Cummins Natural Gas Engines

GNHC 4
GNH 220
GNH 250
GNVH 450
GV12 525

960-10

Service Manual

Cummins Natural Gas Engines

Mod # GV12-525 IPG
Eng # 717603-3
SBM # 67010

Foreword

This manual is applicable to all Natural Gas Engines currently being produced by Cummins Engine Company, Inc. and subsidiaries. It contains instructions for operators that will enable them to get the best service from their engines. Before operating the engine become familiar with the procedures described.

The maintenance section is for the men who are responsible for the upkeep and availability of engine on the job. The maintenance program is simple, realistic, easy to control and a profitable one to practice.

This is a service manual; repair operations should be performed by specially trained personnel. Trained personnel are available at all Cummins Distributor and Dealer locations.

Cummins Engine Company, Inc.
Columbus, Indiana, U.S.A.

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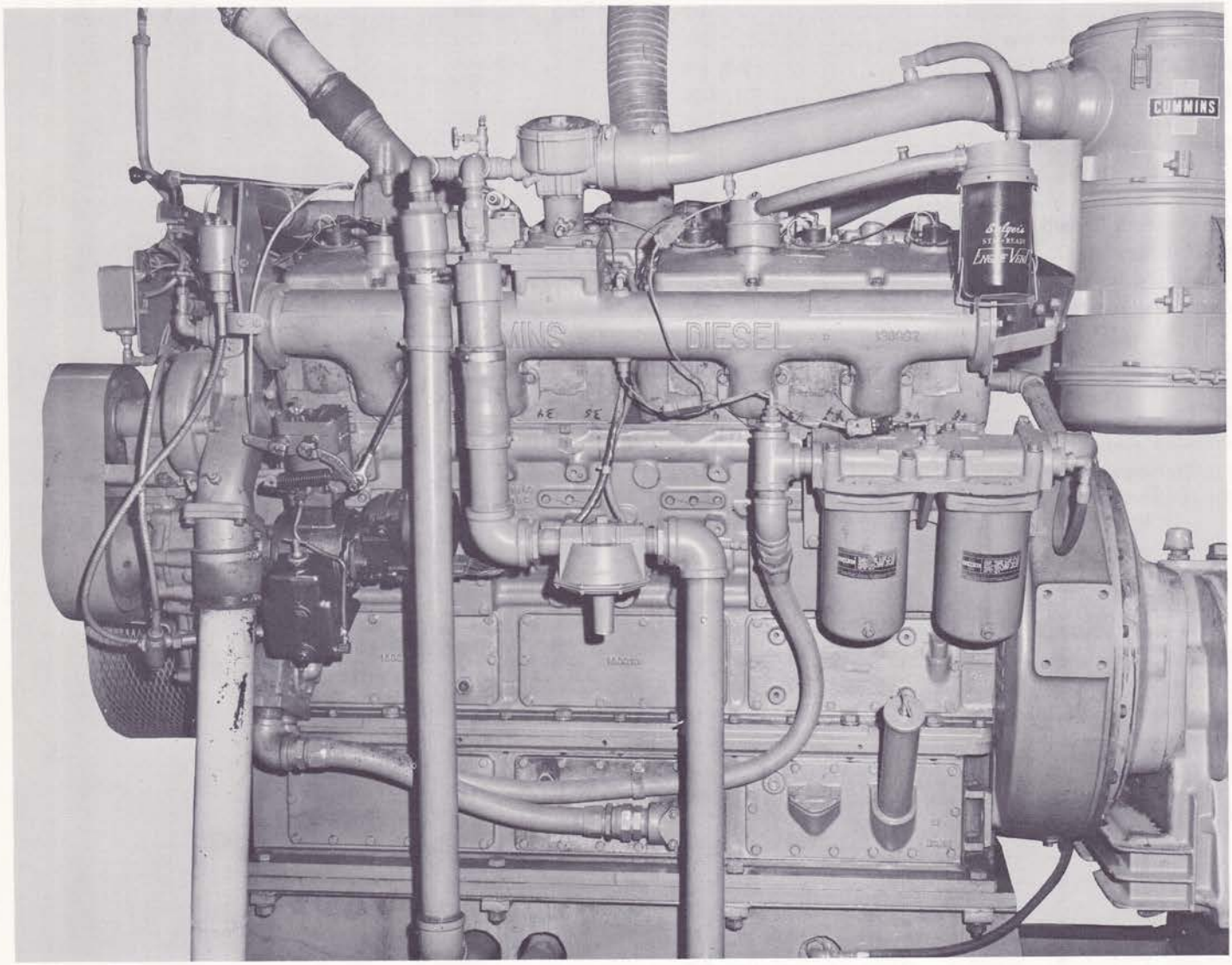


Typical GV12 installation

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-cycle engines that burn a spark-ignited, controlled mixture of natural gas and air. Horsepower ratings and other engine specifications are tabulated in Table 1 following.

Table 1: Engine Models Specifications

Data	GNHC-4	GNH-220	GNH-250	GNVH-450	GV12-525
Horsepower	118	177	204	354	408
Rated Speed, rpm	1800	1800	1800	2100	2100
Bore, in.	5 1/8	5 1/8	5 1/2	5 1/8	5 1/2
Stroke, in.	6	6	6	6	6

Cummins Cycle

It is easier to understand the function of 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.

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 fuel 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 intake valves are closed, the exhaust valves are open, 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.

The Fuel System

Fuel should be clean and must be free of acids, sulphur compounds, water, pipe scale and other foreign material which could cause corrosion of cylinder liners, bearings, etc. Most natural gas marketed by a public service utility is found to be free of these impurities.

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. Pressure Reduction Valve
3. Carburetor

Line Pressure Regulator

The gas pressure must be reduced to 5.8 ounces (10 inches H_2O) per square inch before entering the pressure reduction valve.

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

Pressure Reduction Valve

Pressure reduction valves must be used when gas pressure cannot be reduced and maintained by the line pressure regulator to 1.7 ounces per square inch (3 inches H_2O) for 1000 B.T.U. gas at the carburetor inlet, or when more pressure must be used to overcome line loss due to small pipe, elbows, or line length.

Carburetor

The air-gas flow 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 working parts consist of an Air Measuring Valve mounted on a fibre-glass diaphragm. Mounted within the cup of Air Measuring Valve is a Gas Metering Valve. A metering spring is mounted above the valve assembly which is normally held in a closed position. As air is drawn through the carburetor into the engine, the metering spring causes a pressure drop below the Air Measuring Valve. This pressure drop is transferred to the top of the diaphragm through four small holes in the bottom of the Air Measuring Valve. The lowered pressure above the diaphragm causes the atmospheric pressure below the diaphragm to lift the assembly a distance directly proportional to the volume of air passing through the carburetor thus making the assembly an Air Measuring Device. The Gas Metering Valve, mounted within the assembly, meters the fuel introduced through the jet into the air stream. The natural gas pressure to the carburetor inlet should not exceed 1.7 ounces (3 inches H_2O) per square inch.

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 power.

Caution: Do not mount gas shut-off valve between pressure reduction valve and carburetor.

The Ignition System

The Mag-tronic breakerless ignition system used on Cummins Gas Engines is capable of producing a voltage to fire the spark plugs of high compression engines. Two shafts, an inductor rotor and a magnetic distributor rotor, carried on sealed ball bearings, are the only moving parts.

The inductor rotor is driven at engine speed. An internal steel-fibre gear set reduces the distributor shaft speed to one-half engine speed.

The system is of the low tension type, using a separate transformer for each engine cylinder. The voltage output to the transformers is approximately 100 volts, 80 amp. peak.

The transformers are mounted directly above and in contact with the spark plug in wells in the cylinder head, thus eliminating all high voltage wiring. The transformer is designed to produce a very high rate of voltage rise, approximately 25 kilovolts. These two factors along with high peak power and less total energy combine to reduce spark plug erosion.

