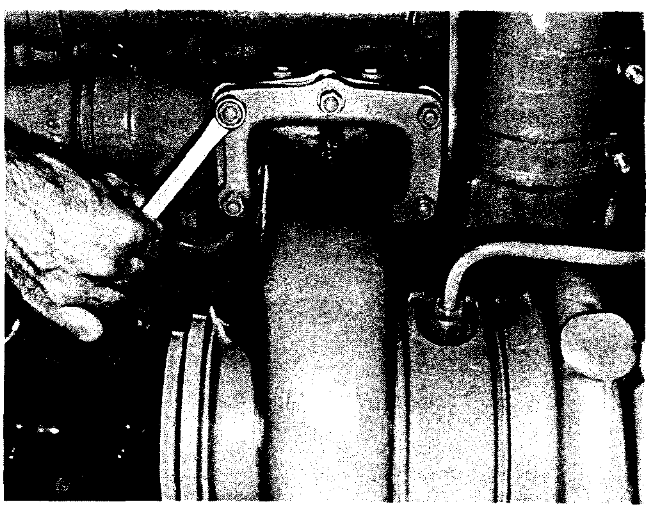


Fig. 2-68, (N11953). Tightening turbocharger mounting marks

Check Fan and Drive Pulley Mounting (Spring)

Check fan to be sure it is securely mounted; tighten capscrews as necessary. Check fan for wobble or bent blades.

Check fan hub and crankshaft drive pulley to be sure they are securely mounted. Check fan hub pulley for looseness or wobble; if necessary, remove fan pilot hub and tighten the shaft nut. Tighten the fan bracket capscrews.

Check Crankshaft End Clearance (Spring)

The crankshaft of a new or newly rebuilt engine must have end clearance as listed in Table 2-19. A worn engine must not be operated with more than the worn limit end clearance shown in the same table. If engine is disassembled for repair, install new thrust rings.

Caution: Do not pry against outer damper ring.

The check can be made by attaching an indicator to rest against the damper or pulley, while prying against the front cover and inner part of pulley or damper. End

Table 2-19: Crankshaft End Clearance — Inch [mm]

Engine Series	New Minimum	New Maximum	Worn Limit
H, NH, NT	0.007 [0.18]	0.017 [0.43]	0.022 [0.56]
V-903, VT-903	0.005 [0.13]	0.015 [0.38]	0.022 [0.56]
V-378, V-504 V-555	0.004 [0.10]	0.014 [0.36]	0.022 [0.56]
V-1710	0.006 [0.15]	0.013 [0.33]	0.018 [0.46]
KT(A)-1150	0.007 [0.18]	0.017 [0.43]	0.022 [0.56]
KT(A)-2300 KTA-3067	0.005 [0.13]	0.015 [0.38]	0.022 [0.56]

clearance must be present with engine mounted in the unit and assembled to transmission or converter.

Check Heat Exchanger Zinc Plugs (Spring)

Check zinc plugs in heat exchanger and change if badly eroded. Frequency of change depends upon chemical reaction of raw water circulated through heat exchanger.

In-Chassis Overhaul/Major Engine Overhaul

In-Chassis Overhaul/Major Engine Overhaul

Operating conditions of the engine, normally dictate when the engine is in need of an in-chassis overhaul or a major overhaul. Oil consumption, excessive drop of oil pressure at idling, oil dilution, excessive blow-by, unusual noise, vibrations and exhaust smoke should be analyzed in determining the next course of action.

At this time, perform all previous checks and inspect the following:

Accessory Drive
Bearings
Cylinder Head
Cylinder Liners
Front Gear Train
Rear Gear Train
Lubricating Oil Pump
Pistons
Connecting Rods
Piston Rings
Crankshaft Journals
Camshafts
Cam Followers
Accessory Drive Seal
Front and Rear Crankshaft Seals
Oil Cooler

Rebuild instructions, new parts or exchange parts are available from any Cummins Distributor or Dealer.

Specifications and Torque

Providing and maintaining an adequate supply of clean, high-quality fuel, lubricating oil, grease and coolant in an engine is one way or insuring long life and satisfactory performance.

Lubricant, Fuel and Coolant

Lubricating Oil

Lubricating oil is used in Cummins engines to lubricate moving parts, provide internal cooling and keep the engine clean by suspending contaminants until removed by the oil filters. Lubricating oil acts as a combustion seal and protects internal parts from rust and corrosion.

The use of quality lubricating oil, combined with appropriate lubricating oil, drain and filter change intervals, is an important factor in extending engine life. Cummins Engine Company, Inc. does not recommend any specific brand of lubricating oil. The responsibility for meeting the specifications, quality and performance of lubricating oils must necessarily rest with the oil supplier.

Oil Performance Specifications

The majority of lubricating oils marketed in North America (and many oils marketed world-wide) are designed to meet oil performance specifications which have been established by the U.S. Department of Defense and the Automobile Manufacturers Association. A booklet entitled "Lubricating Oils for Heavy

Table 3-1: Oil Recommendations

Light Service Only (Stop-and-Go) All Diesel Models	Naturally Aspirated Diesel Models	Turbocharged Diesel Models	All Natural Gas Models All Service
API Class CC/SC[2]/[5] 1.85% Maximum Sulfated Ash Content[3]	API Class CC[1] 1.85% Maximum Sulfated Ash Content[3]	API Class CC/CD[2] 1.85% Maximum Sulfated Ash Content[3]	API Class CC 0.03 to 0.85 Sulfated Ash Content[4]

[1] API classification CC and CD quality oils as used in turbocharged engines and API classification CC/SC quality oils as used for stop-and-go service are satisfactory for use in naturally aspirated engines.

[2] API classification CC/SC and CC/CD indicate that the oil must be blended to the quality level required by both specifications. The range of oil quality permitted by the CC classification is so broad that some oils that meet the classification will not provide adequate protection (varnish and ring sticking) for engines operated in certain applications. For example, turbocharged engines require the additional protection provided by the CD classification. Engines operated in stop-and-go service require the additional protection provided by the SC classification.

[3] A sulfated ash limit has been placed on all lubricating oils for Cummins engines because past experience has shown that high ash oils may produce harmful deposits on valves that can progress to guttering and valve burning.

[4] Completely ashless oils or high ash content oils, are not recommended for use in gas engines; a range of ash content is specified.

[5] SD or SE may be submitted for SC.

Duty Automotive and Industrial Engines" listing commercially available brand name lubricants and the performance classification for which they are designed is available from Engine Manufacturing Association, 111 East Wacker Drive, Chicago, Illinois 60601.

Following are brief descriptions of the specifications most commonly used for commercial lubricating oils.

API classification CC is the current American Petroleum Institute classification for lubricating oils for heavy duty gasoline and diesel service. Lubricating oils meeting this specification are designed to protect the engine from sludge deposits and rusting (aggravated by stop-and-go operation) and to provide protection from high temperature operation, ring sticking and piston deposits.

API classification CD is the current American Petroleum Institute classification for severe duty lubricating oil to be used in highly rated diesel engines operating with high loads. Lubricating oils which meet this specification have a high detergent content and will provide added protection against piston deposits and ring sticking during high temperature operation.

API classification SC, SD and SE were established for the Automobile Manufacturers Association. They require a sequence of tests for approval. The primary advantage of lubricating oils in these categories is low temperature operation protection against sludge, rust, combustion chamber deposits and bearing corrosion. The test procedure for these specifications are published by the American Society for Testing and Materials as STP-315.

Break In Oils

Special "Break-In" lubricating oils are not recommended for new or rebuilt Cummins Engines. Use the same lubricating oil as will be used for the normal engine operation.

Viscosity Recommendations

1. Multigraded lubricating oils may be used in applications with wide variations in ambient temperatures if they meet the appropriate performance specifications and ash content limits shown in Table 3-1. Multigraded oils are generally produced by adding viscosity index improver additives to a low viscosity base stock to retard thinning effects at operating temperatures. Poor quality multigraded oils use a viscosity index improver additive which has a tendency to lose its effectiveness after a short period of use in a high speed engine. These oils should be avoided.
2. Oils which meet the low temperature SAE viscosity standard (0° F [—18° C]) carry a suffix "W". Oils that meet the high temperature viscosity SAE standard 210° F [99° C] as well as the low temperature carry both viscosity ratings — example 20-20W. See Table 3-2.

Table 3-2: Operating Temperatures VS Viscosity

Ambient Temperatures	Viscosity
—10°F [—23°C] and below	See Table 3-3.
—10 to 30°F [—23 to —1°C]	10W
20 to 60°F [—7 to 16°C]	20-20W
40°F [4°C] and above	30

Arctic Operations

For operation in areas where the ambient temperature is consistently below —10° F [—23° C] and there is no provision for keeping engines warm during shutdowns, the lubricating oil should meet the requirements in Table 3-3.

Table 3-3: Arctic Oil Recommendations

Parameter (Test Method)	Specifications
Performance Quality Level	API class CC/SC API class CC/CD
Viscosity	10,000 centistokes Max. @ —30°F 5.75 centistokes Min. @ 210°F
Pour Point (ASTM D-97)	At least 10°F [6°C] below lowest expected ambient temperature
Ash, sulfated (ASTM D-874)	1.85 wt. % Maximum

Due to extreme operating conditions, oil change intervals should be carefully evaluated paying particular attention to viscosity changes and total base number decrease. Oil designed to meet MIL-L-10295-A, which is void, and SAE 5W mineral oils should not be used.

Grease

Cummins Engine Company, Inc., recommends use of grease meeting the specifications of MIL-G-3545, excluding those of sodium or soda soap thickeners. Contact lubricant supplier for grease meeting these specifications.

TEST	TEST PROCEDURE
High-Temperature Performance	
Dropping point, °F.	ASTM D 2265 350 min.
Bearing life, hours at 300°F. 10,000 rpm	*FTM 331 600 min.
Low-Temperature Properties	
Torque, GCM	ASTM D 1478
Start at 0°F.	15,000 max.
Run at 0°F.	5,000 max.
Rust Protection and Water Resistance	
Rust test	ASTM D 1743 Pass
Water resistance, %	ASTM D 1264 20 max.
Stability	
Oil separation, % 30 Hours @ 212°F.	*FTM 321 5 max.
Penetration	
Worked	ASTM D 217 250-300
Bomb Test, PSI Drop	ASTM D 942
100 Hours	10 max.
500 Hours	25 max.
Copper, Corrosion	*FTM 5309 Pass
Dirt Count, Particles/cc	*FTM 3005
25 Micron +	5,000 max.
75 Micron +	1,000 max.
125 Micron +	None
Rubber Swell	*FTM 3606 10 max.

*Federal Test Method Standard No. 791a.

Caution: Do not mix brands of grease as damage to bearings may result. Excessive lubrication is as harmful as inadequate lubrication. After lubricating fan hub, replace both pipe plugs. Use of fittings will allow lubricant to be thrown out, due to rotative speed.

Fuel Oil

Cummins Diesel Engines have been developed to take advantage of the high energy content and generally lower cost of No. 2 Diesel Fuels. Experience has shown that a Cummins Diesel Engine will also operate satisfactorily on No. 1 fuels or other fuels within the following specifications.

Recommended Fuel Oil Properties:

Viscosity (ASTM D-445)	centistokes 1.4 to 5.8 @ 100°F. [30 to 45 SUS)
Cetane Number (ASTM D-613)	40 minimum except in cold weather or in service with prolonged idle, a higher cetane number is desirable.
Sulfur Content (ASTM D-129 or 1552)	Not to exceed 1% by weight.
Water and Sediment (ASTM D-1796)	Not to exceed 0.1% by weight.
Carbon Residue (Ransbottom ASTM D-524 or D-189)	Not to exceed 0.25% by weight on 10% residue.
Flash Point (ASTM D-93)	At least 125°F or legal temperature if higher than 125°F.
Gravity (ASTM D-287)	30 to 42° A.P.I. at 60°F. (0.815 to 0.875 sp. gr.)
Pour Point (ASTM D-97)	Below lowest temperature expected.
Active Sulfur-Copper Strip Corrosion (ASTM D-130)	Not to exceed No. 2 rating after 3 hours at 122°F.
Ash (ASTM D-482)	Not to exceed 0.02% by weight.

Distillation (ASTM D-86)	The distillation curve should be smooth and continuous. At least 90% of the fuel should evaporate at less than 675°F. All of the fuel should evaporate at less than 725°F.

Coolant

Water should be clear and free of any corrosive chemicals such as chloride, sulfates and acids. It should be kept slightly alkaline with pH value in range of 8.5 to 10.5. Any water which is suitable for drinking can be treated as described in the following paragraphs for use in an engine.

Maintain the Fleetguard DCA Water Filter on the engine. The filter by-passes a small amount of coolant from the system via a filtering and treating element which must be replaced periodically.

1. In summer, with no antifreeze, fill system with water.
2. In winter, select an antifreeze and use with water as required by temperature.

Note: Some antifreeze also contain anti-leak additives such as inert inorganic fibers, polymer particles or ginger root; these antifreeze should not be used in conjunction with the water filter. The filter element will filter out the additives and/or become clogged and ineffective.

3. Install or replace DCA Water Filter as follows and as recommended in Section 2.

New Engines Going Into Service Equipped With DCA Water Filters

1. New engines shipped from the Factory are equipped with water filters containing a DCA precharge element. This element is compatible with plain water or all permanent-type antifreeze except Dowtherm 209. See Table 3-4 for Dowtherm 209 precharge instructions.
2. At the first "B" Check (oil change period) the DCA precharge element should be changed to DCA Service Element. See Table 3-4.
3. Replace the DCA Service Element at each succeeding "B" Check.
   a. If make-up coolant must be added between element changes, use coolant from a pre-treated supply, see "Make-Up Coolant Specifications", Section 2.
   b. Each time system is drained, precharge according to Table 3-4.
4. Service element may be changed at "C" Check if 3300858 (DCA-4L) direct chemical additive is added to the cooling system at each "B" Check between service element changes. One bottle of direct additive should be used for every 10 gallon of cooling system capacity. Add one bottle for every 15 gallon capacity if methoxy propanol antifreeze (Dowtherm 209) is used in the cooling system.
5. To insure adequate corrosion protection have the

Table 3-4: Spin-On Type DCA Water Filter

Cooling System	Ethylene Glycol Base Antifreeze		Methoxy Propanol Base Antifreeze (Dowtherm 209)	
Capacity (U.S. Gallons)	**DCA-4L Precharge (P/N 3300858)**	**Service Element(s)**	**DCA-4L Precharge (P/N 3300858)**	**Service Element(s)**
0-8	1	WF-2010 (P/N 299080)	1	WF-2011 (P/N 3300721)
9-15	2	WF-2010	2	WF-2011
16-30	5	WF-2010	4	WF-2011
31-60	10	WF-2010	8	WF-2011
35-90 (V-1710)	12	WF-2016 (P/N 299086)	8	WF-2017 (P/N 300724)
70-90 (KT-2300)	16	WF-2010	16	WF-2011
80-100 (KTA-3067)	16	(4)WF-2010		

coolant checked at each third element change or more often. See "Check Engine Coolant", Section 2.

Engine Now In Service With Spin-On Type Chromate Corrosion Resistor Element

1. Remove chromate element.
2. Clean and flush cooling system.
3. Install service DCA element and precharge according to Table 3-4. Operate engine to next "B" Check; then treat as "New Engine Going Into Service" above. See Table 3-4.

Table 3-5: Canister Type

DCA Precharge Canister	DCA Service Canister	Fleetguard P/N
None*	299071	WF-2001
None *	299074	WF-2004
None *	(2) 299091	(2) WF-2021

*** 3300858 (DCA-4L) Precharge To Be Used With Service Elements.**

Cooling System U.S. Gal.	Service Element 299074	Service Element 299071	Service Element 299091	Service Element (2) 299091
0-5	1			
5-9	2	1		
9-13	3	2	1	
13-17	0	3	2	
17-21	0	4	3	1
21-25	0	5	4	2
25-28	0	0	5	3
28-32	0	0	6	4
32-36	0	0	7	5
36-40	0	0	8	6
40-45	0	0	0	7
45-49	0	0	0	8
49-53	0	0	0	9
53-57	0	0	0	10
57-61	0	0	0	11
61-65	0	0	0	12
65-69	0	0	0	13
69-73	0	0	0	14
73-79	0	0	0	15
79-81	0	0	0	16

Note: Canister type elements are not available for use with methoxy propanol base antifreeze (Dowtherm 209); however, conversion kits are available to convert the pot type water filters to spin-on elements.

Engines Now In Service With Package (Bag) Or Canister Type Chromate Corrosion Resistor Elements

1. Remove chromate package or canister, discard package element and plates or canister, retain spring for use with DCA service element.
2. Flush cooling system.
3. Precharge system with coolant and DCA-4L, Part No. 3300858, according to Table 3-5, using applicable service canister.
4. At next "B" Check install service canister, replacing regularly at each succeeding "B" Check thereafter, except under following conditions:

   a. If make-up coolant must be added between canister changes, use coolant from a pre-treated supply. See "Make-Up Coolant Specifications", Section 2.

   b. Each time system is drained revert back to Step 3 instructions for one oil change period.

