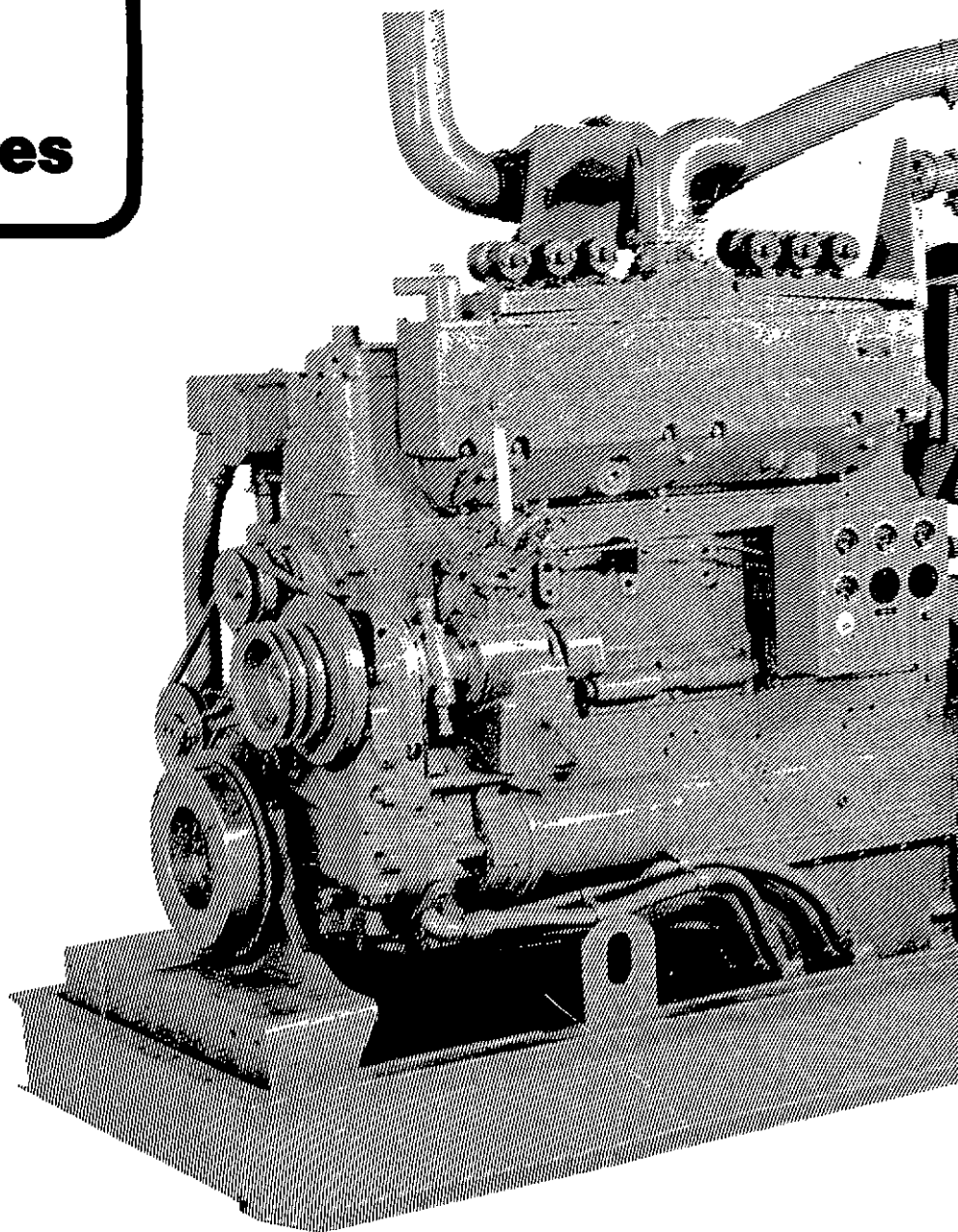


G-495
G-743
G-855
GTA-743A
GTA-743B
GTA-855
G-1710
GTA-1710



Cummins Gas Engine Operation & Maintenance Manual

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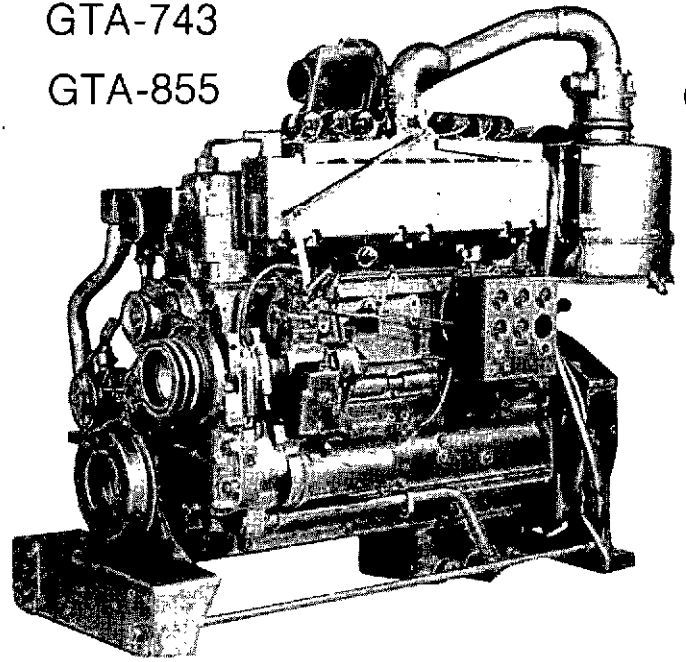
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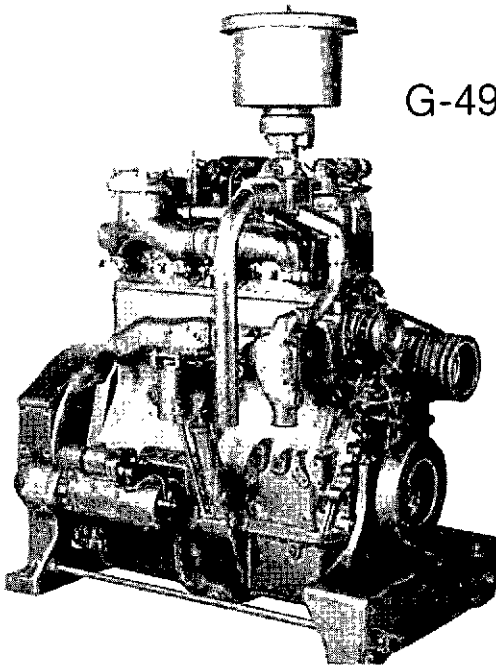
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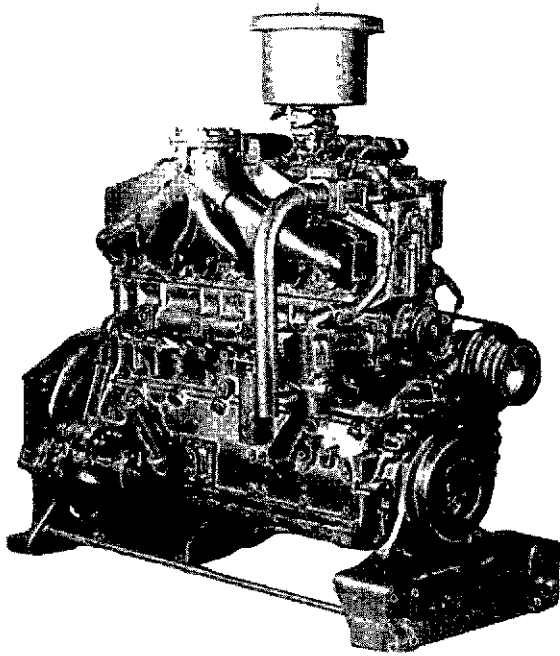
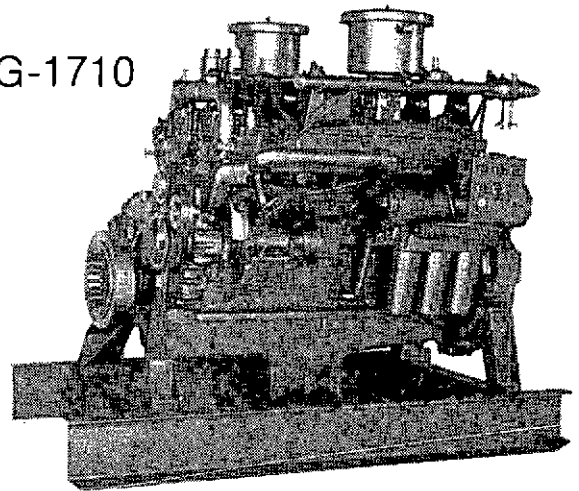
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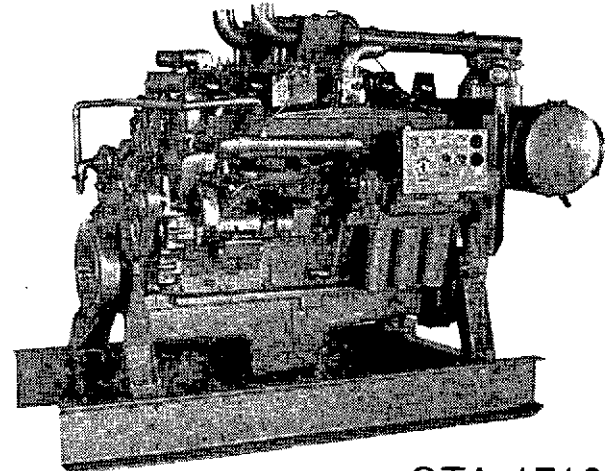


G-1710



G-743

G-855



GTA-1710

Operating Principles

The most satisfactory service can be expected from a Cummins Gas Engine when the operation 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.

The Cummins Gas Engine

Cummins Gas Engines described in this manual are four-stroke spark-ignited engines that burn a controlled mixture of natural gas and air. Horsepower ratings and other engine specifications are tabulated in Table 1 below.

Models	Displacement* Cubic Inches	Horsepower** Application Range		
			to	
G-495	495N	70	to	110
G-743	743N	100	to	165
G-855	855N	150	to	200
G-1710	1710N	300	to	400
GTA-743	743TA	190	to	250
GTA-855	855TA	240	to	300
GTA-1710	1710TA	400	to	600

* N - Naturally aspirated
TA - Turbocharged/Aftercooled

** Continuous horsepower is based on operation at 4000 feet altitude and 100°F air temperature.

Intake Stroke

During the intake stroke, the piston travels downward permitting air and fuel mixture from the carburetor to enter the combustion chamber through the open intake valves.

Compression Stroke

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

At the end of the compression stroke, the air and fuel mixture in the combustion chamber has been forced by the piston to occupy a space about one-twelfth as great in volume as it occupied at the beginning of the stroke. Thus, we say the compression ratio is 12:1. Near the end of the compression stroke, the mixture is ignited by the spark plug.

Power Stroke

During the power stroke with both the intake and exhaust valves closed, the burning fuel causes an increase in pressure above the piston which pushes the piston downward and adds impetus to the crankshaft rotation.

Exhaust Stroke

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

Burned gases are forced out of the combustion chamber through the open exhaust valve ports by the upward travel of the piston.

Cummins Natural Gas Cycle

It is easier to understand the function of the engine parts if it is known what happens in the combustion chamber during each of the four piston strokes of the cycle. The four strokes and the order in which they occur are: Intake Stroke, Compression Stroke, Power Stroke and Exhaust Stroke.

The Fuel System

Fuel must be clean, free of acids, sulphur compounds, water, pipe scale and other foreign materials which could cause corrosion or abrasion of cylinder liners, bearings, and internal engine parts. Dry processed natural gases for pipeline transmission usually have the liquids removed and contain primarily methane and a small percent of ethane gases. This gas is generally 1000 BTU/cu.ft. H.H.V. and can be used in all Cummins Natural Gas Engines. The application of engines on non-processed gas requires careful study for proper compression ratio selection. Check with your dealer for proper compression ratio and power ratings for individual applications.

Located between the gas supply line and the engine intake manifold are the following units which make up the fuel system:

1. Line Pressure Regulator
2. Gas Filter
3. Pressure-Reduction Valve or Thermac
4. Carburetor

Line Pressure Regulator

The gas pressure should be reduced to 5.8-11.6 ounces (10-20 inches H₂O) per square inch before entering the pressure reduction valve.

Note: Contact gas company for gas main pressure in your area.

Gas Filter

The filter removes particulate matter from the gas down to .0004". It is a pleated paper type filter and the element must be inspected regularly and replaced when necessary.

Pressure Reduction Valve (Thermac)

Pressure reduction valves must be used when gas pressure cannot be reduced and maintained by the line pressure regulator at a steady 2.9 ounces per square inch (5 inches H₂O) for 1000 BTU gas at the carburetor inlet, or when more pressure must be used to overcome line loss due to small pipe, elbows, or line length.

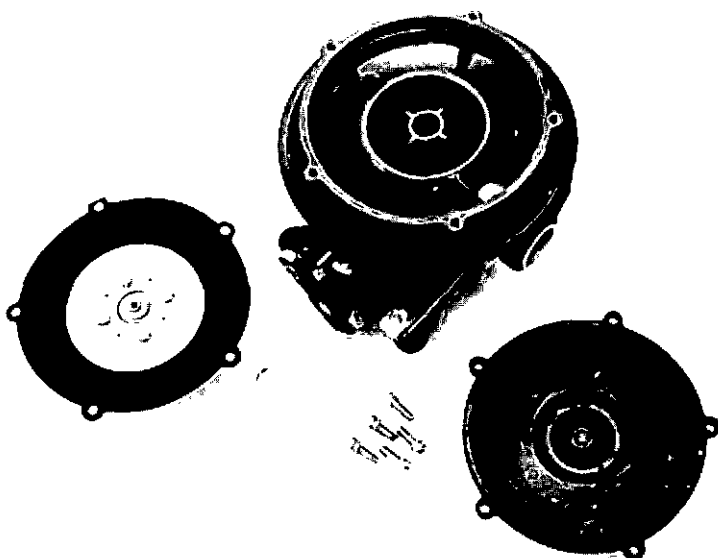
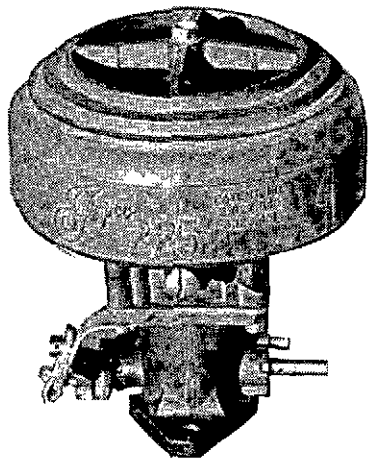
The pressure reduction valve of Thermac is used to fine tune and adjust the gas pressure reaching the carburetor. With this valve it is possible to maintain the 5 inches of H₂O gas pressure to the carburetor.

Carburetor

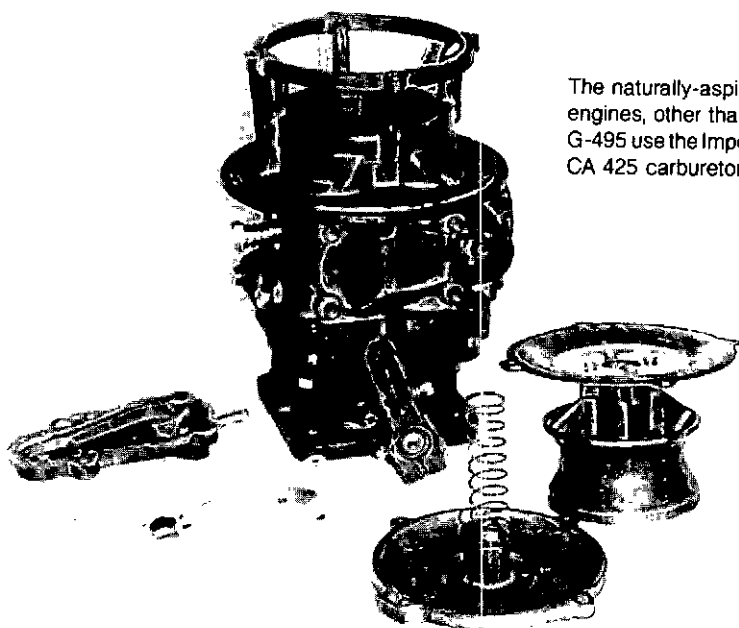
The air-gas mixture through the carburetor is controlled by an air gas valve. The air gas valve meters both air and gas in proper proportions at any throttle setting. It also seals off gas flow when the engine is shut down and provides automatic choke action for starting. The flow of air through the carburetor is controlled by the butterfly valve in the carburetor throat. This flow is measured by the air measuring valve mounted on a diaphragm. The greater the air flow, the higher the air measuring valve rises. The gas metering valve is connected directly to the air valve so that it rises exactly the same amount. The gas valve is shaped to admit the correct amount of gas at any height to which the air measuring valve rises. The natural gas pressure to the carburetor inlet should not exceed 5 inches of water with the engine under full load. This allows a very high metering force up to the fuel entering the carburetor at low engine speeds and allows easy starting without priming, with excellent low speed torque.

Gas Shut-Off Valve

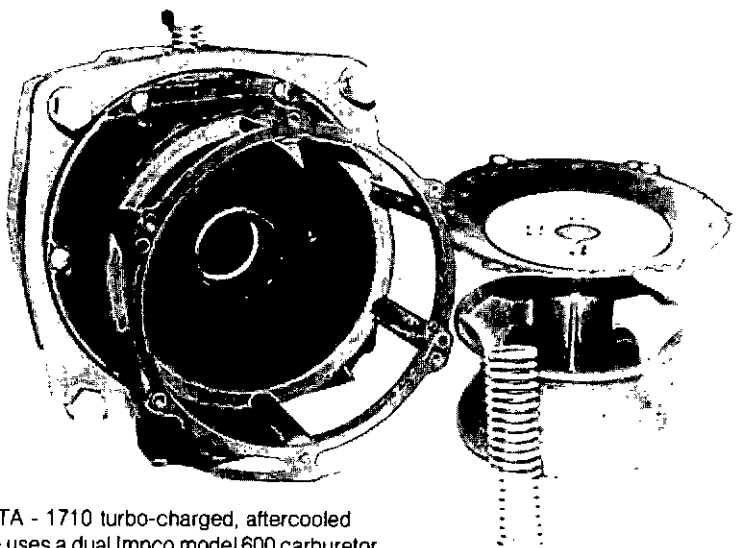
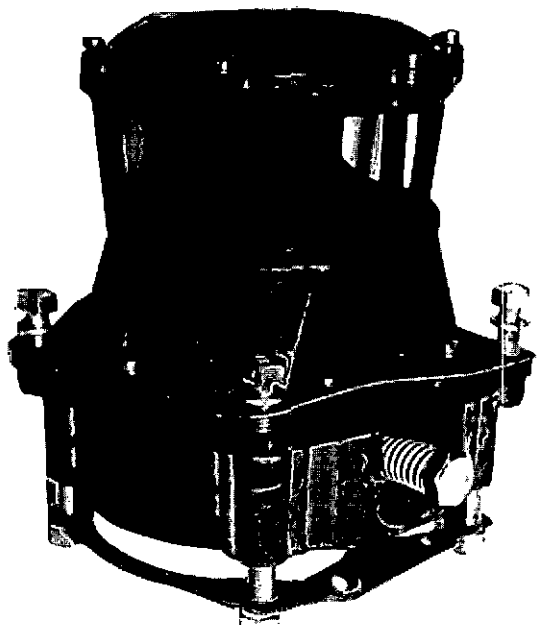
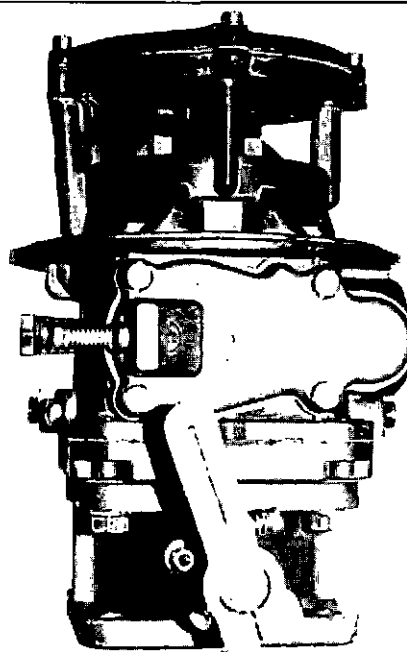
A gas shut-off valve may be mounted between the line pressure regulator and the pressure reduction valve to assure a positive gas shut-off. The valve may be operated manually, electrically, or actuated from ignition system or oil pressure as a safety system.



The G-495 uses an Impco model 225 carburetor.



The naturally-aspirated engines, other than the G-495 use the Impco model CA 425 carburetor.



The GTA - 1710 turbo-charged, aftercooled engine uses a dual Impco model 600 carburetor. The G - 1710 uses two Impco 4250 carburetors.

The Ignition System

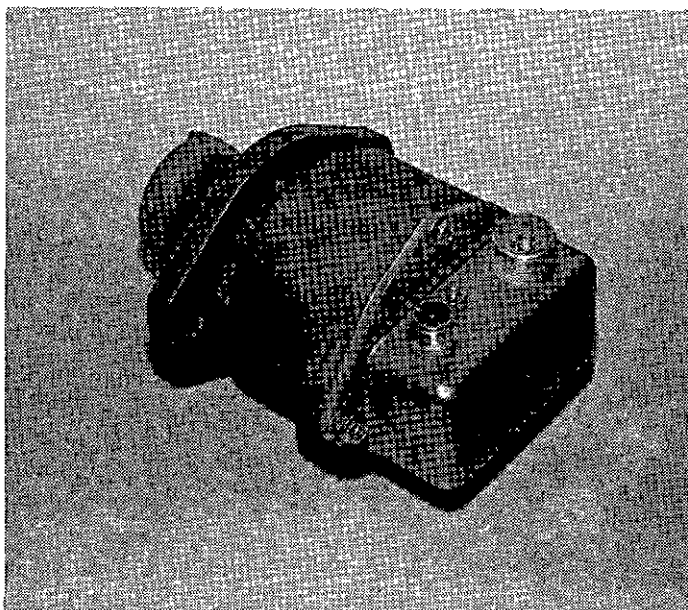
The Altronic Ignition System currently used on Cummins Natural Gas Engines is a self-contained, self-powered, low tension, low fire-hazard, electronic system specifically designed to meet the ignition demand and reliability requirements of high speed spark-ignited engines.

The Altronic I-6 ignition system is used on the four and six cylinder engines. The system consists of a permanent magnet alternator unit, wiring harness, four or six ignition coils, three magnets in an aluminum disc (two on 4 cylinder engines) and an associated pick-up module. The self-powered Altronic I-6 requires no external voltage.

Note: External voltage applied to the ignition system or any grounding to the Altronic box may cause permanent damage to the system.

The system contains a positive output lead (white or lettered P) for grounding the ignition and shutting the engine down.

The alternator provides power to charge an energy storage capacitor mounted to the alternator. The electronic box rectifies the alternator's AC output to DC and stores the energy. When the magnets on the aluminum disc pass the pick-up coil, a Silicone Controlled Rectifier (SCR) switch is triggered to release the stored energy to the ignition transformers.

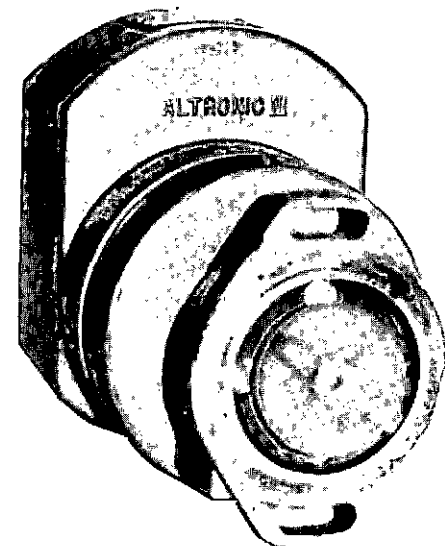


The coils (transformers) are mounted remotely and connected to its spark plugs through high voltage leads. The capacitor discharge principle produces a rapid, powerful spark. The short duration of the spark reduces electrode erosion. The transformer is designed to produce a very high rate of voltage rise, approximately 25 kilovolts. All electronic box parts are encased in epoxy and are immovable.

The alternator performs no timing function and can be either belt or coupling driven. Coupling driven alternators mount to the engine's governor drive. Belt driven alternators usually mount in place of 12 volt automotive type alternators.

Adequate output is available at low cranking RPM. The capacitor will store peak voltage generated during the fastest cranking speed to insure a good spark at the lowest speed. Timing is set only once, after which it remains constant.

The Altronic III is used on the 12 cylinder engines. It works on the same basic principle as the Altronic I-6. Rather than a magnetic disc/pick-up arrangement, the Altronic III works on a distribution principle. Firing is controlled by SCR alternator switches in sequence. The Altronic III is timed to the engine and must be retimed when removed and refitted.



The Lubricating System

Cummins Gas Engines are pressure lubricated. The pressure is supplied by a gear-type lubricating oil pump.

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

A by-pass valve is provided in the full-flow oil filter as insurance against interruption of oil flow by a dirty or clogged element.

1. Oil is drawn into the pump through an external oil line connected to the oil pan. A screen in the sump filters the oil.
2. On 12 cylinder engines, oil flows from the pump to the full-flow filter, to the lubricating oil cooler, then to the rear of the engine block where it is directed to the oil headers which are drilled the full length of the block on each side; oil passages from the headers deliver oil to lubricate moving parts within the engine.
3. Engine oil flow on 4 and 6 cylinder engines is from the pump through a full-flow filter back again into the

pump casting to cylinder block to oil cooler back to block connection. The filter is mounted directly to the rear of the pump or directly beneath the oil cooler. An oil header, drilled the full length of the block on the accessory drive side, delivers oil to branch passages and on to moving parts within the engine.

4. Oil pipes, or a combination of pipes and passages, carry oil from the camshaft to upper rocker housings and various drillings throughout the block, crankshaft, connecting rods and rocker levers complete the oil circulating system.
5. Lubricating oil pressure is controlled by a regulator located in the lubricating oil pump.
6. The by-pass filter, when used, should be connected into the lubricating oil circuit between the oil pump and the full-flow filter. This will increase the service life of the full-flow filter by removing part of the filtering load from the full-flow filter. The return line should discharge below the oil level in the oil pan to prevent aeration.

The Cooling System

On 4 and 6 cylinder engines, coolant is circulated by a centrifugal-type water pump mounted in the block at the gear cover end and driven by belt from the accessory drive.

The water circulates around the wet-type cylinder liners and through the cylinder head. Discharge connections between the heads are provided by a water manifold. The water manifold houses a single thermostat to control engine operating temperature.

On 12 cylinder engines, coolant is circulated by a centrifugal-type water pump mounted at the front of the engine and driven by belts from the accessory drive. The coolant is drawn from the radiator or heat exchanger by the water pump and delivered to the oil cooler then to the center of the block, through the ports, to the cylinder block water jackets and the cylinder heads. Then, the coolant flows into a return header surrounding the exhaust manifolds. The hot exhaust quickly warms the cold water when the engine is first started and keeps it warm during

slow-speed and light-load operations. From the header, the water goes to the thermostat housing where it is directed to the radiator for cooling. If it has not been heated sufficiently to actuate the thermostats, it will be directed through a by-pass tube to the water pump for recirculation. The engine coolant is cooled by a radiator or by heat exchangers, depending on the type of installation.

Irrigation Application

The cooling system on irrigation engines consists of a cooling coil in the product water discharge line. This enables the engine to have a closed system, without the use of a radiator.

Whenever aftercoolers are used on turbocharged Cummins Gas Engines, an auxiliary water pump is used to circulate water through the aftercooler and its separate heat exchanger or radiator core.

The Air System

The required function of an air intake system is to supply clean dry air to the engine without excessive restriction and at a temperature at which the engine will operate efficiently.

The overall system design should provide minimum intake restrictions to maintain adequate air flow to the engine for good air-fuel mixture. In order to provide satisfactory engine performance, intake air should always be routed through an air cleaner.

The cleaner is mounted on the engine and may be either a paper element or composite type depending upon engine application. Air is routed from the air cleaner directly into the carburetor, where it mixes with a metered amount of fuel and is dispersed into the intake manifold(s) and on into the cylinders.