In operation, the electrical energy pulses are rectified and stored in a capacitor. This energy is available to fire any engine cylinder. The distributor portion of the unit has a Silicon Controlled Rectifier (SCR) acting as an electronic switch plus a small magnetic generating coil for each engine cylinder. As the magnetic distributor rotor passes the generating coil for a particular cylinder, the induced electrical pulse activates the SCR switch. The energy stored in the capacitor is released through the SCR and wiring harness into the proper transformer primary winding and high voltage is induced into the secondary of the winding to fire the spark plug.

The GNH series (four and six cylinder) engine ignition system contains a positive output lead, lettered P, for grounding the ignition and shutting the engine down. See wiring diagrams Section 5.

GV12 (12 cylinder) engines ignition system contain two output leads, letter P and N, and are connected through a safety switch adapter for grounding of the ignition. These output leads cannot be connected together due to opposite polarity. See wiring diagrams Section 5.

The Lubricating System

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

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 sump. A screen in the sump filters the oil.
2. On GV12 Series Engines oil flows from the pump to the full-flow filter to the lubricating oil cooler (in Vee), then to the front 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 moving parts within the engine.
3. GNH Series Engine oil flow is from the pump through a full-flow filter back again into the pump to cylinder block connection. The filter may be either bracket-mounted or mounted directly to the rear of the pump. External lines are used in the bracket-mounted arrangement; the filtered oil then flows from the pump-block connection to the oil cooler back to the oil header through internal drillings in the engine block. 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. 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 the GNH Series Engine, coolant is circulated by a centrifugal-type water pump mounted in the block at the gear cover end and driven by belts 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.

The engine coolant is cooled by a radiator or by heat exchangers, depending on the type of installation. In some cases, the heat exchanger and oil cooler are built as one unit.

On the GV12 Series 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 tank by the water pump and delivered to the center of the block through the water header, 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, or 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.

Whenever heat exchangers are used on Cummins Gas Engines, an auxiliary water pump is used to circulate water through the heat exchanger and around the tube bundle that contains engine coolant or lubricating oil.

The Air System

The intake air should always be routed through an air cleaner. The cleaner may be mounted on the engine or equipment and may be either paper element or composite type depending upon the 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.

Installation and Operating Instructions

The operator of the engine assumes the responsibility of engine care while it is being worked. 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 the best service from a Cummins Gas Engine. However, if any of these rules are broken, a penalty is certain 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 driven unit, shim as necessary to obtain desired alignment. Allow sufficient space to provide access to all sides of unit.

   Note: On installations 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.
4. Connect gas supply piping as suggested in Preferred Piping Schematic Fig. 2-1.

   Note: Install flexible connection between line regulator and pressure reduction valve.

   Caution: Do not use rubber hose for flexible connection.
5. Inspect units for damaged or missing parts. Check all bolts and nuts 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.
8. Refer to wiring diagrams, Section 5, for external electrical and ignition wiring, if applicable.

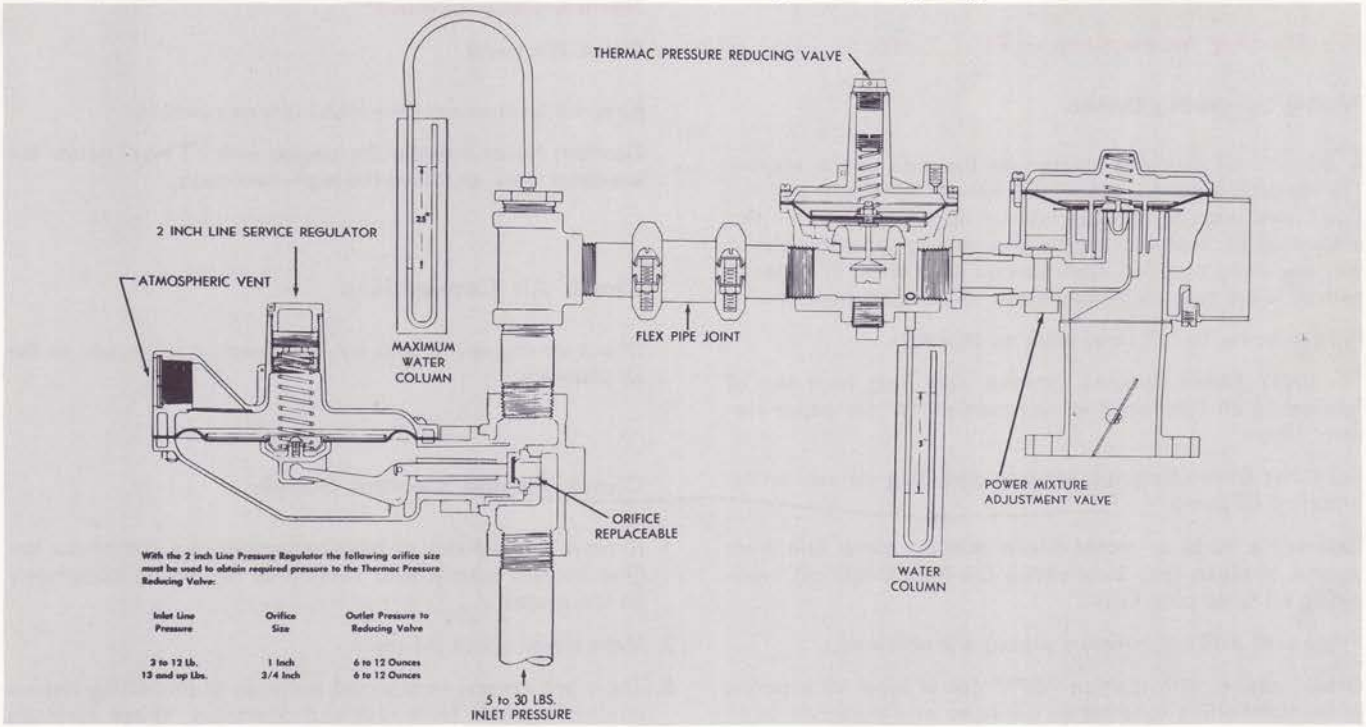


Fig. 2-1. Preferred piping — schematic

NG1

Operating Instructions

New Engine Break-In

The way a new engine is operated during the first 100 hours' service will have an important effect on the life of the engine and its parts. Its moving parts are closely fitted for long service, and even though all Cummins Gas Engines are run on a dynamometer for several hours before they leave the factory, an additional period may be required before uniform oil films are established between all mating parts. During the first 100 hours' service:

1. Operate at one-half to three-quarters throttle. Do not operate at maxmium horsepower for more than five minutes at a time.
2. Do not idle the engine for long periods as this will cause cylinder walls to glaze before the piston rings seat properly and result in excessive lubricating oil consumption.
3. Watch the instruments closely. Decrease engine rpm if oil temperature reaches 225° F or if coolant temperature exceeds 190° F.
4. Operate with a power requirement low enough to allow acceleration to governed speed under any condition.

Pre-Starting Instructions — First Time

Priming Lubricating System

A dipstick oil gauge is located on the side of the engine. The dipstick supplied with 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 type installations and oil pan part numbers.

1. Fill crankcase to "L" (low) mark on dipstick.
2. For GV12 Series Engines, remove pipe plug from top of lubricating oil filter head at port marked "in" for paper element filters.
3. For GNH Series Engines, remove pipe plug on side of lubricating oil pump.
4. Connect a hand or motor-driven priming pump line from source of clean (see Lubricating Oil Specifications) lubricating oil to oil plug boss.
5. Prime until a 30 psi minimum pressure is obtained.
6. Crank engine, with ignition "OFF" for at least 15 seconds while maintaining external oil pressure at a minimum of 15 psi.
7. Remove external oil supply and replace plug in lubricating oil pump or oil filter.
8. 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 engine has run a few minutes it will be necessary to add lubricating oil to compensate for that absorbed by filter element(s) and oil cooler.

Check Hydraulic Governor

1. Many engines used in 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 must be maintained.
2. Oil level in governor sump must be at high-level mark on dipstick.

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

Check Engine Coolant Supply

1. Remove the radiator or heat exchanger cap and check engine coolant supply. Add coolant as needed to completely fill the system.
2. Make 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 3-11.