Capscrew Markings and Torque Values

Current Usage	Much Used	Much Used	Used at Times	Used at Times
Minimum Tensile Strength PSI MPa	To 1/2—69,000 [476] To 3/4—64,000 [421] To 1—55,000 [379]	To 3/4—120,000 [827] To 1—115,000[793]	To 5/8—140,000 [965] To 3/4—133,000 [917]	150,000 [1 034]
Quality of Material	**Indeterminate**	**Minimum Commercial**	**Medium Commercial**	**Best Commercial**
SAE Grade Number	**1 or 2**	**5**	**6 or 7**	**8**
Capscrew Head Markings Manufacturer's marks may vary These are all SAE Grade 5 (3 line)				
Capscrew Body Size (Inches) — (Thread)	**Torque Ft-Lbs [N • m]**	**Torque Ft-Lbs [N • m]**	**Torque Ft-Lbs [N • m]**	**Torque Ft-Lbs [N • m]**
1/4 — 20	5 [7]	8 [11]	10 [14]	12 [16]
— 28	6 [8]	10 [14]		14 [19]
5/16 — 18	11 [15]	17 [23]	19 [26]	24 [33]
— 24	13 [18]	19 [26]		27 [37]
3/8 — 16	18 [24]	31 [42]	34 [46]	44 [60]
— 24	20 [27]	35 [47]		49 [66]
7/16 — 14	28 [38]	49 [66]	55 [75]	70 [95]
— 20	30 [41]	55 [75]		78 [106]
1/2 — 13	39 [53]	75 [102]	85 [115]	105 [142]
— 20	41 [56]	85 [115]		120 [163]
9/16 — 12	51 [69]	110 [149]	120 [163]	155 [210]
— 18	55 [75]	120 [163]		170 [231]
5/8 — 11	83 [113]	150 [203]	167 [226]	210 [285]
— 18	95 [129]	170 [231]		240 [325]
3/4 — 10	105 [142]	270 [366]	280 [380]	375 [508]
— 16	115 [156]	295 [400]		420 [569]
7/8 — 9	160 [217]	395 [536]	440 [597]	605 [820]
— 14	175 [237]	435 [590]		675 [915]
1 — 8	235 [319]	590 [800]	660 [895]	910 [1234]
— 14	250 [339]	660 [895]		990 [1342]

Notes:
1. Always use the torque values listed above when specific torque values are not available.
2. Do not use above values in place of those specified in other sections of this manual; special attention should be observed when using SAE Grade 6, 7 and 8 capscrews.
3. The above is based on use of clean, dry threads.
4. Reduce torque by 10% when engine oil is used as a lubricant.
5. Reduce torque by 20% if new plated capscrews are used.
6. Capscrews threaded into aluminum may require reductions in torque of 30% or more of Grade 5 capscrews torque and must attain two capscrew diameters of thread engagement.

Caution: If replacement capscrews are of a higher grade than originally supplied, adhere to torque specifications for that placement.

Troubleshooting

Troubleshooting is an organized study of the problem and a planned method of procedure for investigation and correction of the difficulty. The chart on the following page includes some of the problems that an operator may encounter during the service life of a Cummins Diesel Engine.

Cummins Diesel Engines

The chart does not give all the answers for correction of problems listed, but it is meant to stimulate a train of thought and indicate a work procedure directed toward the source of trouble. To use the troubleshooting chart, find the complaint at top of chart; then follow down that column to a black dot. Refer to left of dot for the possible cause.

Think Before Acting

Study the problem thoroughly. Ask these questions:

1. What were the warning signs preceding the trouble?
2. What previous repair and maintenance work has been done?
3. Has similar trouble occurred before?
4. If the engine still runs, is it safe to continue running it to make further checks?

Do Easiest Things First

Most troubles are simple and easily corrected; examples are "low-power" complaints caused by loose throttle linkage or dirty fuel filters, "excessive lubricating oil consumption" caused by leaking gaskets or connections, etc.

Always check the easiest and obvious things first; following this simple rule will save time and trouble.

Double-Check Before Beginning Disassembly Operations

The source of most engine troubles can be traced not to one part alone but to the relationship of one part with another. For instance, excessive fuel consumption may not be due to an incorrectly adjusted fuel pump, but instead, to a clogged air cleaner or possibly a restricted exhaust passage, causing excessive back pressure.

Too often, engines are completely disassembled in search of the cause of a certain complaint and all evidence is destroyed during disassembly operations. Check again to be sure an easy solution to the problem has not been overlooked.

Find and Correct Basic Cause Of Trouble

After a mechanical failure has been corrected, be sure to locate and correct the cause of the trouble so the same failure will not be repeated. A complaint of "sticking injector plungers" is corrected by replacing the faulty injectors, but something caused the plungers to stick. The cause may be improper injector adjustment, or more often, water in the fuel.

TROUBLE SHOOTING

CUMMINS ENGINES

System	CAUSES / COMPLAINTS	Hard Starting or Failure to Start	Engine Misses	Excessive Smoking at Idling	Excessive Smoke Under Load	Low Power or Loss of Power	Cannot Reach Governed RPM	Low Air Output	Excessive Fuel Consumption	Poor Deceleration	Erratic Idle Speeds	Engine Dies	Surging at Governed RPM	Excessive Lube Oil Consumption	Crankcase Sludge	Dilution	Low Lubrication Oil Pressure	Fuel Leakage AFC Vent Capscrew	Coolant Temperature too Low	Coolant Temperature too High	Lube Oil too Hot	Piston, Liner and Ring Wear	Wear of Bearings and Journals	Worn Valves and Guides	Fuel Knocks	Mechanical Knocks	Gear Train Whine	Excessive Engine Vibration
AIR SYSTEM	Restricted Air Intake	●			●	●		●	●																			
	High Exhaust Back Pressure				●	●			●											●								
	Thin Air In Hot Weather or High Alt				●	●		●																				
	Air Leaks Between Cleaner and Engine							●														●	●	●				
	Dirty Turbocharger Compressor				●	●		●	●																			
	Improper Use of Starter Aid/Air Temp	●																							●			
FUEL SYSTEM	Out of Fuel or Fuel Shut-Off Closed	●										●																
	Poor Quality Fuel	●	●		●	●			●			●													●			
	Air Leaks in Suction Lines	●	●			●				●	●	●	●												●			
	Restricted Fuel Lines: Stuck Drain Valve	●	●	●	●	●	●		●	●																		
	External or Internal Fuel Leaks					●			●			●				●	●											
	Plugged Injector Spray Holes	●	●	●	●	●			●																			
	Broken Fuel Pump Drive Shaft	●										●																
	Scored Gear Pump or Worn Gears	●				●																						
	Loose Injector Inlet or Drain Connection	●														●												
	Wrong Injector Cups			●	●	●			●							●												
	Cracked Injector Body or Cup	●	●	●	●	●			●							●												
	Mutilated Injector Cup "O" Ring								●							●												
	Throttle Linkage or Adjustment					●	●			●	●	●	●															
	Incorrectly Assembled Idle Springs									●	●	●																
	Governor Weights Assembled Incorrectly										●	●																
	High-Speed Governor Set Too Low					●	●																					
	Water in Fuel	●	●				●					●																
	Aneroid Set Improperly				●	●																						
	Aneroid Check Valve Stuck Open	●																										
	AFC Set Improperly			●		●																						
	Damaged or Worn AFC Plunger Seal																	●										
	Fuel Pump Out of Adjustment					●																						
	Injector Flow Incorrect					●																						
LUBRICATING SYSTEM	External and Internal Oil Leaks													●		●												
	Dirty Oil Filter														●		●						●	●				
	Faulty Cylinder Oil Control			●	●									●		●						●						
	Clogged Oil Drillings																					●	●	●				
	Oil Suction Line Restriction																●					●	●	●				
	Faulty Oil Pressure Regulator																●											
	Crankcase Low or Out of Oil																●			●	●	●	●	●				
	Wrong Grade Oil for Weather Conditions													●			●											
	Oil Level Too High					●			●					●							●							
COOLING SYSTEM	Insufficient Coolant					●											●			●	●							
	Worn Water Pump					●											●			●	●							
	Faulty Thermostats					●									●		●		●	●	●							
	Damaged Water Hose																●			●	●							
	Loose Fan Belts																●			●	●							
	Radiator Shutters Stuck Open														●				●									
	Clogged Water Passages																●			●	●							
	Internal Water Leaks															●												
	Clogged Oil Cooler																●				●							
	Radiator Core Openings Dirty																●			●	●							
	Air in Cooling System																●			●	●							
	Exterior Water Leaks																●			●	●							
	Insufficient Coolant Capacity					●											●			●	●							
	Coolant Temperature Low														●	●									●			
OPERATION AND MAINTENANCE PRACTICES	Dirty Filters and Screens					●									●							●	●	●				
	Long Idle Periods	●	●	●	●	●									●	●												
	Engine Overloaded				●				●								●			●	●	●	●	●	●	●		
	Oil Needs Changing														●							●	●	●				
	Engine Exterior Caked with Dirt																●			●	●							
MECHANICAL ADJUSTMENTS OR REPAIR	Gasket Blow-by or Leakage			●	●	●										●												
	Faulty Vibration Damper																									●		●
	Unbalanced or Loose Flywheel																									●		●
	Valve Leakage	●	●			●																		●				
	Broken or Worn Piston Rings	●	●	●	●	●								●								●				●		
	Incorrect Bearing Clearances					●			●								●						●			●	●	
	Excessive Crankshaft End Clearance																						●			●	●	
	Main Bearing Bore Out of Alignment																						●			●		●
	Engine Due for Overhaul	●		●	●	●			●					●			●					●	●	●		●	●	●
	Damaged Main or Rod Bearings																●						●			●		
	Broken Tooth in Gear Train																									●	●	
	Excessive Gear Back Lash																									●	●	
	Misalignment Engine to Driven Unit								●														●				●	●
	Loose Mounting Bolts																									●		●
	Incorrect Valve and Injection Timing	●		●	●	●																		●	●			
	Worn or Scored Liners or Pistons			●	●	●								●								●				●		
	Injectors Need Adjustment		●	●	●	●			●																●			

Operating Principles

Dependable service can be expected from a Cummins Diesel Engine when the operating procedures are based upon a clear understanding of the engine working principles. Each part of the engine affects the operation of every other working part and of the engine as a whole. Cummins Diesel Engines treated in this manual are four-stroke-cycle, high-speed, full-diesel engines.

The Cummins Diesel Engine

Cummins Diesel Cycle

Cummins Diesel Engines differ from spark-ignited engines in a number of ways. Compression ratios are higher, the charge taken into combustion chamber during the intake stroke consists of air only — with no fuel mixture. Cummins injectors receive low-pressure fuel from the fuel pump and deliver it into individual combustion chambers at the proper time, in equal quantity and atomized condition for burning. Ignition of fuel is caused by heat of compressed air in the combustion chamber.

The four strokes and order in which they occur are: Intake Stroke, Compression Stroke, Power Stroke and Exhaust Stroke.

In order for the four strokes to function properly, valves and injectors must act in direct relation to each of the four strokes of the piston. The intake valves, exhaust valves and injectors are camshaft actuated, linked by tappets or cam followers, push rods, rocker levers and valve crosshead. The camshaft is gear drive by the crankshaft gear, thus rotation of the crankshaft directs the action of the camshaft which in turn controls the opening and closing sequence of the valves and the injection timing (fuel delivery).

Intake Stroke

During intake stroke, the piston travels downward; intake valves are open, and exhaust valves are closed. The downward travel of the piston allows air from the atmosphere to enter the cylinder. On turbocharged engines the intake manifold is pressurized as the turbocharger forces more air into the cylinder through the intake manifold. The intake charge consists of air only with no fuel mixture.

Compression Stroke

At the end of the intake stroke, intake valves close and piston starts upward on compression stroke. The exhaust valves remain closed.

At end of compression stroke, air in combustion chamber has been forced by the piston to occupy a smaller space (depending upon engine model about one-fourteenth to one-sixteenth as great in volume) than it occupied at beginning of stroke. Thus, compression ratio is the direct proportion in the amount of air in the combustion chamber before and after being compressed.

Compressing air into a small space causes temperature of air to rise to a point high enough for ignition of fuel.

During last part of compression stroke and early part of power stroke, a small metered charge of fuel is injected into combustion chamber.

Almost immediately after fuel charge is injected into combustion chamber, fuel is ignited by the existing hot compressed air.

Power Stroke

During the beginning of the power stroke, the piston is pushed downward by the burning and expanding gases; both intake and exhaust valves are closed. As more fuel is added and burns, gases get hotter and expand more to further force piston downward and thus adds driving force to crankshaft rotation.

Exhaust Stroke

During exhaust stroke, intake valves are closed, exhaust valves are open, and piston is on upstroke.

Upward travel of piston forces burned gases out of combustion chamber through open exhaust valve ports and into the exhaust manifold.

Proper engine operation depends upon two things—first, compression for ignition; and second, that fuel be measured and injected into cylinders in proper quantity at proper time.

Fuel System

The PT fuel system is used exclusively on Cummins Diesel. The identifying letters, "PT", are an abbreviation for "pressure-time".

The operation of the Cummins PT Fuel System is based on the principle that the volume of liquid flow is proportionate to the fluid pressure, the time allowed to flow and the passage size through which the liquid flows. To apply this simple principle to the Cummins PT Fuel System, it is necessary to provide:

1. A fuel pump to draw fuel from the supply tank and deliver it to individual injectors of each cylinder.
2. A means of controlling pressure of the fuel being delivered by the fuel pump to injectors so individual cylinders will receive the right amount of fuel for the power required of the engine.
3. Fuel passages of the proper size and type so fuel will be distributed to all injectors and cylinders with equal pressure under all speed and load conditions.
4. Injectors to receive low-pressure from the fuel pump and deliver it into the individual combustion chambers at the right time, in equal quantities and proper condition to burn.

The PT fuel system consists of fuel suction line, fuel filters, fuel pump, aneroid, supply lines, fuel passages, fuel manifolds, injectors, drain passages and drain lines. See Fig's. 5-1 through 5-5 for fuel flow.

There are four types of fuel pumps currently used on Cummins Engines. The PT (type G), PT (type G) VS, PT (type G) AFC and the PT (type G) AFC (without Air/Fuel control).

Fuel Pump

The fuel pump is coupled to the air compressor, vacuum pump or fuel pump drive which is driven from the engine gear train. Fuel pump main shaft in turn drives the gear pump, governor and tachometer shaft assemblies.