A dry type element will keep dirt and dust out of an engine almost 100% if it is sealed properly in its housing and has not been ruptured due to backfire or mishandling.

INSTALLATION & OPERATING INSTRUCTIONS

The operator of the engine assumes the responsibility of engine care while it is running. This is an important job and one that will determine to a large degree the extent of profit from the operation. There are comparatively few rules which the operator must observe to get maximum service

from a Cummins Gas Engine; however, if any of these rules are broken, a penalty is sure to follow. The penalty may be in lack of work accomplished because of lowered engine efficiency or it may be in down time and costly repair bills resulting from premature engine failure.

Installation Instructions

1. Remove all tape and plastic covers from fuel, lubricating oil and air intake connections.
2. Locate unit on a firm base and secure in desired position with anchor bolts and shock mounts. Check alignment of engine with drive unit, shim as necessary to obtain desired alignment. Allow sufficient space to provide access to all sides of unit.

Note: On installation with external coolant lines, such as cooling towers and heat exchangers, piping should be installed with flexible connections to reduce stress on rigid piping due to engine vibration.

3. Provide for outside venting of exhaust gas if unit is installed in an enclosed area; also, venting of radiator cooling air must be provided.

A. Base Measurement & Installation

The engine support base must be located at the proper height and distance from the driven equipment to allow the proper angle on the driveline. A driveline angle of $\frac{1}{2}$ inch above or below horizontal is desirable to allow the driveline cross to carry the load equally. The driven equipment flange should be parallel to the flywheel or driveflange of the engine. The measurements for base can be had by using a string line and string line level tied directly to the driven equipment flange. Note that the distance between engine and equipment flange will vary due to engine clutch, length of driveline, etc.

B. Drivelines

The driveline used on the engine should be of sufficient size for the application to insure adequate service life and reliability. The recommendation of the driveline manufacturers is as follows:

Engine Driveshaft Alignment

After the engine base has been properly set in place, the engine should be placed on it. The proper alignment of the gearhead flange and engine PTO or drive plate is critical to proper driveshaft life.

Watson	Spicer Series	1800 RPM Rated HP	Service Factor	Recommended HP Application
WL-41	1350	130	.75	97.5
WL-48	1400	162	.75	121.5
WL-55	1500	210	.75	159.5
WL-60	1600	260	.75	195.0
WL-65	1600	305	.75	228.8
WL-70	1700	460	.75	345.0
WL-80	1800	630	.75	472.0
WL-85	1800	800	.75	600.0

4. Connect gas supply piping. The size and length of pipe used to deliver fuel to the engine will affect engine performance. A pipe with a small diameter and long length may not supply enough gas for satisfactory performance. Recommended pipe size is 2" from the main line pressure regulator to the engine pressure reduction valve. The main line pressure regulator have at least a $\frac{3}{4}$ " orifice to allow sufficient flow through the line.

The pressure reduction valve, or Thermanic is for fine adjustment of gas pressure.

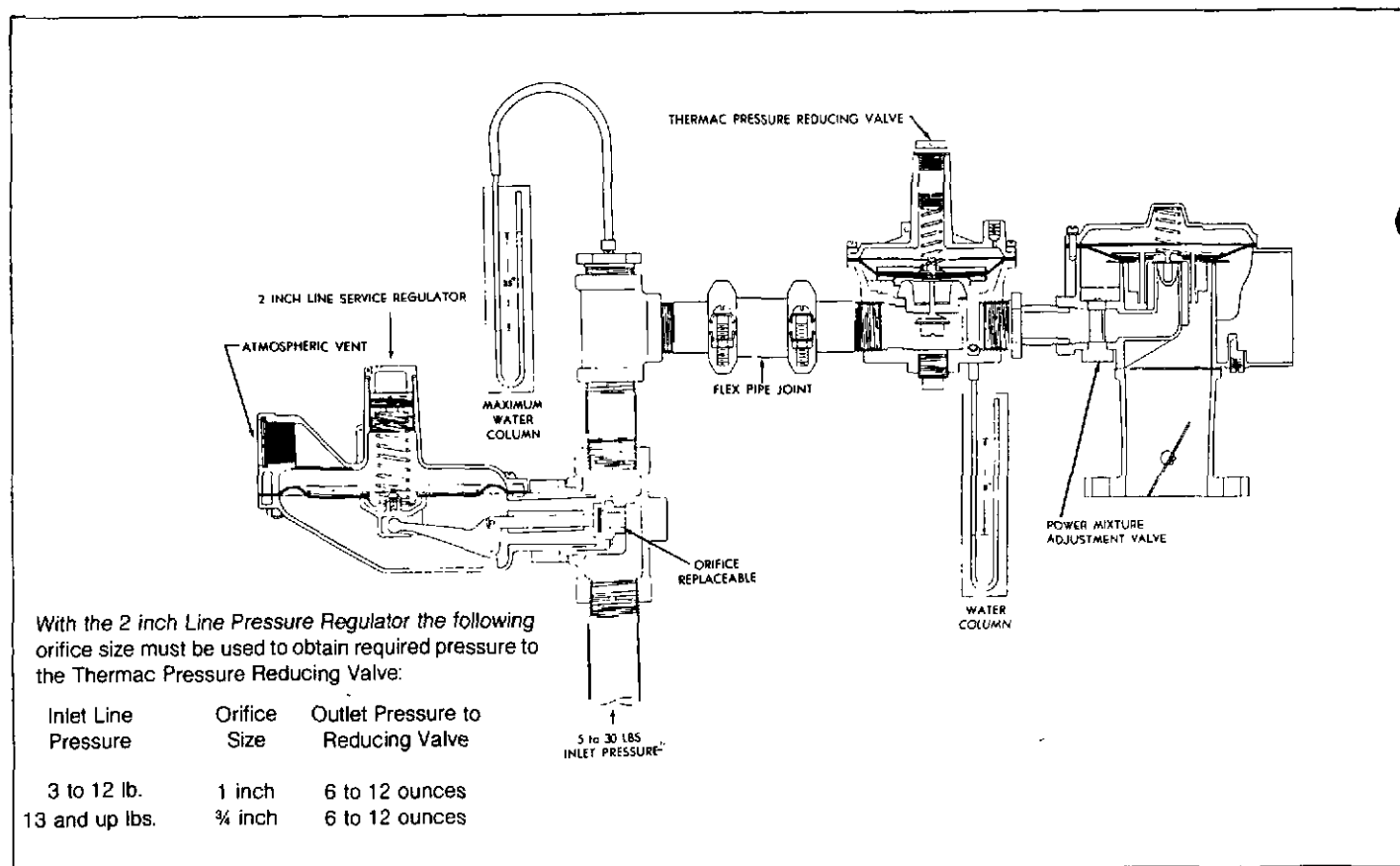
Note: Line pressure of 20" or more will cause a lockup in the Thermac which will prevent the engine from starting. On all models, install the gas inlet pipe on the intake side of the engine toward the front. Install flexible connection between line regulator and pressure reduction valve. The Thermac should not be mounted rigidly on the engine since vibration can cause it to wear out or malfunction.

5. Inspect units for damaged or missing parts. Check all nuts and bolts for tightness; replace as necessary.
6. Inspect all wires for cut or frayed insulation; replace all damaged wiring.

7. Check throttle for free travel; correct as necessary.

C. Cooling System

On installations with external coolant lines, such as cooling towers and heat exchangers, attention must be given to the size of the piping. There should be no restriction to the flow of the coolant to and from the heat exchanger and within the heat exchanger itself. Four and six cylinder engines should have piping with a minimum inside diameter of 2 inches and 12 cylinder engines must have a minimum inside diameter of 3 inches.



Operating Instructions

Cummins engines are run-in on dynamometers before being shipped from the factory and are ready to be put to work. However, to establish conditions for optimum service life, the operator should:

1. Avoid operation for long periods at low speeds or light loads. (Operate the engine at 75% or more of its full continuous duty rating.)
2. Develop the habit of watching engine instruments closely during operation and letting up on throttle if coolant temperature exceeds 190°F (87.8°C).
3. Operate with reserve power setting that allows acceleration to governed speed when conditions require more power.
4. Check the oil level every 4 (four) hours during the break-in period.

Pre-Starting Instructions - First Time

Priming Lubricating System

A dipstick oil gauge is located on the side of the engine. The dipstick supplied with the engine has an "H" (high) and "L" (low) level mark to indicate lubricating oil supply. The dipstick must be kept with the oil pan, or engine, with which it was originally supplied. Cummins oil pans differ in capacity with different types of installations and oil pan part numbers. Check oil level when the engine is stopped.

1. Fill crankcase to "L" (low) mark on dipstick.
2. Crank engine for at least 15 seconds (with ignition "off") while maintaining external oil pressure at a minimum of 15 psi (1 kg/sq cm).
3. Fill crankcase to "H" (high) mark on dipstick with oil meeting specifications. No change in oil viscosity or type is needed for new or newly rebuilt engines.

Caution: After the engine has run a few minutes it will be necessary to add lubricating oil to compensate for that absorbed by the filter element(s) and oil cooler.

Normal-Daily Checks

Check Oil Level

Keep oil level as near the high mark as possible.

Caution: Never operate the engine with oil level below the low-level mark, or above the high-level mark.

Check Air Connections

Check connections to the air equipment, if used, and to the air cleaners.

Check Engine Coolant Supply

1. Remove the radiator or heat exchanger cap and check the engine coolant supply. Add coolant as needed to completely fill the system.
2. Make a visual check for leaks.
3. There are several recognized methods of protecting engine cooling systems from rust and corrosion. These methods are described on Page 14-15

Check Hydraulic Governor (if equipped)

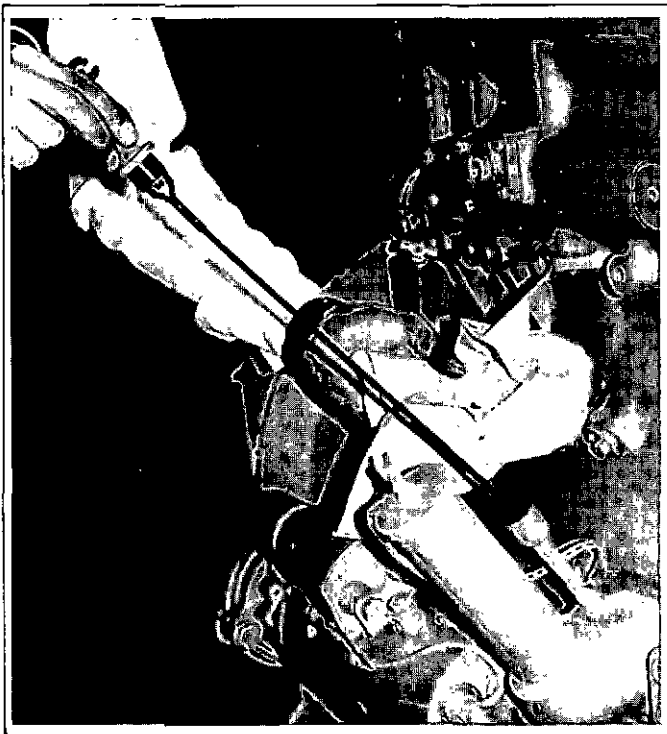
1. Many engines used on stationary power applications are equipped with a hydraulic governor. The governor uses the same type lubricating oil for energy medium as the engine. However, the governor oil system is separate from the engine lubricating oil system and its level must be maintained.
2. Oil level in governor sump must be at the high-level mark on dipstick.

Starting The Engine

Starting requires only that clean air and fuel be supplied to the combustion chamber in proper quantities and be spark-ignited at the correct time.

Normal Starting Procedure

1. Check lube oil and coolant levels.
2. Set the throttle for idle speed.
3. Disengage the clutch (if equipped) or open the main circuit breaker on generator set applications.
4. Open the gas supply shut-off valve (if equipped).
5. Turn the cam on the Sentinel safety shut-off valve clockwise to the open position. The lever will lock in the open position. (It will return to normal position after the oil pressure rises.)
6. Push the "reset" button on the instrument panel mounted Murphy magnetic switch.
7. Hold in the safety switch override button or turn the timer past 20 seconds and push the start button.



Caution: To prevent electric cranking motor damage, do not crank the engine for more than 30 seconds continuously. If the engine does not fire within the first 30 seconds, wait one to two minutes before cranking again.

8. When the engine has started and the oil pressure has risen, release the override button.
9. Engage the clutch and run the engine at just above idle to allow the engine coolant to warm up.

Warm Up Engine Before Applying Load

When the engine has started, it takes a while to get the lubricating oil film re-established between the shafts and bearings and between the pistons and liners. The most favorable clearances between moving parts are obtained only after all the engine parts reach a normal operating temperature. Avoid seizing the pistons in liners and running dry shafts in dry bearings by bringing the engine up to operating speed gradually as it warms up. Allow the engine to run at 800 to 1000 rpm for 4 to 5 minutes or preferably until water temperature reaches 140°F (60°C) before engaging the load, unless the engine is equipped with oil or water heaters. During the next 10 to 15 minutes, or until the water temperature reaches 160° to 165°F (71.0 to 73.9°C), operate at partial load at approximately 75% of governed RPM, if the engine application permits.

Instrument Panels

See page 49 for Shutdown Settings.

Operate by the Instruments

Regardless of application, the operator must use the panel board instruments. The instruments indicate at all times the engine's operating characteristics.

Use the Tachometer (if equipped)

Governed engine speed is the maximum rated RPM which a properly adjusted governor will allow the engine to turn under a full load.

Never over-ride the governor under normal operation or allow the engine to exceed the rated RPM during operation.

Water Temperature

A water temperature of 165°F to 195°F (73.9°C to 90.6°C) is the best assurance that cylinder liners are heated to the proper temperature to support good combustion and that working parts of the engine have expanded evenly to the most favorable oil clearances. See "Engine Warm-Up".

Keep thermostats in the engine at all times and avoid long periods of idling. Keep water temperatures to a minimum of 165°F (73.9°C). If necessary in cold weather, use

radiator shutters to cover part of the radiator to prevent overcooling.

Overheating problems require mechanical correction. They may be caused by loose water pump belts, a clogged cooling system or heat exchanger, or insufficient cooling capacity. Report cases of overheating to the maintenance department for correction. Do not allow the engine coolant temperature to exceed 200°F (93.3°C).

The Oil Temperature Gauge

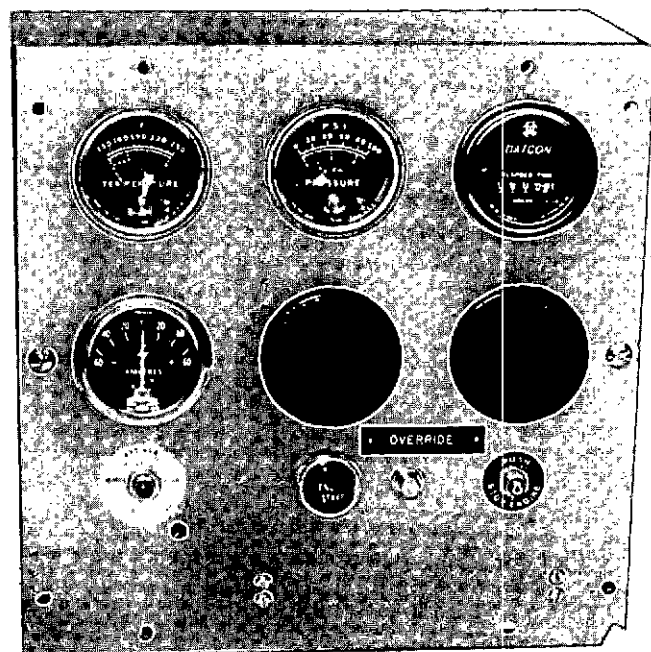
The oil temperature gauge normally should read between 180°F (82.2°C) and 225° (115.6°C) for best lubrication. Under full-load conditions, a temperature of 220°F (129.4°C) for a short period is not to be considered cause for alarm.

Caution: Any sudden increase in oil temperature which is not caused by load increase is a warning of possible mechanical failure and should be investigated at once.

During warm-up period, apply load gradually until oil temperature reaches 140°F (60°C), unless oil immersion heater is used. While oil is cold it does not do a good job of lubricating. Continuous operation with oil temperatures much below 140°F (60°C) increases wear.

Oil Pressure Gauge

The oil pressure gauge indicates any drop in lubricating oil supply or mechanical malfunction in the lubricating oil system. The operator should note loss of oil pressure immediately and shut down the engine before the bearings are ruined.



Normal operating pressures are:

	4 & 6 cyl.	12 cyl.
At idle - 600 RPM	15 psi (min.)	20 psi (min.)
At rated speed	50-70 psi	50-90 psi (min)

Note: Individual engines may vary from above normal pressures. Observe and record pressures when the engine is new to serve as a guide for indication of engine wear.

High Altitude Operation

Engines lose horsepower when operated at high altitude because the air is too thin to burn as much fuel as at sea level. This loss is about 3% for each 1000 ft. (304.8m) altitude above sea level and 1% per 10°F; above 60°F (15.6°C) for a naturally-aspirated engine. Consult your dealer if your engine is applied above 4000 ft. or 100°F.

Engine Shut-Down

Idle the engine 3 to 5 minutes before shutting it down to allow lubricating oil and water to carry heat away from the combustion chamber, bearings, shafts, and turbo.

Stop the Engine Immediately If Parts Fail

Never operate a unit after the engine indicates that something is wrong. Many engines are saved because an alert operator heeds warning signs (sudden drop in oil pressure, unusual noises, etc.) and immediately shuts down the engine. A delay of ten seconds after a bearing failure causes a knock. This may result in a ruined crankshaft or allow a block to be damaged by a broken connecting rod.

Cold Weather Protection

1. For cold weather protection, use of the permanent-type ethylene glycol-base antifreeze with rust inhibitor additives is recommended.
2. To completely drain the cylinder block and heads, open the petcock or remove the drain plug on the water pump (12 cylinder engine only). Open the petcock on side of the cylinder block at the front and rear of the engine and open vent cocks. If an oil cooler, heat exchanger or other "water-cooled" accessory is used, open the petcock on the unit. Failure to drain any of these units may cause serious damage in freezing weather. To drain an oil cooler completely, it must be removed.

Preparation For and Removal From Storage:

If engine must be stored or shut down for long periods of time, follow instructions in Engine Storage Section of this manual.

Operator's Daily Report**Make a Daily Operations Report**

The engine must be maintained in top mechanical condition in order to obtain satisfactory operation. Engine adjustments, etc., are the work of the maintenance department. However, the maintenance department needs daily running reports from the operator to make necessary adjustments in the time allotted and to make provisions for more extensive maintenance work as the reports indicate the necessity.

Comparison and intelligent interpretation of the daily report along with a practical follow-up action will eliminate practically all operating failures and emergency repairs.

Report to the maintenance department any of the following conditions:

1. Low lubricating oil pressure
2. Low power
3. Abnormal exhaust, water or oil temperature
4. Unusual engine noise
5. Misfiring engine
6. Excessive use of coolant, fuel or lubricating oil
7. Any gas or lubricating oil and water leaks

SPECIFICATIONS

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

Coolant Specifications

Coolant

Water should be clean and free of any corrosive chemicals such as chlorides, sulphates and acids. It should be kept slightly alkaline with pH value in the 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 the system with water.
2. In winter, select an antifreeze and use with water as required by temperature.

Note: Some antifreeze also contains 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

New Engines Going Into Service Equipped With DCA Water Filters

1. New engines shipped from the factory are equipped with filters containing a DCA precharge element. This element is compatible with plain water or all permanent-type anti-freeze except Dowtherm 209.
2. At the first "B" check (oil change period) the DCA precharge element should be changed to DCA Service Element. See Table 2
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 pretreated supply.
 - b. Each time system is drained, precharge according to Table 2

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 gallons of cooling system capacity.

5. To insure adequate protection have the coolant checked at each third element change or more often.

Table 2: Spin-On Type DCA Water Filter

Ethylene Glycol Base Antifreeze		
Cooling System Capacity (U.S. Gallons)	DCA-4L Precharge (P/N 3300858)	Service Element(s)
0-8	1	WF-2010 (P/N 299080)
9-15	2	WF-2010
16-30	5	WF-2010
31-60	10	(2) WF-2010
35-90 (V-1710)	12	(2) WF-2016 (P/N 299086)

Lubricating Oil Specifications

Lubricating oil is used in Cummins engines to reduce friction, temperature, and wear on moving parts, provide internal cooling and keep the engine clean by suspending contaminants until removed by the oil filters. Lubricating oil also acts 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 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.

Cummins Gas Engines has developed a new intake and exhaust valve design for the Cummins natural gas engines which provides for a longer life. The design features a wider valve seating area for better heat transfer and rotators on both intake and exhaust.

This new design which is incorporated into all of the exchange cylinder heads requires the use of an ashless or very low ash oil.

Check the ash content of your current oil with your supplier and, if necessary, switch to an oil that meets the following specifications:

Service Rating:

1. Cummins Gas Engines require the use of high quality gas engine lubricating oils, specifically refined for high performance application. Proper lubrication and satisfactory operation of the oil within the operating environment or each engine shall be the responsibility of the oil refiner, his agent and the engine owner.
2. MIL-2104A (CB), MIL-2104B (CC) or MIL-2140C (CD/SC)
3. Maximum sulfated ash content of 0% (zero) to 0.1% (one tenth of one percent)

No warranty consideration will be given on any valve failure in a new engine or rebuilt head if the proper oil is not used. Ashless or low ash oil will also improve the service life of your older Cummins engines.

Water Pump & Fan Hub Lubricants

Grease

Cummins Engine Company, Inc. recommends the use of grease meeting the specifications of MIL-G3545, excluding those of sodium or soda soap thickeners. Contact your 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 10,000RPM	*FTM 331	600 min

Low-Temperature Properties

Torque, GCM	ASTM D 1478	
Start at 0°F		1500 max
Run at 0°F		5000 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
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Penetration

Worked	ASTM D 217	250-300
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Bomb Test, PSI Drop

100 Hours		10 max
500 Hours		25 max

Copper, Corrosion

*FTM 5309	Pass
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Dirt Count, Particles/cc

25 Micron +	5000 max
75 Micron +	1000 max
125 Micron +	None

Rubber Swell *FTM 3606 10 max

*Federal Test Method Standard No. 791a.

Oil

Fan hubs utilizing tapered roller bearings (12 cylinder engines) can be lubricated with SAE 90 Gear Lubricant which meets U.S. Military Specifications MIL-L-2105B.

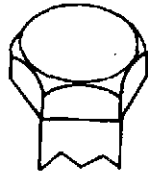
Caution: Do not mix grades or brands of grease as damage to bearings may result. Excessive lubrication is as harmful as inadequate lubrication. After lubricating fan hub replace both pipe plugs. Use of fittings will allow grease to be thrown out, due to rotation speed.

Capcrew Markings & Torque

Usage	Much Used	Much Used	Used at Times	Used at Times
	To 1/2 – 69,000 To 3/4 – 64,000	To 3/4 – 120,000 To 1 – 115,000	To 5/8 – 140,000 To 3/4 – 133,000	150,000
Capcrew Diameter and Minimum Tensile Strength psi	To 1 – 55,000			
Quality of Material	Indeterminate	Minimum Commercial	Medium Commercial	Best Commercial
SAE Grade Number	1 or 2	5	6 or 7	8

Capcrew Head Markings

Manufacturer's marks may vary. These are all SAE Grade 5 (3-line).



Capcrew Body Size (Inches) – (Thread)	Torque Ft-Lb [kg m]	Torque Ft-lb [kg m]	Torque Ft-lb [kg m]	Torque Ft-lb [kg m]
1/4 – 20	5 [0.6915]	8 [1.1064]	10 [1.3830]	12 [1.6596]
– 28	6 [0.8298]	10 [1.3830]		14 [1.9362]
5/16 – 18	11 [1.5213]	17 [2.3511]	19 [2.6277]	24 [3.3192]
– 24	13 [1.7979]	19 [2.6277]		27 [3.7341]
3/8 – 16	18 [2.4894]	31 [4.2873]	34 [4.7022]	44 [6.0852]
– 24	20 [2.7660]	35 [4.8405]		49 [6.7767]
7/16 – 14	28 [3.8132]	49 [6.7767]	55 [7.6065]	70 [9.6810]
– 20	30 [4.1490]	55 [7.6065]		78 [10.7874]
1/2 – 13	39 [5.3937]	75 [10.3725]	85 [11.7555]	105 [14.5215]
– 20	41 [5.6703]	85 [11.7555]		120 [16.5960]
9/16 – 12	51 [7.0533]	110 [15.2130]	120 [16.5960]	155 [21.4365]
– 18	55 [7.6065]	120 [16.5960]		170 [23.5110]
5/8 – 11	83 [11.4789]	150 [20.7450]	167 [23.0961]	210 [29.0430]
– 18	95 [13.1385]	170 [23.5110]		240 [33.1920]
3/4 – 10	105 [14.5215]	270 [37.3410]	280 [38.7240]	375 [51.8625]
– 16	115 [15.9045]	295 [40.7985]		420 [58.0860]
7/8 – 9	160 [22.1280]	395 [54.6285]	440 [60.8520]	605 [83.6715]
– 14	175 [24.2025]	435 [60.1605]		675 [93.3525]
1 – 8	235 [32.5005]	590 [81.5970]	660 [91.2780]	910 [125.8530]
– 14	250 [34.5750]	660 [91.2780]		990 [136.9170]

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 capcrews.
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 capcrews are used.
6. Capcrews threaded into aluminum may require reductions in torque of 30% or more, unless inserts are used.

GAS ENGINE MAINTENANCE

Maintenance is the key to lower operating costs. A Cummins engine requires regularly scheduled maintenance to keep it running efficiently. Most engines are purchased and used for the sake of revenues; it also requires additional funds for repair.

Investigate any successful operation where engines are used and you will find a good, regularly scheduled maintenance program in effect.

Scheduled Maintenance

Preventive maintenance is the key to long engine life and low operating expense. If the engine is properly maintained, most potential problems can be checked before causing a major breakdown of the engine.

Accessories must also be included in a maintenance schedule. Accessory failure may put an entire engine out of operation.

A Good Maintenance Schedule

The maintenance schedules in the following sections are guidelines around which individual maintenance programs may be established.

A lubricating oil analysis should be the basis of establishing a maintenance schedule.

Conditions under which an engine is operating determine the frequency of a good maintenance schedule. Engines operating in a dusty or dirty environment will require checks to be performed more often than engines running under relatively clean conditions.

Extending The Maintenance Schedule

Depending upon climate conditions, changes or extensions may need to be made. Such changes should be done only after a complete study; basically it should be the same as used in establishing the original maintenance schedule period. The operation should be re-analyzed and a lubricating oil analysis made.

Using The Schedule Check Sheet

The maintenance schedule check sheet is designed as a guide until you have adequate experience to establish a schedule to meet your specific operation.

A detailed list of component checks is provided through several check periods; also, a suggested schedule basis is given for hours of operation.

Maintenance Operations Summary Sheet

The maintenance operations summary sheet is designed to be used to summarize scheduled maintenance checks for a specific engine, by unit or engine serial number. The summary sheet records operation or checks performed, fuel used, mechanic, labor costs, parts used, etc. A complete record of this type is essential to perform a thoroughly efficient cost record of the operation.