Starting The Engine

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

Normal Starting Procedure

If engine is equipped with overspeed stop, push "Reset" button before attempting to start engine.

1. Set throttle for idle speed.
2. Disengage driven unit or make sure main disconnect switch is open.
3. Open gas supply shut-off valve.
4. Turn on ignition switch. Press starter button or press "stop-run-start" switch to "start" position.
5. On engines equipped with an oil pressure safety control the momentary start position on ignition switch is utilized as a safety control override circuit (Wiring Diagrams — Section 5). The starter circuit is controlled by a push button switch. The "stop-run-start" switch must be held in the start position until the engine starts and oil pressure comes up to normal. On sentinel safety controls, turn cam lever clockwise for start position. Cam will return to neutral position as soon as engine starts, or when cranking oil pressure is sufficient to raise piston.

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

Warm Up Engine Before Applying Load

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

Instrument Panels

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

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

Never override the governor under normal operation or allow the engine to exceed governed rated rpm during operation.

The Oil Temperature Gauge

The oil temperature gauge normally should read between 180° F and 200° F for best lubrication. Under full-load conditions, a temperature of 225° F 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, 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 increases likelihood of crankcase acids in the lubricating oil which quickly accelerate engine wear.

Keep Water Temperature Between 165° And 195° F

A water temperature of 165° F to 195° F 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 summer and winter, avoid long periods of idling and do whatever else is required to keep water temperatures up to a minimum of 165° F. If necessary in cold weather, use radiator shutters or cover a 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; **200° F maximum engine coolant temperature should not be exceeded.**

Keep An Eye On The 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 bearings are ruined.

Normal Operating Pressures are:

	GNH Series	GV12 Series
At idle — 600 rpm	5-35 psi	15 psi (Min.)
At rated speed	30-70 psi	40 psi (Min.)

Note: Individual engines may vary from above normal pressures. Observe and record pressures when engine is new to serve as a guide for indication of progressive 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 percent for each 1000 feet of altitude above sea level and 1 percent per 10° F above 60° F for a naturally-aspirated engine.

Engine Shut-Down

Let the engine idle a few minutes before shutting it down.

It is important to idle an 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, etc.

Turn Ignition Switch To "Off" Position To Shut Down The Engine

The engine can be shut down by turning off the ignition switch. This grounds the ignition which prevents the spark plugs from firing. On engines equipped with gas shut down valves which are actuated by the ignition system also closes the gas valve shutting off the gas supply to the carburetor. See wiring diagrams — Section 5.

Stop The Engine Immediately If Any Parts Fail

Practically all failures give some warning to the operator before the parts fail and ruin the engine. 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, may result in a ruined crankshaft or allow a block to be ruined by a broken connecting rod.

Never continue to operate the unit after engine indicates that something is wrong.

Cold Weather Protection

1. For cold-weather operation, use of permanent-type ethylene glycol-base antifreeze with rust inhibitor additives is recommended. See Page 5-1.
2. To completely drain cylinder block and head, open petcock or remove drain plug on water pump (V12 Series only), open petcock on side of cylinder block at front and rear of engine and open vent cocks. If an oil cooler, heat exchanger or other "water-cooled" accessory is used, open petcock on unit. Failure to drain any of these units may cause serious damage in freezing weather.

Operator's Daily Report

Make a daily report of engine operation.

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 alotted 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 water or oil temperature.
4. Unusual engine noise.
5. Misfiring engine.

Gas Engine Maintenance

Maintenance is the key to lower operating costs and a gas engine — like any other unit — requires periodic maintenance to keep it running profitably. Failure or inefficient operation usually results in a double loss — reduced profits plus increased repair costs.

Scheduled Maintenance

Preventive maintenance performed on schedule is the easiest as well as the least expensive type of maintenance. It permits the maintenance department to do the work on schedule rather than at unusual hours.

Engine Wear, Engine Work And The Maintenance Schedule

Although it may vary in different applications, engine wear is, for the most part, proportional to engine work.

Engine work, measured in horsepower, is obtained from burning fuel to generate power. Engine application, difficult working conditions, adverse weather and excessive engine loads must also be considered when determining a practical maintenance schedule.

Scheduled Maintenance Operations

This section is arranged so a maintenance program can be set up immediately. Instructions are complete for each operation and necessary forms are shown which may be reproduced and used as check sheets.

The schedule can be applied to all Cummins Gas Engine Units, allowing operators of equipment powered by various models to establish an integrated maintenance schedule by using one form.

Maintenance Operations

Effective maintenance objectives can be accomplished by performing "system" maintenance as outlined on the chart on Page 3-2 and detailed in the following pages. Study this section carefully to familiarize yourself with the procedure. Later, the chart will be needed only as a check-off sheet.

Maintenance intervals given on the chart are based on average operation. To adapt the chart effectively to your specific application, calculate exact hourly figures into the chart.

Major Inspection

At the "F" check, the Cummins Gas Engine unit must have a major inspection. This is not routine maintenance and therefore is described separately on Page 3-21.

The kind of oil used, the efficiency of the filtering system and condition of the engine must be considered in determining when oil needs changing. The above schedule is based upon use of both full-flow and by-pass filters. IF A BY-PASS FILTER IS NOT USED, THE OIL CHANGE PERIOD SHOULD BE REDUCED. The safest method for determining oil change is by lubricating oil analysis; see Section 5.

On continuous power units, the oil change periods suggested in the regular maintenance schedule can be followed safely; however, laboratory analysis may indicate possible lengthening of time between changes for greater economy.

For standby units adjust schedule as follows and with due consideration.

A — weekly, B — monthly, C — every 3 months, D — every 6 months, E — yearly.

Lubricating oil standing in engines on stand-by basis may tend to oxidize and require changing even though it is not dirty. Laboratory testing is a way to determine whether oil is oxidizing under these conditions, and we suggest that oils be checked regularly. After several tests it will be possible to schedule oil changes on stand-by units where the oil is not actually being contaminated due to dirt or working conditions.

Stand-by electric power generating units should be started once each week in locations where ambient temperature remains below 70° F and conditions of high humidity exist. Start engine and bring unit up to normal operating temper-

Maintenance Schedule

*Under extremely dust and/or high humidity conditions, perform at more frequent intervals.