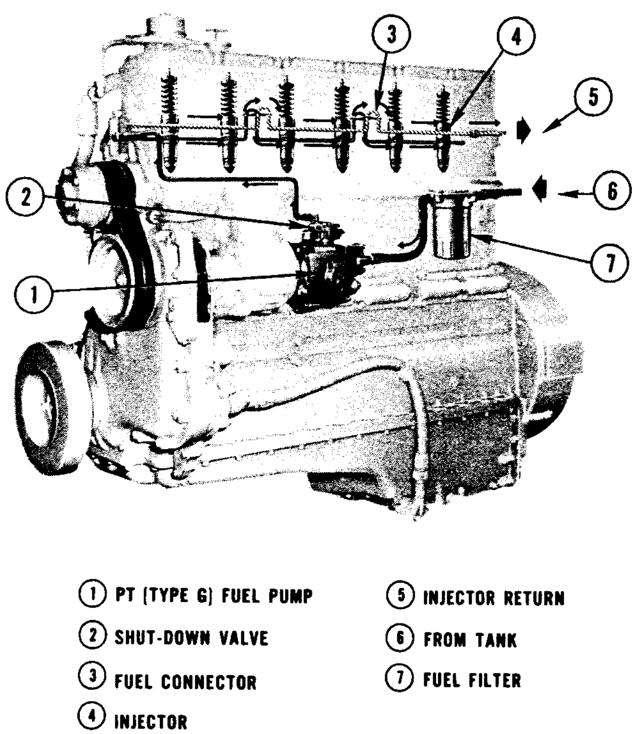


Fig. 5-1, (FWC-13). Fuel flow schematic — N/NT-855 Engine

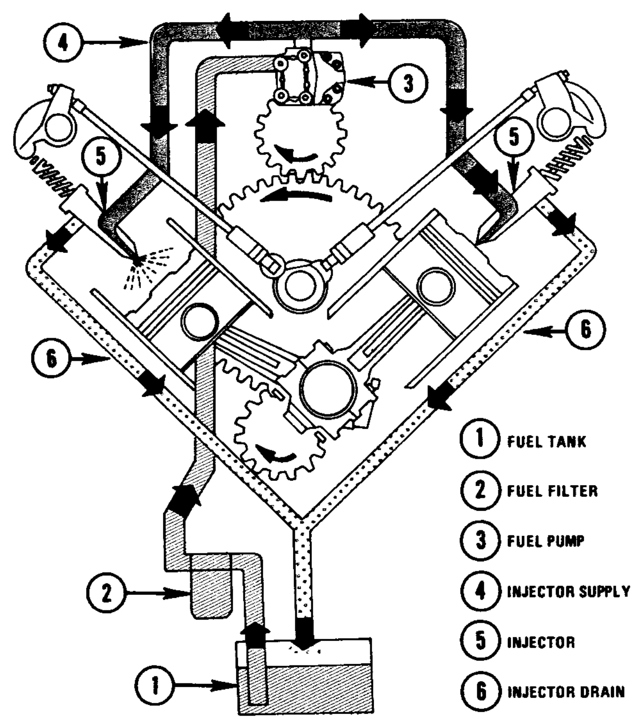


Fig. 5-2, (FWC-30). Fuel flow schematic — V Engine

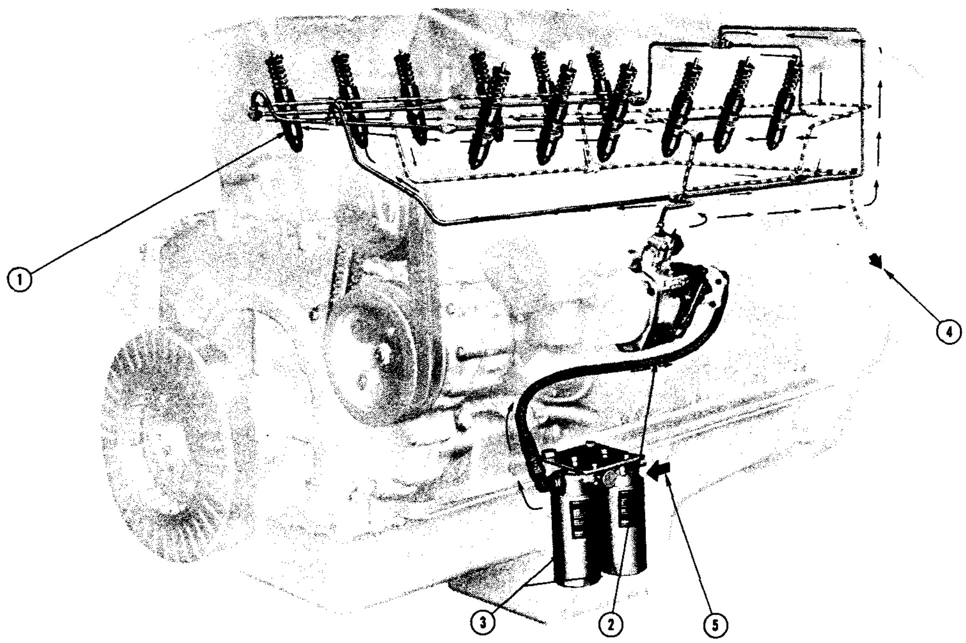


Fig. 5-3, (FWC-15A). Fuel flow schematic — V-1710 Engine

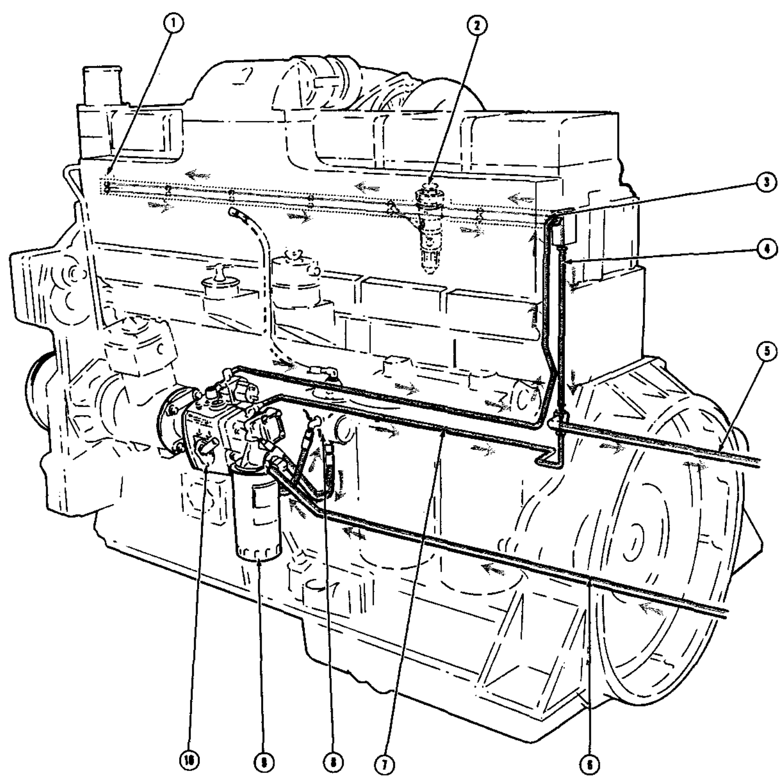


Fig. 5-4, (K11941). Fuel flow schematic — KT(A)-1150 Engine

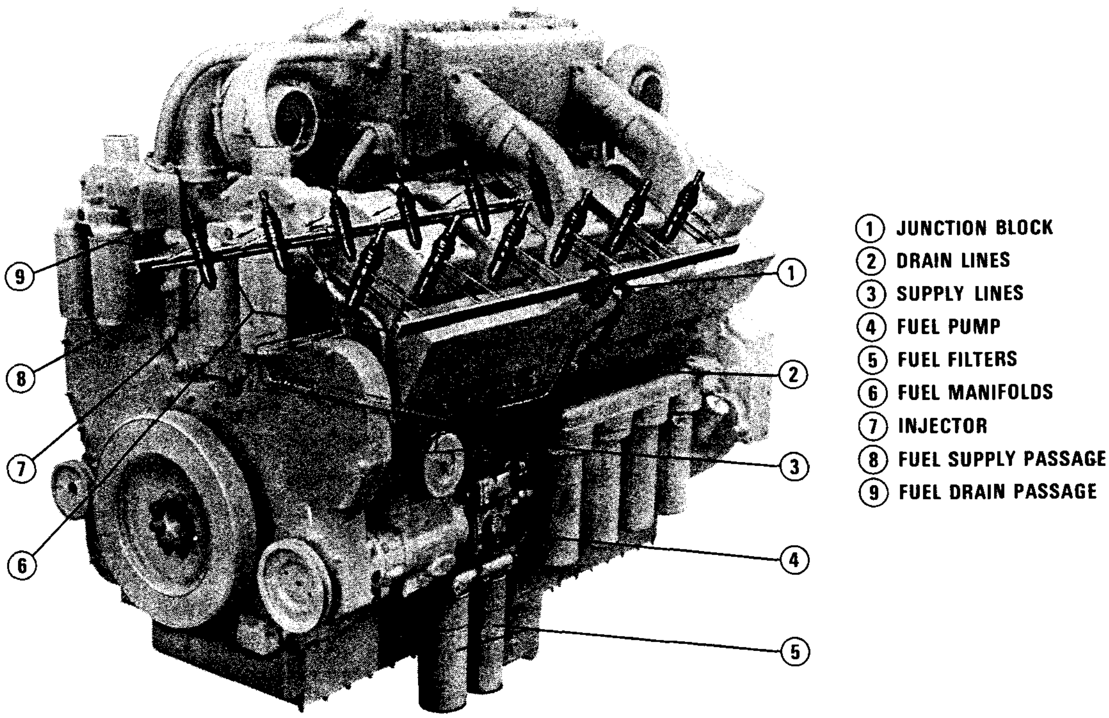


Fig. 5-5, (FWC-40). Fuel flow schematic — KT(A)-2300 Engine

PT (type G) Fuel Pump

The PT (type G) fuel pump assembly, Fig. 5-6, is made up of three main units: the gear pump, standard governor and throttle.

PT (type G) VS Fuel Pump

The PT (type G) VS fuel pump, Fig. 5-7, is made up of four main units: the gear pump, standard governor, throttle as in PT (type G) Fuel Pump and a VS (Variable Speed) governor.

Gear Pump and Pulsation Damper

The gear pump is driven by the pump main shaft and contains a single set of gears to pick up and deliver fuel throughout the fuel system. Inlet to the gear pump on small V-type engines may be through the fuel pump main housing. On other engines it's at the rear of the gear pump.

A pulsation damper mounted to the gear pump contains a steel diaphragm which absorbs pulsations and smooths fuel flow through the fuel system. From the gear pump, fuel flows through the filter screen and:

In the PT (type G) and PT (type G) VS fuel pumps to the governor assembly as shown in Fig's. 5-6, 5-7 and 5-8.

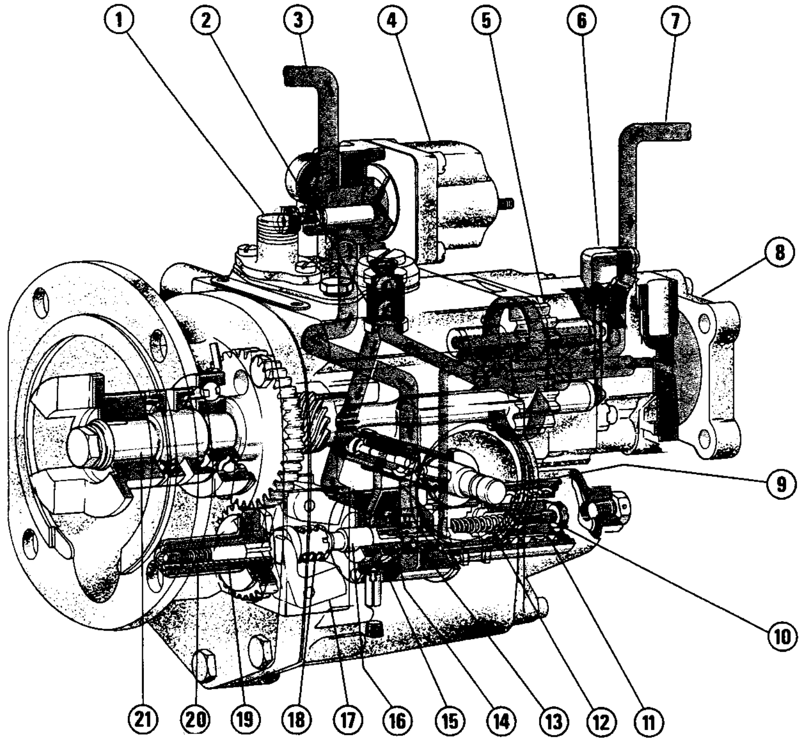
Throttle

The throttle provides a means for the operator to manually control engine speed above idle as required by varying operating conditions of speed and load.

In PT (type G) and PT (type G) VS fuel pumps, fuel flows through the governor to throttle shaft. At idle speed, fuel flows through idle port in governor barrel, past the throttle shaft. To operate above idle speed, fuel flows through the main governor barrel port to throttling hole in shaft.

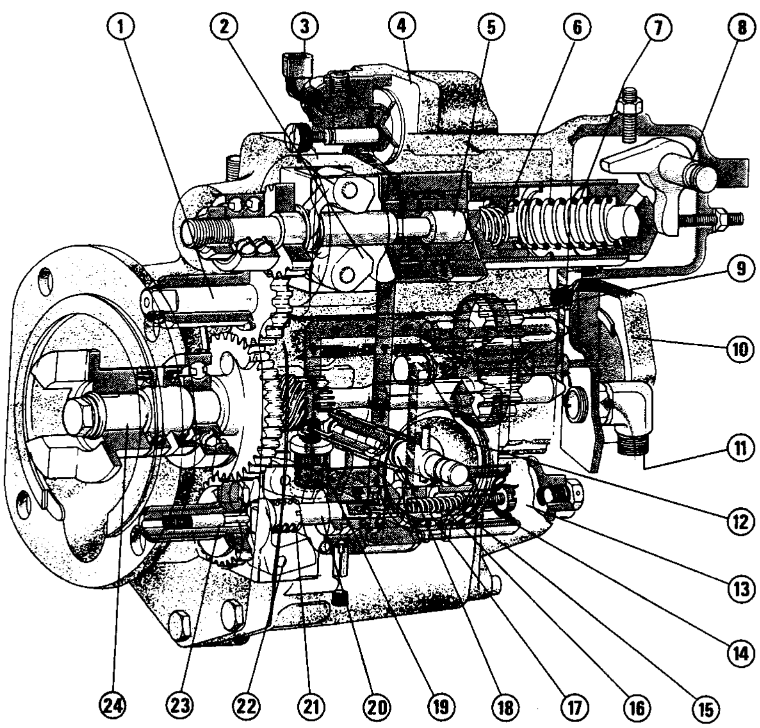
Governors

Idling and High-Speed Mechanical Governor: The mechanical governor, is actuated by a system of springs and weights, and has two functions. First, the governor maintains sufficient fuel for idling with the throttle control in idle position; second, it cuts off fuel to the injectors above maximum rated rpm. The idle springs in the governor spring pack, position the governor plunger so the idle fuel port is opened



1. TACHOMETER SHAFT
2. FILTER SCREEN
3. FUEL TO INJECTORS
4. SHUT-DOWN VALVE
5. GEAR PUMP
6. CHECK VALVE ELBOW
7. FUEL FROM TANK
8. PULSATION DAMPER
9. THROTTLE SHAFT
10. IDLE ADJUSTING SCREW
11. HIGH SPEED SPRING
12. IDLE SPRING
13. GEAR PUMP PRESSURE
14. FUEL MANIFOLD PRESSURE
15. IDLE PRESSURE
16. GOVERNOR PLUNGER
17. GOVERNOR WEIGHTS
18. TORQUE SPRING
19. GOVERNOR ASSIST PLUNGER
20. GOVERNOR ASSIST SPRING
21. MAIN SHAFT

Fig. 5-6, (FWC-31). PT (type G) fuel pump and fuel flow



1. IDLER GEAR AND SHAFT
2. VS GOVERNOR WEIGHTS
3. FUEL TO INJECTORS
4. SHUTDOWN VALVE
5. VS GOVERNOR PLUNGER
6. VS IDLE SPRING
7. VS HIGH SPEED SPRING
8. VS THROTTLE SHAFT
9. GEAR PUMP
10. PULSATION DAMPER
11. FUEL FROM FILTER
12. PRESSURE REGULATOR VALVE
13. IDLE ADJUSTING SCREW
14. SPRING SPACER
15. HIGH SPEED SPRING
16. IDLE SPRING
17. IDLE SPRING PLUNGER
18. THROTTLE SHAFT
19. FILTER SCREEN
20. GOVERNOR PLUNGER
21. TORQUE SPRING
22. GOVERNOR WEIGHTS
23. GOVERNOR ASSIST PLUNGER
24. MAIN SHAFT

Fig. 5-7, (FWC-35). PT (type G) VS (Variable Speed) fuel pump and fuel flow

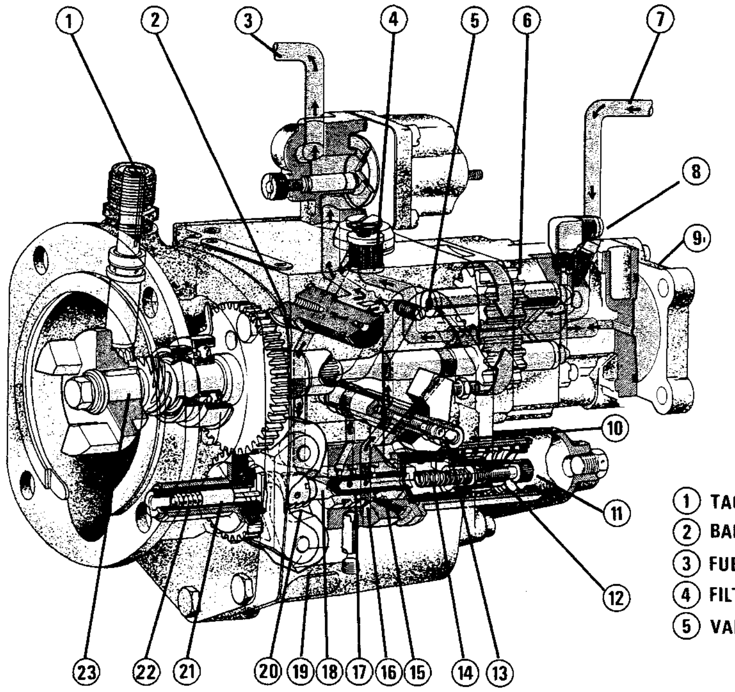


Fig. 5-8, (FWC-52). PT (type G) fuel pump (Non-air fuel control)

enough to permit passage of fuel to maintain engine idle speed.

During operation between idle and maximum speeds, fuel flows through the governor to the injectors. This fuel is controlled by the throttle and limited by the size of the idle spring plunger counterbore on PT (type G) fuel pumps. When the engine reaches governed speed, the governor weights move the governor plunger, and fuel passages to the injectors are shut off. At the same time another passage opens and dumps the fuel back into the main pump body. In this manner, engine speed is controlled and limited by the governor regardless of throttle position. Fuel leaving the governor flows through the shut-down valve, inlet supply lines and on into the injectors.

PT (type G) Variable-Speed Governors

The VS governor, Fig. 5-7, in the upper portion of the fuel pump housing, operates in series with the standard governor to permit operation at any desired (near constant) speed setting within the range of the standard governor. Speed can be varied with the VS speed control lever, located at top of pump. This pump gives surge free governing throughout the engine speed range with a speed droop smaller than the standard governor and is suited to the varying speed requirements of power take-off etc., in which the same engine is used for propelling the unit and also driving a pump or other fixed-speed machine.

When operating the PT (type G) VS fuel pump at any desired constant speed, the VS governor lever should be placed in operating position and the throttle locked in full open position to allow a full flow of fuel through the standard governor.

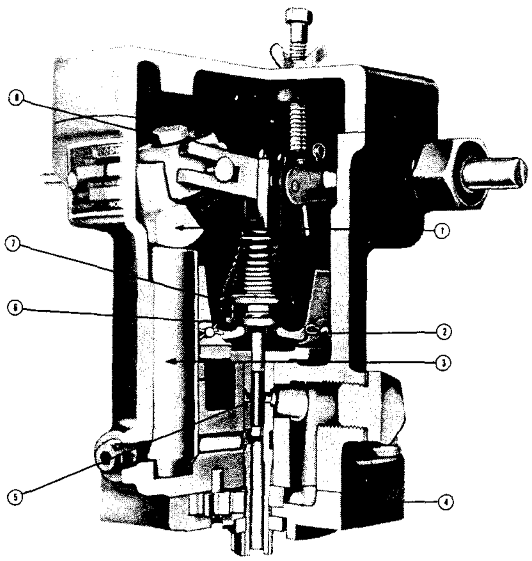
Hydraulic Governor

Hydraulic governors are used on stationary power applications where it is desirable to maintain a constant speed with varying loads.