Maintenance Schedule

Cummins Gas Engines

LOCATION _____ ENGINE SERIAL NO. _____
 MECHANIC _____ HOURS _____
 TIME SPENT _____ CHECK PERFORMED _____
 PARTS ORDER NO. _____ DATE _____

A-CHECK	B-CHECK	C-CHECK	D-CHECK	E-CHECK
DAILY	500 HOURS	1000 HOURS	2000 HOURS	15000 HOURS
<input type="checkbox"/> Check Operators Report <input type="checkbox"/> Check Leaks and Correct <input type="checkbox"/> Check Engine Oil Level <input type="checkbox"/> Check Coolant Level <input type="checkbox"/> Check Gas Leaks and Correct <input type="checkbox"/> Check Air Cleaner and Element <input type="checkbox"/> Check Hydraulic Governor Oil Level (if so equipped) <input type="checkbox"/> Lubricate PTO Bearing <input type="checkbox"/> Check and Adjust Belt Tension <input type="checkbox"/> Check Governor sump oil level	<input type="checkbox"/> Repeat "A Check" <input type="checkbox"/> Change Engine Oil <input type="checkbox"/> Change Engine Oil Filter <input type="checkbox"/> Record Oil Pressure <input type="checkbox"/> Lubricate Electrical Equipment <input type="checkbox"/> Lubricate Water Pump/Fan Hub <input type="checkbox"/> Adjust Throttle Linkage (12 Cyl. engines) <input type="checkbox"/> Clean and Tighten Electrical connections <input type="checkbox"/> Check Auxiliary Water Pump <input type="checkbox"/> Clean Crankcase Breather <input type="checkbox"/> Check Inlet Air Restriction <input type="checkbox"/> Change Water Filter <input type="checkbox"/> Change Governor Sump oil	<input type="checkbox"/> Repeat "A and B Checks" <input type="checkbox"/> Clean/Replace Spark plugs <input type="checkbox"/> Check Fan Hub and Drive Pulley <input type="checkbox"/> Check Air Piping and Vent Tube Connections <input type="checkbox"/> Clean Complete Air Cleaner <input type="checkbox"/> Check Vibration Damper Alignment <input type="checkbox"/> Check Cylinder Compression and Record <input type="checkbox"/> Check Gas Pressure to Carburetor <input type="checkbox"/> Check Gas Filter and replace if necessary <input type="checkbox"/> Replace mounting 'O' Rings on Spin-on Oil Filter adapter (if used)	<input type="checkbox"/> Repeat "A, B, & C Checks" <input type="checkbox"/> Check Thermostat <input type="checkbox"/> Tighten Mounting Bolts and Nuts <input type="checkbox"/> Check Crankshaft End clearance <input type="checkbox"/> Check Engine Blow-by <input type="checkbox"/> Clean Radiator Core (Externally) <input type="checkbox"/> Check Zinc Plugs on Surge Tank (if used) <input type="checkbox"/> Adjust valve/crossheads	<input type="checkbox"/> Repeat A, B, C, & D Checks <input type="checkbox"/> This Maintenance check is often referred to as "In-Chassis Inspection" where some key parts, such as bearings, are checked for wear to determine if the engine may be operated for another service period. Likewise, oil consumption, and other signs of wear should be analyzed during the check. Wear limits and other information is available from the Cummins Shop Manuals which can be purchased from any Cummins Gas Engine dealer.

Maintenance - Standby Service Engines

For units in standby service, or when hours of operation fall far below those listed, adjust the maintenance schedule accordingly as follows and with due consideration:

1. Monthly, perform "A" Checks.
2. Every 3 months, perform "B" Checks.
3. Every 6 months, perform "C" Checks.
4. Yearly, perform "D" Checks.

Lubricating oil standing in engines that are used infrequently or are in storage between seasons may tend to oxidize and require changing even though it is not dirty. Laboratory testing is the best way to determine whether oil is oxidizing under these conditions. Check the oil regularly. After several tests, it will be possible to schedule oil changes where the oil is not actually being contaminated due to dirt.

Units in standby service should be started once a week in locations where ambient temperature remains below 70°F (21.1°C) and contains a high percentage of humidity. Start the engine, bring the unit up to normal operating temperatures and run for approximately thirty minutes. Check electrical equipment for corrosion on all relays and switch terminals. Check controls for leaks and proper operation.

On units in locations where ambient temperature is normally above 70°F (21.1°C), perform starting procedure as described above once every two weeks.

The operator must take into consideration the environment of his particular unit installation in establishing a routine maintenance schedule.

● 'A' Maintenance Checks

Check Operator's Report

Check the operator's daily reports; investigate and correct reported cases of:

1. Low lubricating oil pressure.
2. Low power.
3. Abnormal water or oil high exhaust temperature.
4. Unusual engine noises.
5. Rough running or engine misfiring.

Check Leaks and Correct

● Lubricating Oil

Check for evidence of external oil leakage. Tighten capscrew, fittings, connections and gaskets as necessary to correct. Check the oil dipstick and filler tube caps to assure that they are tightened securely.

Gas Leaks

Check for evidence of gas leakage at regulator and all pipe connections.

1. Apply liquid soap around the regulator to check for leaking gaskets and ruptured diaphragms.
2. Check for leaks at all line connections by soaping.
3. GTA at power, check throttle shaft seals for leaks.

Coolant

Check for evidence of external coolant leakage. Tighten capscrews, hose clamps, fittings and connections. Replace gaskets or hose as necessary to correct.

● Air Connections

Visually check air system connections for leaks or damage.

Check Coolant Level

Keep the cooling system filled to operating level. Check the coolant level daily. Investigate causes of any coolant loss or gain. Recheck the level after the engine reaches its normal operating temperature. At operating temperatures the thermostat is open and water is free to circulate to all parts of the system and fill all air pockets.

Many operators have been shocked to find water in the crankcase and to learn it got there through "pinholes" or pitted areas that started on the water side of cylinder liners.

This "eating away of metal", or corrosion, as it is commonly called, is likely to occur in any heating or cooling system. Corrosion may or may not be associated with iron rust, and as a result may not show up in the coolant.

Research has shown that there are many causes of corrosion and among the most serious are acid, salt or aeration of the coolant. Acid and salt can be controlled by a properly maintained water filter.

Aeration refers to air bubbles which may be drawn into the radiator core tubes, then into the water pump and engine. The loss of water pump prime due to an accumulation of air will result in a complete flow stoppage. Entrained air promotes accelerated internal corrosion. Air in the coolant will increase the water temperature due to a reduction in heat transfer.

An open (non-baffled) radiator top tank is often the cause of air entering the system. Due to the high velocity of coolant entering the top tank, the surface becomes very agitated and tends to draw air into the core tubes along with the coolant. It is very difficult on many units to completely fill the cooling system initially. This is due to the trapping of air in pockets in the engine or other parts of the system. The system should be bled of the air or refilled after a short period of operation to purge the air from the coolant. Open the vent valve atop the thermostat housing and continue to add coolant until no air is expelled from the vent.

Fill Cooling System

Keep the cooling system completely filled. Check coolant level daily before starting the engine and after the engine cools. Do not check the coolant on a hot engine unless a pressure cap is not used in the system, except in an emergency.

Check the pressure cap at each "E" Check to prevent coolant loss through overflow. Investigate any excessive loss of coolant.

Clean Air Cleaner Element

On engines working under extremely dirty conditions an air pre-cleaner may be used. Clean pre-cleaner and dry-type air cleaner dust pans daily or more often as necessary depending on operating conditions.

Engines operating in very dusty areas, such as in open fields, or alongside a dirt road, should have the air cleaner checked daily, and in some cases, every few hours and replaced when necessary.

Check Engine Oil Level

Check the oil level with the dipstick oil gauge located on the engine. For accurate readings, the oil level should not be checked for approximately 30 minutes after engine shut-down. Keep the dipstick with the oil pan with which it was originally supplied. Keep the oil level as near the "H" mark as possible.

Caution: Never operate engine with an oil level below the "L" mark or above the "H" mark.

Lubricate Power Take-off and Clutch Throw-out Bearing

Power Take-Off (if equipped)

Apply a small amount of any high-grade, soda base, short fiber, heat-resistant, gun-lubricant grease once a day through the fitting on the tapered part of the housing to the throw-out collar.

Manual Spring-Loaded Input Disconnect Clutch

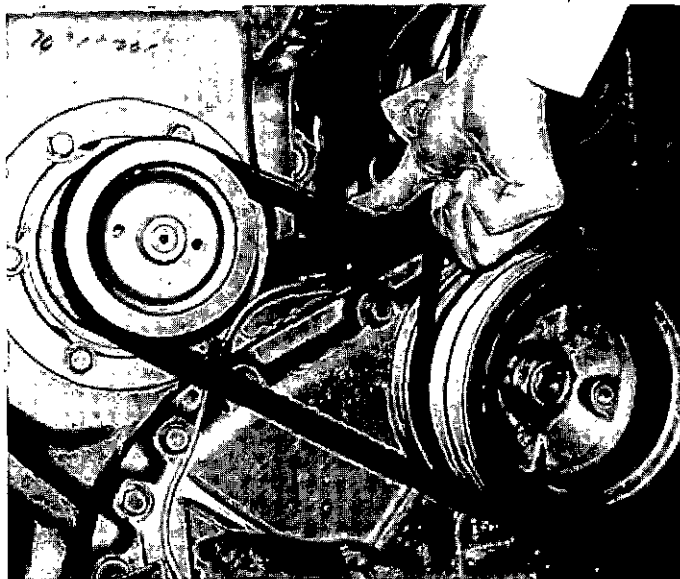
Approximately once a week, lubricate the release bearings with two "shots" from a grease gun using the grease described above. Two grease fittings are usually provided atop the clutch housing.

Check and Adjust Belt Tension

The service life of belts used to drive fans, water pumps and alternators can be greatly extended by proper installation, adjustment and maintenance practices. Neglect or improper procedures often lead to problems of cooling or bearing failures, as well as short belt life.

Belt tension adjustments are often neglected because of difficult accessibility. One general rule is applicable to all such operations:

ALL DRIVEN ASSEMBLIES MUST BE SECURED IN THE OPERATING POSITION BEFORE READING OR JUDGING THE BELT TENSION.



Check Governor Oil Sump Level

1. Many engines used in stationary power applications are hydraulic-governed. This governor uses lubricating oil (of the same weight as used in the engine) as an energy medium.
2. Oil level in governor sump must be at the full mark on dipstick, or half-way level on the inspection glass.

'B' Maintenance Checks

Change Engine Oil

Oil change periods may be based on the schedule indicated in the Maintenance Schedule; and then extended, or in unusual cases reduced, based upon the type of oil used, the efficiency of the filtering system and the condition of the engine.

Factors to be checked and limits for oil analysis are listed below:

1. Bring the engine to operating temperature; shut off the engine and remove the drain plug from the bottom of the oil pan. Drain the oil into a suitable container.
2. Install the drain plug in the oil pan and torque to 60-70 ft-lb (8.2980-9.6810 k-gm).
3. Fill the crankcase to the "H" (high-level) mark on the dipstick.

Start the engine and visually check for oil leaks.

Note: It is important to visually check for oil leaks after every oil and/or filter change.

5. Shut down the engine; allow 15 minutes for the oil to drain back into the pan; recheck the oil level with the dipstick. Add oil, as required, to bring the oil level to the "H" mark on the dipstick.

Lubricating Oil Analysis

The most satisfactory method for determining when to change lubricating oil is by oil analysis using laboratory tests. After several tests, a time interval for the oil change can be established; however, a new series of tests should be run if filters, oil brands or grades are changed.

Analysis Test For Lubricating Oil

Check the oil properties in the following list during analysis. These methods are fully described in the American Society for Testing Materials Handbook.

Oil Property	Test Number
viscosity at 100° and 200° F	ASTM-D 445
Sediment	ASTM-D 893
Water	ASTM-D 95
Acid and Base Number	ASTM-D 664

General Limits for Oil Change

1. Minimum viscosity (dilution limit); minus one SAE grade from original.
2. Maximum viscosity; plus one SAE grade from original.
3. Total base number and total acid number; check with lubricating oil supplier for amount of change acceptable with the brand and grade being used.
4. Water content; check with supplier on the compatibility of the lubricating oil being used to water content.
5. Additive reduction; blotter or spot test.

Caution: If the above tests indicate a presence of any bearing metal particles, or if particles are found in the filters, the source should be determined before a failure results.

The efficiency of any maintenance program can only be judged on the basis of the failures prevented or intercepted before the engine or unit is damaged.

Change Governor Sump Oil

1. Remove governor oil sump drain plug and drain.
2. Install drain plug and refill governor sump to proper level with lubricating oil (of the same weight as used in the engine).

Change Engine Full-flow Element

1. Remove the drain plug from the filter case and allow oil to drain.
2. Loosen and completely unscrew the center capscrew; remove the filter case assembly (with the element) from the filter head.
3. Withdraw the filter element and inspect for metal particles.

Caution: If the above tests indicate the presence of any bearing metal particles, or if particles are found in the filters, the source should be determined before a failure results.

Inspect the outside wrapper of the element for wrinkles, pleats, waviness, or bunching. Presence of these conditions indicates that the oil contains moisture.

4. If the element is relatively clean, it may be possible to lengthen the change periods.

If the element is clogged, the change period should be shortened. The oil pressure drop reading across the filter is the best way to determine change periods. The pressure drop from inlet to outlet side of the filter should not exceed 10 psi (0.7030 kg/sq cm) with 140°F (60°C) oil and the engine at a high-idle speed.

Discard the element after inspection.

OIL FILTER
CARTRIDGE



5. Remove the seal ring from the filter head and discard.
6. Clean the filter case thoroughly. Handle the case and/or store in a manner so as to prevent an out-of-round condition.
7. Check to make sure the element end seals are in place and install the new element over the spring support assembly.
8. Position the new seal ring on the filter head; apply oil; install the new element in the filter case and fill with clean lubricating oil. Tighten the center capscrew to 25-35 ft/lb (3.4575-4.8405 k/gm). Tighten the clamp-type filter capscrews securely.
9. Spin-On (if used)

Spin-On Lubricating Oil Filter Adapter Maintenance (All Series Engines)

To prevent gasket/seal leakage caused by "age hardening" it is recommended that gaskets used in spin-on lubricating oil filter adapter be replaced at each "C" 1000 hrs. Check maintenance interval or as required to prevent leakage. Reference (1 and 2, Fig. 1) for gasket/seal locations. Refer to Table 1 for spin-on lubricating oil filter adapter kit application and part number.

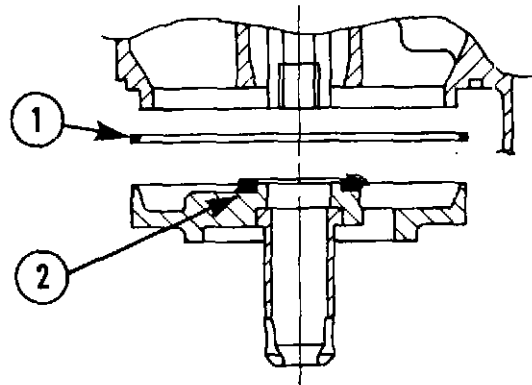


Fig. 1: Spin-on filter adapter gasket/seal locations.

10. Check the oil level. Run the engine and check for leaks.
11. Recheck the engine oil level; add oil as necessary to bring the oil level to the "H" mark on the dipstick.

Note: Always allow 15 minutes for the oil to drain back into the oil pan before checking the level.

Record Oil Pressure

Start the engine and operate at 800 to 1000 RPM. Reduce engine speed to idle and record the oil pressure. A comparison of pressure at idling speed with previous readings will give an indication of progressive wear of the lubricating oil pump, bearings, shafts, etc. These readings are more accurate and reliable when taken immediately after an oil change.

Change Oil in Oil Bath Air Cleaner (If equipped)

Before dirt build-up reaches ½" (12.70 mm) remove the oil cup from the cleaner. Discard the oil and wash the cup in cleaning solvent or fuel oil.

Fill the oil cup to the level indicated by the head on its side with clean, fresh oil and assemble onto the cleaner. An oil of the same grade as that in the crankcase should be used in the cleaner; however, in extremely cold weather a lighter grade may be necessary. A straight mineral, non-foaming detergent, or non-foaming additive oil may be used in air cleaners.

Lubricate Electrical Equipment Alternator - Battery Charging

If no oilers are present, the unit contains sealed bearings and requires no lubrication.

Water Pump Belts

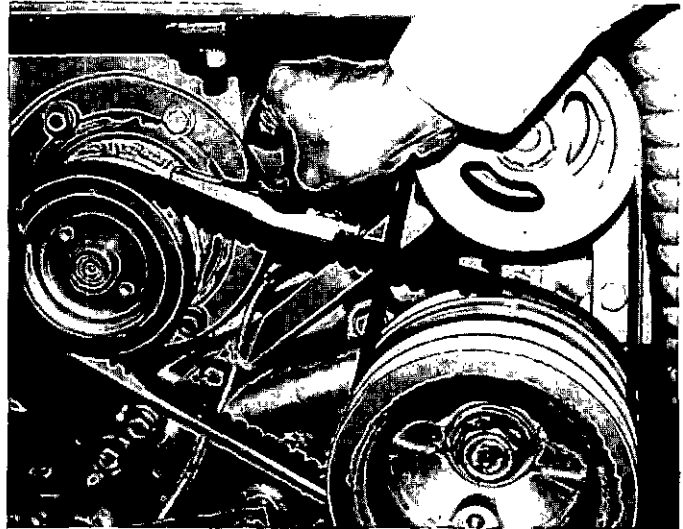
1. Eccentric water pump adjustment
 - a. Loosen the water pump clamp ring to allow the pump body to turn.
 - b. Loosen the pump body by pulling up on the belts. A sharp jerk may be required. Some coolant will be lost.
 - c. Insert a bar in the water pump body slots and rotate the pump body counterclockwise to tighten the belts.

Caution: Do not adjust to final tension.

- d. Snug the clamp ring capscrew farthest from the belts on exhaust side, to 5 ft/lb (0.6915 k/gm).
- e. Snug the two capscrews above and below the first one to 5 ft/lb (0.6915).
- f. Snug the clamp capscrews on the belt side, then the two remaining capscrews, to 5 ft/lb (0.6915 k/gm).
- g. Finish tightening by alternating from side to side in 5 ft/lb (0.6915 k/gm) increments to a final torque of 12 to 15 ft/lb (1.6596 to 2.0745 k/gm).
- h. Check the belt tension with an applicable belt tension gauge. Correct tension is 90 to 110 pounds as indicated on this gauge. If a belt tension gauge is not available, apply pressure from the index finger at the center of the longest span of the belt. Deflection should be one belt thickness per foot of pulley center distance.

Note: Use ST-1274 for belts which are 3/8 to 1/2 inch in width. Use the ST-1138 Gauge for belts which are 11/16 to 1 inch in width.

Notice that the final belt tension was not obtained by the adjustment alone. The water pump body was pulled straight by snugging the capscrew in the order described, thus increasing belt tension to its final value.



2. Adjustable (split) pulley water pumps (old V-12 only)
 - a. Remove the capscrews which join the two halves of the pulley.
 - b. The outer half of the pulley is screwed onto the hub extension of the inner half. Some pulleys are provided with flats, and some with lugs, for barring.
 - c. Bar the engine over to roll the belt outward on the pulley as the outer half is turned in.
3. Auxiliary water pump on aftercooled engines

Belt adjustment is obtained by loosening the pump mounting bolts and moving the pump to obtain proper tension.

Belt Tension - In. (mm)

<u>Belt Width</u>		<u>Deflection Per Ft. (0.3048 m) of Span</u>	
1/2	(12.700)	13/32	(10.318)
11/16	(17.462)	13/32	(10.318)
3/8	(19.050)	7/16	(11.112)
7/8	(22.225)	1/2	(12.700)
1	(25.400)	9/16	(14.287)

Adjust Throttle Linkage (12 cylinder)

Check throttle linkage and make sure it is in good operating condition. Check throttle travel to make sure the linkage operates the throttle from stop to full throttle and that the degree of travel is within specifications for application.

Adjust Valves

1. Pump the hydraulic lifter with oil by first releasing the check ball in the lifter and then pouring engine oil into the top of the lifter moving the sleeve in and out.

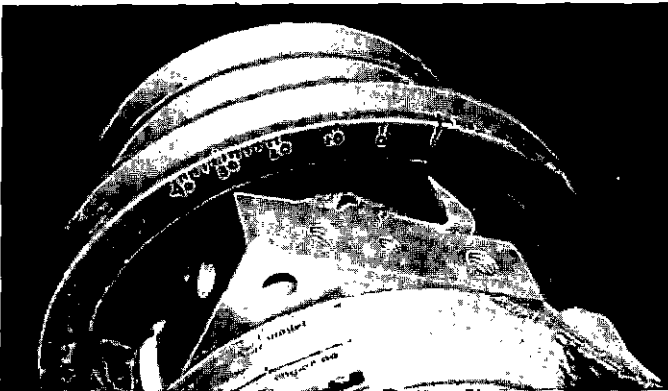
When the lifter is completely full, release the check ball. The lifter should be solid, with no in or out movement possible.

2. Loosen the locknut and advance the adjusting screw to make light contact with the crosshead. Then turn the screw one full revolution.

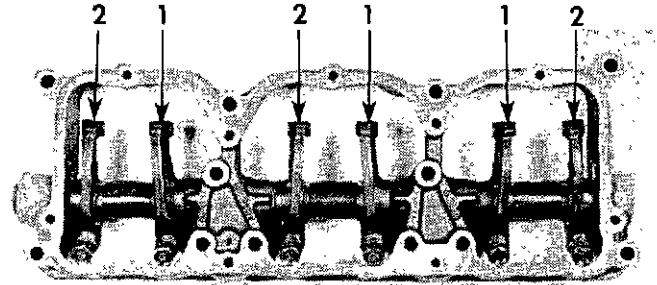
3. Lock the adjusting screw nut.

After the hydraulic push tubes are initially adjusted, no periodic adjustments are needed, unless repairs involving the hydraulic push tubes are performed, or the cross heads are adjusted.

4. Bar the engine in the direction of rotation until the No. 1 VS mark appears on the accessory drive pulley. In this position, both intake and exhaust valves will be closed for cylinder No. 1 if it is in the firing position. If not, rotate the engine one complete revolution.



5. Adjust the crossheads and valves of No. 1 (No. 1L on V12) cylinder as explained in the succeeding paragraphs. Turn the crankshaft in the direction of rotation to the next VS mark corresponding to the firing order of the engine and the corresponding cylinder will be ready for adjustment.



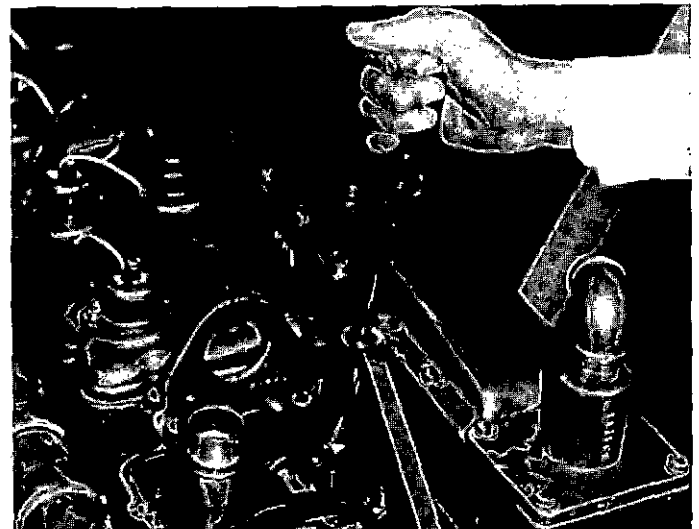
① Intake Valve

② Exhaust Valve

Engine Firing Order

Engine Series	No. of Cylinders	Right-Hand Rotation
G-495	4	1-2-4-3
G-743	6	1-5-3-6-2-4
G-855	6	1-5-3-6-2-4
GTA-855	6	1-5-3-6-2-4
GTA-743	6	1-5-3-6-2-4
GTA-855	6	1-5-3-6-2-4
G-1710	12	1L-6R-2L-5R
GTA-1710	12	4L-3R-6L-1R 5L-2R-3L-4R

6. Facing the 12 cylinder engine at the end opposite the flywheel, the left bank is on the left hand side of the block and No. 1L and No. 1R cylinders are at the end opposite the flywheel. Four and six cylinder engines are numbered from the end opposite the flywheel.
7. Continue turning the crankshaft in the direction of rotation and making adjustments until all valves have been correctly adjusted.

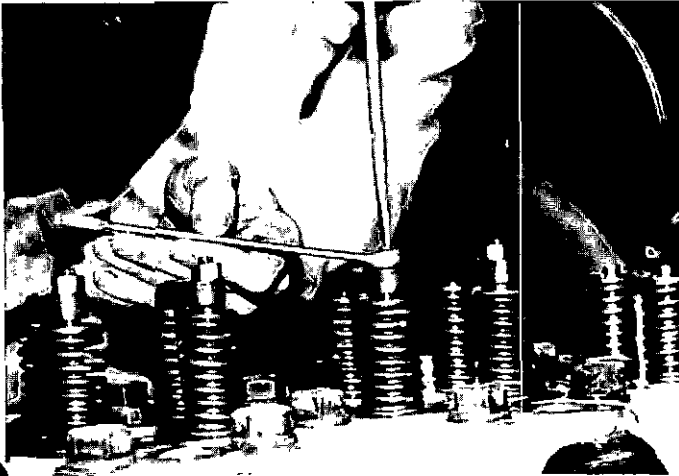


Note: Two complete revolutions of the crankshaft are needed to set all valves. Valves can be adjusted for only one cylinder at any one VS setting.

Crosshead Adjustments

All Cummins gas engines have four-valve heads, and it is necessary to adjust the crossheads before making the valve adjustment.

1. Loosen the valve crosshead adjusting screw locknut and back off the screw one turn.
2. Use light finger pressure at the rocker lever to hold the crosshead in contact with valve stem nearest the push tube.

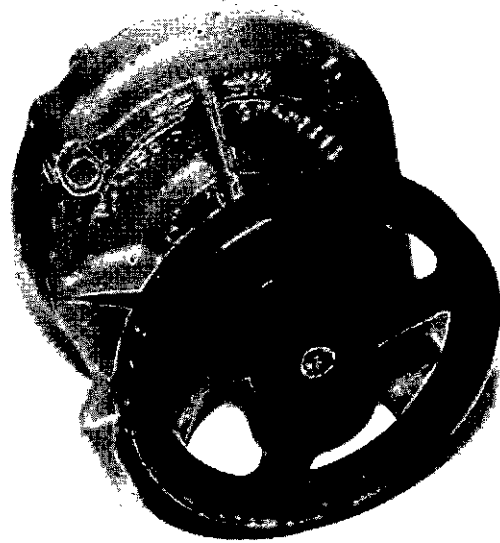


3. Turn down the crosshead adjusting screw until it contacts its corresponding valve stem.
4. With new crossheads and guides, advance the screw an additional one-third of one hex (20°) to straighten the guide on the stem and compensate for slack in the threads. With worn crossheads and guides, it may be necessary to advance the screw as much as 30° to straighten.
5. Hold the adjusting screw in this position and tighten the locknut to 25-30 ft/lb (3.4575 to 4.1490 k/gm) torque.
6. Check the clearance between crosshead and the valve spring retainer with wire gauge. There must be a minimum of 0.020 inch clearance at this point.

Check Auxiliary Water Pump

(On Turbocharged/Aftercooled Models)

Maintenance and service periods for auxiliary water pump must be adjusted necessarily to agree with the type of application to which it is subjected. If coolant being pumped through the water pump is relatively free of sediment, corrosive chemicals, foreign material and abrasives such as sand or mud, normal maintenance periods are sufficient.



Tighten Electric Connections

Hard starting is often traceable to loose or corroded battery connections. A loose connection will overwork the battery-charging alternator and regulator and shorten their lives.

1. Add distilled water to battery cells to keep tops of plates covered.
2. Remove corrosion from and around terminals; then coat with petroleum jelly.
3. Keep connections clean and tight. Prevent wire and lugs from touching each other or any metal except screw terminals to which they are attached.
4. Replace broken or worn wires and their terminals.
5. Have the battery tested periodically. Follow the battery manufacturer's instructions for maintenance.

Check Air and Vapor Line Connections

Check all air and vapor line connections from the air starting motor, compressor, rocker housing cover, and cylinder head for leaks, breaks, stripped threads, etc.; correct as needed.

In cold weather, condensed moisture in air tanks and lines may freeze. Open petcocks in air tanks and drain condensation.