			A	B	C	D	E	F
LUBRICATING SYSTEM	Check Engine Oil Level		✓	✓	✓	✓	✓	✓
	Check Leaks and Correct		✓	✓	✓	✓	✓	✓
	Change Engine Oil				✓	✓	✓	✓
	Change Engine Filter (Full-Flow)				✓	✓	✓	✓
	Change Hydraulic Governor Filters				✓	✓	✓	✓
	Record Oil Pressure				✓	✓	✓	✓
	Lubricate Electrical Equipment				✓	✓	✓	✓
	Change By-Pass Filter Element				✓	✓	✓	✓
	Lubricate Water Pump and Fan Hub						✓	✓
FUEL SYSTEM	Check Gas Leaks and Correct		✓	✓	✓	✓	✓	✓
	Check Hydraulic Governor Oil Level				✓	✓	✓	✓
	Adjust Valves/Crossheads					✓	✓	✓
	Change Hydraulic Governor Oil						✓	✓
	Lubricate Hydraulic Governor Motor						✓	✓
IGNITION SYSTEM	Clean and Tighten Electrical Connections	*B		*	✓	✓	✓	✓
	Clean and Check Spark Plugs					✓	✓	✓
	Check Wiring Harness					✓	✓	✓
COOLING SYSTEM	Fill Cooling System. Check Leaks and Correct		✓	✓	✓	✓	✓	✓
	Check Heat Exchanger Zinc Plugs				✓	✓	✓	✓
	Check and Adjust Belt Tension				✓	✓	✓	✓
	Check Engine Coolant and Corrosion Resistor				✓	✓	✓	✓
	Check Auxiliary Water Pump				✓	✓	✓	✓
	Check Fan Hub and Drive Pulley					✓	✓	✓
	Check Thermostats					✓	✓	✓
	Clean Heat Exchanger and Cooling System		SPRING AND FALL					
	Clean Auxiliary Coolant Heater		ONCE A YEAR					
AIR SYSTEM	Check Air Cleaner Oil Level		✓	✓	✓	✓	✓	✓
	Clean Pre-Cleaner/Dust Cup		✓	✓	✓	✓	✓	✓
	Clean Composite/Dry-Type Cleaner Element	*A	*	✓	✓	✓	✓	✓
	Change Air Cleaner Oil	*A	*	✓	✓	✓	✓	✓
	Clean Crankcase Breather	*B		*	✓	✓	✓	✓
	Clean Tray Screen	*B		*	✓	✓	✓	✓
	Check Air Piping and Vent Tube Connections	*B		*	✓	✓	✓	✓
	Check Inlet Air Restriction	*C			*	✓	✓	✓
	Replace Composite/Dry-Type Cleaner Element	*C			*	✓	✓	✓
	Clean Oil Bath Air Cleaner	*D				*	✓	✓
GENERATOR POWER	Clean Exciter Regulator	*A	*	✓	✓	✓	✓	✓
	Check Connections and Gauges			✓	✓	✓	✓	✓
	Check for Dust			✓	✓	✓	✓	✓
	Check Intake and Exhaust Openings			✓	✓	✓	✓	✓
	Check Bearing Temperature			✓	✓	✓	✓	✓
	Check Slip Ring and Brushes				✓	✓	✓	✓
	Check Brush Pressure or Replace					✓	✓	✓
	Inspect Windings and Electrical Connections					✓	✓	✓
	Flush Grease Cavity		5000 Hours					
OTHER MAINTENANCE	Check Operator's Report		✓	✓	✓	✓	✓	✓
	Check Vibration Damper Alignment					✓	✓	✓
	Clean Electric Units and Tighten Connections					✓	✓	✓
	Check Alternator/Generator Brushes and Commutator					✓	✓	✓
	Clean Engine					✓	✓	✓
	Tighten Mounting Bolts and Nuts					✓	✓	✓
	Check Engine Blow-By						✓	✓
	Check Crankshaft End Clearance						✓	✓

As applicable to your unit, check each operation on check mark as performed.

ature and run for approximately thirty minutes. Check for corrosion on all relays and switch terminals. Correct as necessary.

On units in location where ambient temperature is normally at or above 70° F, perform starting procedure as above every two weeks.

The above procedures are only recommendations; therefore, the operator must take into consideration the environment of unit installation.

Suggested Hourly Intervals For Checks

Engine Series	Check Performed					
	A	B	C	D	E	F
GNH	Daily	200	400	800	1600	6400
GV12	Daily	250	500	1000	2000	6000

Lubricating System Maintenance

Lubricating oil performs four functions in an engine.

1. Reduces friction (heat and wear) by providing a film between bearing surfaces.
2. Scavenges by picking up carbon and other small particles, carrying them to the oil filter where they are taken out of circulation.
3. Cools pistons, liners and bearings and absorbs heat from the engine. This heat is then dissipated by radiation from the pan and by an oil cooler. It is important that air be free to flow around the oil pan.
4. Completes the seal of rings to pistons and cylinder walls.

There are two broad classes of lubrication failures:

Those caused by running an engine without or low on oil resulting in seizures of pistons or bearings. Failures due to poor or marginal lubrication, from low oil pressure, dilution, partially clogged oil passages and dirty or clogged lubricating oil filters or improper clearances.

Check Engine Oil Level (Daily)

Check oil level with dipstick oil gauge located on the engine. For accurate readings, oil level should not be checked for approximately 30 minutes after engine shutdown. Keep dipstick with the oil pan with which it was originally supplied. Keep oil level as near "H" mark as possible. Fig. 3-1.

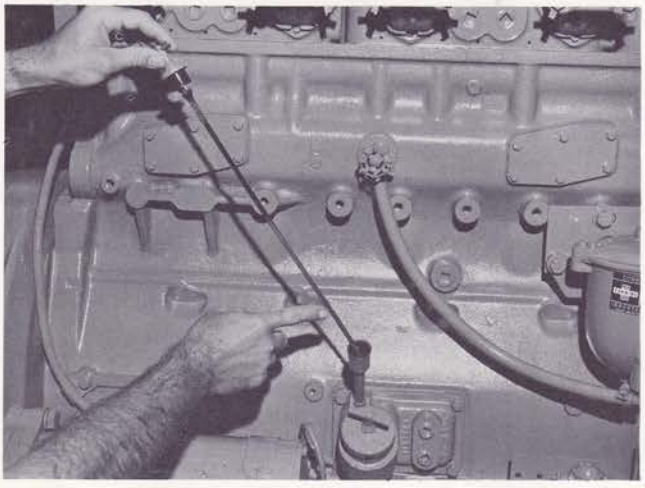


Fig. 3-1. Checking engine oil level NG2

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

Check Leaks And Correct (Daily)

Check for evidence of external oil leakage. Tighten capscrews, fittings, connections or replace gaskets as necessary to correct. Check oil dipstick and filler tube caps. See that they are tightened securely.

Change Engine Oil (C Check)

The kind of oil used, the efficiency of the filtering system and the condition of the engine must be considered in determining when oil needs changing.

The schedule for oil changes is based on average crankcase and filter capacity when both full-flow and by-pass filters are used.

Note: If a by-pass filter is not used, the oil change period must be reduced by one-third.

The safest method for determining oil change period is by lubricating oil analysis. See "Lubricating Oil Specifications", Page 5-2.

1. Remove pipe plug from bottom of oil pan; drain oil in a suitable container. Do not install plug until all oil has drained from engine.

   Caution: On engines equipped with double sump oil pans, both sumps must be drained when changing oil.

2. Install drain plug and torque to 60/70 ft. lb., fill crankcase to high level on dipstick.

Change Engine Full-Flow Filter (Paper Element) (C Check)

1. Remove drain plug from filter case and allow oil to drain.
2. Loosen center bolt or remove capscrews and remove filter case from filter head. Fig. 3-2.
3. Withdraw filter element, inspect, then discard.

   Note: Inspect for metal particles. If metal is found, a check of connecting rods and main bearings should be made at once.

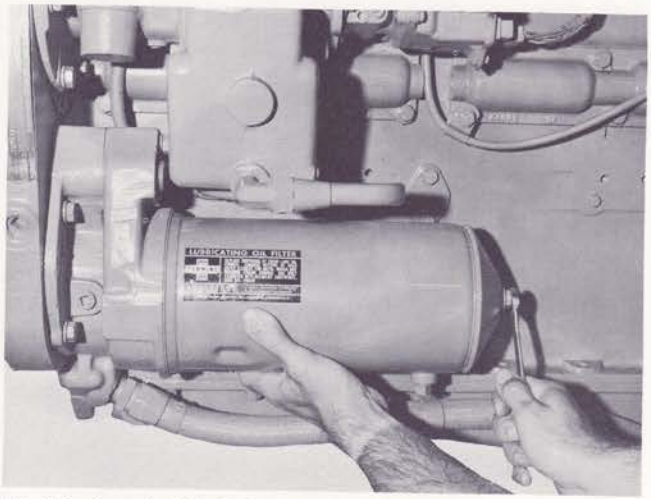


Fig. 3-2. Removing lubricating oil filter center bolt NG3

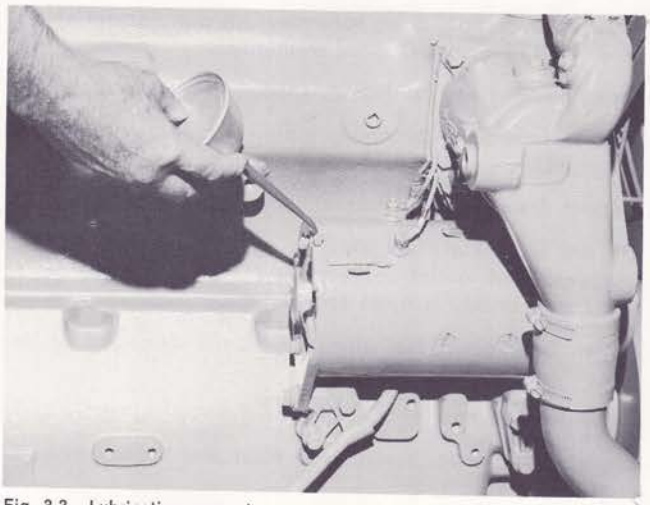


Fig. 3-3. Lubricating generator N11934

4. Remove seal ring from filter head and discard.
5. Clean filter case thoroughly.
6. Check to make sure element seals are in place and install new element over pilot and/or valve assembly in bottom of filter case.
7. Position new seal ring in place; assemble filter case to head and tighten center bolt (if used) to 30/35 foot-pounds.
8. Check oil level. Run engine and check for leaks.
9. Recheck engine oil level; add oil as necessary to bring oil level to "H" mark on dipstick.