The Woodward Hydraulic Governor uses lubricating oil, under pressure, as an energy medium. It is supplied from a sump on governor drive housing. For oil viscosity, see Page 3-2.

The governor acts through oil pressure to increase fuel delivery. An opposing spring in governor control linkage acts to decrease fuel delivery.

In order that its operation may be stable, speed droop is



1. TERMINAL LEVER
2. BALLARM PIN
3. SERVO MOTOR PISTON
4. GOVERNOR BASE
5. PILOT VALVE PLUNGER
6. THRUST BEARING
7. SPRING SEAT
8. SPEED DROP ADJUSTING SCREW

Fig. 5-9, (FWC-1). Woodward hydraulic governor

introduced into governing system. Speed droop means the characteristic of decreasing speed with increasing load. The desired magnitude of this speed droop varies with engine applications and may easily be adjusted to cover a range of 0 to 5 percent on the PSG to 7 percent on SG.

Assume a certain amount of load is applied to the engine. The speed will drop, flyballs will be forced inward and will lower pilot valve plunger. This will admit oil pressure underneath servo piston, which will rise (as shown in Fig. 5-9). The movement of servo piston is transmitted to terminal shaft by terminal lever. Rotation of terminal shaft causes fuel setting of engine to be increased.

Aneroid

The aneroid control, Fig. 5-10, provides a fuel by-pass system that responds to air manifold pressure and is used on turbocharged engines for close control of exhaust smoke.

The aneroid limits fuel pressure to the injectors when accelerating the engine from speeds below normal operating range, and while air intake manifold air pressure is not sufficient for complete combustion. Air intake manifold pressure rises with the turbocharger speed which is powered by exhaust gas energy and is therefore low at low engine speed and exhaust gas output.

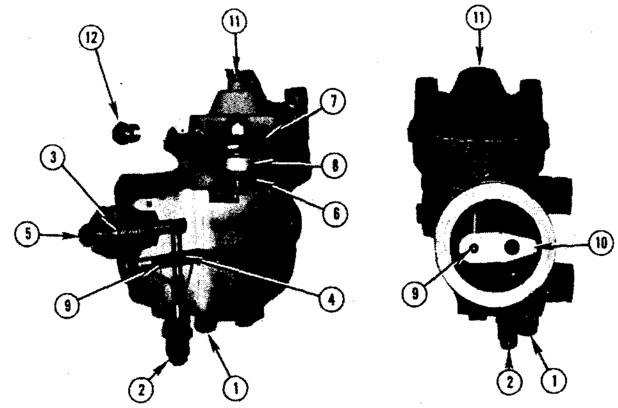


Fig. 5-10, (F-5244). Aneroid cutaway

During acceleration or rapid engine load changes, turbocharger speed (intake manifold pressure) change inherently lags behind the power or fuel demand exercised by opening of the throttle. This lag does not exist in the fuel system; therefore, an overrich or high fuel to air ratio, usually accompanied by smoke, occurs until the turbocharger "catches up".

The function of the aneroid is to create a lag in fuel system so response is equivalent to the turbocharger, thus controlling engine smoke level.

Caution: Aneroids must not be removed, disconnected or otherwise rendered ineffective, nor should settings be altered to exceed specifications as set at the factory. See "Maintenance Schedule".

Fuel Flow

1. Fuel from the fuel pump enters the aneroid and is directed to starting check valve area (5, Fig. 5-10).
2. The starting check valve (3) prevents aneroid from by-passing fuel at engine cranking speeds. For speeds above cranking, fuel pressure forces the check valve open, allowing fuel to flow to valve port (4) of shaft (9).
3. Shaft (9) and its bore form a fuel by-pass valve. This shaft and bore allows passage or restricts fuel flow.
4. The shaft and sleeve are by-passing fuel when arm

(10) of lever is resting against adjusting screw (1). The amount of fuel by-passed is adjusted by this screw, which protrudes from bottom of aneroid.

5. The lever arm connected to piston (8) by actuating shaft (6), rotates shaft, closing valve port. The lever is rotated by action of air intake manifold pressure (11) against piston and diaphragm (7), moving actuating shaft downward against resisting spring force.
6. Anytime engine intake manifold air pressure is above preset "air actuation pressure", aneroid is "out of system".
7. The aneroid begins dumping when intake manifold pressure drops below preset value.
8. The aneroid does not by-pass fuel under full throttle lug down conditions until speed is low enough to reduce intake manifold air pressure to aneroid operating range (usually below engine stall-out speed).
9. Fuel allowed to pass through by-pass valve is returned (2) to suction side (inlet fitting) of PT gear pump. The by-passed fuel reduces fuel pump output to engine and reduces fuel manifold pressure in proportion to the by-pass rate.

PT (type D) Injectors

The injector provides a means of introducing fuel into each combustion chamber. It combines the acts of metering, timing and injection. Principles of operation are the same for inline and V-engines but injectors size and internal design differs slightly. Fig. 5-11 and 5-12.

Fuel supply and drain flow are accomplished through internal drillings in the cylinder heads. Fig's. 5-1 through 5-5. A radial groove around each injector mates with the drilled passages in the cylinder head and admits fuel through an adjustable (adjustable by burnishing to size at test stand) orifice plug in the injector body. A fine mesh screen at each inlet provides final fuel filtration.

The fuel grooves around the injectors are separated by "O" rings which seal against the cylinder head injector bore. This forms a leak-proof passage between the injectors and the cylinder head injector bore surface.

Fuel flows from a connection atop the fuel pump shut-down valve through a supply line into the lower drilled passage in the cylinder head. A second drilling in the head is aligned with the upper injector radial groove to drain away excess fuel. A fuel drain allows return of the unused fuel to the fuel tank.

The injector contains a ball check valve. As the injector plunger moves downward to cover the feed opening, an impulse pressure wave seats the ball and at the same time traps a positive amount of fuel in the injector cup for injection. As the continuing downward plunger movement injects fuel into the combustion chamber, it also uncovers the drain opening and the ball rises from its seat. This allows free flow through the injector and out the drain for cooling purposes and purging gases from the cup.

Fuel Lines, Connections and Valves

Supply and Drain Lines

Fuel is supplied through lines to cylinder heads. A common drain line returns fuel not injected, to supply tank.

On engines using flanged injectors, fuel is supplied through a single tube to the fuel supply manifold. The drain manifold returns fuel not injected to the supply tank through a drain line.

Connections

Fuel connectors are used between the inline engine cylinder heads to bridge the gap between each supply and drain passage (3, Fig. 5-1).

Flanged injectors are connected to the supply and drain manifolds through connections. The inlet connection contains a fine mesh screen which acts as the final filter before fuel enters the combustion chamber.

Shut-Down Valve

Either a manual or an electric shut-down valve is used on Cummins fuel pumps.

With a manual valve, the control lever must be fully clockwise or open to permit fuel flow through the valve.

With the electric valve, the manual control knob must be fully counterclockwise to permit the solenoid to open the valve when the "switch key" is turned on. For emergency operation in case of electrical failure, turn manual knob clockwise to permit fuel to flow through the valve.

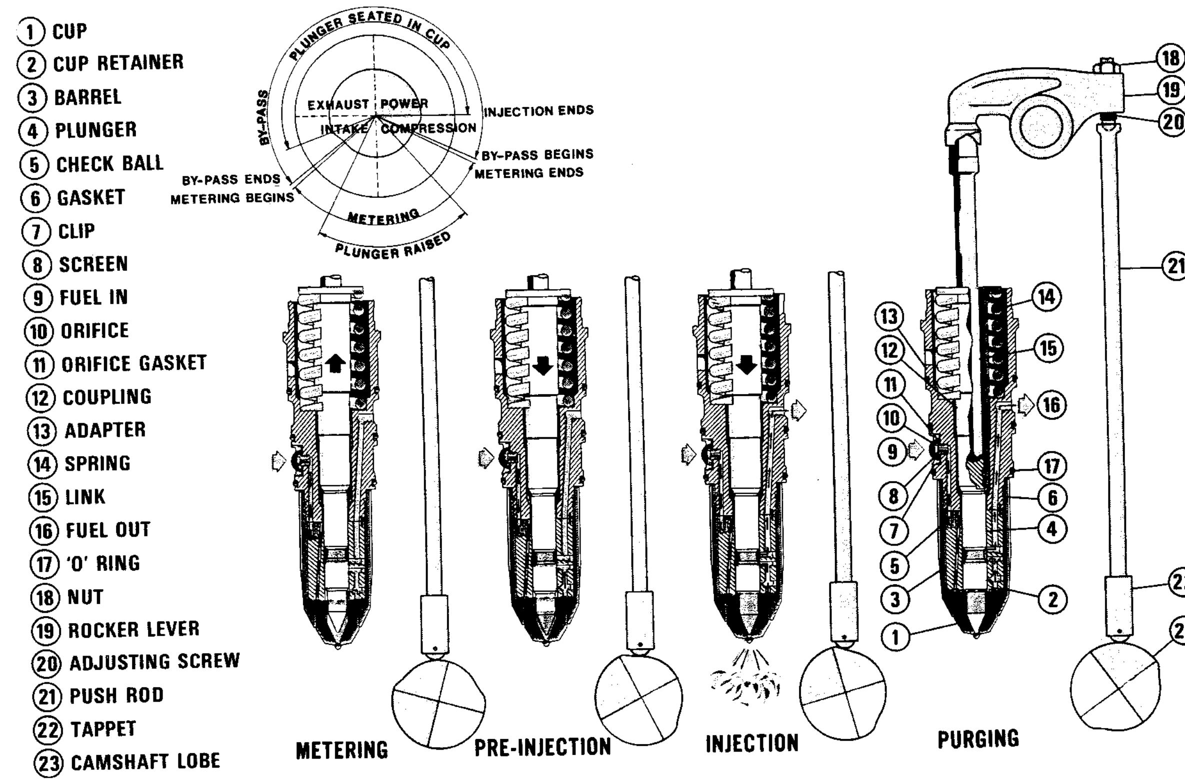


Fig. 5-11, (FWC-24). Fuel injection cycle PT (type D) injector 3/8 inch diameter plunger

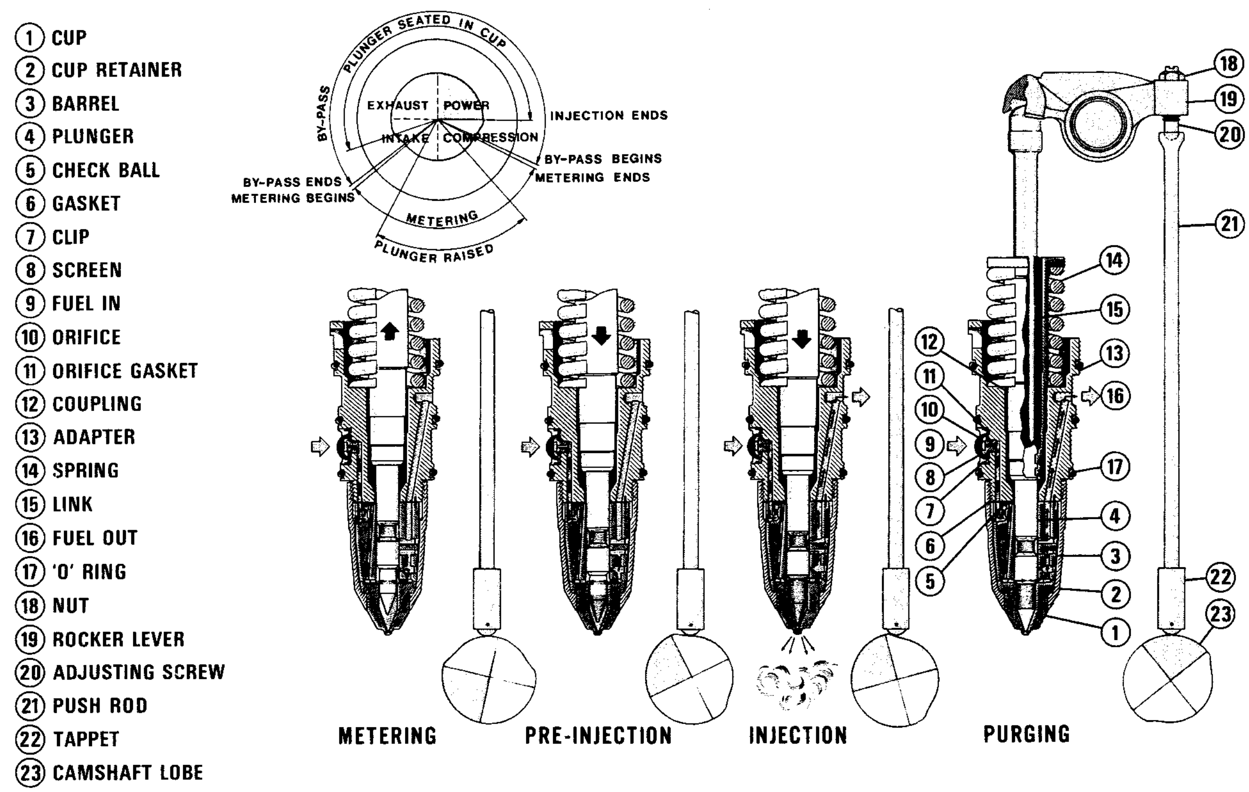


Fig. 5-12, (FWC-29). Fuel injection cycle PT (type D) injector 5/16 inch diameter plunger

Lubricating System

Cummins engines are pressure lubricated; pressure is supplied by a gear-type lubricating oil pump located in oil pan or on side of the engine.

A pressure regulator is mounted in the lubricating oil pump to control lubricating oil pressure.

Filters and screens are provided in lubricating oil system to remove foreign material from circulation and prevent damage to bearings or mating surfaces. A by-pass valve is provided in full-flow oil filter head as insurance against interruption of oil flow by a dirty or clogged element.

Maximum cleansing and filtration is achieved through use of both by-pass and full-flow lubricating oil filters. Full-flow filters are standard on all engines; by-pass filters are used on all turbocharged models and optionally on all other engines.

Some engines are equipped with special oil pans and filters for specific applications, and others with auxiliary oil coolers to maintain closer oil temperature regulation.

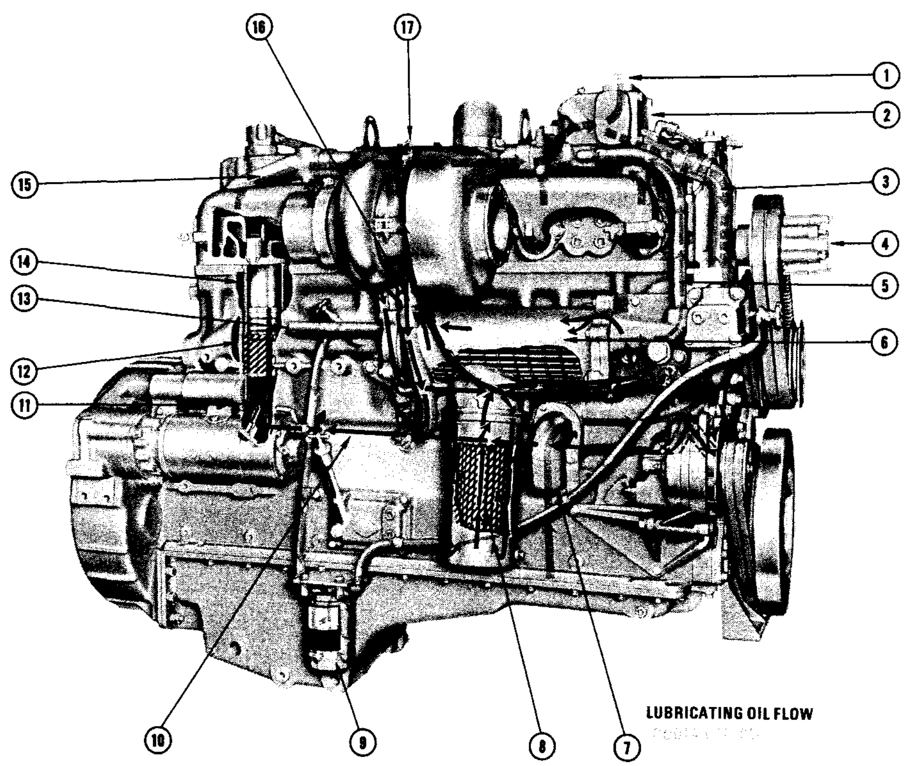
Air compressors and turbochargers are lubricated from engine oil system. Turbocharger is also cooled by same lubricating oil used for lubrication.

Fuel pumps and injectors are lubricated by fuel oil.