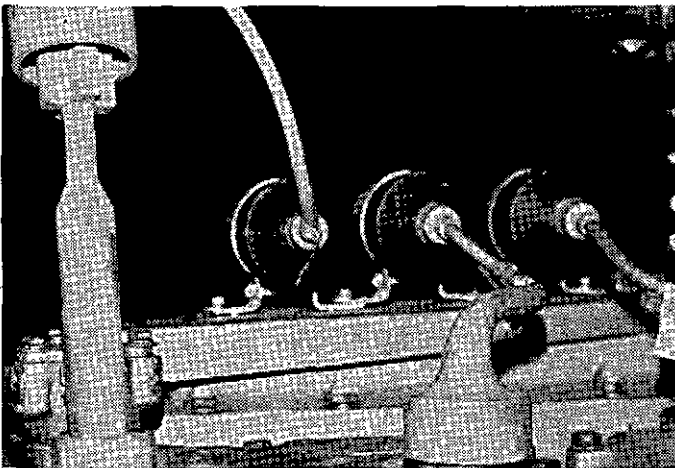
'C' Maintenance Checks

At each "C" Maintenance Check, perform all "A" and "B" Checks in addition to the following:

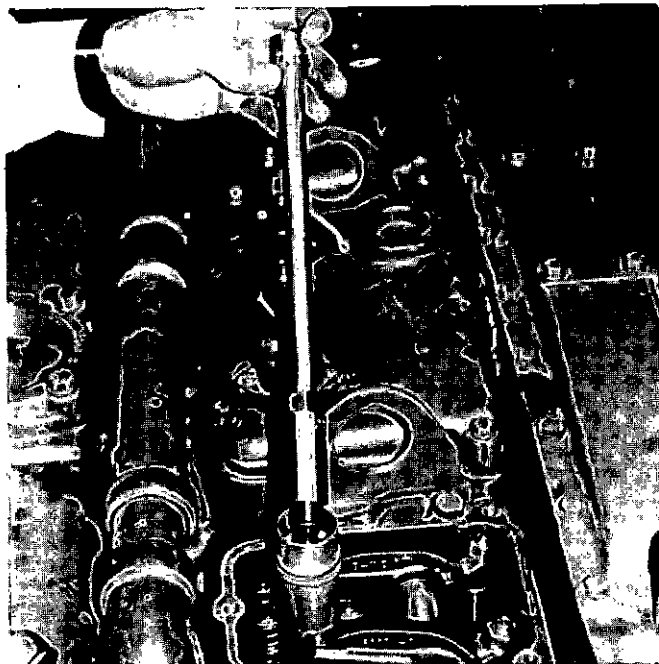
Clean or Replace Spark Plugs

Removal (on external assemblies)

1. Disconnect spark plug wire at coil.
2. Lift off blue rubber cap with extension.



3. Using an extra long 13/16 inch (0.8125 mm) deep-well rubber insert spark plug socket, remove the spark plug from adapter. Lift out spark plug and gasket (Valve covers need not to be removed to check or replace spark plugs.)



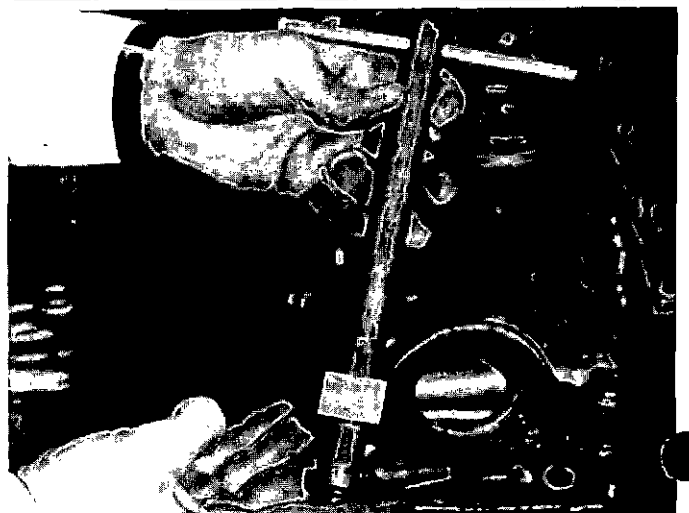
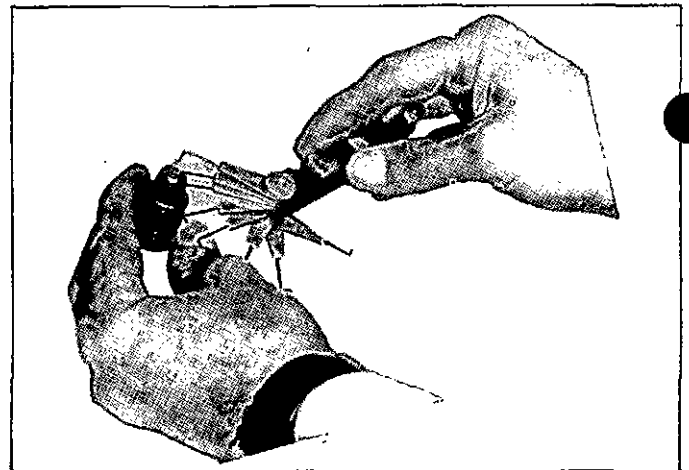
4. Visually examine spark plug well for traces of water or oil. If oil is present, "O" rings on the spark plug adaptor tubes must be replaced. If water is present inside cylinder, adaptor "O" rings and adaptor gasket must be replaced.

Note: A 3/4 inch reach, 14 mm spark plug is recommended on all Cummins Natural Gas Engines.

Caution: Spark plug adapter, part #173416, identified by a two (2) slot upper socket, requires the use of .125 inch spark plug gasket-spacer for proper positioning of 3/4 inch reach spark plug. All other spark plug adapters utilize standard spark plug gasket.

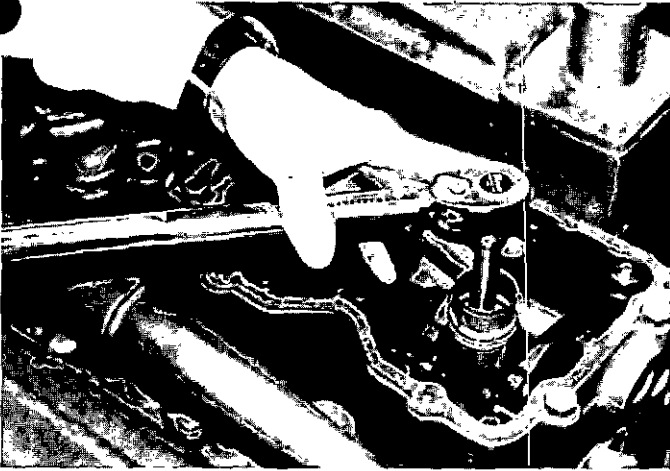
Installation

1. Check the spark plug gap; it should be 0.020-0.025 inches (0.508-0.635 mm).



2. Inspect the spark plug seating area in the adapter and clean to insure a good seating surface for the spark plug.

- Position the new gasket on the spark plug; insert the spark plug in the adapter and tighten to 28-30 ft/lb (3.8132-4.1490 k/gm) torque.



Check Fan Hub and Drive Pulley

Check the fan hub and drive pulley to be sure that they are securely mounted.

Tighten the fan capscrews. Check the drive pulley for looseness or wobbles, and, if necessary, remove the fan and hub and tighten the shaft nut. If fan wobble, check the bearings for excessive wear. Tighten the bracket capscrews. Lubricate bearings if necessary.

Check Air Piping and Vent Tube

Check air intake piping from the air cleaner to the intake manifold. Check for loose clamps or connections, cracks, punctures, or tears in the hose or tubing, collapsing hose, or other damage.

Tighten clamps, or replace parts as necessary to insure an air-tight air intake system. Make sure all air goes through the air cleaner.

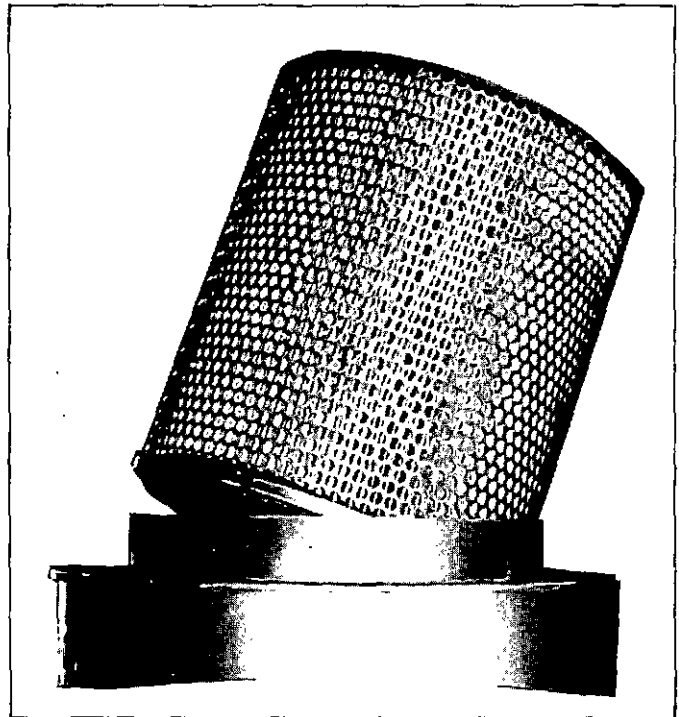
Clean Complete Air Cleaner

Heavy Duty Dry Type Air Cleaner

Heavy duty air cleaners combine centrifugal cleaning with element filtering before air enters the engine.

Dirty air enters through an opening on the side of the cleaner body then travels immediately through a ring of vanes around the outside of a primary element. Centrifugal force throws the heavier dust particles outward and down into a slot in the cup disc. 80-85% of the dust enters the disc slot and drops into the cup where it is retained; the remaining fine dust particles are trapped by the paper element while the cleaned air continues on into the engine.

Some air cleaners are equipped with an optional ejection valve, which extends the operating life of the cleaner. This valve remains closed until the engine speed (or vacuum) is reduced, or until sufficient weight of water or dust forces the valve open allowing all or part of the contents to unload.



The paper element may be cleaned several times by using an air jet to blow off dirt or by washing with non-sudsing household detergent and warm water, preferably 120 to 140 °F (48.9 to 60.0°C) then drying with compressed air approximately 40 psi (2.8124 kg/sq cm). Do not hold air jet too close to the paper element so as to prevent damage to the element.

Elements that have been cleaned several times will finally clog and air flow to the engine will be restricted. After cleaning, check restriction and replace the element if necessary. Replace the paper element when holes, loose end seals, dented surfaces or breaks appear, or if air restriction is still excessive after the element has been cleaned.

To Change Element:

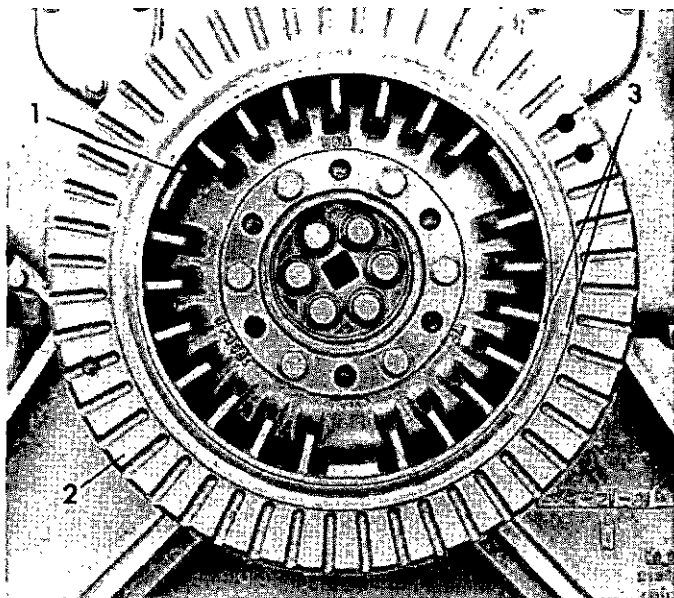
- Loosen the wing nut securing cover to cleaner housing and remove cover.
- Remove dust shield.
- Pull the element from the center bolt.
- When installing the element, make sure it seats on the gasket at the air cleaner outlet end.

Caution: Holes in the element render cleaner inoperative. **DO NOT USE DAMAGED CLEANER ELEMENT.**

Inspect Vibration Damper

Rubber Damper

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



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 the 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 inches (3.18 mm) from outside edge of front cover plate.
4. Replace damper if variation of the four (4) readings excess 0.010 inch (0.25 mm).

5. Replace damper if premature gear failure occurs.

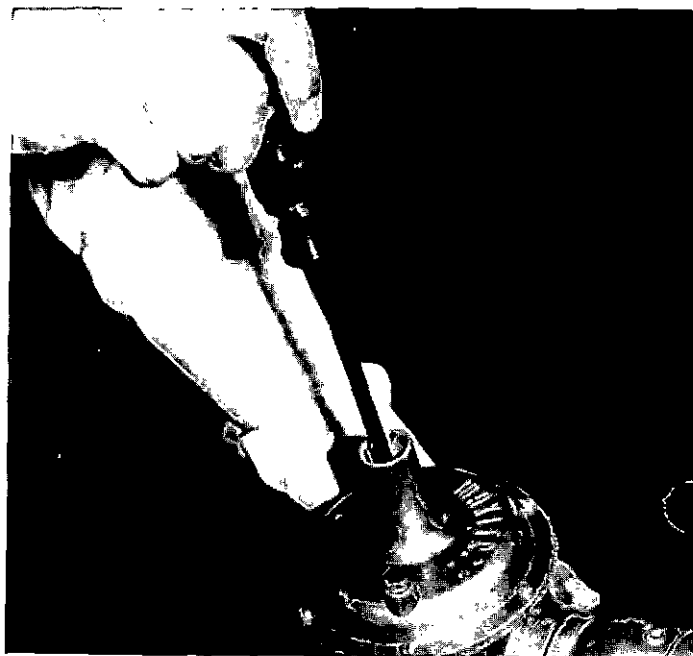
Check Cylinder Compression and Record

1. Place the carburetor butterfly in full open position, after engine is at operating temperature.
2. Remove all spark plugs.
3. Attach a compression gauge (Kent Moore or equivalent) by utilizing a 14 mm spark plug adapter, to No. 1 cylinder spark plug opening.
4. Remove the wiring harness from the Altronic connector at the Altronic.
5. Crank the engine with the starter motor a minimum of 6 revolutions at which time the compression gauge should reach maximum pressure. To obtain accurate readings, each cylinder should be checked at the same cranking speed and revolutions.
6. Proceed to check each cylinder as described above.

Compression pressure will vary depending on the cranking speed, altitude, air density and sealing ability of the engines. The maximum pressure is not as important as the pressure variation of the individual cylinders, and any one or more cylinders indicating a pressure differential of 7% or more would indicate excessive compression loss in that cylinder.

Check Gas Pressure to Carburetor

Gas pressure should be reduced to 5.8 ounces (10 inches H₂O) per square inch before entering the pressure reduction valve or Thermanac by installing a line pressure regulator.



The Thermanac must be used when gas pressure cannot be reduced and maintained by the line pressure regulator to 2.9 ounces per square inch (5 inches of H₂O) for 1000 BTU gas at the carburetor inlet, or when more pressure must be used to overcome line loss due to small pipe, elbows or line length. These pressures will be adjusted according to load, type of gas, engine timing and exhaust temperature.

Tighten Exhaust Manifold Capscrews

G/GTA-1710

At each "C" check tighten wet type exhaust manifold capscrews to 70 to 80 ft/lbs (9.7 to 11.1 kg/m) torque. Retorquing exhaust manifold capscrews should be done with engine cold.

Cooling System

Clean (Externally) Radiator Core

Blow out all insects, dust dirt and debris (leaves, bits of paper, etc.) that may be on front of radiator or lodged between radiator core fins and tubes.

Inspect/Rebuild 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 ReCon Inc. units.

Inspect Water Pump and Fan Hub

Inspect water pump and evidence of grease leakage. Replace with rebuilt prelubricated units as necessary.

Idler Pulley V 12

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

Change Hydraulic Governor Oil

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

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

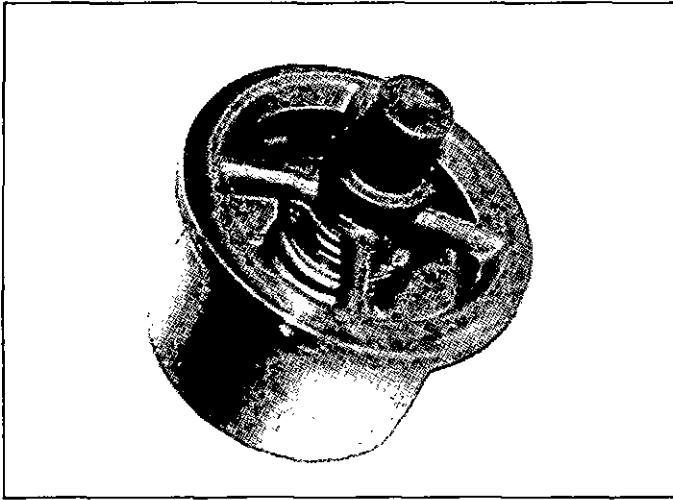
Note: When temperature is extremely low, it may be necessary to dilute the lubricating oil with enough fuel oil or other special fluid to insure free flow for satisfactory governor action.

'D' Maintenance Checks

Check Thermostats

Cummins gas engines are equipped with either low (160-175°F [53.4-61.7°C]) or high (170-185°F [58.9-67.2°C]) and in a few cases higher range (180-195°F [64.5-72.8°C]) thermostats, depending on engine application.

Caution: Do not run the engine without a thermostat as it will cause overheating.



Tighten Mounting Bolts and Nuts in General

Mounting bolts will occasionally work loose and cause the supports and brackets to wear rapidly. Tighten all mounting bolts or nuts and replace any broken or lost bolts or capscrews.

Check Engine Blow-by

Engine blow-by, or the escape of combustion gases past the pistons and liners, is usually caused by worn or stuck piston rings, worn cylinder liners, or worn pistons.

Blow-by can be detected by running the engine and observing the gas escape from the lubricating oil filler hole with the cap or breather open or removed. There is always some vapor or gas escaping at this point due to heated oil and piston movement, but distinct puffs indicate blow-by. Experience and comparison with other units operating at the same speed are needed to make a conclusion as to the extent of blow-by. Normally, excessive blow-by is accompanied by oil consumption.

Cummins dealers are equipped to check engines for blow-by under loaded conditions, with special tools, to determine if blow-by is excessive.

Clean (Externally) Radiator Core

Blow out all insects, dust dirt and debris (leaves, bits of paper, etc.) that may be on the front of the radiator or lodged between radiator core fins and tubes.

Check Crankshaft End Clearance

The crankshaft of a new or newly built engine must have end clearance as listed below. A worn engine must not be operated with more than the worn limit end clearance shown in the table.

Crankshaft End Clearance In. (mm)

No. cyl. Engine	New Min.	New Max.	Worn Limit
4 and 6	0.007 (0.18)	0.017 (0.43)	0.022 (0.89)
12	0.006 (0.15)	0.013 (0.33)	0.022 (0.89)

The check can be made by attaching an indicator to rest against the flywheel or on the crankshaft throw while prying against a crankshaft throw through an inspection plate if the oil pan is not removed. End clearance must be present with the engine mounted in the unit or assembled to a generator.

'E' Maintenance Checks

At each "E" Maintenance Check, perform all "A", "B", "C" and "D" Checks in addition to those following.

The "E" Maintenance Check is often referred to as an inframe overhaul, where the engine is not removed from the job site, but some assemblies are rebuilt. In addition, a major inspection should be performed to determine whether the engine may be operated for another service period, or whether it should be completely overhauled. Oil consumption, no oil pressure at igniting, and other signs of wear should be analyzed as part of the inspection.

Since major inspection requires partial disassembly of the engine, it should be done only by mechanics thoroughly familiar with worn replacement limits and disassembly and assembly procedures. This information is available in all Cummins Shop Manuals which can be purchased from any Cummins dealer.

Main and Connecting Rod Bearing Shells
Crankshaft Journals
Camshaft Lobes

Cylinder Heads (Grind Valves)
Cylinder Liners
Pistons and Rings
Pressure Reduction Valve
Carburetor
Gas Shut-Off Valve
Oil Cooler (Clean)
"Altronic" Ignition and Spark Plugs
Battery-Charging Alternator and Cranking Motor
Intake and Exhaust System (Clean and Correct Leaks)

If, during major inspection, it is determined that crankshaft journals or any other engine parts are worn beyond worn replacement limits, the engine should be removed and completely rebuilt.

Parts which are worn beyond replacement limits at this inspection should be replaced with new or rebuilt parts or units.

Engine Storage

On any engine not in service, whether installed in equipment or waiting to be installed, the unpainted machined surfaces are subject to rust and corrosion. Often an engine is not prepared for storage with rust-proofing measures taken, because it is not thought that the engine will be out of service for a long period. However, any engine temporarily stored, whether one taken out of service, or a new engine not yet placed in service, is subject to rust damage.

The rate of corrosion varies with climatic conditions. An engine stored in a climate with a high amount of moisture in the air will corrode more rapidly than an engine stored in a dry climate. Variance in climatic conditions makes it impossible to state the length of time an engine can be stored without rust and corrosion damage.

Temporary Storage

If an engine remains out of service for three or four weeks (maximum six months) and its use is not immediately forthcoming, special precautions should be taken to prevent rust. Only the operations listed below are required to minimize or prevent damage resulting from lack of attention to temporarily stored engines.

1. The engine must be started and the speed gradually increased to 1,200 RPM or a fast idle, with no load, and operated until the engine is thoroughly warm.
2. The oil sump must be drained and drain plugs reinstalled. New oil may be added or sump may remain empty until engine is ready for use. If sump remains empty, tag engine with warning tag.
3. Shut off main gas supply and disconnect one wire from each transformer, so engine will not start.
4. Remove 1" pipe plug in intake manifold. Remove "Altronic" Box. With hand or power sprayer, spray minute amounts of SAE 10 lubricating oil into intake manifold while cranking engine slowly using intermittent turning of switch key.
5. Cover all intake manifold openings with tape to prevent entrance of dirt and moisture.
6. Cover all engine openings, including coolant inlets, cylinder block, oil breather and crankcase.
7. Drain coolant from cooling system unless it is permanent type antifreeze with rust inhibitor added.
8. Store engine in a place protected from weather where air is dry and temperature is uniform.
9. Bar engine crankshaft two or three revolutions each three to four weeks.

Permanent Storage

1. When an engine is to be stored for a long time (six months or more), the lubricating system, cooling system, fuel system crankcase and external parts must be protected against rust and corrosion.
2. The engine should be started and the speed gradually increased to 1200 RPM or a fast idle, with no load, and operated until the engine is thoroughly warm. Stop engine and drain old oil.
3. Fill crankcase to full mark on bayonet gauge or dipstick with preservative oil, U.S Military Specification MIL-L-21260, Type P-10, Grade 2 SAE 30. This specification may be obtained as Shell-Brand Code 66202, Texaco Preservative Oil 30 or equivalent.
4. Start the engine and operate five to ten minutes on the preservative oil. Stop the engine, and remove spark plugs, pour 3 to 4 oz. oil in each cylinder. Install plugs and turn engine over for 30 seconds or so.
5. Drain all oil sumps of pumps and compressors, coolers, filters and crankcase. Replace all plugs after draining.
6. Remove intake and exhaust manifolds.
7. Spray all intake and exhaust ports with preservative oil.
8. Replace intake and exhaust manifolds.
9. Inspect coolant in cooling system. If coolant is contaminated, drain and flush, fill with rust preventative compound. Drain while hot and replace plug. Use a water soluble oil with anti-rust inhibitors obtainable from an oil company. Soluble oil requires thorough flushing of the cooling system before placing in service.
10. If air starter is used, remove exhaust plate from top of starting motor and spray with preservative oil. Replace exhaust plate.

11. Loosen V-belt tension.
12. Brush or spray a film of rust preventative compound on all exposed, unpainted surfaces of engine. Use a rust preventative conforming to Type P-2, Grade 1 or 2, as described in U.S. Military Specification MIL-C-16173C. Compounds to this specification can be purchased from Daubert Chemical Co., Nox-Rust 207, E.F. Houghton Co., Cosmoline 1046, Pennsylvania Refining Co. Petrotect 3 or equivalent.
13. Remove valve covers and spray preservative oil over rocker levers, valve stems, springs, guides, crossheads and push tubes. Replace cover.
14. Remove air cleaner, drain and store separately. Cover air intake opening of carburetor with heavy paper and tape.
15. Cover all engine openings, including main gas supply inlet, manifold exhaust and intake port, coolant inlets to cylinder head and block, oil breather and crankcase with heavy paper and tape.
16. Tag engine to indicate that it has been treated with preservatives and that crankshaft should not be barred over until ready to run due to possible reduction of the protective film. Tag should show coolant has been removed. The tag should show date of treatment and indicate that engine is not ready to run without prior removal of film.
17. Store engine in a place protected from weather and where air is dry and temperature uniform, if possible.

Note: Engines in storage more than 24 months should, if practical, be thoroughly flushed out with a suitable solvent or light, hot oil and then be reprocessed with rust preventative materials. Periodically inspect engines for rust or corrosion. Take corrective action if necessary.

18. Although the preservative materials may be added to and used for the same purpose repeatedly, they must be kept clean. When repeatedly used, the accumulated deposits should be removed after being allowed to settle.

Preparing A Stored Engine For Service

When an engine is removed from storage and put into service, the following operations should be performed. Inspections will be limited to operations indicated for applicable length of storage time.

Clean Engine

1. Clean off all accumulated dirt from exterior of engine.
2. Remove all paper covers, tape and wrappings.
3. Use suitable solvent, cleaner or degreaser to remove rust preventative compound from unpainted surfaces of the engine.
4. Refill crankcase with clean lubricating oil.
5. Flush cooling system.

Inspection

1. When an engine has been stored for six months or less it is necessary to make only a routine initial inspection. This inspection includes adjustment of valves and belts and checking head capscrews, oil filter and connections, air filter, screens and traps.
2. When an engine has been stored for a period of six months or more, the following inspection procedure should be followed:
 - a. Remove plug from oil header and force hot, light mineral oil through the oil passages to flush away all preservative oil and gummed oil that may have accumulated. Bar over engine crankshaft three or four revolutions during flushing operations.
 - b. Remove all screens and check to make sure they are clean before engine is started.

Precautions

1. When recommissioning a stored engine, care should be taken to see that any foreign matter which may collect on screens and strainers during initial operation is removed before considering the engine properly prepared for future service.
2. Pressurize the lubricating system including the turbo-charger prior to starting the engine.
3. The engine is now ready to start.

Starting The Engine

After inspecting the engine and parts, make sure all preservative oil and gummed oil has been flushed away. Start the engine as described in Operation and Maintenance Manuals.

STANDARD & OPTIONAL COMPONENT SERVICE

For all unit rebuilding or parts installation, see the nearest Cummins dealer who is equipped to rebuild Cummins gas engines or engine units. Through the use of the shop manual, factory approved service tools and trained mechanics, a rebuilt engine will perform as well as a new one.

Removal, Installation and Adjustment

The design of Cummins Gas Engines makes it possible to replace worn units with new or rebuilt units in a short time so the engine may be placed back in service with a *minimum of downtime.*

Use only Cummins parts in Cummins Gas Engines. Years have been spent developing and testing these parts - each in relation to its mating part. Cummins Gas Engines deserve only the finest replacement parts - genuine Cummins parts.

Use the proper tools for the job. Good work is impossible with poor or improper tools.

Protect all machined surface from contact with corners, edges, rough surfaces, dust or dirt or any material that will mar, scratch or damage these surfaces in any way. Protect all parts which are to be stored with an oil or grease film.

Always provide a clean place to work and clean the outside of the engine before removing any units.

Clean Engine Exterior

After removal of electrical equipment, but before removal of other components, steam clean the engine thoroughly. Refer to the Engine Wiring Diagram. In addition to the actual time saved by engine cleaning, the quality of work will be improved.

A portable fuel oil or steam cleaner is very satisfactory for general use on Cummins Engines. This type of cleaner can be used in either the cleaning room or the yard.

Altronic Ignition

The Altronic I-6 Ignition System includes an ignition generator, a wiring harness, and one ignition transformer for each spark plug, one or more safety switch adapters, and/or circuit isolator. For further description of the system, see "The Ignition System" under Operating Principles.

Safety switches and associated wiring must be in top condition for proper operation due to the low primary current output of the alternator. All uninsulated switch connections exposed to the weather should be insulated using silicone rubber adhesive

Individual customer requirements result in factory installation of various safety switches. Regardless of the type of switch, the ignition circuit of the gas engine must be wired "Open to Run". In case of an engine malfunction, the closing to ground of one or more switches will grounds and stop the engine. The ignition circuit must be open from "P" lead to ground for the engine to start or operate properly.