   Note: Always allow oil to drain back to oil pan before checking level.

Record Oil Pressure (C Check)

Start the engine and increase speed until the oil temperature gauge reads 140° F. 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 lubricating oil pump, bearings, shafts, etc. These readings are most accurate and reliable when taken immediately after an oil change.

Lubricate Electrical Equipment Alternator Or Generator — Battery Charging (C Check)

Lubricate alternator or generator by adding 5 or 6 drops of SAE 20 lubricating oil to oil cup, Fig. 3-3, or by turning down grease cup a maximum of one turn.

Caution: Avoid over-lubrication which is harmful to insulation.

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

When a generator or alternator filter is used, clean filter screen at each lubrication period. Remove filter screen and wash in an approved cleaning solvent; blow dry with compressed air and reassemble.

Electric Cranking Motor

Add 5 or 6 drops of clean SAE 30 lubricating oil to cranking motor bearings.

Air Or Natural Gas Cranking Motor

The air or natural gas cranking motor may be equipped with grease fittings, felt wicks with lubricating oil caps, outer grease cups or air line lubricators. Follow manufacturer's recommendation for procedure, interval and lubricant specification. See Section 5.

Change Engine By-Pass Filter Element (C Check)

Change by-pass filter elements on engines so equipped as follows:

Caution: Never use a by-pass filter in place of a full-flow filter.

1. Remove drain plug from bottom of housing and drain oil.
2. Remove clamping ring capscrew and lift off cover.

3. Unscrew pack hold-down assembly; lift out element(s) and hold-down assembly. Discard element(s).
4. Clean housing and hold-down assembly in solvent.
5. Inspect hold-down assembly spring and seal. Replace if damaged.
6. Inspect drain plug and connections. Replace plug.
7. On the Cummins Fleetguard by-pass filter, check orifice plug inside oil outlet connection; blow out with air jet to make sure orifice is open and clean.
8. Check filter cover "O" ring. Replace if damaged or deteriorated.
9. Install new element(s) in housing.
10. Replace hold-down assembly in filter and tighten down to stop.
11. Position cover "O" ring seal.
12. Install cover and clamping ring; tighten capscrew until clamping lugs come together.
13. Add enough extra oil to crankcase to fill case and element.
14. Loosen vent plug in cover and start engine. Close vent plug when oil reaches vent. Shut down engine and check oil level; add oil as necessary.

Lubricate Water Pump And Fan Hub (C Check)

1. If water pump and fan hub contain grease fittings or plugs through which grease may be applied, give one "shot" (approx. 1 tablespoon) each "E" check.
2. Completely disassemble, clean and inspect at each third "E" check. Pack bearings and fill water pump and fan hub bearing cavities 1/2 to 2/3 full of high quality industrial grease meeting specifications in Section 5.
3. Remove grease fittings and re-install pipe plugs.

Fuel System Maintenance

Check For Gas Leaks And Correct (Daily)

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

1. Apply liquid soap around regulator to check for leaking gaskets.
2. Check for leaks at all gas line connections by soaping.

Check Hydraulic Governor Oil Level (C Check)

If the engine has a hydraulic governor, use clean lubricating oil of the same grade as used in the engine in the governor sump.

Keep oil to high level mark on dipstick oil gauge. Fig. 3-4.

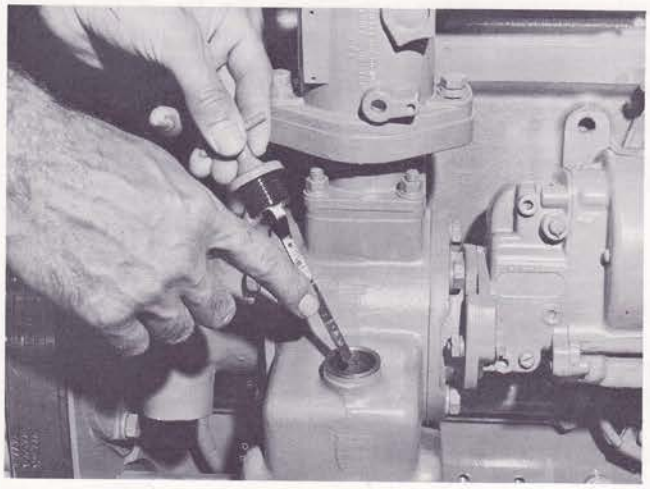


Fig. 3-4. Checking hydraulic governor oil level NG4

Adjust Valves (D Check)

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

Adjust valves at "D" checks. Final adjustment must be made when the engine is at operating temperature. The procedure is as follows:

Timing Mark Alignment

1. Bar engine in direction of rotation until No. 1 VS mark appears. See Fig. 3-5 through 3-6 for location of valve set marks. In this position, both intake and exhaust valves will be closed for cylinder No. 1. If not, rotate engine one complete revolution.

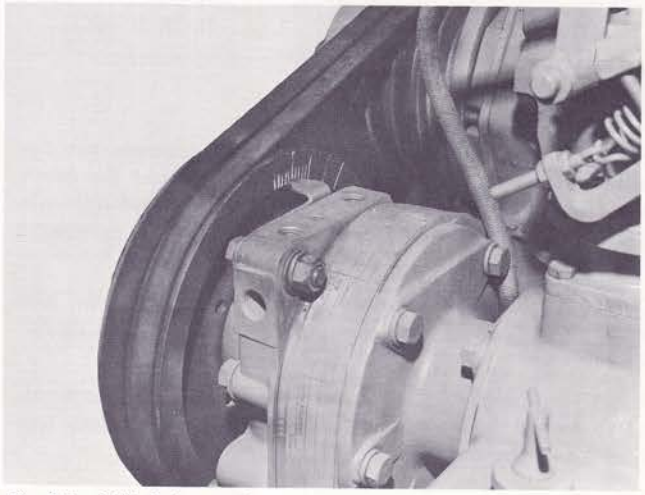


Fig. 3-5. GNH timing marks NG5

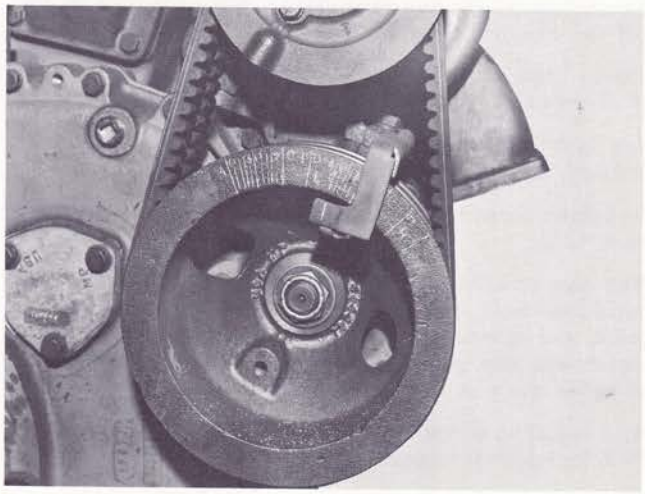


Fig. 3-6. GV12 timing marks NG6

2. Adjust crossheads and valves of No. 1 (No. 1L on V12) cylinder as explained in succeeding paragraphs. Turn crankshaft in 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.
3. Firing order is as follows:

Table 3-1: Engine Firing Order

Engine Series	No. of Cylinders	Right-hand Rotation	Left-hand Rotation
GNHC	4	1-2-4-3	1-3-4-2
GNH	6	1-5-3-6-2-4	1-4-2-6-3-5
GV12 & GNVH	12	1L-4R-3L-2R-5L-1R-6L-3R-4L-5R-2L-6R	1L-6R-2L-5R-4L-3R-6L-1R-5L-2R-3L-4R

Facing the V12 series 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. NH Series Engine Cylinders are numbered from the end opposite the flywheel.