Inline Engines

NH and NT Series

Oil is drawn into the pump through an external oil line connected to the oil pan sump. A screen in the sump filters the oil. On NH and NT Engines (Fig. 5-13) oil is drawn from the pan by the pump out through a full-flow filter and circulates back into the block. The filter may be mounted directly to the rear of pump, vertically mounted on exhaust side of engine or remote



1. WATER TO RADIATOR
2. THERMOSTAT HOUSING
3. WATER BY–PASS
4. FAN HUB
5. WATER FROM COOLER TO THERMOSTAT HOUSING
6. LUBRICATING OIL COOLER
7. WATER FROM RADIATOR
8. LUBRICATING OIL FILTER
9. WATER FILTER
10. LUBRICATING OIL HEADER
11. PISTON COOLING OIL
12. WATER HEADER
13. WATER TO COOLER FROM BLOCK
14. WATER JACKET
15. WATER MANIFOLD
16. TURBOCHARGER OIL DRAIN
17. TURBOCHARGER OIL SUPPLY

Fig. 5-13, (LWC-18). Lubricating oil and coolant flow — N/NT-855 Engine mounted. External lines are used for remote mounting arrangements.

On remote and pump mounted filters oil flows from the pump to the oil cooler then flows to oil headers through internal drillings in the gear case. On NTA Engines oil flow is from pan to pump, to filter, to oil cooler, to block.

An oil header drilled full length of block, fuel pump side, delivers oil to moving parts within the engine. Internal oil passages carry oil from the camshaft to upper rocker housings and drillings through the block, crankshaft, connecting rods, and rocker levers completes the oil circulation.

On engines equipped with oil cooled pistons, an oil header drilled the length of the block, exhaust manifold side, supplies oil to six spray nozzles used for piston cooling.

A piston cooling oil pump, as a second section of engine lubricating oil pump or a larger capacity oil pump, pumps this oil to the oil header.

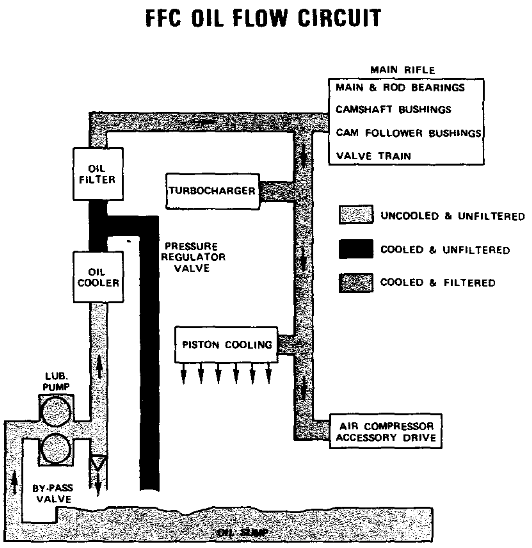


Fig. 5-14, (N10740). Full flow oil cooling schematic — NTC-855 Engine

NTC Engines (Full Flow Oil Cooling)

The NTC (FFC) Engine is pressure lubricated by a gear-type lubricating oil pump located on the intake manifold side of the engine. Oil pressure to the main rifle is controlled by a regulator located in the cooler support on the exhaust side of the engine.

Lubricating oil is drawn from the pan, through a suction tube, by the lubricating oil pump, Fig's. 5-14 and 5-15, then transferred from the suction cavity by the pump gears into the pressure cavity.

Lubricating oil passes from the pump into the block, then across the front of the block by means of an internal oil passage and enters the cooler support. Oil is routed out of the cooler support and into the cooler housing, passing through the cooler housing. (The oil cooler is a counterflow tube-and-shell type heat exchanger, with oil passing from front to rear through the shell and coolant passing from rear to front through the tubes.) Oil exits the cooler housing and passes into the cooler cover, then enters the "rifle drilling" at the bottom rear of the cooler housing and flows forward into the filter head.

Lubricating oil flowing into the filter shell from the filter head enters outside the filter element and passes through the element from outside to inside. Filtered lubricating oil then re-enters the filter head and flows through rifle drilling in the bottom of the cooler housing, then flows forward out of the cooler housing and into the cooler support where the flow divides.

Filtered and cooled lubricating oil from the cooler support is routed to the turbocharger through the supply hose. Turbocharger return oil is then routed by the drain hose back to the crankcase.

Filtered and cooled lubricating oil re-enters the block from the cooler support and is transferred internally back across the front of the block through a drilled oil transfer passage to the head of the main rifle drilling. Accessory drive lubrication is supplied from the transfer passage leading to the head of the main rifle drilling. An intersection drilling routes lubricating oil from the transfer passage out the front of the block and into the gear cover on the exhaust side of the engine, then across the front of the engine through a tube in the gear cover. The flow path then splits, part being routed to the accessory drive bushing in the gear cover and the rest being routed to the air compressor.

Piston-cooling is supplied from the transfer passage leading to the head of the main rifle drilling. An intersecting drilling allows flow to the piston-cooling rifle from the oil transfer passage. The piston-cooling rifle extends from the front to the rear of the block on the exhaust side of the engine. Six piston-cooling nozzles

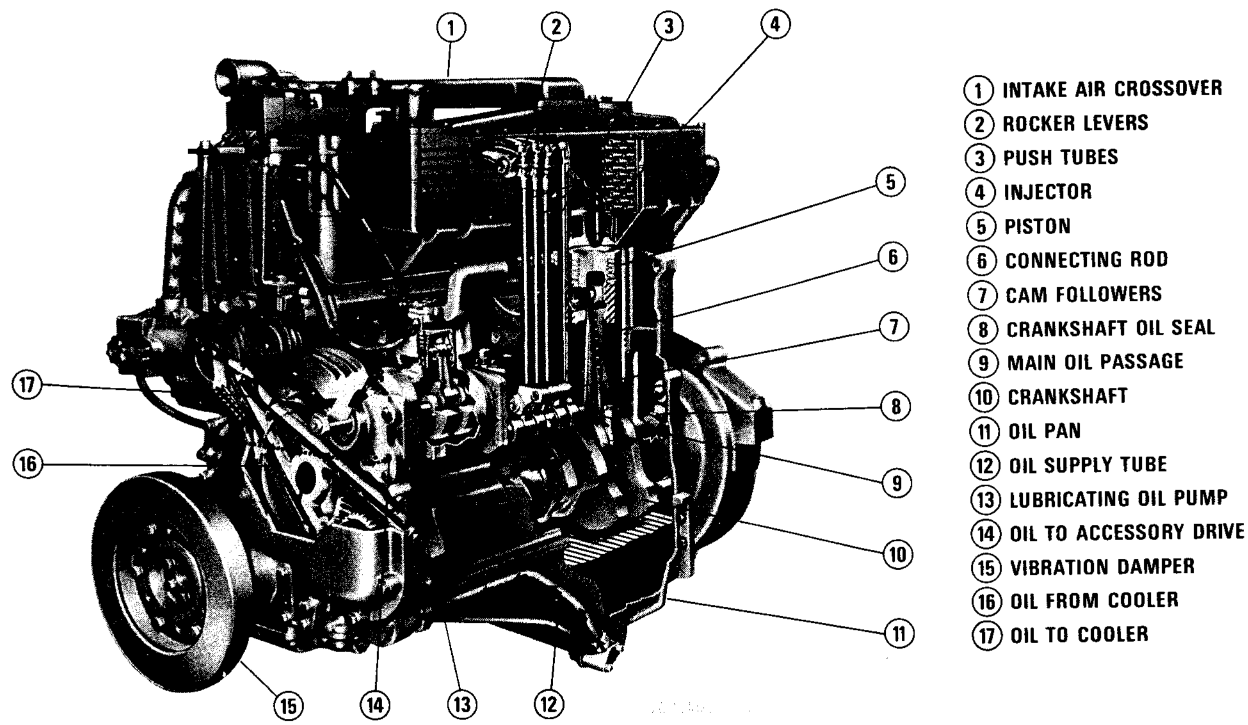


Fig. 5-15, (LWC-25). Lubricating oil and coolant flow — FFC (NTA Engine)

inserted from the outside of the block direct a spray of lubricating oil from the piston-cooling rifle to the bottom of each piston.

Lubricating oil entering the main rifle is routed by means of drilled passages to the main bearings, rod bearings, piston pin bushings, camshaft bushings, cam followers shafts and levers, rocker box shafts and rocker arms, etc., then returns to the oil pan.

V Engines

V6 and V8 Engines are pressure lubricated by a gear type lubricating oil pump mounted on bottom of block, enclosed in oil pan, and gear driven from crankshaft gear.

Oil drawn from pan sump through a screen is delivered to engine working components through oil lines and oil headers which are drilled the length of block. Drillings in block, cylinder head, crankshaft and rocker lever shafts complete oil circulation passages. Fig's. 5-16 and 5-17.

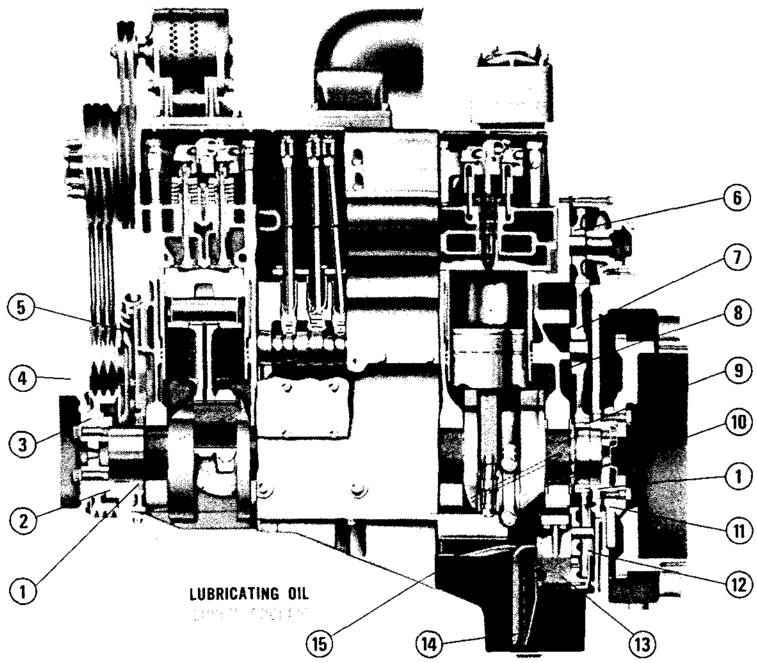
Oil flows through a suction tube to the lubricating oil pump up a passage in rear of block to the cooler (if used) and filter.

V-903 Engines

1. Oil flows from cooler and filter to right bank of oil drilling at front of engine to front center of block. Oil flows through crossover at front of block to left bank and right bank main oil drillings (drilled length of block). Fig. 5-16.
2. Oil flows through left bank drilling toward rear of engine to left bank tappets, accessory drive, to numbers 2, 3, 4 and 5 cam bushings, main bearings and connecting rods.
3. At the same time oil flows to a right bank drilling toward rear of engine to oil right bank tappets.
4. Right bank rocker levers are oiled intermittently from rear cam bushing location. Left bank rocker levers are oiled intermittently from front cam bushing.

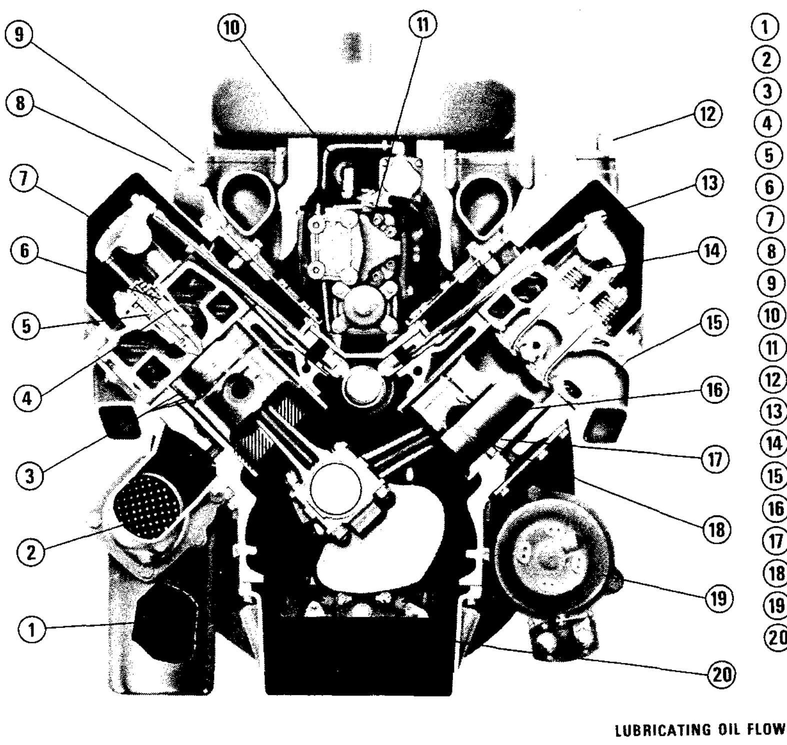
V-378, V-504 and V-555 Engines

1. Oil flows from filter to right bank oil drilling at rear of engine to accessory drive gear, rear cam bushing and rear main bearing which in turn supplies the two rear connecting rods. Fig. 5-17.



1. SEAL WEAR SLEEVE
2. CRANKSHAFT PULLEY ADAPTER
3. CRANKSHAFT PULLEY
4. VIBRATION DAMPER
5. WATER PUMP
6. ACCESSORY DRIVE GEAR
7. CAMSHAFT GEAR
8. CAMSHAFT THRUST RING
9. CRANKSHAFT GEAR
10. CRANKSHAFT THRUST RINGS
11. FLYWHEEL ADAPTER
12. LUBRICATING OIL PUMP DRIVE GEAR
13. LUBRICATING OIL PUMP
14. LUBRICATING OIL SUCTION TUBE
15. LUBRICATING OIL BY-PASS TUBE

Fig. 5-16, (LWC-16). Lubricating oil and coolant flow — V-903 Engine



1. FULL-FLOW LUBRICATING OIL FILTER
2. OIL COOLER
3. PISTON RINGS
4. FUEL IN
5. FUEL OUT
6. INJECTOR
7. INJECTOR ROCKER LEVER
8. LIFTING BRACKET
9. AIR INTAKE MANIFOLD
10. FUEL SUCTION INLET TO PUMP
11. FUEL PUMP
12. OIL FILLER CAP
13. VALVE ROCKER LEVER
14. VALVE CROSSHEAD
15. EXHAUST MANIFOLD
16. CYLINDER LINER
17. CREVICE SEAL
18. PACKING RING
19. CRANKING MOTOR
20. LUBRICATING OIL PUMP

Fig. 5-17, (LWC-4). Lubricating oil and coolant flow — V-378. V-504, V-555 Engines

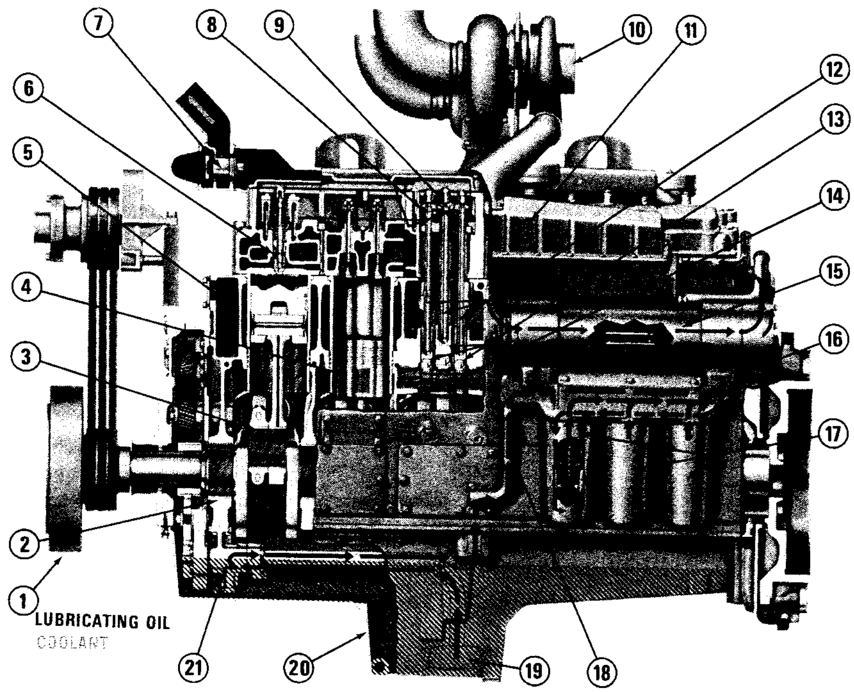


Fig. 5-18, (CWC-13). Lubricating oil and coolant flow — V-1710 Engine

2. Right bank rocker levers are oiled intermittently from rear cam bushing location.
3. Oil flows through the right bank drilling toward front of engine to right bank injector tappets, to center cam bushings, main bearings and connecting rods.
4. Oil flows through a crossover at front of block to left bank.
5. Left bank rocker levers are oiled intermittently through front cam bushing.
6. Oil then flows to a left bank drilling toward rear of engine to oil left bank injector tappets.

V-1710 Engines

Cummins V-1710 Engines, Fig. 5-18, are pressure lubricated, pressure being supplied by a gear-type lubricating oil pump, located in the oil pan and gear driven from the crankshaft gear.