The Altronic III, used on all 12 cylinder engines works on the same basic principles as the Altronic I-6, and is installed the same way, but the wiring on the Altronic III is distinctly different (See diagram).

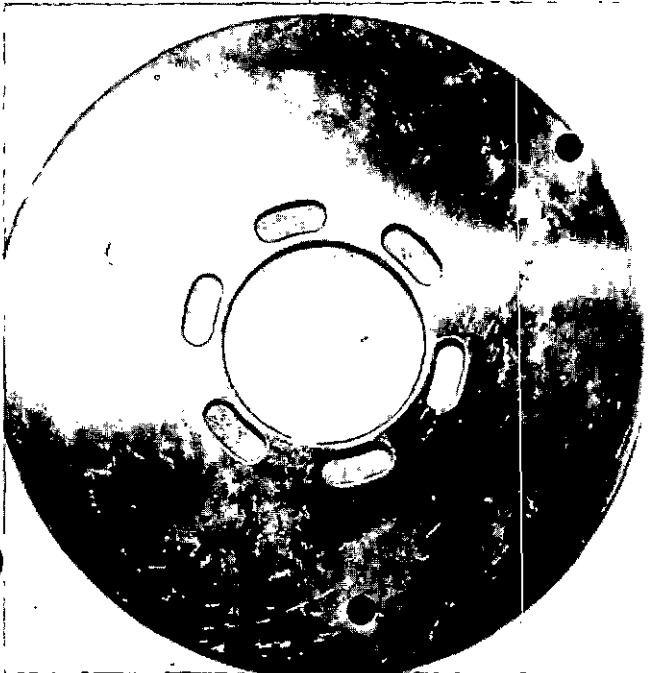
Initial timing of the Altronic III is made by turning the engine to place No. 1 cylinder on top dead center of its compression stroke, rotating the drive coupling of the Altronic III by hand to locate the red mark visible in the timing window and installing the Altronic III to the engine drive coupling. Timing is set only once, after which it remains constant.

Initial timing on the Altronic I-6 is made by turning the engine to the timing mark on the accessory drive pulley (.026 to .034 on the pointer). Align the top magnet on the aluminum disc, mounted on the vibration damper, to where the top pick-up button barely begins to meet the top magnet.

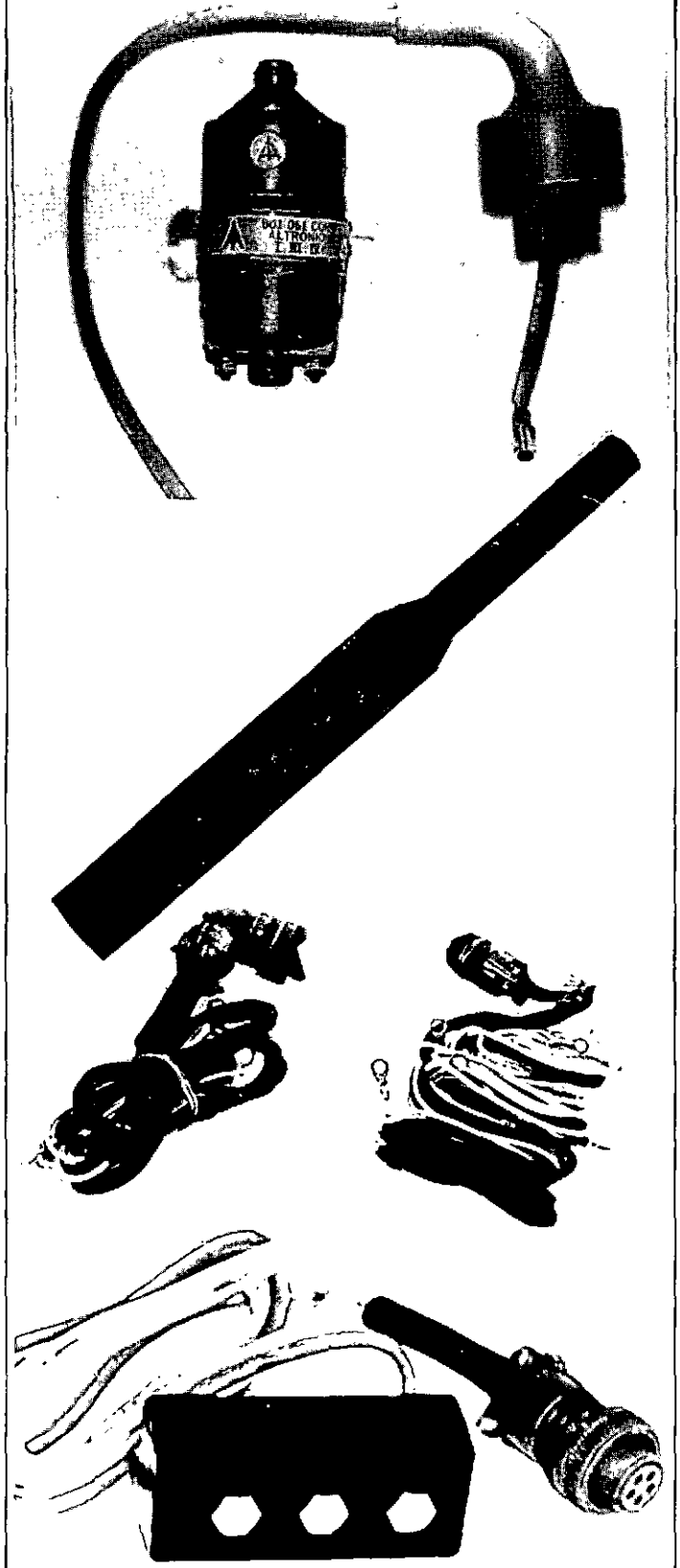
Start engine and check with a timing light. Adjustments can be made by rotating the aluminum disc on the crank shaft hub or moving the pick up block by the adjusting screw.

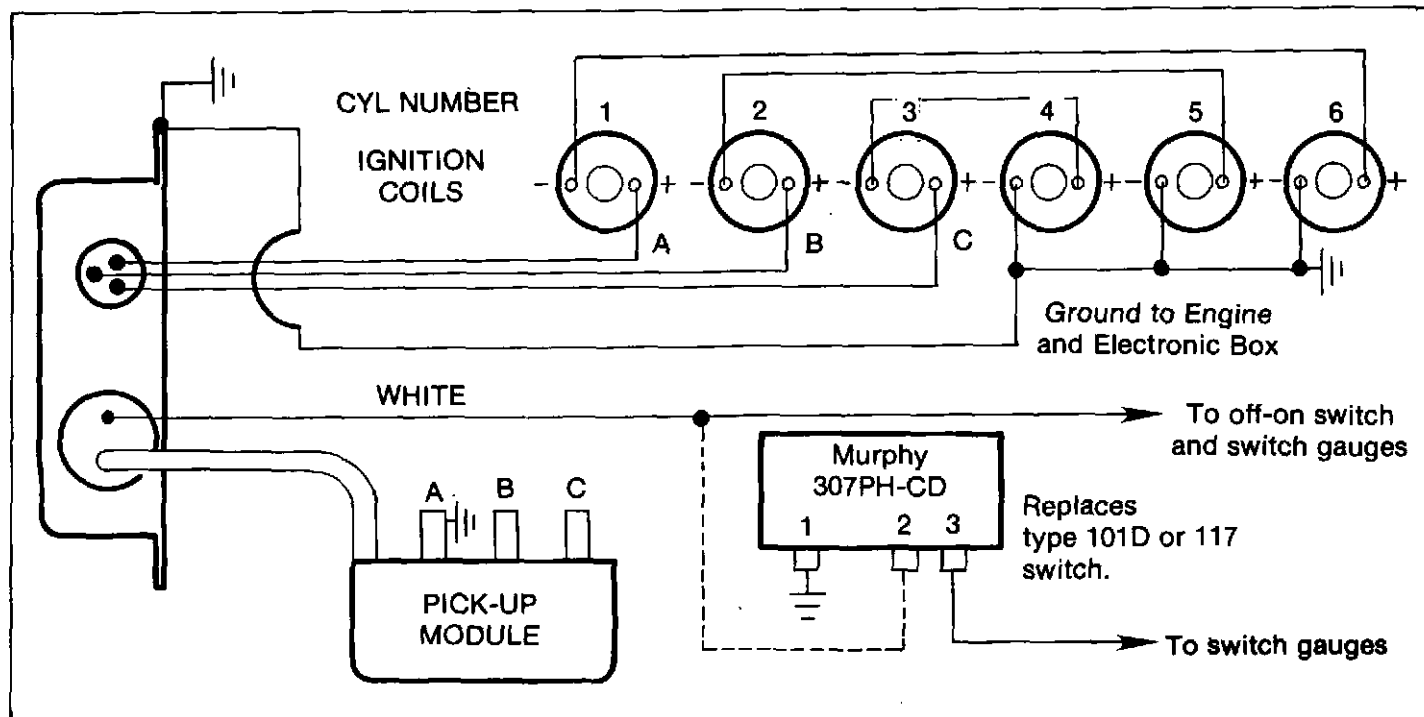
Allow disc about 1/8 inch clearance from pick-up block. Make sure the pick-up block is centered to crankshaft. For further timing procedures follow instructions on page 42.

aluminium disc with magnets



COMPONENTS OF EXTERNAL IGNITION SYSTEM





Altronic 1 - 6 (all 4 & 6 cylinder models)

1. Coupling driven Altronic alternators mount to the engine's magneto drive. Use $\frac{3}{8}$ "-16 x $\frac{7}{8}$ " button head screw, $\frac{3}{8}$ "-16 x $1\frac{1}{2}$ " hex head screw, $\frac{3}{8}$ "-16 nut.
2. The 3-prong harness connector and 5-prong pick-up connector plug into their respective electronic box outlets.
3. Mount the ignition coils and connect them to spark plugs via the HT leads. On four cylinder engines, #1 and #4 #2 and #3 are connected together in series. The negative terminals of #4 and #3 are connected together and grounded to the engine block and electronic box.
4. Connect the leads of the harness to the positive terminals of the coils as follows: B to #1, C to #2.

Note: "A" pick-up module bolt must be well grounded to the engine.

5. On six cylinder engines, the coils on #1 and #6, #2 and #5, and #3 and #4 are connected together in a series. The negative terminals of the coils on cylinders #4, #5, and #6 are connected together and grounded to the electric box and valve cover or aftercooler housing.
6. Connect the leads of the harness to the positive terminals of the first three coils as follows: A to #1, B to #2, C to #3.
7. Running the white shutdown lead next to the gray pick-up module cable should be avoided. Do not attempt to remove the hex nut located between the two electronic box connectors as damage may result to the electronic box components.

Altronic III

G-1710 GTA-1710

1. Set the engine so that the #1 cylinder is at the ignition firing point.
2. Line up the red rotating line with the stationary CW line on the back cover window and set timing mark on timing pulley to 1 and 6 right bank 30°. Mount the unit to the engine keeping the two red lines together as close as possible. If the two lines cannot be made to meet by rotating the engine unit, remove the four screws which fasten the back cover assembly to the unit. The entire back cover assembly should then be pulled away from the unit about 2". Carefully tilt the top of the cover away from the unit keeping the internal plug (underside of the circuit board) connected. Rotate the distributor shaft until the two marks described above line up.
3. Reinstall the cover to the unit, engaging the gears, and keeping the two red marks together.
4. Securely tighten the four fastening screws.
5. Final timing should be checked using a timing light with the engine at operating speed.
6. Altronic III Output Voltmeter Reading

A voltmeter check on the "G" wire will give an indication of the unit's performance. Depending on the speed and the number of cylinders, this reading will range from 50 V. to 80 V. It would be helpful to take a reading of this type when the Altronic III system is installed to use as a future reference.

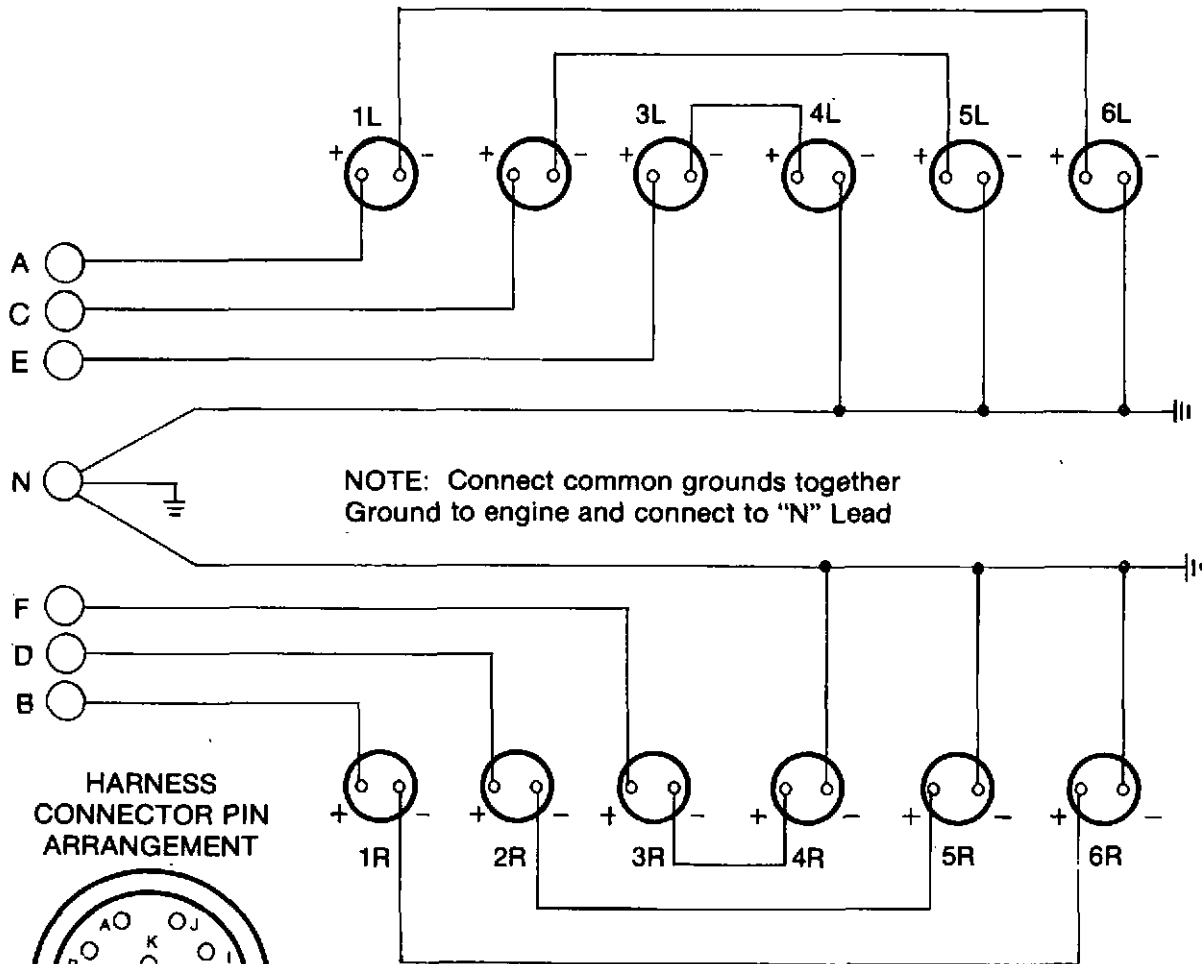
7. Install the Altronic III to the engine as described above in steps 1-6.
8. On the twelve cylinder engines, the coils that are connected together in a series are as follows: #1L and #6L, #2L and #5L, and #3L and #4L; #1R and #6R, #2R and #5R, and #3R and #4R.
9. The negative terminals of the coils on the cylinders #4L, #5L, and #6L are connected together to the "N" lead and grounded to the engine block. The negative terminals of the coils on cylinders #4R, #5R and #6R are connected together to the common "N" lead and grounded to the engine block.

10. Connect the leads of the harness to the positive terminals of the coils as follows: A to #1L, B to #1R, C to #2L, D to #2R, E to #3L, and F to #3R.

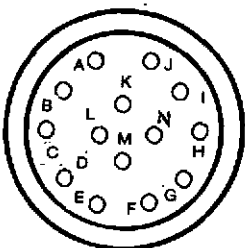
Final Adjustments

All Natural Gas Engines are presently intended for heavy duty application and, as such, will normally operate over their RPM range of 900 to 1800 RPM (1200-1800 RPM on turbocharged models). Engine timing must be adjusted to maximize engine efficiency to the particular load and speed required at the job site. Once the timing is set at a permanent operation, the adjusting screw may be removed to discourage tampering. For adjustment of timing, see Adjustment Procedures.

ENGINE CYLINDER	1L & 6L	1R & 6R	2L & 5L	2R & 5R	3L & 4L	3R & 4R
ALTRONIC III LEAD	A	B	C	D	E	F



HARNESS CONNECTOR PIN ARRANGEMENT



20 - 27S
Letter G represents P/Lead

Carburetor and Pressure Reduction Valve

Removal (for G Series only)

1. Shut off the main gas supply valve.
2. Remove air intake piping from the carburetor.
3. Remove gas supply line from the pressure reduction valve.
4. Remove throttle linkage from the carburetor.
5. Remove clamps securing the pressure reduction valve to the mounting bracket.
6. Remove capscrews and washers securing the carburetor to the intake manifold; lift off the carburetor and pressure reduction valve and discard gasket.
7. Separate the carburetor and pressure reduction valve; remove pipe fittings.

NOTE: Pressure reduction valve should be remote mounted, not on engine.

Installation

1. Remove gaskets and pipe sealing compound from all parts.
2. Apply sealing compound and install pipe fittings in the carburetor and pressure reduction valve; connect the carburetor to the pressure reduction valve.

Note: Install valve with the arrow on the bottom of the pressure reduction valve pointing toward the carburetor gas inlet.

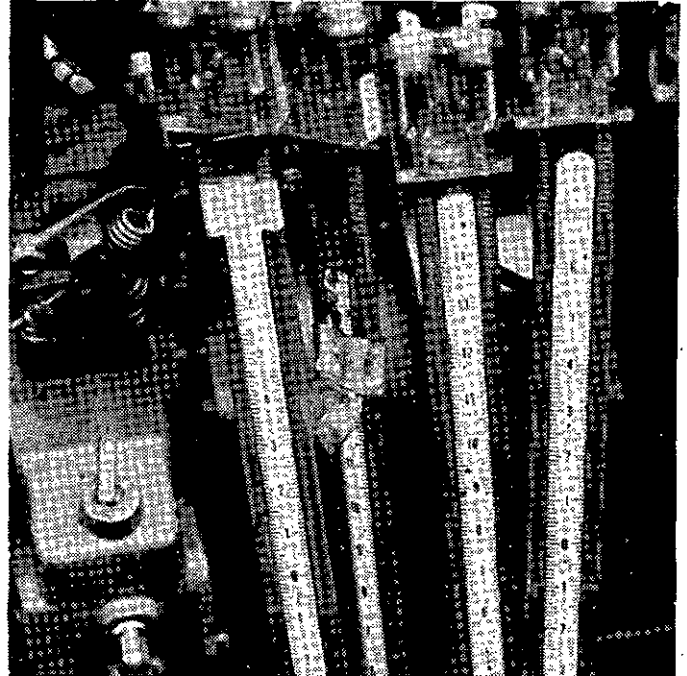
3. Position the carburetor with new gasket on the intake manifold; secure with washers and capscrew.
4. Secure the pressure reduction valve to the mounting bracket with clamps. Connect the gas supply line.
5. Connect throttle linkage and air intake piping to the carburetor. Open the main gas supply valve.

Field Adjustment - Carburetor

Intake manifold vacuum on the Natural Gas Engine is the one most important measurement of engine efficiency. This vacuum should be measured by a "U" tube manometer of at least 0 to 15 inch column of mercury (Hg). It is permissible to use a dial type gauge; however, more accuracy can be obtained by using the "U" tube manometer. The dial type vacuum gauge is also calibrated in inches of mercury, 0 to 30 inches Hg.

Procedure

1. Close the main gas supply valve.
2. Set the carburetor power mixture adjustment valve at the center of the "R" (Rich) and "L" (Lean) marks G495 only.



3. Close the idle adjustment; then open two and one-half turns.
4. Remove the pipe plug and attach a pressure gauge (water manometer) between the main line pressure regulator and the "Thermac" pressure reduction valve. Also remove the pipe plug and attach a pressure gauge (water manometer) on the "Thermac" pressure reduction valve, or 1/8 pipe plugs on thermac in and out.
5. Remove the pipe plug from the intake manifold and install a vacuum gauge or mercury manometer.
6. Open the main line gas supply valve.
7. Adjust the line gas pressure to the "Thermac" pressure reduction valve to 10 inches (254 mm) of water.
8. Start the engine, using normal starting procedure.
 - a. Remove the cap from the "Thermac" pressure reduction valve.
 - b. Insert screw driver in adjusting screw, and adjust to obtain desired pressure, 3 to 6 in. on water manometer, replace cap.
9. After the engine coolant attains operating temperature (140-160°F) operate the engine at the rated RPM and system load.

a. With the engine operating at system load and speed check the gas pressure to the "Thermac" pressure reduction valve. If this differs considerably from the pressure as set in step 7 above: 1) the main line pressure regulator is faulty; 2) the main line is undersized; 3) the orifice is incorrect for main line pressure, see drawing on page 10. Any of the above three steps, or all three could cause faulty gas pressure. Consult the recommendations and instructions of the main line pressure regulator manufacturer.

b. Check the "Thermac" pressure reduction valve for proper operation with the engine shut down and the main gas valve "on". Apply a liquid soap solution to the atmospheric vent to check for gas leakage through the diaphragm.

If proper adjustment cannot be obtained, or the "Thermac" valve fails to function properly, remove the faulty valve and replace it.

Caution: The maximum allowable main outlet setting is 20 inches (635 mm) of water with the engine shut down. If this does not correct the "Thermac" carburetor gas pressure, check the main line pressure regulator for proper operation per the manufacturer's instructions.

c. With the engine running at the rated RPM and load, move the carburetor power mixture adjustment valve slowly toward the "L" position. Check the intake manifold vacuum reading until the highest vacuum is obtained, or lowest turbo boost.

Any and all final adjustments on the engine should be made to obtain the highest amount of manifold vacuum, or lowest boost. Any adjustment that causes increased boost or less vacuum, is an incorrect adjustment. Final adjustments must be made with the engine operating at its rated load and speed.

NOTE: Best overall adjustments will yield lowest exhaust gas temperature.

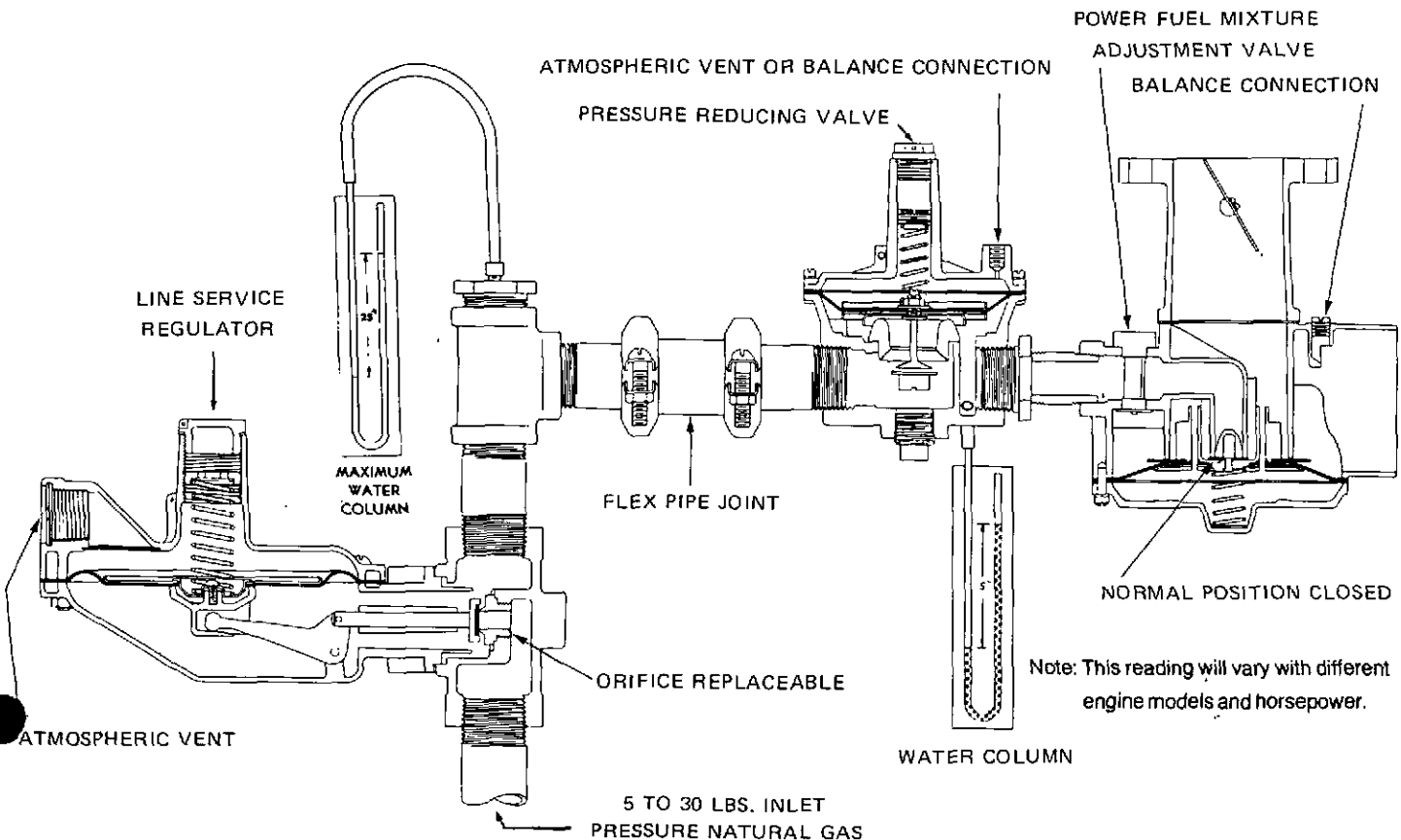
d. G-GTA 1710

The intake manifold adjustment on the twelve cylinder engine is a dual operation of the six cylinder and requires a power adjustment of each of the two carburetors plus an adjustment of the carburetor butterfly. This butterfly adjustment is made by attaching a "U" tube mercury manometer 15 inches to 0 to 15 inches range to each intake manifold, shut off equalized tube valve, on G-GTA, adjust butterflys at idle, and adjust butterflys to get even manifold vacuum. Rated speed and load must be maintained and the throttle butterfly of one carburetor adjusted open to decrease the vacuum, closed to increase the vacuum to correspond and equal the vacuum of the opposite manifold. The final power adjustment is to be made with equal manifold vacuum and exhaust stack temperature.

10. Shut down the engine.

11. Close the main gas supply valve.

12. Remove the two water manometers and the mercury manometer and replace all pipe plugs.



Adjustment Procedures

1. Gas adjustment - Install water manometers on both sides of Thermac valve. Adjust the main line regulator to obtain proper gas pressure to the Thermac valve. Initial adjustment on Thermac should be in the median position. It will not function if adjusted all the way open or all the way closed. Adjust gas pressure in and out of Thermac as given in the fuel system.
2. Engine Timing - Since engine timing is not a fixed value but depends upon load, fuel, altitude and RPM, it is the single most important adjustment made on each engine installation. Set initial engine timing to 30° to 32° BTDC for all Naturally Aspirated models and 24° to 28° for Turbocharged 743 and 855 models and 28° to 32° for Turbocharged 1710.

Proceed to fine tune engine as follows:

- a. Install a pyrometer in ¼" pipe tapped hole below the turbo mounting flange.
- b. Install a mercury manometer on the intake manifold.
- c. Connect a low and high tension timing light to the #1 cylinder.
- d. With the engine running, adjust the power valve on the carburetor to obtain the lowest possible exhaust temperature. This can best be obtained by turning the power valve closed (lean mixture) until the engine starts loosing RPM, then turn the power valve out (rich mixture) until the exhaust temperature reaches the lowest reading.