4. Continue turning crankshaft in 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

On engines having four-valve heads, it is necessary to adjust the crossheads before making valve adjustments.

1. Loosen valve crosshead adjusting screw locknut and back off screw one turn.
2. Use light finger pressure at "A" to hold crosshead in contact with valve stem "B". Fig. 3-7.
3. Turn down crosshead adjusting screw until it touches valve stem "C".
4. With new crossheads and guides, advance screw an additional one-third of one hex (20°) to straighten stem in guide and compensate for slack in threads. With worn crossheads and guides, it may be necessary to advance screw as much as 30° to straighten stem in guide.
5. Hold adjusting screw in this position and tighten locknut to 25/30 foot-pounds torque.
6. Check clearance between crosshead and valve spring retainer with wire gauge. There must be a minimum of 0.020 inch clearance at this point.

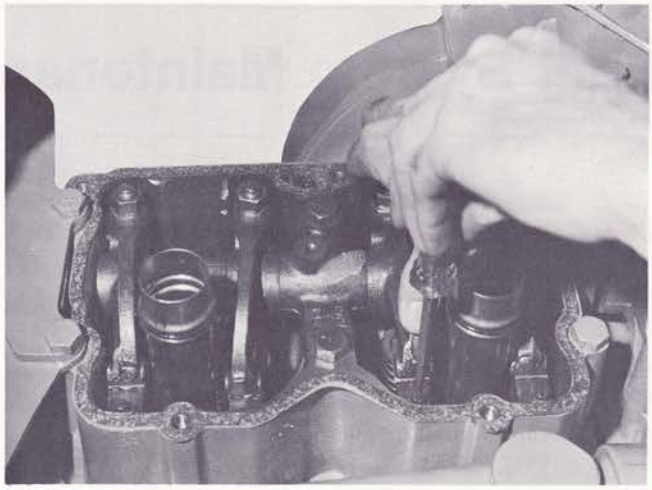


Fig. 3-7. Crosshead adjustment NG7

Valve Adjustment

1. Loosen locknut and back off the adjusting screw. Insert feeler gauge between rocker lever and top of the valve stem or crosshead. Turn the screw down until the lever just touches the gauge, and lock the adjusting screw in this position. Tighten the locknut to 70/80 foot-pounds torque.
2. Always make final valve adjustment with the engine at operating temperature. Valve clearances are shown in Table 3-2.

Table 3-2: Valve Clearance At Oil Temperature

Engine Series	Intake Valves 70° F	Intake Valves 140° F	Exhaust Valves 70° F	Exhaust Valves 140° F
GNHC/ GNH	0.016"	0.014"	0.029"	0.027"
GV12/ GNVH	0.016"	0.014"	0.029"	0.027"

Change Hydraulic Governor Oil (E Check)

Use the same grade oil as used in the engine. See "Lubricating Oil Specifications". Section 5.

Note: When temperatures are 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.

Lubricate Hydraulic Governor Motor (E Check)

BEARING LUBRICATION: Under normal, intermittent operation, the motor bearings should be lubricated — through the oil cup provided — every six months with Gulfcrest A or Stanoil No. 18, or their equivalent.

GEAR LUBRICATION: The speed reduction gear housing of a new motor is filled with sufficient lubricant to last for a one-to two-year period. When lubricating, clean out the old grease and refill the gear housing ¾ full of one of the following greases, or their equivalents, depending upon the service in which the unit is used:

— 65 degrees F to 32 degrees F — use Bodine LG2 or Beacon No. 325.

32 degrees F to 212 degrees F — use D. A. Stuart H.M.P. No. 1 or Hodson No. 2-1000.

Above 212 degrees F — Use Dow Corning No. 44; put grease directly on gears.

Cooling System Maintenance

Many operators have been shocked to find water in the crankcase and to learn that it got there through "pin holes" or pitted areas that started on the water side of the 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 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 corrosion resistor as described in the following paragraphs.

Aeration refers to the air bubbles which may be drawn into the radiator core tubes, then into the water pump and engine. The worst effect of aeration is the loss of water pump prime due to an accumulation of air resulting in complete flow stoppage. Entrained air promotes accelerated internal corrosion. Entrained air in the coolant will increase the temperature differential from the combustion gases to the water due to the 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 the 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 at initial fill, 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 air or refilled after a short period of operation to purge air from the coolant.

Fill Cooling System, Check Leaks And Correct (Daily)

Keep cooling system completely filled. Check the coolant level daily. Investigate for cause of coolant loss. Recheck the level after engine reaches normal operating temperature. At operating temperature the thermostat is open and water is free to circulate to all parts of the system and fill all air pockets.

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

Check Heat Exchanger Zinc Plugs (C Check)

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

Check And Adjust Belt Tension (C Check)

The service life of belts used to drive fans, water pumps, and battery-charging generators or 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. Following are the most important rules to be observed to extend belt life:

Installation

1. Always shorten distance between pulley centers so belt can be installed without force. Never roll or tighten a belt over the pulley and never pry it on with a tool such as a screwdriver. Both of these methods will damage belts and cause early failure. Diagonal cuts on a failed belt indicate that the failure was caused by rolling a tight belt over the pulley. Cuts from prying a belt in place may be either diagonal or vertical.
2. Always replace pairs of belts in complete sets to prevent early failure and to provide efficient operation. Belt riding depth in groove should not vary over $\frac{1}{16}$ inch on matched belt sets.
3. Pulley misalignment must not exceed $\frac{1}{16}$ inch for each foot of distance between pulley centers.
4. Belts should not bottom on the pulley grooves nor should they protrude over $\frac{3}{32}$ inch above top edge of groove.
5. Do not allow belts to rub any adjacent parts.

Belt Tension

1. Tighten belts until a reading of 90 to 110 pounds is indicated on ST-968 Belt Tension Gauge.
2. If belt tension gauge is not available, tighten belts so that the pressure of the index finger will depress belt as shown in Table 3-3. The index finger should be extended straight down from the hand; in this manner, force will be approximately 13 pounds.

Re-Tensioning New Belts

All new belts will loosen after running for an hour or more and must be retensioned. Retension as described under "Belt Tension".

Table 3-3: Belt Tension

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

Belt Care Or Maintenance

Belts often slip or squeak because of the glaze which forms due to dirt or steam cleaning.

To clean a belt, wipe it off with belt lubricant or hydraulic brake fluid. Cleaning in this manner will eliminate most cases of squeaking.

Do not tighten belt beyond figures given to eliminate belt squeak. Squeak does not necessarily mean belt slippage. Tightening to excess may damage bearings as well as belts.

Check Engine Coolant

Corrosion Resistor

Periodic tests of engine coolant should be made to insure the frequency of corrosion resistor servicing or concentration of chromate is adequate to control corrosion for the specific condition of operation.

When using plain water in a cooling system with a corrosion resistor (with chromate-type element) or when treating with chromate compounds, the concentration of effective inhibitor dissolved in the coolant can be measured by the color comparison method. Cummins Coolant Checking Kit ST-993 is available from Cummins Distributors for this check.

Most commercially available antifreezes contain a coloring dye which renders the color comparison method ineffective. When colored antifreezes are present in the coolant, effective control of corrosion can be determined by inspecting the coolant for accumulation of reddish-brown or black, finely granulated dirt. A small amount of corrosion produces significant quantities of these corrosion products; therefore, if corrosion resistor servicing is adjusted at the first indication of increased accumulation of these products, actual corrosion will be limited to a negligible amount.