1. Oil is drawn into pump through an oil line to oil pan sump. A screen in pump strains the oil.
2. Internal lubricating oil flows from pump to cooler to full-flow filters mounted on side of engine, then to oil headers in block.
3. Main oil header, drilled full length in center of block delivers oil to moving parts within engine.
4. Oil pipes — or a combination of pipes and passages — carry oil from camshaft to upper rocker housings; various drillings through block, crankshaft, connecting rods and rocker levers complete oil circulating system.
5. On engines equipped with oil-cooled pistons, oil is supplied from the front of the block to oil headers which are drilled the length of block on each side; headers supply oil to spray nozzles, which direct oil to piston skirts.
6. Lubricating oil pressure is controlled by a regulator located in the lubricating oil pump.

KT(A)-1150 Engines

The KT(A)-1150 Engines are pressure lubricated by a gear-type lubricating oil pump located on the exhaust manifold side of the engine directly below the water pump inside the gear cover.

Lubricating oil is drawn from the pan, through a suction tube, by the lubricating oil pump, Fig. 5-19, then transferred from the suction cavity by the pump gears

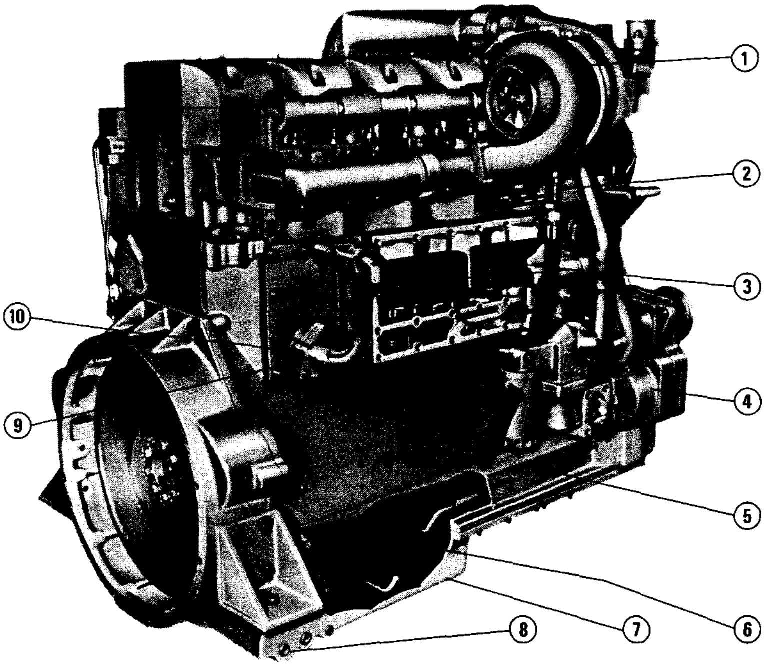


Fig. 5-19, (LWC-29). Lubricating oil flow — KT(A)-1150 Engine

into the pressure cavity. A pressure regulator valve dumps excess oil directly into the pump intake rather than back into the oil pan.

From the lubricating oil pump, oil flows to lubricating oil cooler, through the cooler, then across the block. On air intake side of block it flows to filter head. A by-pass valve is provided in the oil inlet cavity to assure against interruption of oil flow if filter elements become clogged. From the filter head oil enters the shells and passes through the elements, then up, splitting into two passages. One flows to the main engine oil passage and the other to the piston-cooling passage. A second pressure control valve, located in the base of the filter head, limits the flow of lubricating oil to nozzles depending on pump supplied pressure.

Main bearings are lubricated through intersecting drillings, directly from the main oil passage. Oil flows from the main passage into camshaft bushings; from there, by constant flow, it goes to cam follower shafts and up through the cylinder heads. The cam followers are lubricated from their shaft; the cam followers are individually drilled to supply lubricating oil to rollers and push tube seats. The rocker lever bushings are also shaft lubricated. Adjusting screws are lubricated through drillings in levers and bushings. See Fig. 5-20.

The connecting rod bearings get lubrication from cross drillings in the crankshaft; oil then flows through angle drillings in the connecting rods to lubricate piston pins and bushings. It is then routed from the main passage through drillings in the gear housing and cover to the camshaft and water pump idler gears. It then moves across to the gear cover and is routed by drillings to the rest of the gears and bushings.

Filtered and cooled lubricating oil is routed to the turbocharger through an external drilling in the gear housing. Turbocharger drain oil is dumped directly into the crankcase. Fig. 5-19.

KT(A)-2300 and KTA-3067 Engines

The KT(A)-2300 and KTA-3067 Engines are pressure lubricated by a gear-type lubricating oil pump located in the oil pan at the rear of the engine. The pump is mounted to block directly below crankshaft and is driven from rear crankshaft gear.

Lubricating oil is drawn from the pan, through a suction tube, by the pump then transferred from suction cavity by pump gears into pressure cavity. A pressure regu-

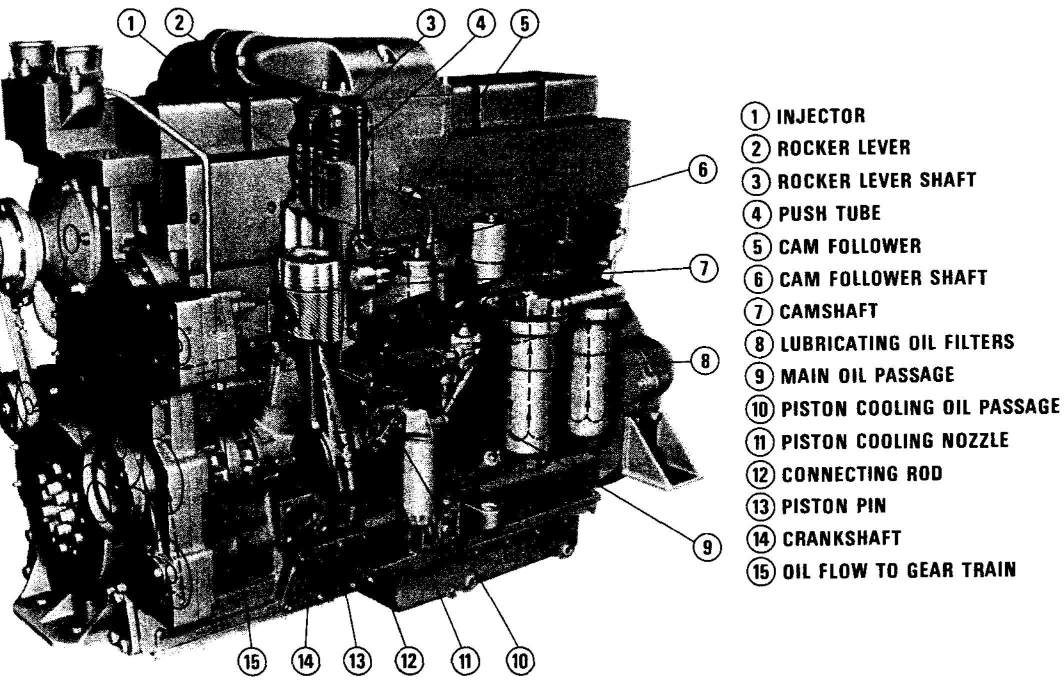


Fig. 5-20, (LWC-28). Lubricating oil flow — KT(A)-1150 Engine

lator valve dumps excess oil back into the oil pan.

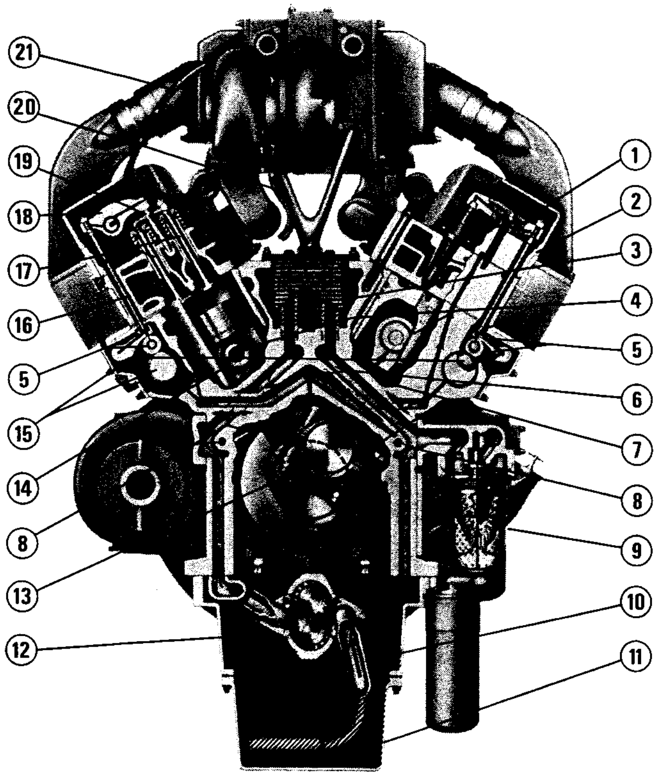
From lubrication oil pump, oil flows through block drillings to lubricating oil cooler located in block "V", through cooler, then to filters which may be mounted on either side of block. Fig's. 5-21, 5-22, 5-23 and 5-24. A by-pass valve is provided in filter head oil inlet cavity to assure against interruption of oil flow if filter elements become clogged.

From filter head, oil enters and passes through filter elements; it then flows to the main oil passage located in block "V". This passage feeds two (2) camshaft and two (2) piston cooling drillings in the block. Pressure control valves limit the flow of lubricating oil to piston cooling nozzles, depending on lubricating oil pump pressure.

Main bearings are lubricated through intersecting drillings, directly from the main oil passage. Oil flows from cam passages into camshaft bushings; from there by constant flow, it goes to cam follower shafts and up through cylinder heads. The cam followers are lubricated from their shaft; cam followers are individually drilled to supply lubricating oil to rollers and push tube seats. Rocker lever bushings are also shaft lubricated. Adjusting screws and valve guides are lubricated through drillings in rocker levers and bushings.

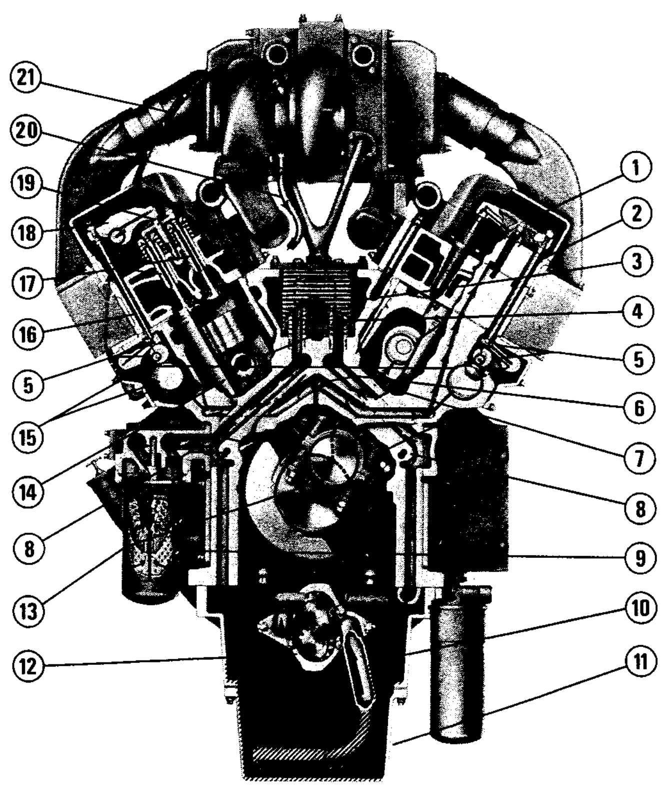
Connecting rod bearings are lubricated from cross drillings in the crankshaft; oil then flows through angle drillings in connecting rods to lubricate piston pins and bushings. Lubricating oil is routed from main oil passage through passages in gear housing and cover to lubricate front gear train gears, bushings and idler shafts. The rear gear train receives lubrication through an intersecting drilling from the right bank camshaft passage.

Filtered and cooled lubricating oil is routed from camshaft passages to each turbocharger through external lines from drillings in cylinder block. Turbocharger drain oil is dumped back into oil pan through drilling in cylinder block.



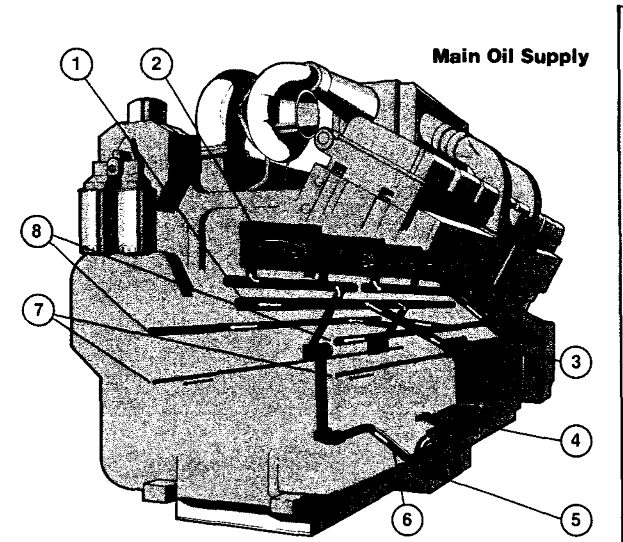
1. INJECTOR ROCKER LEVER
2. INJECTOR PUSH TUBE
3. OIL COOLER ELEMENT
4. PISTON PIN
5. CAM FOLLOWER
6. MAIN OIL RIFLE
7. CONNECTING ROD
8. PISTON COOLING RIFLE
9. FULL FLOW OIL FILTER
10. OIL SUCTION TUBE
11. OIL PAN
12. OIL PUMP
13. CRANKSHAFT
14. CYLINDER LINER
15. CAMSHAFT
16. VALVE PUSHROD
17. VALVE GUIDE
18. VALVE ROCKER ARM
19. VALVE CROSS HEAD
20. TURBO DRAIN LINE
21. TURBO SUPPLY HOSE

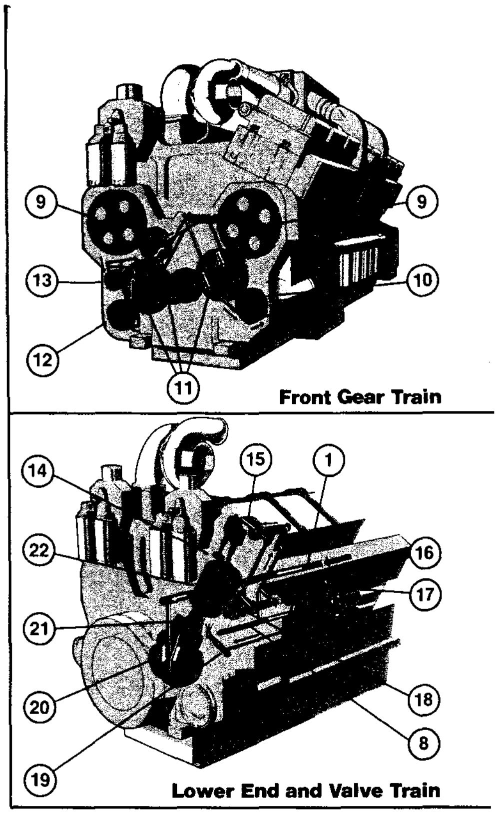
Fig. 5-21, (LWC-35). Front view standard lubricating oil flow — KT(A)-2300 Engine



1. INJECTOR ROCKER LEVER
2. INJECTOR PUSH TUBE
3. OIL COOLER ELEMENT
4. PISTON PIN
5. CAM FOLLOWER
6. MAIN OIL RIFLE
7. CONNECTING ROD
8. PISTON COOLING RIFLE
9. FULL FLOW OIL FILTER
10. OIL SUCTION TUBE
11. OIL PAN
12. OIL PUMP
13. CRANKSHAFT
14. CYLINDER LINER
15. CAMSHAFT
16. VALVE PUSHROD
17. VALVE GUIDE
18. VALVE ROCKER ARM
19. VALVE CROSS HEAD
20. TURBO DRAIN LINE
21. TURBO SUPPLY HOSE

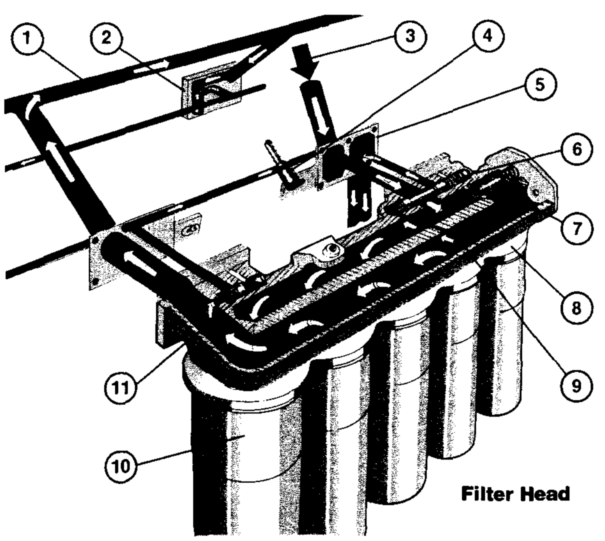
Fig. 5-22, (LWC-34). Front view optional lubricating oil flow — KT(A)-2300 Engine