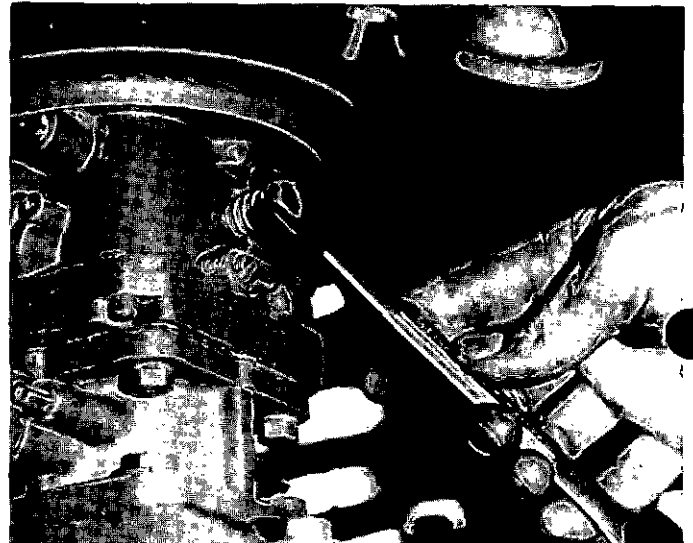
If the power valve is opened beyond the ultimate point, the mixture will become too rich and the exhaust temperature will start to increase. It may be necessary to perform this adjustment two or three times to obtain the proper point of fuel-air ratio which will result in the coolest possible exhaust temperatures.

- e. Retard and advance the timing by two degree increments and repeat Step D to determine if the lowest possible exhaust temperature and lowest manifold vacuum (or boost pressure on turbocharged models) has been obtained without loosing engine RPM. Repeat and confirm your readings several times.

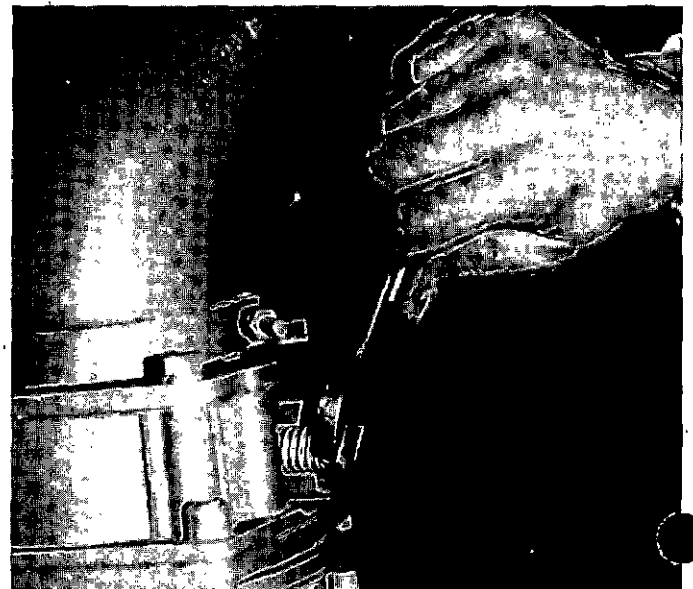
Note: Lower BTU fuels may require higher main line pressure to obtain proper pressure to the carburetor mixer valve. Do not exceed 20 inches of water to Thermac inlet or possible hard starting could result.

3. Power valve - On a naturally aspirated engine with the Impco 425 or 225 carburetor, adjust the power valve to obtain the highest manifold vacuum reading, then turn the power valve counterclockwise on the 225. Remember that the most efficient setting that produces sufficient power for the application may not be the maximum power setting.

On turbo gas engines the power valve should be turned in until the engine begins to lose power, then counterclockwise one turn. A more desirable method of adjustment is with an exhaust temperature pyrometer. Adjust the carburetor until the coolest exhaust temperature is reached.



ADJUSTING POWER VALVE ON IMPCO 425



ADJUSTING POWER VALVE ON IMPCO 600

4. Carburetor idle - Adjust the carburetor idle screw until the engine operates smoothest at approximately 800 RPM. There is no idle screw in the Impco 225 or 600 carburetor.

Derating Procedure

To compensate for intake air temperatures above 100°F and altitudes over 4000 feet above sea level, the naturally aspirated gas engine must be derated as follows:

1% per each 10° F (5.6° C) above 10°F (37.7°C)
plus 3% for each 1000 ft. (304.8 m) altitude above 4000 feet above sea level.

Cylinder Heads - 4 and 6 Cylinder Engines

Alternative Fuels:

Propane and Digester gas can be consumed by these engines. Lower compression ratios and deration should be considered when applying these fuels. For Fuel and Timing adjustments, consult Cummins Gas Engines, Inc.

Removal

1. Shut off the gas supply and remove the gas lines.
2. Remove the ignition harness by disconnecting the Altronic at each ignition transformer connector and at the ignition switch, if necessary.
3. Remove the ignition transformers, and high tension leads with rubber gromets.
4. Remove air piping or air cleaner to facilitate removal of the intake manifold.
5. Remove throttle linkage at the carburetor lever, intake manifold capscrews, lockwashers and flat washers; lift off the manifold and carburetor assembly; discard gaskets.
6. Disconnect exhaust piping; remove capscrews and lockplates at each exhaust port; lift exhaust manifold(s) from the engine. Discard lockplates and gaskets.

Caution: Inlet and Outlet connections should be kept covered with plates or gummed paper to keep out foreign objects. Do not stuff rags into ports.

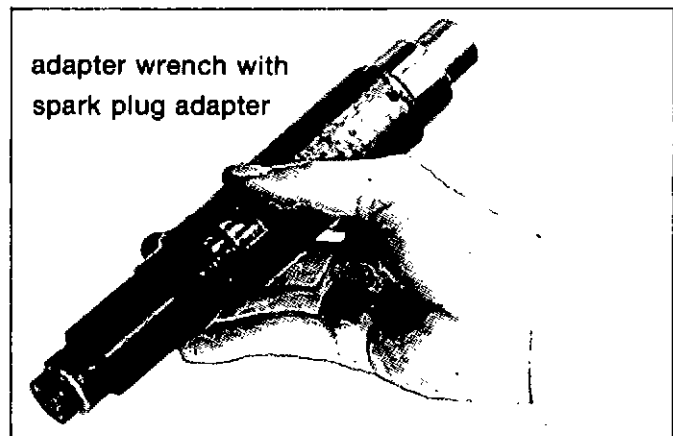
1. Remove capscrews and lockwashers from the water by-pass connection; remove capscrews and lockwashers from each foot of the water manifold assembly and lift from the engine; remove steel retainers and seal rings; discard seal rings.

8. Remove rocker housing cover capscrews and lift off covers, discard gaskets.
9. Remove G-495 & 743 lubricating oil pipe cap and gasket.
10. Remove capscrews from each rocker housing. Remove lifting brackets, when used, and lift housings from the engine; discard gaskets.
11. Remove screws and yokes; lift out the spark plug adapter tubes and discard O rings.
12. Lift push tubes from their sockets.
13. Remove the spark plugs.
14. Remove cylinder head capscrews and lift the heads from the engine; discard gaskets, grommets, retainers and O rings.

Caution: Do not allow machined surfaces to become scratched or marred in any way.

Cleaning and Repair

1. Using an adapter wrench, remove the spark plug adapters from heads. Remove and discard gaskets and O rings.
2. Clean and lubricate the spark plug adapter threads in the cylinder head by "chasing" with a 7/8-14 UNF tap or capscrew coated with lubricating oil. Clean the machined O ring seating surface in the cylinder head with fine emery paper to remove scale buildup, etc., and to insure proper seating of the adapter O ring.
3. Clean the threads and gasket seating areas of the adapters.



4. Lubricate the O rings and O ring seating areas in the bores in the head with clean engine oil.
5. Position the new gaskets and O rings on spark plug adapters.

6. Using the wrench, screw the adapters into the cylinder head and tighten to 100 ft/lb (9.6810/11.0640kg/m).

Installation

1. Make sure that cylinder heads have top breather holes plugged with a 1/8 inch pipe plug. The breather hole is located at the top of the cylinder head and is open to the intake manifold.
2. Wipe the cylinder block and cylinder head mating surfaces clean.

Caution: Do not use any type of gasket sealing compound

3. Install the head gasket, with the stamped work "TOP" on top, over the oil pipes.
4. Place grommets in water passages.
5. Lower the head into place and install new cork washers on the oil pipes after the cylinder heads have been placed on the block (5-1/8" bore) (G-495, G-GTA-743).
6. Lubricate capscrews with Shell Rust Preventive - ENSIS-105 or equivalent and tighten each slightly in sequence. Complete the tightening procedure, following the steps outlined below.
7. Insert push tubes into sockets of the cam follower levers after priming hydraulic lifters.
8. Assemble the crossheads with adjusting screw toward the water manifold assembly. Adjust as described in Section "C" Check.
9. Install new rocker housing gaskets on the cylinder heads.
10. Loosen locknuts and rocker lever adjusting screws. Hold levers in place position each housing in place with ball ends of levers in their respective push tube sockets. Position lifting brackets, when used, in desired location.

5 1/8 Inch Bore Cylinder Head

Tightening Sequence G-495, G-743, GTA-743

Step	Torque	
	ft-lbs	(kgm)
1	225-275	(31.1175 to 38.0325)
2	350-400	(48.4050 to 55.3000)
3	460-480	(63.6180 to 66.3840)

5 1/2 Inch Bore Cylinder Head

Tightening Sequence G-855, G-1710,
GTA-855, GTA-1710

Torque

Step	ft-lbs	(k)
1	25 ft. lbs.	(3.4575)
2	100 ft. lbs.	(13.8300)
3	200 ft. lbs.	(27.6600)
4	280/300 ft. lbs.	(38.7240 -41.49)

11. Place a new gasket on each lubricating oil pipe; tighten caps to 55/75 ft/lb (7.6065/10.3725kg/m) torque (G-495, G-GTA 743).
12. Replace and tighten rocker housing scapscrews to 55/75 ft/lb (7.6065/10.3725 kg/m) in sequence.
13. Adjust valves; see Section 3.
14. Carefully position rocker housing covers over the adapter tubes, with new gaskets, on the rocker housings; secure with flatwashers, lockwashers and capscrews. Torque to 20/25 ft/lb (7.6065/10.3725 kg/m).
15. Coat new water manifold sealing rings on manifold connecting tubes with clean engine oil; position the steel retainers with new sealing rings on the cylinder heads (dry). Position water manifolds on the cylinder heads and secure with lockwashers and capscrews.
16. Position the exhaust manifold(s) with new steel gaskets on the cylinder heads; secure with lockplates and capscrews.

Note: Side of manifold gaskets stamped "OUT" must be facing manifold flanges.

17. Install intake manifolds using new gaskets. Secure with flatwashers, lockwashers and capscrews.

Caution: Keep outlets covered until connected to mating parts.

18. Install ignition transformers on appropriate brackets on air manifold.
19. Install ignition harness. Refer to wiring diagrams for Altronic ignition installation.
20. Install air intake and exhaust piping.
21. Install the gas line.

Cylinder Heads - 12 Cylinder Engines

Removal

1. Shut off the gas supply and remove gas lines to the pressure reduction valves.
2. Remove the ignition harness by disconnecting the Altronic at each ignition transformer connector, and at the safety switch adapter, if necessary.
3. Remove ignition transformers and spark plugs.
4. Remove the throttle linkage and cross shaft; disconnect air intake and exhaust piping.
5. Remove capscrews, lockwashers and flatwashers at each intake port; lift the intake manifolds from the engine and discard gaskets.
6. Loosen clamps and remove water connections from thermostat housing. Remove stud nuts securing the thermostat housing to the exhaust manifold; lift off housing and discard gaskets.
7. Remove stud nuts securing lifting eyes to the exhaust manifold; lift off the lifting eyes.
8. Remove stud nuts, capscrews and lockwashers securing the exhaust manifolds to the cylinder heads. Lift the manifolds from the heads and discard gaskets. If the manifold is stuck on a gasket, use extreme caution in prying against the cylinder head. Never use a screwdriver or wedge between machined surfaces.
9. Remove rocker housing covers and discard gaskets.
10. Remove stud nuts, capscrews and lockwashers from each
11. Remove push tubes.
12. Lift crossheads from guides.
13. Remove screws and yokes securing spark plug adapter tubes in heads; lift out tubes and discard O rings.
14. Remove cylinder head capscrews; using a chain hoist, lift cylinder heads from the engine. Discard grommets, retainers and gaskets.

Cleaning and Repair

1. Using an adapter wrench, remove the spark plug adapters from the heads; remove and discard gaskets and O rings.

2. Clean and lubricate the spark plug adapter threads in the cylinder head by "chasing" with a $\frac{7}{8}$ -14 UNF tap or capscrew coated with lubricating oil.

Clean the machined O ring surface in the cylinder head with fine emery paper to remove scale build-up, etc., and to insure proper seating of the adapter O ring.

3. Clean threads and gasket seating area of the adapter
4. Lubricate O rings and O ring seating areas in bores in heads with clean engine oil. Position new gaskets and O rings on the spark plug adapters. Using the wrench, screw the adapters into the cylinder heads and tighten to 120 ft/lb.

Installation

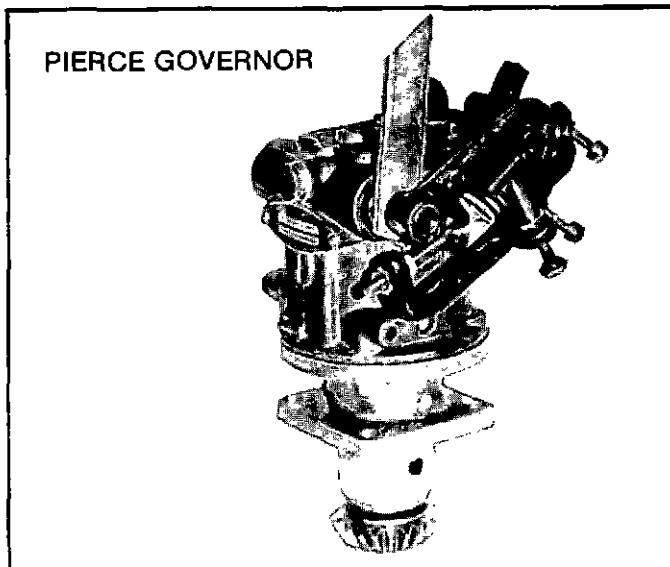
1. Cylinder heads should have valve guides, valves and springs assembled in position and check for missing keepers.
2. Clean the mating surfaces of the cylinder block and cylinder heads. See that cylinder walls are clean and lubricated with clean lubricating oil.
3. Place cylinder head gaskets on the block with the stamped word "TOP" up.
4. Lubricate capscrews with Shell Rust Preventive ENSIS 105 or equivalent and tighten each as shown in Table 2 and in sequence shown in Table 3.
5. Position crossheads on guides. Adjust crossheads as described in page 26. Make sure proper clearance is obtained between crosshead and valve retainer (.020-.025).
6. Install push tubes in proper positions.
7. Install spark plugs with new gaskets. See Section 3.
8. Install new rocker housing gaskets on cylinder heads.
9. Loosen locknuts and rocker lever adjusting screws and install rocker housing assemblies. Hold rocker levers in place with ball ends of rocker levers fitting in their respective push tube sockets.
10. Secure rocker housings with lockwashers and capscrews; torque to 55-75 ft/lbs (7.6065 to 10.3725 kg/m).
11. Position new exhaust manifold gaskets on the cylinder heads; install exhaust manifolds over studs to the cylinder heads. Position lifting eyes on studs provided and secure manifolds and lifting eyes with lockwashers and stud nuts.

12. Position thermostat housings with new gaskets to the exhaust manifolds; secure with lockwashers and capscrews.
13. Prime hydraulic push tubes as described on page 25.
14. Bar engine to appropriate valve set markings and adjust valves.
15. Carefully position rocker housing covers over spark plug adapter tubes, install with new gaskets and secure with flatwashers, lockwashers and capscrews.
16. Install ignition transformers.
17. Install intake manifolds, cross shaft and throttle linkage.
18. Install ignition harness. Refer to wiring diagrams for proper wiring or ignition ground leads and safety switch adapter.
19. Install air intake and exhaust piping.
20. Install gas line.

Variable Speed Mechanical Governor

Removal

1. Disconnect the linkage from the governor speed control lever.
2. Disconnect the linkage from the governor throttle control lever.
3. Remove nuts, lockwashers and flatwashers securing the governor to the drive housing; lift off the governor assembly and discard gasket.

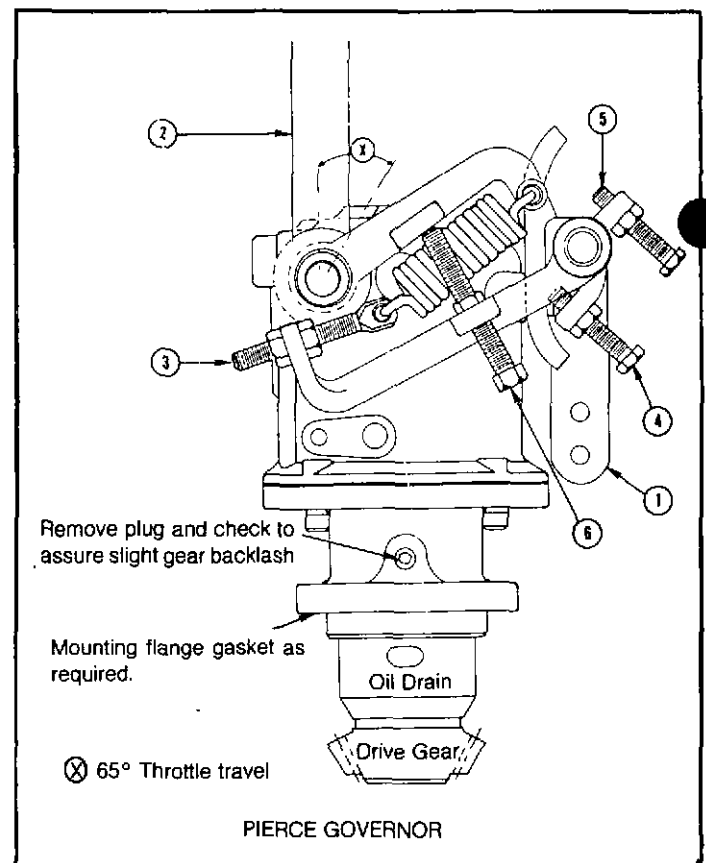


4. Remove oil pressure line to top of governor.

(Note: Either the 90° fitting on the block or on the governor should be orificed (Orifice size = .047), preferably the block fitting.

Installation and Adjustment

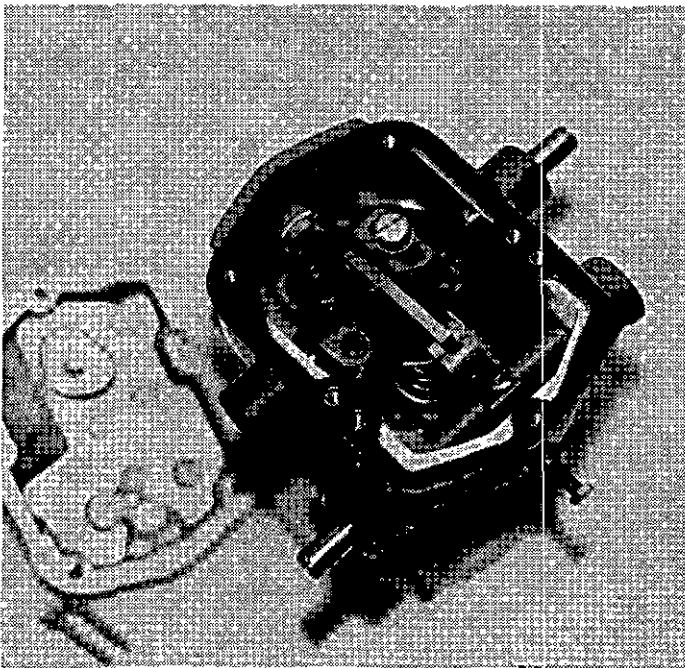
1. Position governor with new gaskets to drive housing, engaging governor gear in the gear of the drive shaft; secure it with flatwashers, lockwashers and nuts.
2. Remove 1/8" pipe plug from the governor base and bar the engine until a hole in the governor drive shaft is visible through the governor base. Insert 3/16" diameter pin in the shaft hole and check the gear play for slight backlash; movement of the governor shaft should be approximately .005 inch (0.1270 mm). Gasket governor flange as required. Replace pipe plug.
3. Place tension on governor spring.



4. Install linkage from governor throttle control lever (2) to carburetor throttle lever; adjust length of linkage to hold carburetor in wide-open position. Release spring tension and operate governor throttle control manually to check linkage operation.
5. Reconnect speed control linkage to speed control lever (1).

6. Reconnect oil pressure hose.
7. Start engine, operate at idle until engine coolant is at operating temperature.
8. Move speed change lever (1) to a point approximately $\frac{3}{4}$ of the travel toward the wide-open position.
9. Obtain no-load speed by adjusting spring tension with adjusting screw (3).
10. Check regulation by applying and removing engine load. If regulation is too broad, move speed change lever (1) approximately $\frac{1}{4}$ " toward closed position and increase spring tension with adjusting screw (3) and move speed change lever (1) toward open position to again obtain top no-load speed. Repeat until desired performance is obtained.
11. Recheck speed by applying and removing load. Set high speed stop screw (5) and lock with locknut.
12. Idle engine and set low speed stop screw (4) and idle speed. Lock screws with locknuts.
13. Recheck no-load speed and load-speed as set in (9).

SG & PSG Hydraulic Governor Adjustment



Carburetor Throttle Travel

Carburetors on Cummins Gas Engines have a throttle travel of about 65° from idle to full-open position. A correct relationship between governor lever and carburetor throttle travel must be maintained for proper operation.

Governor Shaft and Linkage Adjustment

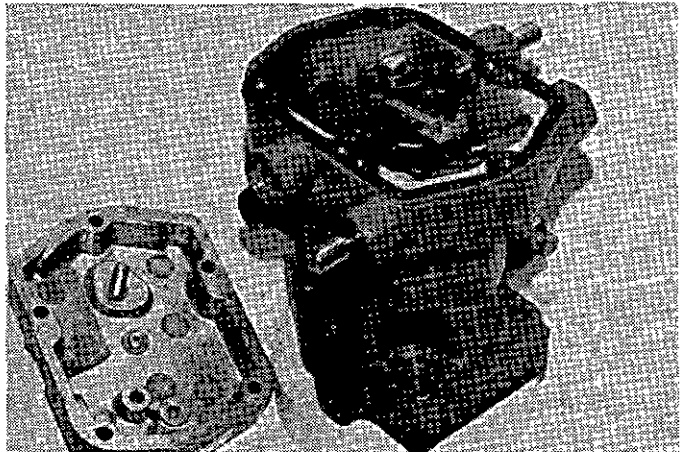
After the installation of the governor lever and linkage to the carburetor throttle, check carburetor throttle for idle position against the throttle stop pin. If the idle throttle plate adjustment screw does not rest against the stop pin, adjust linkage length until the screw rest against the stop pin.

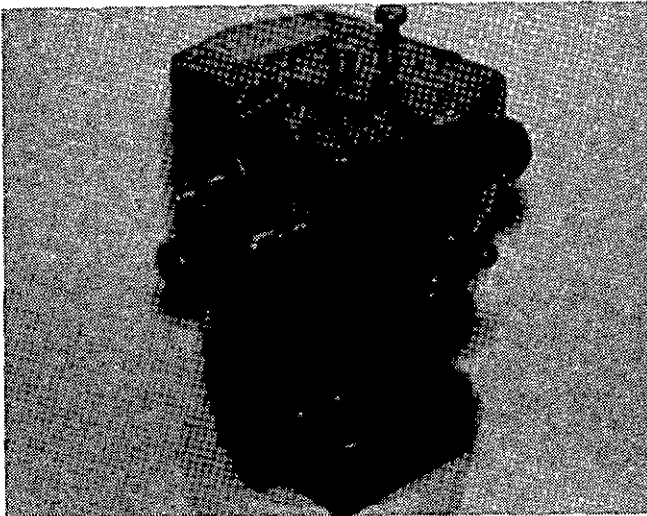
Manually lift the governor lever through the carburetor throttle travel range and check for linkage bind. If necessary, adjust linkage length and carburetor throttle lever position to eliminate any binding through the throttle travel range. Tighten linkage and lever assemblies.

Start the engine and adjust the low-speed stop screw on top of the governor head for desired idling speed, approximately 600 RPM.

Speed Droop Adjustment

1. Remove the top cover from the governor to expose the speed droop mechanism and adjustments.
2. The speed droop bracket is clamped to the terminal lever by the slotted hexagonal head screw. When loosened, it can be moved to the front or rear. Moving the bracket to the rear produces more speed droop.
3. The speed droop lever movement thus produces a speed setting which is a function of terminal shaft position. THIS IS SPEED DROOP.
4. Speed droop is increased by moving the bracket to the rear and is reduced to approximately zero when the pivot pin is all the way forward. Since there is no calibration for the droop adjustment, the zero droop position may be precisely set only by trial and error on the engine or by use of a dial indicator on the speed droop lever during manual rotation of the terminal shaft.
5. Speed droop is required when using SG Woodward Governors. It must be set by operation on the engine. The speed droop bracket is adjusted to obtain the desired speed droop between full load and no-load.





Surging

PSG-Type Woodward Governor

1. Turn the compensation needle valve counterclockwise until surging occurs and allow 5 to 10 surges to bleed the air from the governor.
2. Turn the compensation needle valve clockwise until surging stops. (The needle valve is near the bottom of the governor, to the rear and facing outside.)

Note: Inadequate droop settings can cause surging on both types of governors.

3. If surging continues at no-load, increase the droop setting (move droop bracket to the rear).

Sentinel Safety Control System

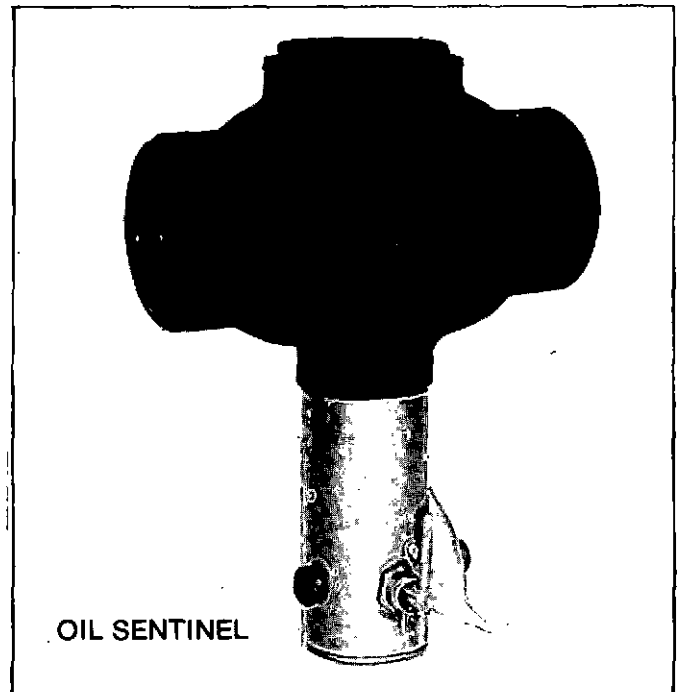
The Sentinel Safety Control System is an independent mechanical shutdown system which uses engine lubricating oil pressure as a control medium.

The basic component of the Sentinel System is the Oil Sentinel which contains a flow valve for the engine gas supply and a cavity for high-pressure lubricating oil. A spring-loaded balance piston within the housing allows gas to flow through a valve unrestricted when there is sufficient lubricating oil pressure. When lubricating oil pressure falls below a pre-set point, the gas supply is shut off completely, thus shutting the engine down. A cam arrangement is included to permit a small amount of gas to by-pass for starting. This override is automatically reset when sufficient lubricating oil pressure is produced. Lubricating oil pressure setting varies with an average of 20 psi (0.7030 kg/cm²).

Temperature sensing units in this system are dump valves which open when the temperature of the coolant exceeds

the specified setting. When the temperature sensing units dump oil, the oil pressure is reduced in the Oil Sentinel, and it actuates to shut down the gas supply to the engine. Oil released from the Heat Sentinel is returned to the oil pan. The following Heat Sentinel settings are used and identified by the following color indicator on the end of the unit cap:

1. Coolant temperature; 200°F (93.3°C) setting (blue cap).
2. Coolant temperature; 190°F (87.8°C) (green cap) (for applications above 5000 ft. altitude).