Examine the sump of corrosion resistor for these "dirt" materials at time of servicing or inspect for them in a small sample of coolant drained from the bottom of the radiator after allowing coolant to settle.

Note: Use of chromate compound (added to the coolant without a corrosion resistor) with antifreeze is not recommended.

pH Value Test:

1. Separate tubes marked "pH" are furnished in the test kit. Select a tube and fill to mark with coolant to be checked.
2. Add eight drops of the pH Reagent to tube and mix thoroughly.
3. Insert the tube in the comparator, hole marked "pH".
4. Compare color of test sample with color standards on either side. Preferred range is 8.3 to 9.5.
5. Wash out test tubes after each test and keep reagent container caps in place.

Chromate Concentration Test:

1. Draw sample of coolant and pour into tube marked "chromate".
2. Insert sample into comparator hole marked "chromate".
3. Compare color of test sample with color standards on either side. Preferred range is 100 to 150 grains per gallon or 1700 to 2500 parts per million (ppm).
4. Wash out test tubes after each test.

Adjusting Coolant To Specifications

If the above tests indicate that the coolant is outside specifications, make an adjustment immediately to prevent corrosion.

If the Cummins Corrosion Resistor is used, change the element or elements and run engine four to six hours; then check coolant again; in extreme cases it may be necessary to change element a second time. However, the latter condition may be due to larger coolant system than corrosion resistor was designed to treat; note reference on resistor label.

If chromate compounds are used, add enough compound to bring concentration to proper level. Normal usage is one-half ounce chromate for each one gallon of coolant.

Table 3-4: Comparison Units Chromate Concentration

Ounces Per Gallon (Oz./Gal.)	Parts Per Million (PPM)	Grains/Gallon (Gr./Gal.)
0.16	850	50
0.32	1700	100
0.50	2550	150

Change Corrosion Resistor (C Check)

Change corrosion resistor element at each "C" check unless facilities are available for testing. See "Check Engine Coolant", preceding. Change element when concentration drops below 100 grains per gallon.

To Change Element:

1. Close shut-off valves on inlet and drain lines. Unscrew drain plug at bottom of housing.
2. Remove cover capscrews and cover.
3. Remove plate securing element(s); lift element(s) from housing and discard. Remove plate below element.
4. Lift spring from housing.
5. Polish plates. If less than half of metal plates can be exposed by polishing, install new plates.
6. Replace spring and lower plate.
7. Remove transparent bag from new element(s); install element(s) in housing.
8. Replace upper plate, gasket and cover.
9. Replace drain plug and open shut-off valves in inlet and drain lines.

Heat Exchanger Systems

1. Determine complete capacity of cooling system over and above that of engine itself.
2. Add one-half ounce of Nalco 38, Dearborn Formula 517 or equivalent chromate treatment for each gallon of water over that stated in Step 1.
3. Start unit and check pH value and chromate concentration after solution is thoroughly mixed.
4. The single-element corrosion resistor will maintain the proper chromate concentration for systems up to 16 gallons coolant capacity. If above this capacity, it is recommended that treated "make-up" coolant be added to the system. See "Check Engine Coolant" preceding.

Check Auxiliary Water Pump (C Check)

Maintenance and service periods for auxiliary water pump must necessarily be adjusted 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.

Accelerated maintenance periods are necessary to compensate for undesirable operating conditions.

1. Check all pipes and fittings for leaks. Tighten as necessary.
2. Remove cover plate to drain pump.
3. Lift out rubber impeller and check for cracks, breaks, or other damage.

   Note: If impeller is subjected to extreme temperatures, either hot or cold, impeller life is shortened and inspection periods must be adjusted accordingly.
4. Clean out all sediment and install new impeller if necessary.
5. Install new cover plate gasket and install cover on pump. Use a 0.015 inch gasket to maintain proper impeller-to-cover clearance.
6. The auxiliary water pump is self-priming.

Check Thermostats (D Check)

Cummins Engines are equipped with either low (160/175° F) or high (170/185° F) and in a few cases higher range (180/195° F) thermostats, depending on engine application.

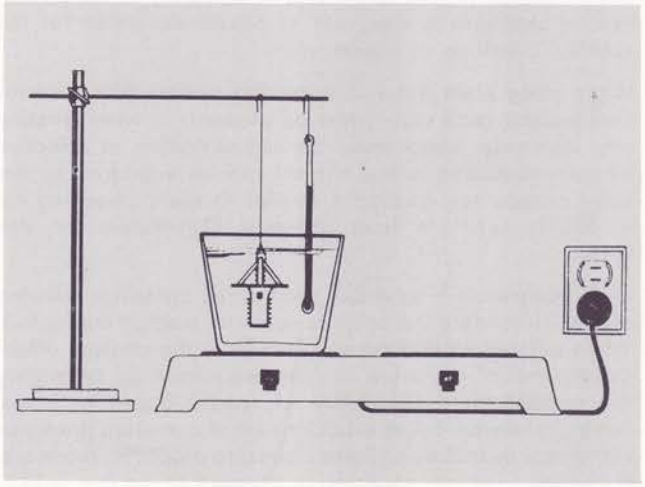


Fig. 3-8. Testing thermostat N10809

The lower value indicates where thermostat starts to open and the higher value where it is fully open. Check stamping on thermostat; install same range new thermostat as that removed.

The opening and closing of thermostats can be checked against a thermometer while immersed in water as the water is brought up to temperature by heating. Fig. 3-8.

Check Fan Hub And Drive Pulley (D Check)

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

Tighten fan capscrews each "D" check. Check drive pulley for looseness or wobble, and if necessary, remove fan and hub and tighten the shaft nut. If fan hub wobble is found check bearings for excessive wear. Tighten the bracket capscrews.

Clean Cooling System (Spring And Fall)

The cooling system must be clean to do its work properly. Scale in the system slows down heat absorption from water jackets and heat rejection from the coolant supply. Use clean water which will not clog any of the small passages in the block or head.

Clean out radiator cores, heater cores, oil cooler, and engine block passages which have become clogged with scale and sediment by chemical cleaning, neutralizing and flushing.

Pressure Flushing (Yearly)

Flush the cooling system and block when anti-freeze is added or removed, or before installing a Corrosion Resistor on a used engine.

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

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

Clean Engine Coolant Heater

1. Disconnect electrical supply.
2. Drain cooling system.
3. Disconnect coolant inlet and outlet connections.
4. Remove capscrews and lockwashers securing head to heater assembly; lift off head and discard gasket.
5. Unscrew heating element from body.
6. Remove all lime deposit and sludge from element and housing. Check for free action of gate valve.
7. Install heating element in housing.
8. Position head with new gasket to body; secure with lockwashers and capscrews.
9. Connect coolant inlet and outlet connections.
10. Fill cooling system; connect electrical supply; start engine and check for leaks.

Air System Maintenance

When engines operate under extremely dusty conditions, adjust the maintenance intervals indicated on Page 3-2 and 3-3 as necessary.

Check Air Cleaner Oil Level (Daily)

Check oil level in oil bath air cleaner to be sure oil level is at indicated mark. Fig. 3-9. During wet weather and in winter months, excessive moisture in air cleaner oil sometimes causes the cleaner to become flooded and results in oil pullover or plugging of the bottom air cleaner screen. Add or change oil as necessary. This is especially important if oil bath cleaner is the only cleaner on the engine.