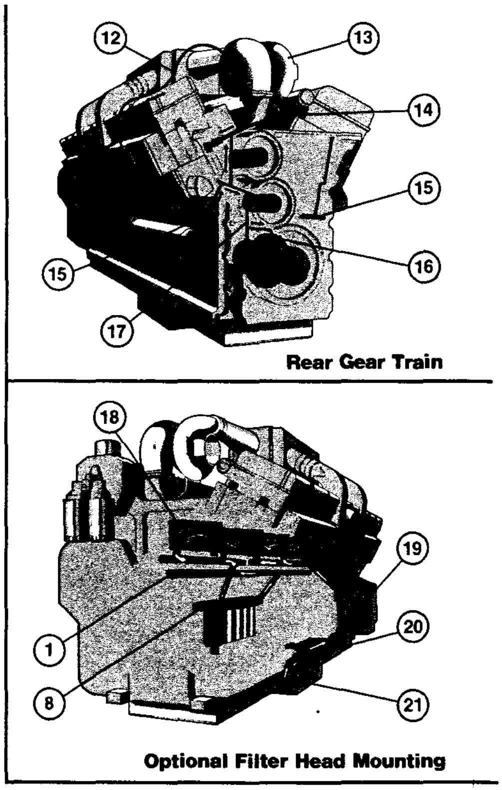




1 MAIN OIL RIFLE
2 OIL COOLER
3 FILTER HEAD
4 LUBRICATING OIL PUMP
5 SUCTION TUBE
6 DISCHARGE TUBE
7 PISTON COOLING OIL RIFLES
8 CAMSHAFT OIL RIFLES
9 CAMSHAFT DRIVE GEAR
10 ACCESSORY DRIVE GEAR
11 IDLER GEARS
12 HYDRAULIC PUMP DRIVE GEAR
13 WATER PUMP DRIVE GEAR
14 EXHAUST VALVES
15 ROCKER LEVER
16 OIL CONTROL ORIFICE
17 CAMSHAFT
18 CAM FOLLOWER
19 PISTON COOLING NOZZLE
20 CRANKSHAFT
21 CONNECTING ROD
22 PISTON

Fig. 5-23, (LWC-35). Lubricating oil flow schematic — KTA-3067 Engine





1 MAIN OIL RIFLE
2 PISTON COOLING REGULATOR R. B.
3 FLOW FROM OIL COOLERS
4 PISTON COOLING NOZZLE
5 BYPASS TO OIL PAN
6 PRESSURE REGULATOR
7 BYPASS VALVE
8 FILTER HEAD
9 REGULATOR CONTROL RIFLE
10 FILTERS
11 PISTON COOLING REGULATOR L. B.
12 TURBOCHARGER OIL SUPPLY LINE
13 TURBOCHARGER
14 TURBOCHARGER OIL DRAIN LINE
15 CAMSHAFT OIL RIFLE
16 THRUST BEARINGS
17 FROM MAIN OIL RIFLE
18 OIL COOLERS
19 DISCHARGE TUBE
20 LUBRICATING OIL PUMP
21 SUCTION TUBE

Fig. 5-24, (LWC-36). Optional lubricating oil flow schematic — KTA-3067 Engine

Cooling System

Water is circulated by a centrifugal water pump mounted either in or on the front of the engine belt driven from the accessory drive or crankshaft.

Water circulates around wet-type cylinder liners, through the cylinder heads and around injector sleeves. Fig. 5-13 through Fig. 5-18. Injector sleeves, in which injectors are mounted, are designed for fast dissipation of heat. The engine has a thermostat or thermostats to control engine operating temperature. Engine coolant is cooled by a radiator and fan or a heat exchanger.

The Fleetguard Water Filter is standard on Cummins Engines. The filter by-passes a small amount of coolant from the system via a filtering and treating element which must be replaced periodically. Refer to "Coolant Specifications" for water filter capacity and treatment of make-up water.

NTA Aftercooled Engine

Water flows from radiator into cavity of water pump, where water flow splits. One portion circulates to the cylinder block water header around wet type cylinder liners, through the cylinder head and around the injector sleeves, upwards to the water manifold, to the thermostat housing. At the rear of the block water header, water is directed to the aftercooler, Fig. 5-25. Water flows forward through the aftercooler to the water crossover to the thermostat housing. The second portion of water flows from the cavity of the water pump housing through the oil cooler and tubing to the rear of the water manifold forward to the thermostat housing, to control engine temperature.

KT(A)-1150 Engines

Water is circulated by a centrifugal water pump, Fig.

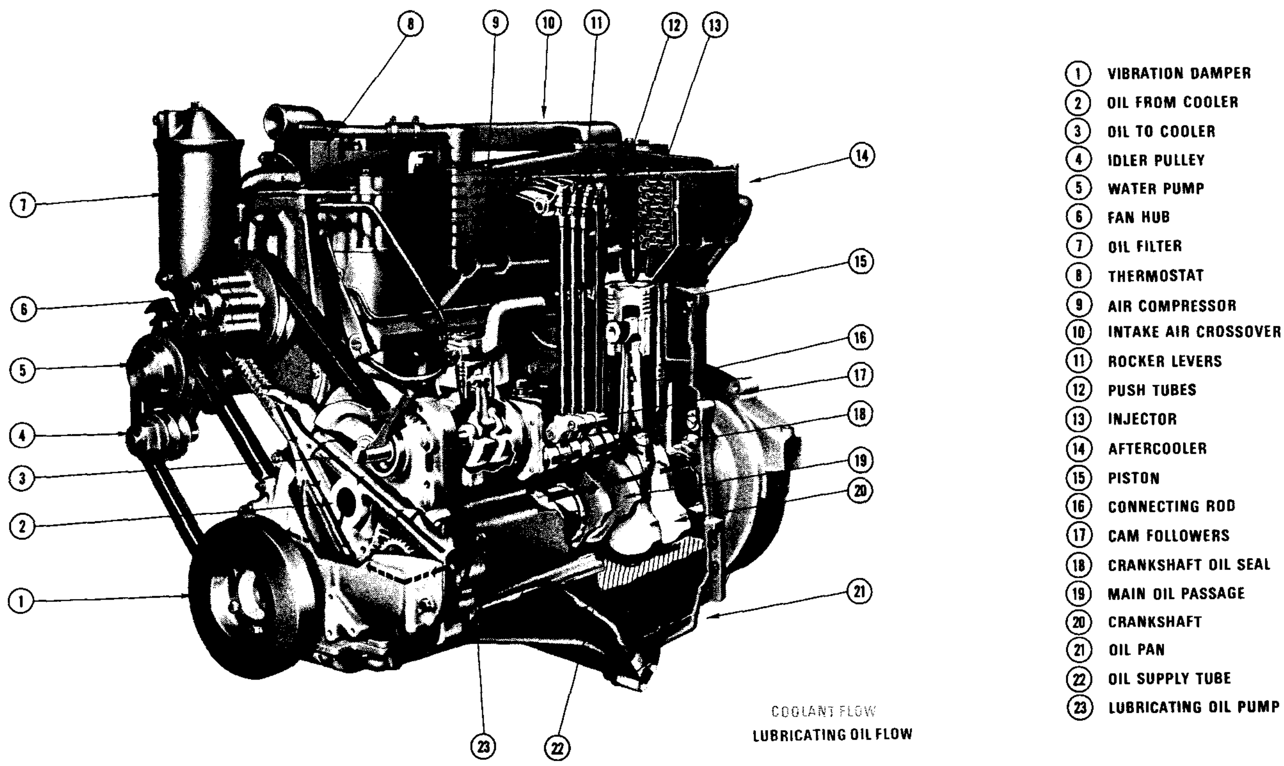


Fig. 5-25, (LWC-22). Coolant and lubricating oil flow — NTA Engine

5-26, mounted on exhaust side of block. The pump is driven by an idler gear from the crankshaft.

Coolant flows from water pump volute into the oil cooler housing, through cooler housing (serving as a water distribution manifold) into block, maintaining an equal flow around all cylinder liners. From liner area coolant flows into individual cylinder heads through holes drilled between valves and around injector "wells". From cylinder heads water flows to rocker housing (water outlet manifold) then to thermostat housing. At thermostat housing water is returned to water pump via a by-pass tube until engine coolant temperature activates dual thermostats. Coolant flow is then directed through a radiator or heat exchanger.

KT(A)-2300 and KTA-3067 Engines

Water is circulated by a centrifugal water pump mounted on right bank side of block. The pump is driven by an idler gear from the crankshaft. Fig's. 5-27 and 5-28.

Coolant flows from water pump volute into the center of "V" of cylinder block, around lubricating oil cooler elements. The center of "V" serves as a water distribution manifold to supply a flow of coolant through aftercooler elements and around cylinder liners.

From liner area coolant flows into individual cylinder heads through passages between valves and around injector "wells". From cylinder heads coolant flows to rocker housing (water outlet manifold) then to thermostat housings. At thermostat housings coolant is returned to water pump via a by-pass tube until engine coolant temperature activates thermostats. Coolant flow is then directed through a radiator or heat exchanger. Coolant circulated through the aftercooler is also returned into the thermostat housings.

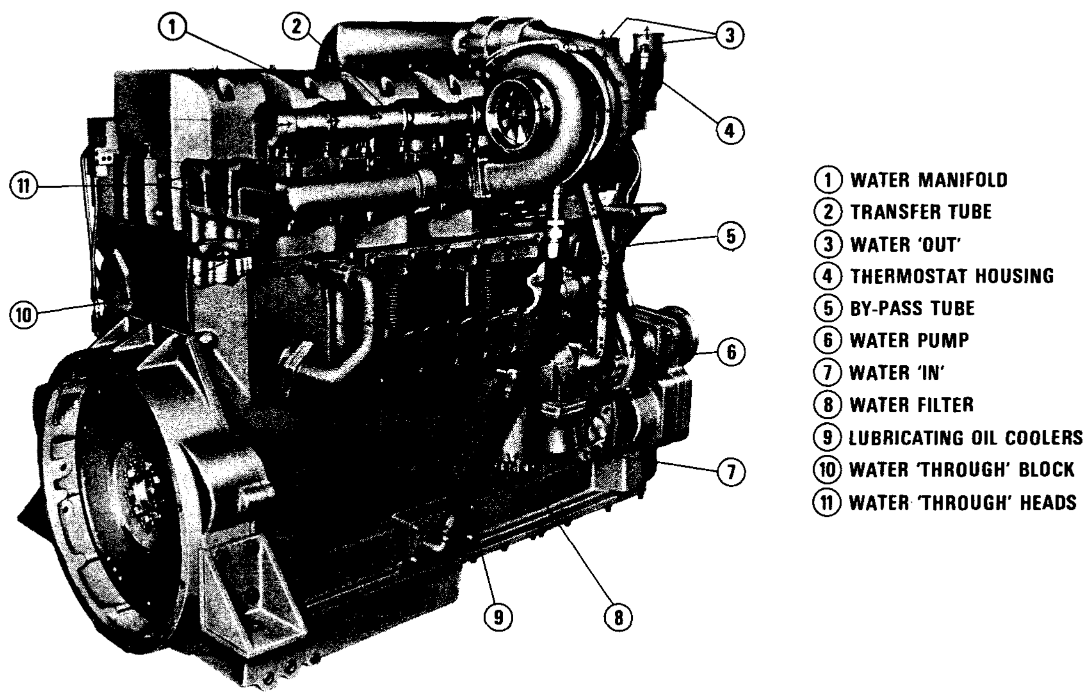
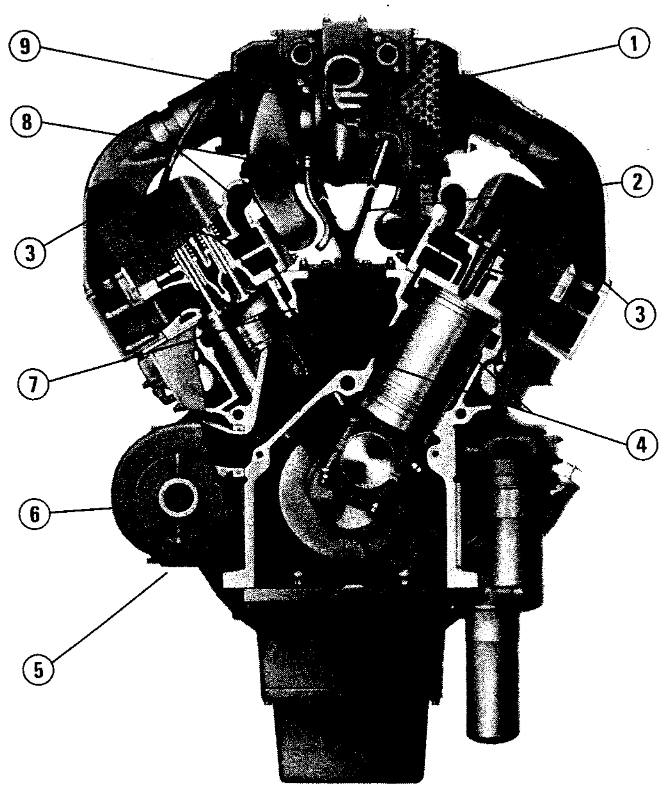
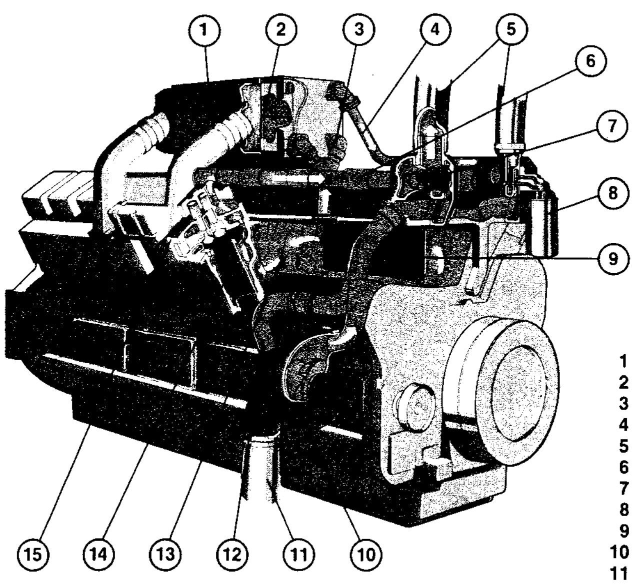


Fig. 5-26, (CWC-14). Coolant flow — KT(A)-1150 Engine



1. AFTERCOOLER ELEMENTS
2. AFTERCOOLER COOLANT SUPPLY
3. COOLANT PASSAGES IN HEADS
4. COOLANT AROUND LINERS
5. COOLANT INLET
6. WATER PUMP
7. COOLANT IN BLOCK "V".
8. COOLANT TRANSFER TUBE (HEAD TO HEAD)
9. AFTERCOOLER OUT TO THERMOSTAT HOUSING

Fig. 5-27, (CWC-27). Coolant flow — KT(A)-2300 Engine



1 AFTERCOOLER HOUSING
2 AFTERCOOLER CORE
3 AFTERCOOLER COOLANT SUPPLY
4 AFTERCOOLER COOLANT RETURN
5 COOLANT RETURN TO RADIATOR
6 COOLANT TRANSFER TUBE (HEAD TO HEAD)
7 THERMOSTAT
8 COOLANT FILTERS
9 OIL COOLER
10 WATER PUMP
11 COOLANT SUPPLY FROM RADIATOR
12 BYPASS TUBE
13 COOLANT IN BLOCK "V"
14 CYLINDER LINER
15 CYLINDER HEAD

Fig. 5-28, (CWC-29). Coolant flow schematic — KTA-3067 Engine

Air System

The diesel engine requires hundreds of gallons of air for every gallon of fuel that it burns. For the engine to operate efficiently, it must breathe freely; intake and exhaust systems must not be restricted.

The intake air should always be routed through an air cleaner. The cleaner may be mounted on engine or equipment and may be either oil bath, paper element or composite type depending upon engine application. Air is routed from air cleaner directly to intake air manifold, or turbocharger.

NTA and KT(A)-1150 Aftercooler

An aftercooler (or intercooler as it is sometimes called) is a device in the engine intake system designed to reduce intake air temperature and/or preheat intake air temperature.

The aftercooler consists of a housing, used as a portion of the engine intake air manifold, with an internal core. The core is made of tubes through which engine coolant circulates. Air is cooled or heated by passing over the core prior to going into the engine combustion chambers. Fig. 5-29. Therefore, improved combustion results from better control of intake air temperature cooling or warming as applied by the aftercooler.

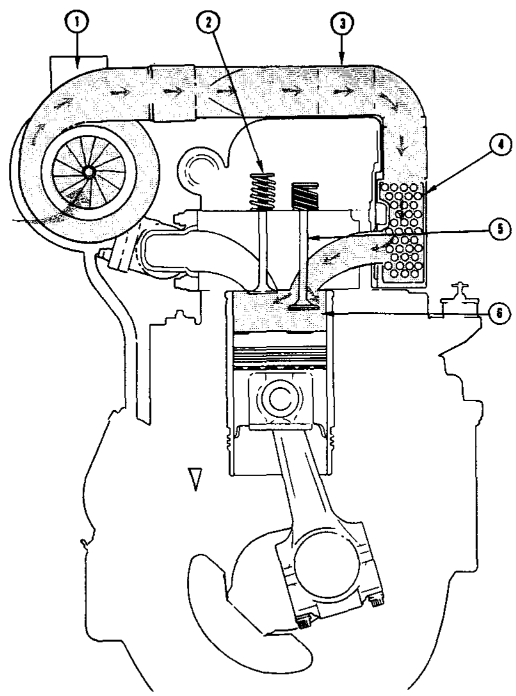


Fig. 5-29, (K11947). Intake air flow schematic — KT(A)-1150 Engine

KT(A)-2300 and KTA-3067 Aftercooler

The aftercooler consists of a housing, mounted above the cylinder block, with two (2) internal cores. The cores through which engine coolant circulates, cools or heats the air passing over the core prior to going into the engine combustion chambers. Therefore, improved combustion results.