Installation

When installing a Sentinel Safety System, the manufacturer recommends that reasonable care be taken not to restrict the oil flow between the Oil Sentinel and the Heat Sentinel. This allows oil to flow freely if the Heat Sentinel actuates, thus dropping the oil pressure in the Oil Sentinel sufficiently to shut off the gas supply. To prevent restriction in this line no more than two 90° fittings should be used in each Heat Sentinel dump circuit; including angle fittings or tees at the Oil Sentinel outlet; the hose sizes specified as follows must be used:

Note: Make sure that the oil pressure to the Oil Sentinel is metered through an orifice at the Sentinel, or that the orifice does not get plugged up. (Orifice size = .047).

1. Oil Sentinel - Oil inlet from the pressure gallery of the engine uses 1/8 inch I.D. flexible line.
2. Oil Sentinel outlet to oil inlet of Heat Sentinel uses 5/16 inch I.D. flexible line.

3. Heat Sentinel Oil inlet and outlet uses 5/16 inch I.D. flexible lines. Outlet connects to non-pressure opening in block or oil pan.

The Oil Sentinel gas valve may be remotely mounted if desired and plumbed to the gas line, before the carburetor.

When measuring coolant temperatures, install the Heat Sentinel in a water outlet manifold or thermostat housing. AMOT overspeed device can be used with sentinel to shut down engine overspeed for it will dump sentinel oil to pan on overspeed which will shut off gas supply.

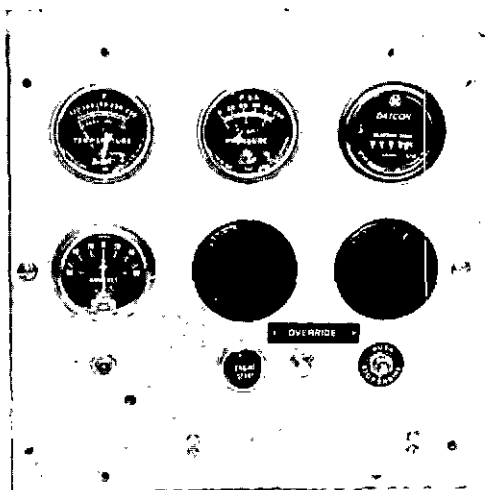
Engine Instrument Panel

Safety shutdown instruments mounted in the engine panel on naturally aspirated engines include the oil pressure gauge, water temperature gauge, vacuum gauge, water pressure gauge, start/stop switches, and magnetic safety switch for ignition shutdown. The entire panel is mounted on vibration isolators.

Safety shutdown instruments in the engine panel of a turbocharged/aftercooled engine include those mentioned above, plus an air temperature gauge and a turbo-boost gauge in place of the vacuum gauge.

Before any engine is started all gauges should be visually checked for correct shutdown positions, especially if it is a new engine startup as the gauges are not pre-set at the factory.

Normal settings: water temperature 10° above operating temperature or 205°F maximum, oil pressure 15 PSI, water pressure 5 PSI, air temperature 10° above operating temperature or 145°F maximum, turbo boost 2 PSI above engine



operating level, ie (if engine pulls full load at 4 PSI turbo boost gauge setting is 6 PSI). NOTE: turbo boost should not exceed 7 PSI at sea level to 9 PSI at 4000 ft.

Whenever an instrument fails to function, check connections on the defective gauge and at the termination point. Should wiring or tubing be in good condition, tag all leads or tubing; remove the defective part and replace with a new gauge. Remove the tags and connect leads or tubing. See wiring diagram.

Optional Dynalco (overspeed safeties)

The engine revolutions are monitored through a pick-up probe pointed at the flywheel ring gear. Current generated is passed to an engine speed transmitter which is preset to a determined RPM. Any variation over this predetermined RPM will ground Altronic or shut off the Asco gas shut-off valve.

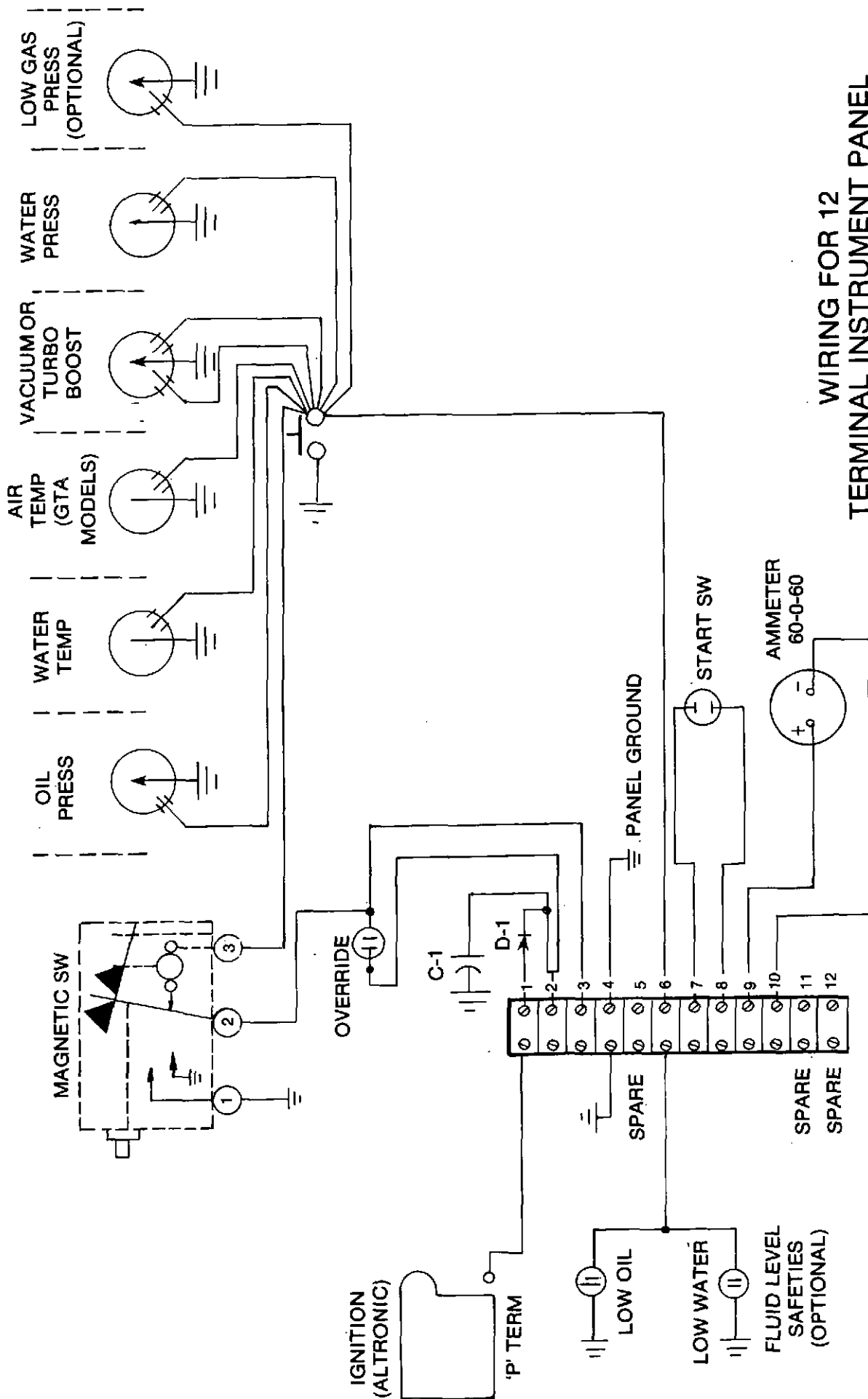
Nason Safety Control

The Nason (formerly the Hawk) Safety Control System provides protection from low lubricating oil pressure and excessively high coolant temperature of preset values. When either is exceeded, the controls disrupt the electrical circuit to the fuel solenoid shut-down valve and shut down the engine. The oil pressure safety control is mounted with a short pipe nipple in a main oil gallery.

The temperature safety control mounts directly in the thermostat housing or water manifold as required. This safety control system necessitates use of a progressive toggle switch as a permissive starting switch and a push button-type cranking motor switch.

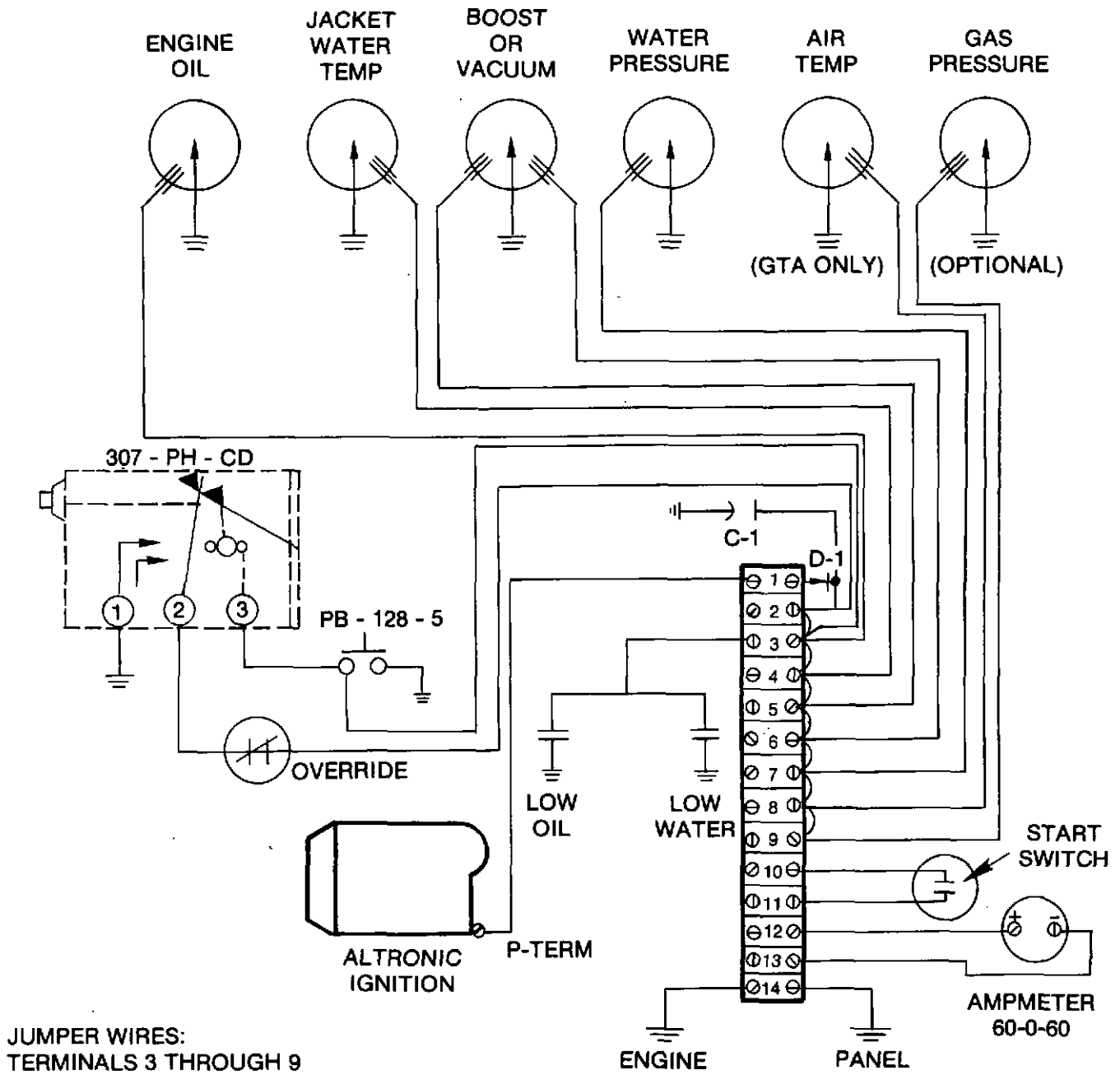
Mechanical Overspeed

Switches in conjunction with stop crank and field flash are sometimes used with Generator Sets. These switches are preset. No adjustments are recommended. Should you experience any difficulty, contact your local Cummins Dealer.

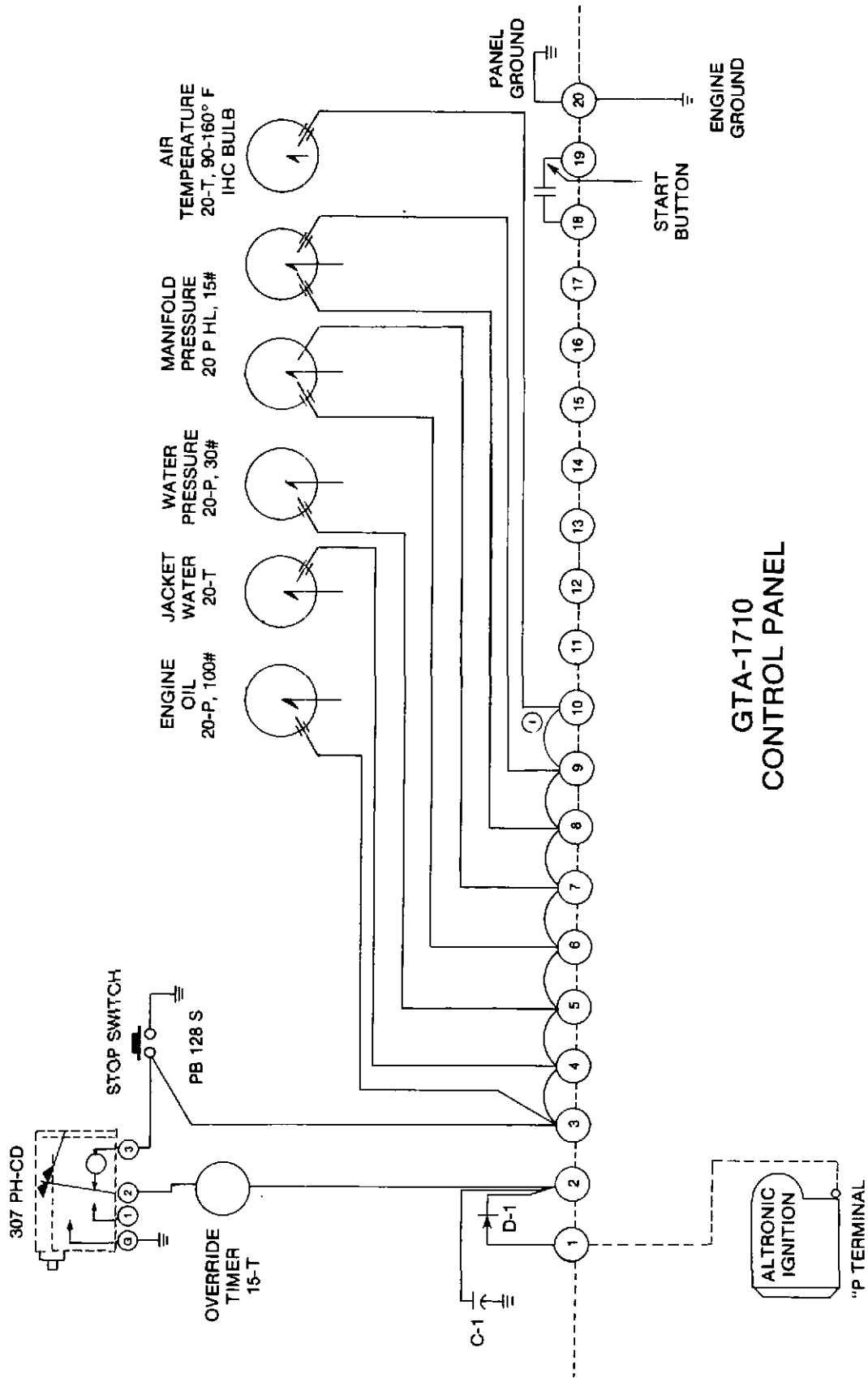


**WIRING FOR 12
TERMINAL INSTRUMENT PANEL**

NOTE: All panel ground connections are common and attach mounting bolts



INDUSTRIAL & IRRIGATION PANEL WIRING



GTA-1710
CONTROL PANEL

Starter & Electrical Equipment Group

The principle function of the Electrical System on Cummins Gas Engines is that of cranking or starting and operating electrical accessories as required by the unit being powered.

Cranking Motors

The two basic cranking systems used on Cummins engines are electrical and air. The selection of the type of system to be used is generally dependent upon the operator's preference or such factors as cost, weight or special operating requirements. Each system, when properly designed for engine and operating conditions, will perform satisfactorily.

Electrical Cranking System

This unit includes:

- Electric Cables and Connections
- Cranking Motor
- Batteries

The information contained in this section is limited to a brief description of the function and operation of electric units used on Cummins Engines and to simple tests and adjustments that can be made without special equipment.

Repair of electrical units should be done in manufacturer's service stations. Their stations are well-equipped and well-distributed.

If this service is not available, further specific information can be obtained as follows:

Delco-Remy Equipment

Electrical Equipment Operation and Maintenance Handbook DR-324-1 or -2,-3,-4 and Test Specifications DR-324-S-1 may be purchased from the nearest United Motor Service Station, or the Service Dept., Delco-Remy Division, General Motors Corp., Anderson, Indiana.

Electric Cables and Connections

Electric current traveling through a wire may be compared to water flowing through a hose or pipe. Voltage in the electric circuit is like pressure behind water in the hose. Water pressure is lost if it is allowed to leak or if hose diameter is so small that it offers resistance to flow. This loss of water pressure compares with loss of electric pressure, or voltage, because of poor connection or conductors of insufficient capacity.

Battery Cables

Starter circuit resistance can have a significant effect on *performance of the system to satisfactorily start an engine*. An increase in the circuit resistance, due to cable and connection deterioration, will reduce cranking speed and starter cranking torque, and result in more difficult engine starting, even with batteries of good capacity.

The total resistance of the circuit must not exceed "maximum circuit resistance" shown in Table 3-1-1. Resistance reduces electric current and cranking effort. The low-voltage high-amperage current in the cranking motor circuit requires heavy-duty cables and good connections. Battery cable size is based on total cable length (over to starter and back to battery).

Ground Connections

In engine applications a common ground connection is sometimes used. This system uses the metal of the unit as one side of the electric circuit and, as such, makes all metal that lies between the electrical unit and battery or generator an electrical conductor. See Figs. 3-1-1 and 3-1-2. Therefore, it is advisable to make all ground connections to the same solid metal member.

An occasion may arise when the battery is grounded to one beam of the frame, and it is necessary to make ground connections to a second section of beam from the superstructure which is jointed to the first. This can be done safely if you first bolt and sweat-solder a flexible, heavy metal strap between the two beams to bridge the joint. This has the effect of making the jointed member a part of the beam which grounds the battery. All metal joints in the circuit should be treated in this manner. This will also hold true for instrument ground connections in the cab, on the instrument panel, etc.

Many engines are installed on rubber or other flexible mountings. These mountings, in themselves, provide practically no electric connection to the frame. Even a solid-type engine mounting in which the flywheel housing is bolted directly to the frame makes a poor electric connection. All ground connections from any electrical unit should be made to the same solid or bridged metal member to which the battery itself is grounded. See Figs. 3-1-3, 3-1-4.

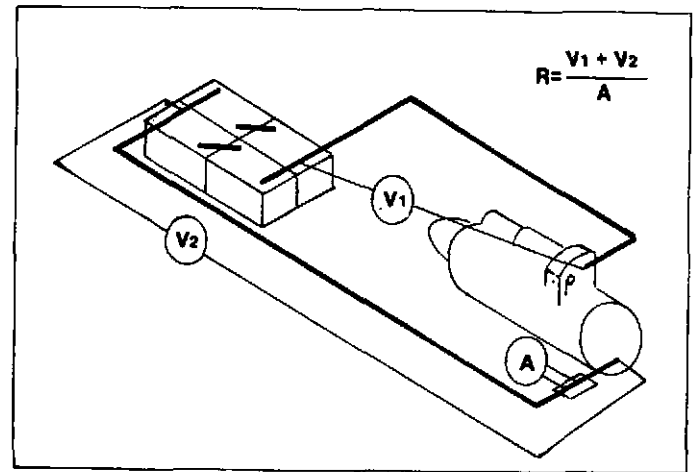


Fig. 3-1-3. Single battery location - single pair of cables.

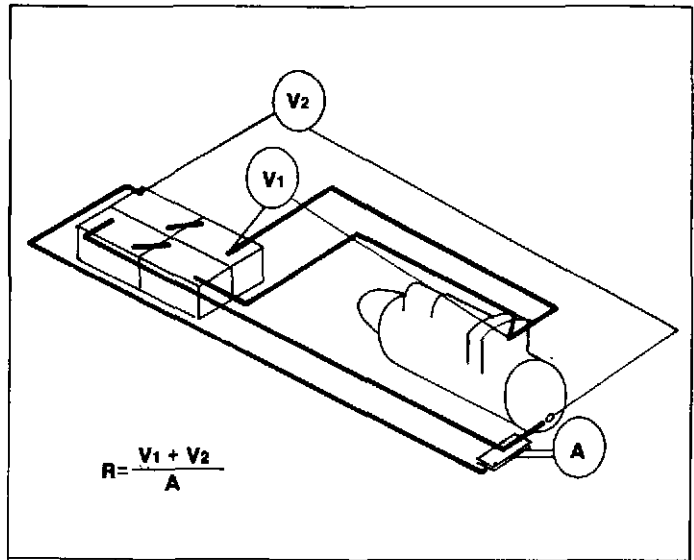


Fig. 3-1-4. Single battery location - parallel cables.

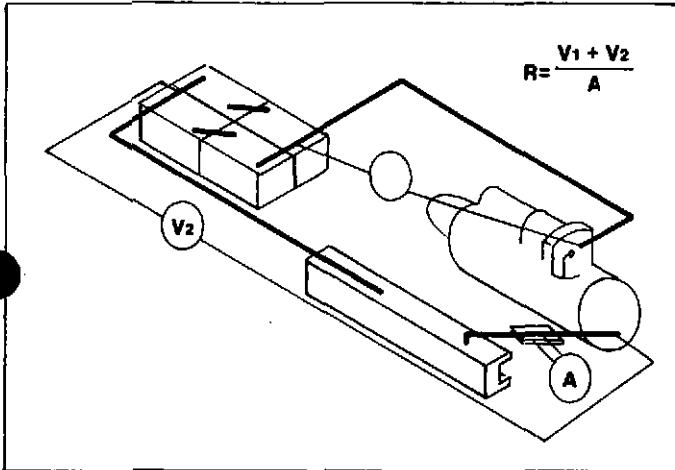


Fig. 3-1-1. Single battery location - single pair of cables with frame ground return.

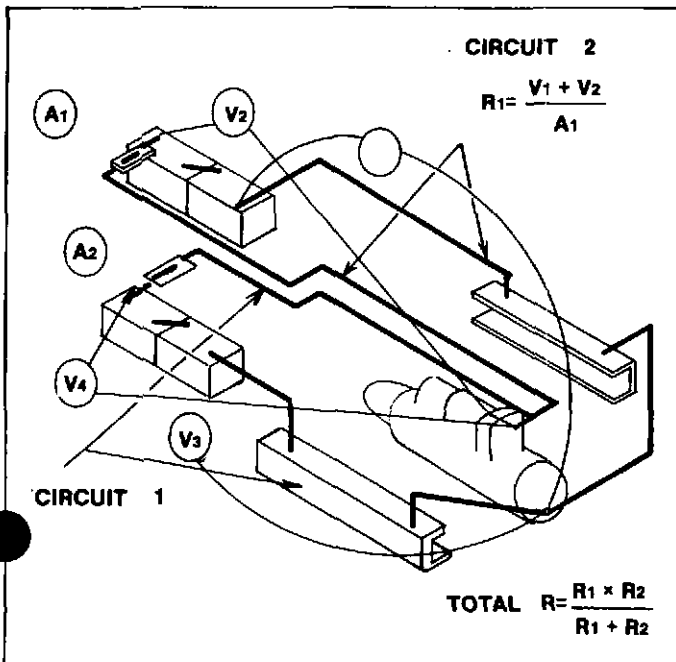


Fig. 3-1-2. Two battery location - frame ground return.

Never install a battery or electrical connection in a dirt stream or where excessive dirt, oil or corrosion will collect. Dirt, oil and corrosion act as an effective resistor, taking away current needed for engine cranking. Never attach ground wires to a rusty, greasy or dirty surface.

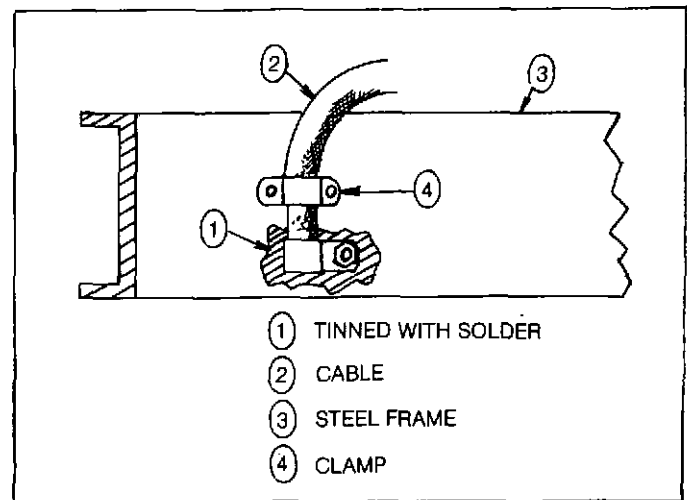
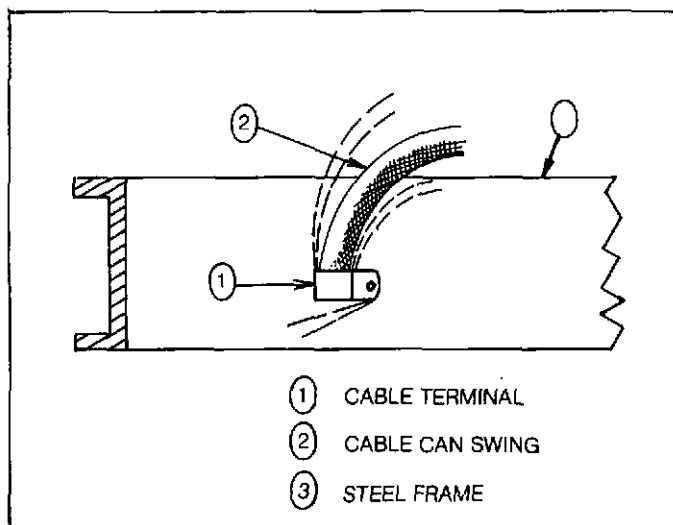
Regardless of where magnetic switches, cut-out relays and other control units are mounted, a separate ground wire should be run from the proper terminal or designated part of the unit to the same solid metal member grounding the battery. Whenever possible, make ground connections directly to the battery's grounding bolt. This will provide a dependable ground return circuit and permit unretarded passage of current to allow units to function as they are intended.

The sketches shown here indicate the proper method of grounding certain units. They are not complete wiring diagrams, and under no circumstance should they be used as such.

To make a good electric connection between a cable terminal and the frame, you must clean and scrape metal surfaces until they are bright; then tin these surfaces to prevent rust and corrosion. To make a dependable, permanent joint, sweat-solder cable and frame after they are bolted together.

The heavy cables used to make ground connections from the battery, cranking motor or engine should not swing. A single bolt connection as shown in Fig. 3-1-6 is unreliable. The surface of the frame at the joint is not tinned and, in addition, the heavy cable can swing back and forth to loosen the connection. Loose connections leave a space between the cable terminal and frame, which may allow the entrance of dirt or moisture to form rust or corrosion.

Recommended ground connections and methods of preventing cable swing are shown in Fig. 3-1-7. The surface of the frame at the connection is tinned to prevent rust and corrosion.



Cleaning

All parts should be cleaned after disassembly. Do not clean the armature or fields in a degreasing tank; compounds used in this type of cleaner may cause damage to insulation material.

1. If the commutator is dirty, it may be cleaned with a strip of No. 00 sandpaper.

Caution: Never use emery cloth to clean commutator.

2. All dust must be blown for cranking the motor after the commutator has been cleaned.

3. If the commutator is rough, out-of-round, or has a high mica, remove cranking motor from engine and disassemble. Turn the commutator down in a lathe, removing only sufficient material to true-up the commutator and remove roughness and high mica. Undercut the mica.

4. Replace worn brushes. If the brushes wear rapidly check for incorrect brush spring tension and roughness or high mica on the commutator.

Lubrication

1. All bearings provided with hinge cap or ball-type oilers should have 8 to 10 drops of light engine oil every 400 hours.

2. On units so equipped, keep grease cups filled with medium cup grease. Turn down one turn every 400 hours for proper lubrication.

3. Oil plugs should be removed every 6 months and the reservoir packed with graphite grease. On tractor, marine and stationary applications, lubricate at every unit rebuild.

Cranking Motor

The cranking motor used on a Cummins Engine is a special overload motor capable of delivering high horsepower. In order to obtain this power, it is necessary to build the cranking motor with a minimum of resistance so a large current will be taken through it. The cranking motor should be used for short periods only (30 seconds maximum) to avoid the possibility of failure due to overheating.

The cranking motors available for Cummins Engines are of 24 volt series.

4. Do not lubricate excessively, since excessive oiling may cause oil and grease to gum on the commutator and reduce the cranking ability of the motor. Never oil the commutator.
5. On some models, oil wicks are used for lubrication of the center or drive-end bearing. The wick is saturated with oil before assembly. When the cranking motor is removed from the engine, oil wick should be saturated with oil before unit is reinstalled.
6. All oil-less type bushings should be supplied with a few drops of light engine oil whenever disassembled.
7. Lubricate cranking motor drives with a few drops of light engine oil during installation. Avoid excessive oiling.

Battery Specifications

1. The batteries listed in Table 1 are the minimum capacities that must be provided to crank engines at

minimum engine temperatures expected. Battery capacities are given in ampere-hours.

2. Minimum battery capacities are based on engines with no externally connected parasitic loads (such as torque converters, hydraulic pumps, etc.). Any parasitic load that is coupled during cranking must be determined at lowest starting temperatures so an equivalent increase can be made to the minimum battery capacity. Cable circuit resistance must not exceed Cummins limits. Battery cable size is based on total cable length (over to starter and back to battery).

In order to obtain optimum battery service life and dependable engine starting, the battery capacity to be provided should not be less than recommended in the following table. Accessories or drive lines which cause additional load must be compensated for by additional battery capacity.

Minimum Battery Capacity in Ampere Hours

Cummins Engine Series	Engine Displ. Cu. In. [cc]	Winter Climate 0°F [-18°C] Minimum Engine Temperature *			Mild Climate 32°F [0°C] Minimum Engine Temperature *		
		12V.	24V.	30V.	12V.	24V.	30V.
G/GTA	Up to 743	400**	200	170	300**	150	130
G/GTA	855	520**	260	200	340**	170	150

* "Minimum engine temperature" is the temperature of the engine rather than the lowest night-time temperature. As an example, during a night when the temperature drops to -10°F [-23°C] for only a few hours, the minimum engine temperature would probably be no less than 0°F [-18°C]. An engine and battery would have to be cold soaked with no shelter at -10°F [-23°C] for 6-10 hours for the engine lubricating oil and battery to reach -10°F [-23°C]. All minimum capacities for batteries are based upon using Cummins recommended lubricating oils which are SAE 10W for winter climate and SAE 20 for mild and warm climates.

** Minimum capacity shown is for 12V high output type starters only.

Table 1 Ampere Hour Capacity Ratings of Battery Systems

24 Volt	Four—6-Volt Batt. in series	Eight—6-Volt Batt. in series parallel	Two—12-Volt Batt. in series
* Battery AABM Group Size		Total ampere hour system rating at the indicated voltage.	
	3H	130	260
	4H	150	300
	5D	165	330
	7D	200	400
	9D	340	680
	4D		150
	6D		165
	8G		175
	8D		200

* Association of American Battery Manufacturers

Alternator

The battery-charging generator or alternator selection is, for the most part, dependent upon the end users' requirements and preference. However, in the interest of avoiding unnecessary problems, it is important that certain precautions be taken before the selection is finalized.

The charging system must have sufficient capacity to sustain the operating load requirements and at the same time recharge the batteries sufficiently for subsequent engine starts.

The speed ratio of the generator or alternator should be reviewed to insure that the necessary charging rate is obtained and the maximum operating speed is within the limits established by the manufacturer for safe operation and long life. To provide maximum generator voltage regulator life, generator speed ratio shall be selected so the regulator does not cut in within plus or minus 50 RPMs of engine idle at either hot or cold generator performance curve condition. This is necessary to prevent failure of the regulator cut-out relay which will tend to cut in and out with resultant arcing and eventual failure.

Alternator

Self-rectifying AC generators are designed and constructed to give long periods of trouble-free service with a minimum amount of maintenance. The rotor is mounted on ball bearings, and each bearing has a grease reservoir which eliminates the need for periodic lubrication. Only two brushes are required to carry current through two slip rings to fuel coils which are wound on four-pole rotor. The brushes are extra long and under normal operating conditions will provide long periods of service.

The stator windings are assembled on the inside of a laminated core that forms the generator frame. Six rectifier diodes are mounted in the slip ring end frame and are connected to the stator windings through connectors mounted internally in two nylon holders, or a separately mounted rectifier; they act to change the alternator AC voltage to a DC voltage which appears at the "BAT" terminal on the alternator.

Even though the alternator is constructed to give long periods of trouble-free service, a regular inspection procedure should be followed to obtain maximum life from the alternator.

Many mechanics who have learned proper procedures for installation, operation and adjustment of DC generators have encountered some trouble with AC systems. Following is a list of important rules - mostly DON'Ts - which must be observed with alternators and regulators. Failure to observe these precautions will result in serious damage to the electrical equipment.

1. Do not install either an alternator or a regulator without checking the manufacturer's specifications and confirming that they are matched for each other as to type, polarity and part numbers.
2. When installing a battery, always make absolutely sure that the ground polarity of battery and ground polarity of alternator are the same.
3. When connecting a booster battery, be sure to connect the negative battery terminals together and the positive battery terminals together.
4. When connecting a charger to battery, connect charger positive lead to battery positive terminal and charger negative lead to battery negative terminal.
5. Never operate an alternator on an open circuit. Make absolutely certain all connections in the circuit are secure.
6. Do not short across or ground any of the terminals on the alternator or regulator.
7. Do not attempt to polarize the alternator. This procedure will almost certainly ruin the diodes.

For additional information on alternators, contact the Delco-Remy or Leece-Neville Distributor in your area.

Inspection

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

At regular intervals, inspect terminals for corrosion and loose connections, and wiring for frayed insulation. Check mounting bolts for tightness, and belt for alignment, proper tension and wear. Because of higher load capacity and higher inertia of heavy rotor used in AC generators, proper

belt tension is more critical than on DC generators to prevent slippage and wear. A cog belt is recommended for the most satisfactory service. The slip rings and brushes can be inspected through the end frame assembly. If the slip rings are dirty, they should be cleaned with 400-grain or a finer polishing cloth.

Never use emery cloth to clean slip rings. Hold polishing cloth against slip rings with alternator in operation, and blow away all dust after the cleaning operation. If they are rough or out-of-round, alternator must be removed and disassembled so slip rings can be trued in a lathe. If brushes are worn close to holder, alternator must be removed and disassembled so brushes can be replaced.

Noisy Alternator

Noise from an AC generator may be caused by worn or dirty bearings, loose mounting bolts, loose drive pulley or a defective diode or rectifier.

Lubrication

Under normal conditions, the alternator will not require lubrication between engine overhaul periods. The grease reservoir in each frame provides an adequate supply of lubricant for long periods of operation.

Output Check

To check alternator on test bench, make electrical connections as shown in Fig. 3-2-1, operate at specified speed and check for rated output. Adjust the load rheostat, if necessary, to obtain the desired output.

Caution: On negative ground alternator, connect negative battery post to alternator frame, and on positive ground alternator, connect positive battery post to alternator frame.

Air Starting

Air starting is available as an engine option for most engine models and is acceptable for use on all Cummins engines. It provides a generally higher cranking speed than electric starting motors and the compressed air source suffers less energy loss at low ambients than electric storage batteries.

The requirement for a bulky air receiver proves to be a major disadvantage on some applications. Air starting also calls for particular attention to ensure that the air supply does not bleed down during the periods the equipment is not operating.

Because of the difficulties involved in maintaining air pressure on the brake and service air systems during shut down, it is best to provide a separate air receiver for the starting motor. If the same air tank is used for service

and starting air, a relay valve is needed that will isolate the tank when the parking brake is set. A good quality manual globe type valve can be used on applications which do not have air parking brakes.

Manufacturers of air starting motors state their air consumption in cu. ft./sec of free air. In order to determine receiver size, this air consumption has to be multiplied by the ratio of atmospheric pressure to the change in pressure during cranking, and by the number of seconds of cranking time desired.

Example:

Starter Air Consumption	5 cu. ft./sec
Cranking Time	10 sec.
Initial Air Pressure	135 psi
Lowest Air Pressure For Cranking	60 psi

$$\text{Receiver Size ft} = 5 \text{ cu.ft./sec} \times \frac{14.7 \text{ psi}}{(135 - 60) \text{ psi}} = 9.8 \text{ cu. ft.}$$

Since there are 7.5 gals. per cu. ft., the receiver size in gallons is 9.8 x 7.5 or 73.5 gallons.

Ten seconds cranking time with an air starter is considered adequate for all Cummins engines. In general, the air tank size must be at least 75 gallons for engines of less than 1200 cubic inch displacement. Construction equipment engines larger than 1200 cubic inches will probably require a 100 gallon tank.

An ether-type starting aid should be utilized at all temperatures below 35°F to ensure that a start is accomplished within the 10 seconds cranking period. The ether should be introduced directly into the intake manifold. The use of a hand spray-can at the air cleaner inlet is not recommended for engines using an air starter.

Figure 4 is a typical piping schematic for an air starting system. The precise piping requirements will depend on the starting motor make and particular accessories used. For instance, with reference to Figure 8, if a Bendix drive starter is used, the outlet from the starter protection valve will be connected directly to the starter relay valve. In other cases, the starter protection valve, which is designed to prevent starter engagement when the engine is running, may not be used.

The piping from the starter air receiver to the starter should be as short as possible in order to limit line losses. This necessitates mounting the receiver on the same side of the engine as the starter and arranging the starter connection on the tank end nearest the starter.

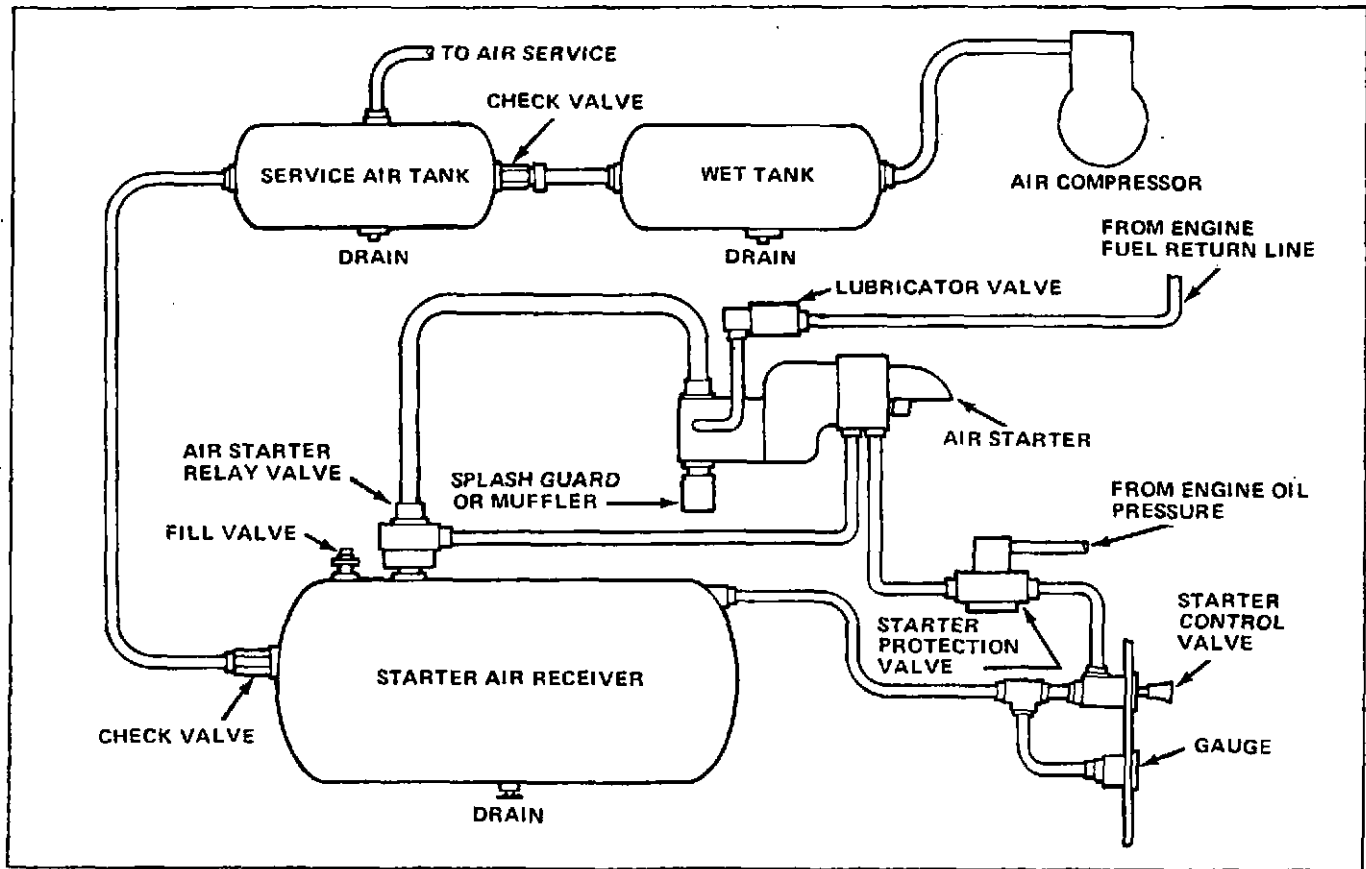


Figure 4 : Typical Air Starting Piping Arrangement

Connections to the receiver are ordinarily made above the horizontal centerline. This reduces the possibility of moisture entrainment and/or freezing in the air lines. In no case should there be any connections except the drain in the bottom of the tank. If the starter relay valve is mounted directly on the tank, it will minimize air leakage during engine shutdown. In any event, it should be mounted as close to the tank as possible and never on the starter. Drain valves of the screw-out tapered-seat variety are recommended since others are unreliable and are a common source of system leaks.

The best position for the inlet check valve is directly on the receiver where it is supported and provides maximum protection to the air supply.

Automatic lubricators are recommended to increase air motor reliability and extend its life. Various types are available, but the kind most commonly found on construction equipment applications of Cummins engines uses the air pressure at the starting motor to force a metered amount of fuel into the starting motor at the time it is energized. The fuel inlet connection to these valves is teed into the engine fuel return line. The valve has to be located below the return line connection so that it receives fuel by gravity. It is intended to inject fuel into the starting motor vanes when it is first operated and this requires that it be located close to the motor. The installer must bleed the air out of the lubricator after the initial engine start in order to prevent a permanent air-lock.

The exhaust port in the starting motor must be protected from the entry of dirt and water, particularly from road splash. The silencer, which is available as an optional accessory on all air starters, will supply this protection when it is installed. The noise from an unmuffled starter is considered objectionable on some applications and a silencer is recommended.

Provision for initial and emergency fill of the starter air receiver has to be provided. Various types of charging connections are available and the selection will depend on the type of air charging equipment available to the end users. The connection needs to be protected from dirt and grease. If an air line quick disconnect is used, a dummy fitting closed with a pipe plug can be used. The Gladhand fittings common to vehicular applications are available with a dummy coupling for contamination protection. Tire valve type fittings designed to be installed by threading into a pipe tap are offered commercially, and these employ a standard sealing cap. If charging air is available at more than 150 psi, a relieving type pressure regulator must be furnished on either the charging air line or the outlet side of the air receiver. When applied on the outlet side, the installer should ascertain that the tank has an adequate pressure rating.

When the starting motor is not furnished with the engine, it should be sized according to the manufacturer's recommendations for the particular engine model. The recommended working air pressure is usually 135 to 150

psi. Frequently, a "lowest pressure recommended" is also stated. This is the lowest air pressure which will crank the engine under average conditions and may be used as the minimum pressure in calculating air receiver size.

The vibration in rigid tubing tends to cause the fittings to loosen to the point where leakage occurs. Therefore, well supported, good quality, flexible hose is recommended for all parts of the starting air circuit. The hose should have J.I.C. fittings with dry seal threads. Any pipe fittings used should also be dry seal type. All connections should be made up with Loctite pipe sealant or equivalent. Teflon tape does not introduce enough friction into the pipe threads to prevent loosening, and when carelessly applied, it may get inside the piping and clog valves. Its use should be avoided in starting air systems.

The following lists the minimum recommended line sizes for piping between the starter air receiver and the starting motor. Larger line sizes are optional. All valves and accessories in the system need to be especially designed for diesel air starting service.

Maximum Starter Air Consumption - Ft. ³ /s	Minimum Recommended Hose Size
3-4	.12
5	.16
6-8	.20
9-12	.24
13 or more	.32

TROUBLE SHOOTING

Trouble shooting is an organized study of the problem and a planned method of procedure for investigation and correction of the difficulty. The chart at the end of this section includes some of the problems that an operator may encounter during the normal service life of a Cummins Gas Engine.

Cummins Gas Engines

The term "trouble shooting" means locating the basic cause of the difficulty so that when repairs are made there will be no repetition of the failure. Trouble shooting, in most cases, is very simple. In the majority of problems, the only requirement is a knowledge of construction of the unit and the principles of its operation. Knowing these two factors, anyone who is qualified to make repairs on the unit can start at the beginning and follow through each step in the functioning of each part until the cause of the trouble is found.

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 gas filters, "excessive lube oil consumption" caused by leaking gaskets or connections, etc.

Always check the easiest and obvious things first; following the simplest 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 to another. 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 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.

Listed on the following pages are some of the problems, causes and remedies used in trouble shooting.

Hard Starting or No Start

Trouble	Probable Cause	Remedy or Check
1. No spark at the spark plug. (Refer to Ignition System.)	Ignition firing circuit grounded.	Safety switch failed - closed.
		Ignition switch failed - closed.
		Instrument Panel grounded.
		Timing Disc improperly gapped or aligned.
		Altronic ground wire loose, no ground of alternator case or pickup block.
	Altronic faulty.	Check (P) lead for proper (60-70V) voltage. (40V and below is bad.)
		Check spark plug primary leads for proper voltage.
		Bad wiring harness.
		Check Altronic capacitor for correct charging.
		Check ignition timing.
Ignition transformers faulty.	Remove and inspect transformers for cracks, moisture or broken connections.	
	Inspect transformer well in cylinder head for coolant leakage or rain water.	
	Check continuity of transformer.	
v1 Incorrect or defective spark plugs.	Check for recommended type.	
	Check spark plug gap.	
	Check for damaged insulators.	
	Check for shorted electrodes.	
Water in cylinder or on plug.	Water in cylinder could possibly be caused by spark plug adapter gasket leaking. Remove spark plug adapter from the cylinder head using the 60210001 tool. Clean cylinder head seating area and adapter thoroughly. Install adapter with new seating gasket and O ring. Torque to 120 ft. lbs. New gasket part number 90210030.	

Hard Starting or No Start (Continued)

Probable Cause	Trouble	Remedy or Check
2. Insufficient or no gas supply.	Gas shut-off closed.	Check manual valve; if closed, open slowly. Check electric or Sentinel valve with manual re-set. Re-set to run.
	<p>Note: If no gas shut-off is installed between a faulty valve and main gas line regulator, do not attempt to remove valve until local gas company has been notified and a representative is present to approve removal.</p> <p>Gas valve open, low gas pressure to Thermac, engine running.</p>	<p>Check electric valve for proper voltage being supplied to open. If valve fails to open with proper voltage present, solenoid, or complete valve must be replaced.</p> <p>Bad in-line gas filter.</p> <p>Consult local gas company for gas supply pressure.</p> <p>Request gas company to supply minimum 10 inches H₂O if supply line is of recommended size.</p> <p>If supply line is not of recommended size, an increased pressure to maximum of 20 inches of H₂O may be required.</p>
	Gas valve open, low gas pressure from Thermac, engine running.	<p>Pressure test prior to starting engine indicate 10 inches H₂O minimum of gas from main line regulator to Thermac.</p> <p>If static pressure minimum of 10 inches of H₂O existed, adjust Thermac to 5 inches H₂O with engine idling.</p>
	Low gas pressure. Thermac adjusted full open, engine running.	Request local gas company to remove orifice and spring from main line regulator to check if they are proper size.
	<p>Note: Thermac should not be operated in full open position. Re-position adjusting screw to minimum of 10 turns from full open position.</p>	<p>Inspect supply line for recommended size and to assure no leakage is evident.</p> <p>With the assistance of local gas company, inspect piping valves, regulator and fittings for obstructions.</p>

Hard Starting or No Start (Continued)

Trouble	Probable Cause	Remedy or Check
3. Excess gas.	Hard starting - rough idle.	<p>Stop engine, raise supply line gas pressure from main line regulator to 15 inches H₂O.</p> <p>Restart engine. Adjust Thermanac to provide 5 inches H₂O gas pressure. If unable to maintain 5 inches H₂O, stop engine, raise static gas pressure in one inch water column increments until 5 inches of H₂O Thermanac to carburetor gas pressure can be maintained. Do not exceed 20 inches H₂O supply line gas pressure with engine stopped. If 5 inches H₂ gas pressure cannot be maintained, a supply problem exists. Contact local gas company.</p>
	<p>Note: Excess gas can be detected by odor, indicating a leak or flooding condition.</p>	<p>Inspect and adjust gas pressure regulator valves.</p> <p>Check Thermanac pressure reducing valve for proper operation and controllability.</p> <p>Check Thermanac atmospheric vent for gas leakage.</p> <p>Check Impco carburetor air/gas valve diaphragm for leakage at seating area. Warped diaphragm plate.</p> <p>Check gas power mixture adjustment valve for correct setting.</p>
4. Insufficient air. (Refer to Air System.)	Restricted air intake.	<p>Remove carburetor cover and inspect for broken air valve spring.</p> <p>Remove and inspect air cleaners.</p> <p>Inspect air piping.</p>
5. Unbalanced compression pressure	Piston ring or valve leakage.	<p>Check individual cylinder compression.</p> <p>Check intake and exhaust valve clearance.</p> <p>Check crosshead adjustment.</p>

Engine Will Not Idle Properly

Trouble	Probable Cause	Remedy or Check
1. Uneven firing of cylinders. (Refer to Ignition System.)	Weak spark at spark plug.	<p>Check Altronic capacitor for proper charging.</p> <p>Check Altronic output voltage.</p> <p>Inspect primary wiring harness for open or shorted wiring.</p> <p>Incorrect Pick-up Block alignment and /or gapped.</p> <p>Check Altronic ground connection for loose connection.</p> <p>Inspect ignition transformers and HT leads.</p> <p>Check transformer ground connection.</p> <p>Missing magnet on Timing Disc.</p>
	Incorrect or defective spark plugs.	<p>Check for recommended type.</p> <p>Check spark plug gap.</p> <p>Check for damaged insulators.</p> <p>Check for shorted electrodes.</p> <p>Defective Hyd. lifter.</p>
2. Improper combustion.	Incorrect fuel mixture.	<p>Consult gas company to determine if approved gas is being supplied.</p> <p>Check pressure adjustment to determine proper operations of pressure controls.</p> <p>Adjust gas power mixture.</p> <p>Inspect carburetor air/gas diaphragm for rupture or broken spring. Bent B.</p> <p>Inspect gas metering valve for obstruction or improper seating.</p> <p>Inspect cylinder heads to be sure head vent holes are plugged.</p> <p>Check carburetor and intake manifold gaskets for leakage.</p> <p>Check carburetor balance of right and left cylinder banks (12 cylinder engine only).</p>

Engine Will Not Idle Properly (continued)

Trouble	Probable Cause	Remedy or Check
3. Unbalanced compression.	Piston ring or valve leakage.	Check individual cylinder compression. Check intake and exhaust valve clearance.
4. Incorrect timing.	Valve or ignition timing.	Check ignition timing. Remove and inspect air cleaner. Bad turbo. Check intake and exhaust valve timing.

Engine Fails To Operate Properly Under Load Has A Miss Or Vibration

Trouble	Probable Cause	Remedy or Check
1. Ignition	Ignition system functioning improperly.	Check for proper operation of Altronic.
2. Engine shakes or vibrations		Timing DOC alignment or missing magnet. Check for proper operation of ignition transformers. <i>Check for incorrect or inoperative spark plugs.</i> Adjust timing.
3. Fuel	Incorrect or improperly adjusted fuel system.	Check Thermanc for proper operation. Check and adjust gas pressure, check carburetor balance on 12 cylinder engines only.
4. Air	Insufficient air supply.	Check for air intake restriction and adequate supply.
5. Unbalanced compression	Piston ring or valve leakage.	Inspect and adjust gas control valves. Check and adjust gas control valves. Check and adjust intake and exhaust valve clearance. Check individual cylinder compression.
6. Engine speed falls off greatly.	Governor not functioning properly.	Check governor adjustment and wear. Check speed of governor. Check throttle linkage.
7. Very bad or no governor action	No orifice fitting. Flooding governor housing.	Install gas orifice in Pierce governor feed oil line. Bad turbo.

Engine Data

G-495

Model	G-495	
Number of Cylinders	4	
Bore	5 1/8"	(130mm)
Stroke	6"	(152mm)
Piston Displacement	495 cu.in.	(8.1 liters)
Aspiration	Natural	
Compression Ratio	12:1, 10:1, 8.5:1	
Weight	2100 lbs.	(953 kg.)

G-743

Model	G-743	
Number of Cylinders	6	
Bore	5 1/8"	(130mm)
Stroke	6"	(152mm)
Piston Displacement	743 cu.in.	(12.2 liters)
Aspiration	Natural	
Compression Ratio	12:1, 10:1, 8.5:1	
Weight	2900 lbs.	(1315kg.)

G-855

Model	G-855	
Number of Cylinders	6	
Bore	5 1/2"	(140mm)
Stroke	6"	(152mm)
Piston Displacement	855 cu.in.	(14 liters)
Aspiration	Natural	
Compression Ratio	12:1, 10:1, 8.5:1	
Weight	3100 lbs.	(1406 kg.)

G-1710

Model	G-1710	
Number of Cylinders	12	
Bore	5 1/2"	(140mm)
Stroke	6"	(152mm)
Piston Displacement	1710 cu.in.	(28 liters)
Aspiration	Natural	
Compression Ratio	12:1, 10:1, 8.5:1	
Weight	7900 lbs.	(3583kg.)

GTA-743

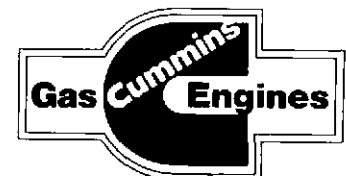
Model	GTA-743	
Number of Cylinders	6	
Bore	5 1/8"	(130mm)
Stroke	6"	(152mm)
Piston Displacement	743 cu.in.	(12.2 liters)
Aspiration	Turbo/Aftercooled	
Compression Ratio	10:1 & 8.5:1	
Weight	3200 lbs.	(1452 kg.)

GTA-855

Model	GTA-855	
Number of Cylinders	6	
Bore	5 1/2"	(140mm)
Stroke	6"	(152mm)
Piston Displacement	855 cu.in.	(14 liters)
Aspiration	Turbo/Aftercooled	
Compression Ratio	10:1 & 8.5:1	
Weight	3400 lbs.	(1542kg.)

GTA-1710

Model	GTA-1710	
Number of Cylinders	12	
Bore	5 1/2"	(140mm)
Stroke	6"	(152mm)
Piston Displacement	1710 cu.in.	(28 liters)
Aspiration	Turbo/Aftercooled	
Compression Ratio	10:1 & 8.5:1	
Weight	8200 lbs.	(3720 kg.)



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**CUMMINS NATURAL
GAS ENGINES, INC.**

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