Turbocharger

The turbocharger forces additional air into combustion chambers so engine can burn more fuel and develop more horsepower than if it were naturally aspirated. In some cases the turbocharger is used for the engine to retain efficiency (balanced fuel to air ratio) at altitudes above sea level.

The turbocharger consists of a turbine wheel and a centrifugal blower, or compressor wheel, separately encased but mounted on and rotating with a common shaft.

The power to drive the turbine wheel—which in turn drives the compressor—is obtained from energy of engine exhaust gases. Rotating speed of the turbine changes as the energy level of gas changes; therefore, the engine is supplied with enough air to burn fuel for its load requirements. Fig's. 5-32, 5-33, 5-34 and 5-35. The turbocharger is lubricated and cooled by engine lubricating oil.

Air Compressor

The Cummins air compressor may be either a single or two cylinder unit coupling or gear driven from the engine gear train accessory drive. Lubrication is received from the engine lubricating system, with oil carried by internal drillings; on 80 degree tilt engines air compressor crankcase is drained by a scavenger pump

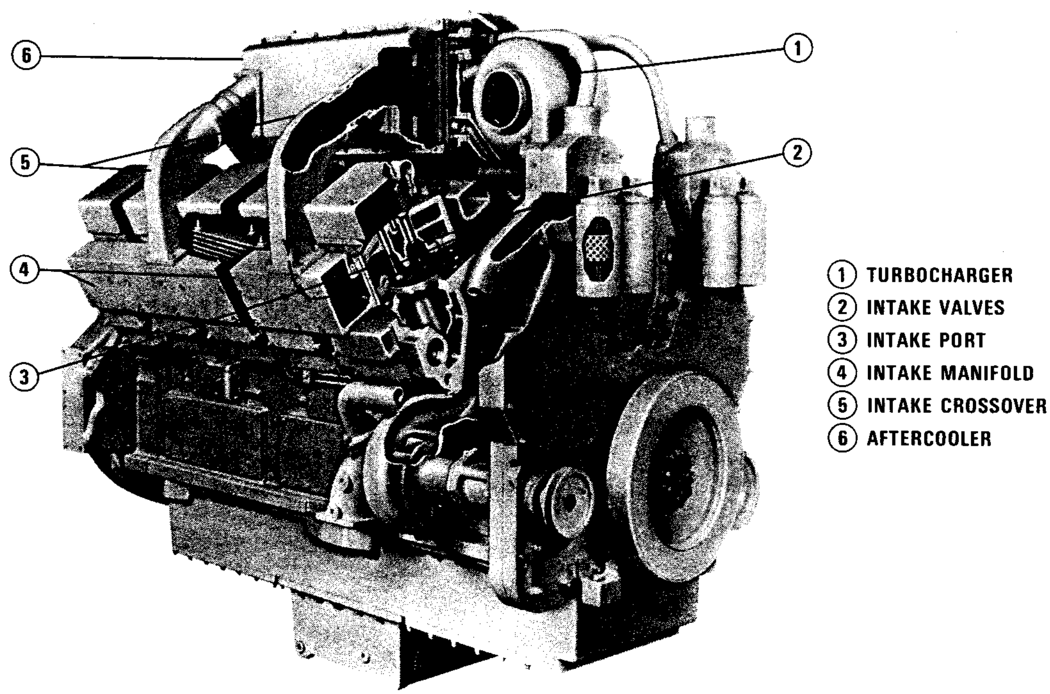


Fig. 5-30, (AWC-19). Intake air flow — KT(A)-2300 Engine

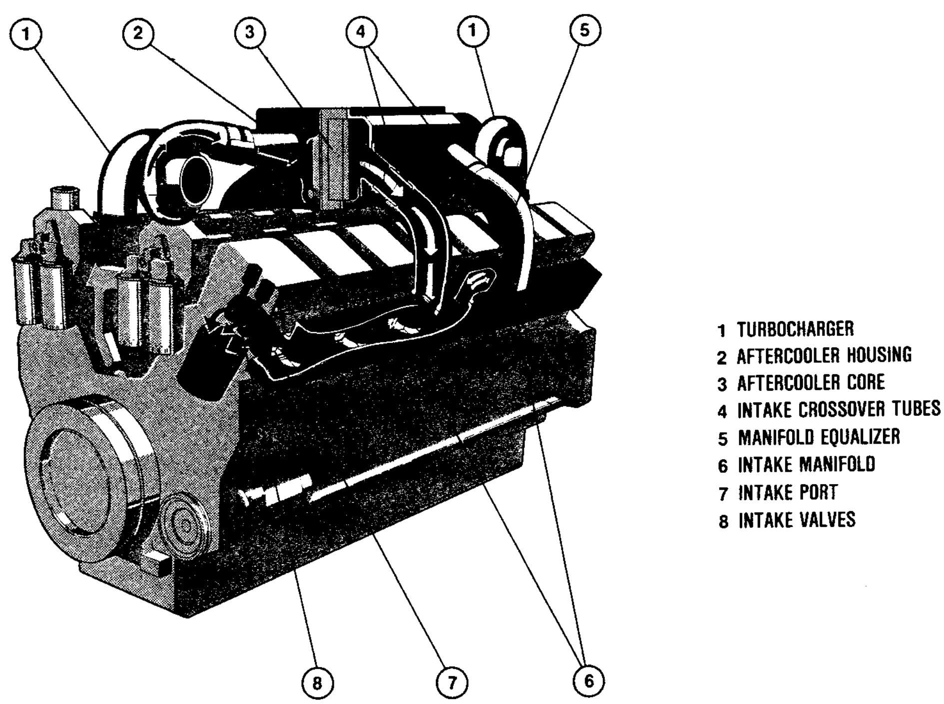
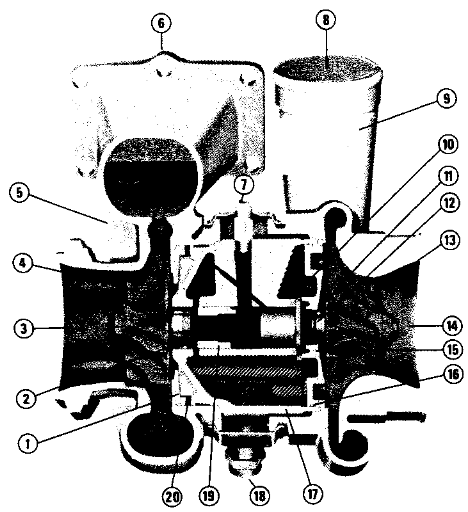
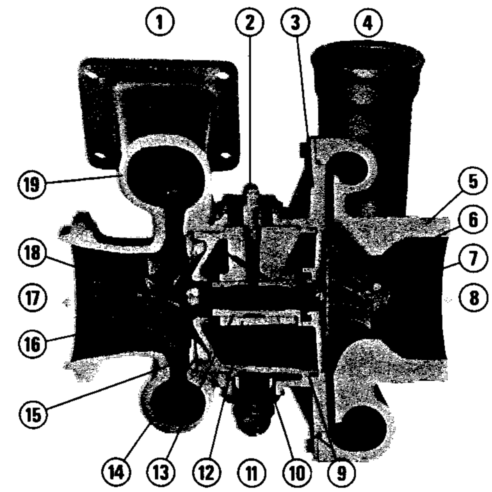


Fig. 5-31, (AWC-21). Intake air flow schematic — KTA-3067 Engine



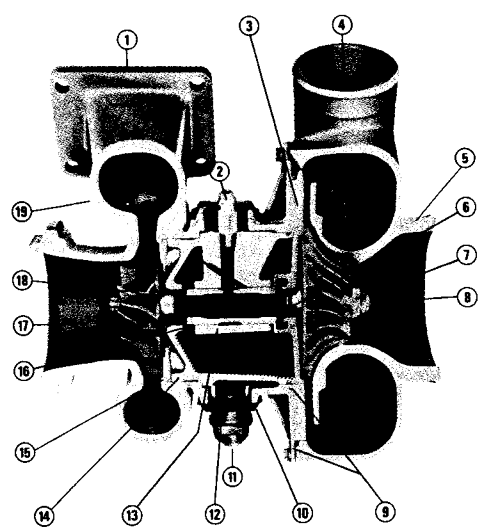
(1) HEAT SHIELD
(2) SEALING RING
(3) EXHAUST OUT
(4) TURBINE WHEEL AND SHAFT
(5) TURBINE CASING
(6) EXHAUST IN
(7) OIL IN
(8) AIR TO ENGINE
(9) COMPRESSOR CASING
(10) BEARING INSERT
(11) OIL SEAL SLEEVE
(12) SEALING RING
(13) COMPRESSOR WHEEL
(14) AIR IN
(15) OIL SEAL PLATE
(16) "O" RING SEAL
(17) BEARING HOUSING
(18) OIL OUT
(19) FLOATING BEARING
(20) INSULATION BATT

Fig. 5-32, (AWC-8). T-50 Turbocharger (cross section)



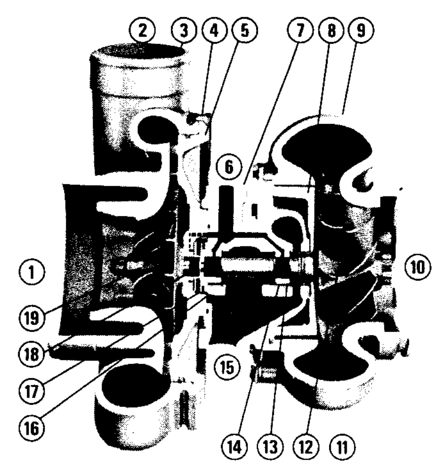
(1) EXHAUST IN
(2) OIL IN
(3) DIFFUSER PLATE
(4) AIR TO ENGINE
(5) COMPRESSOR CASING
(6) OIL SEAL SLEEVE
(7) COMPRESSOR WHEEL
(8) AIR IN
(9) "O" RING SEAL
(10) "V" BAND CLAMP
(11) OIL OUT
(12) BEARING HOUSING
(13) FLOATING BEARING
(14) INSULATION BATT
(15) HEAT SHIELD
(16) SEALING RING
(17) EXHAUST OUT
(18) TURBINE WHEEL AND SHAFT
(19) TURBINE CASING

Fig. 5-34, (AWC-12). ST-50 turbocharger (cross section)



(1) EXHAUST IN
(2) OIL IN
(3) DIFFUSER PLATE
(4) AIR TO ENGINE
(5) COMPRESSOR CASING
(6) OIL SEAL SLEEVE
(7) COMPRESSOR WHEEL
(8) AIR IN
(9) "O" RING SEAL
(10) "V" BAND CLAMP
(11) OIL OUT
(12) BEARING HOUSING
(13) FLOATING BEARING
(14) INSULATION BATT
(15) HEAT SHIELD
(16) SEALING RING
(17) EXHAUST OUT
(18) TURBINE WHEEL AND SHAFT
(19) TURBINE CASING

Fig. 5-33, (AWC-9). VT-50 turbocharger (cross section)



(1) AIR IN
(2) AIR OUT
(3) COMPRESSOR HOUSING
(4) V-BAND CLAMP
(5) BACKPLATE
(6) OIL IN
(7) CENTER HOUSING
(8) SHROUD
(9) TURBINE HOUSING
(10) EXHAUST OUT
(11) EXHAUST IN
(12) TURBINE WHEEL AND SHAFT
(13) BEARINGS
(14) SNAP RINGS
(15) OIL OUT
(16) THRUST WASHER
(17) THRUST COLLAR
(18) OIL SEAL ASSEMBLY
(19) COMPRESSOR WHEEL

Fig. 5-35, (TA-1). T-18 turbocharger (cross section) mounted on gear case cover and is driven by lubricating oil pump drive gear. The cylinder head is cooled by engine coolant. Operating functions are as follows:

Air Intake

Air is drawn into the compressor through the engine intake air manifold or compressor mounted breather. As the piston moves down, a partial vacuum occurs above it.

The difference in cylinder pressure and atmospheric pressure forces the inlet valve down from its seat, allowing the air to flow through the intake port and into the cylinder. When the piston has reached the bottom of its stroke, spring pressure is sufficient to overcome lesser pressure differential and forces the valve against its seat. Fig's. 5-36 and 5-37.

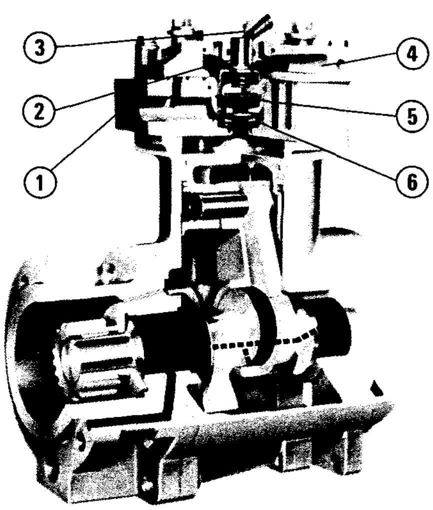


Fig. 5-36, (AWC-10). Cummins air compressor (single cylinder)

Compression

When the piston starts its upward stroke, the increased pressure of air in the cylinder and head forces the outlet valve away from its seat. The compressed air then flows through outlet ports and into the air tank as the piston continues its upward stroke. On piston downstroke, the exhaust valve closes and the intake valve opens except during unloading period.

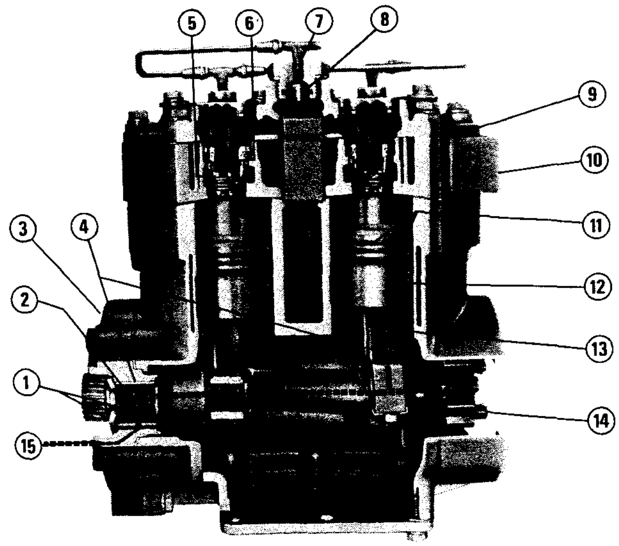


Fig. 5-37, (AWC-11). Cummins air compressor (two cylinder)

Unloading

When pressure in the air tank is at a predetermined level, air pressure is applied to top of unloader cap by a compressor governor. This pressure forces the unloader cap down and holds the intake valve open during non-pumping cycle.

When pressure in air tank drops, the unloader cap returns to its upper position and intake and compression sequences begin once again.

Vacuum Pump

The Cummins Vacuum Pump, shown in Fig. 5-38, is an adaptation of Cummins Air Compressor; it is a single-cylinder unit driven from engine gear train accessory drive. Lubrication is received from engine lubricating system, with oil carried by internal drillings. The cylinder head is cooled by engine coolant. Operating functions are as follows:

Air Intake

As piston moves downward on intake stroke a vacuum occurs above piston. The difference in cylinder pressure and atmospheric pressure forces inlet valve

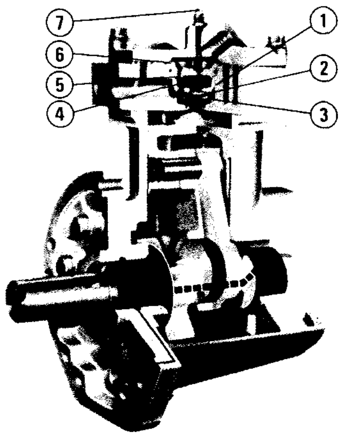


Fig. 5-38, (V11205). Cummins vacuum pump

from its seat allowing air to flow through intake port into cylinder from vacuum tank thus creating vacuum in vacuum tank. When piston has reached bottom of its stroke, spring pressure is sufficient to overcome lesser pressure differential and forces valve against its seat.

Compression

When piston starts upward stroke, increased pressure of air in cylinder and head forces outlet valve away from seat. Air then flows through outlet port and is discharged into vacuum pump crankcase or engine crankcase, as piston continues upward stroke. When piston reaches end of stroke, air pressure in head drops to a point where spring forces exhaust valve against seat and closes outlet passage.

Torque Converter Governor on PT (type G) VS Fuel Pump

When a torque converter is used to connect engine with its driven unit, an auxiliary governor is driven off torque converter output shaft to exercise control over engine governor. The torque converter governor controls converter output shaft speed. The engine governor and converter governor must be adjusted to work together.

The PT-G — VS governor and the torque converter governor are two separate mechanical variable-speed governors — one drive by engine, the other by converter.

A conventional VS governor allows variable speed governing when operating at low tailshaft speeds or with the tailshaft governor disconnected. The converter governor is in series with the automotive and VS governors and controls engine speed by sensing converter tailshaft speed. Dual levers in the cab allows the operator to operate on either the tail-shaft governor or VS governor. There is no automotive throttle lever.

An adjustable converter plunger stop prevents the tail-shaft governor from shutting off the engine, when the load motors and overspeeds the tailshaft, as is the case when moving vehicles down hill.

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