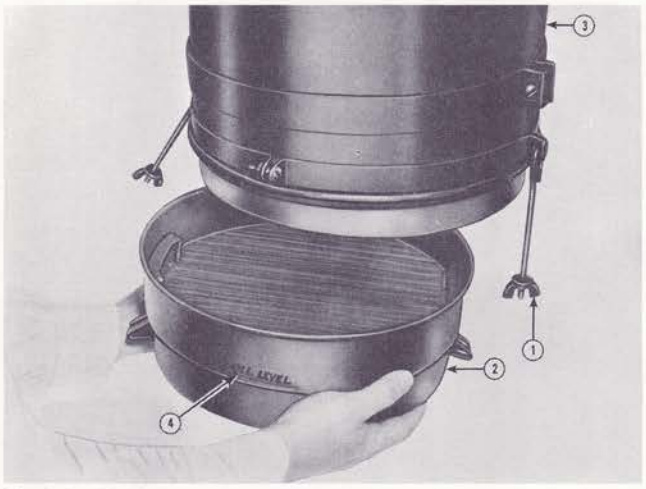


Fig. 3-9. Checking air cleaner oil level N11001

Clean Pre-Cleaner And Dust Pan (Daily)

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

Clean Composite/Dry-Type Cleaner Element (B Check)

The paper element in a dry-type air cleaner may be cleaned several times by using compressed air. Do not hold air jet too close to paper element or element will be damaged.

When installing the element, make sure it seats on the gasket at the air cleaner outlet end. Fig. 3-10.

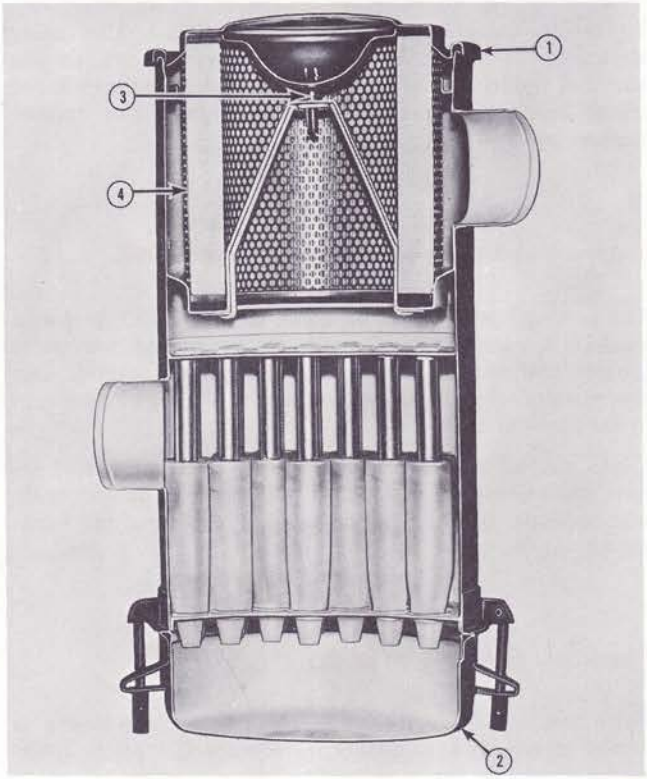


Fig. 3-10. Air cleaner — composite dry type N11004

Caution: Holes in the element of a dry-type air cleaner render cleaner inoperative, and the element must be replaced.

Composite cleaners combine a centrifugal cleaning stage with a paper filter element. Fig. 3-11.

Air enters the cleaner through a hooded inlet on the side of the cleaner and passes into a tube. Vanes on the tube impart a cyclonic twist to the air which throws dust particles to the outside.

The separated dust collects in a cup at bottom of cleaner while clean air passes up through center of tube to a paper filter. The paper filter then removes any small particles remaining in the air.

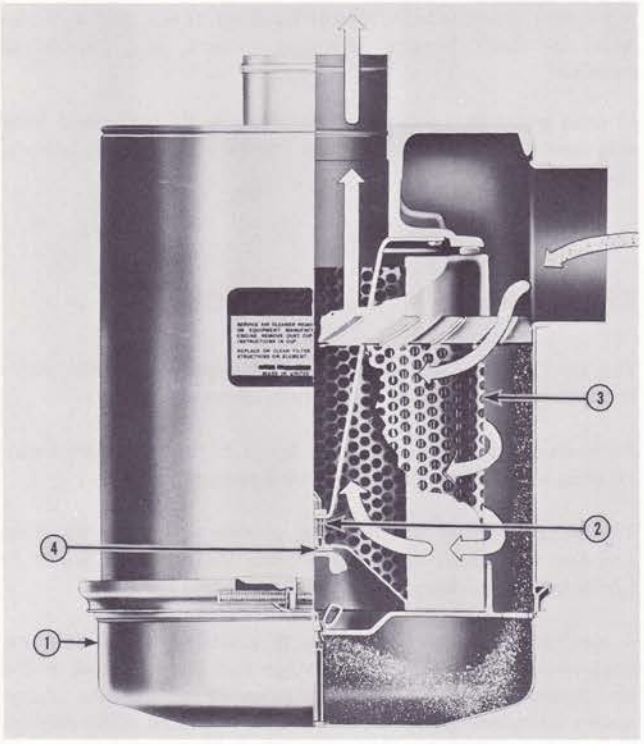


Fig. 3-11. Air cleaner — centrifugal type N11005

Before disassembly, wipe dirt from cover and upper portion of air cleaner. To clean composite-type:

1. Loosen clamps and remove cover.
2. Unscrew wing bolt holding inner cover and element in position; remove element carefully so loose dirt will not fall into chamber.
3. Remove dust cap and clean.
4. Tap side or bottom ring of element with palm of hand or soft mallet.
5. Blow out element from clean-air side with compressed air.

   Caution: Air pressure should not be more than 100 psi to avoid rupturing element. Do not concentrate air pressure in one spot.
6. Wash element with non-sudsing household detergent and warm water (120-140 F). Dry with compressed air (40 psi).
7. Remove retainer clamp. Separate upper and lower bodies; remove "O" ring.
8. Hold element up to light and inspect tubes for dust deposits. Remove dust with stiff fiber brush.
9. Inspect gaskets and "O" rings; discard if worn or mutilated.
10. Inspect element after cleaning to be sure there are no holes in filter.
11. Position upper body with gasket on lower body; secure with retainer clamp.
12. Install element and inner cover in position.
13. Be sure gasket washer is in place under wingnut before tightening.
14. Install cover.
15. Install dust cap.

Change Air Cleaner Oil (B Check)

Before dirt build-up reaches ½ inch, remove oil cup from cleaner. Discard oil and wash cup in cleaning solvent or fuel oil.

Fill oil cup to level indicated by bead on its side with clean, fresh oil and assemble to 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.

Clean Crankcase Breather (C Check)

Wire Mesh Element

1. Remove wing nut, flatwasher and seal from center stud securing cover to breather body. Lift off cover.
2. Lift out upper screen, wire-mesh element and lower screen.
3. Wash screens and wire mesh element in cleaning solvent and dry with compressed air.
4. Wipe out breather body and cover with a clean cloth. In-

Fig. 3-12. Installing clean wire-mesh element NG8

spect sealing gasket; remove and replace if damaged.

5. Insert lower screen, wire-mesh element, Fig. 3-12, and upper screen in breather body. Position cover over center stud; secure with seal, flatwasher and wing nut.

Screen Element

1. Remove capscrews, lockwashers and flatwashers securing cover to breather body; lift off cover and discard gasket.
2. Lift out screens and baffle from breather body.
3. Wash screens and baffle in cleaning solvent and dry with compressed air. Wipe out breather body with a clean cloth.
4. Insert baffle and screens in breather body; position cover with new gasket on breather body. Secure cover with flatwashers, lockwashers and capscrews.

Paper Element

Dry-type crankcase breathers containing a chemically treated paper element are used on naturally aspirated engines. Install new element — DO NOT ATTEMPT TO CLEAN. DO NOT USE ON ENGINES WITH PRESSURIZED SYSTEMS.

Clean Air Cleaner Tray Screen (C Check)

1. Remove tray screen from air cleaner body.
2. Immerse the tray screen in kerosene or cleaning solvent. Slosh the screen up and down several times. Dry thoroughly with compressed air, and reassemble to air cleaner.

Note: If the tray screen is extremely dirty or coated with varnish, it may be necessary to singe the screen with a flame. Be careful not to melt tin plate on screens.

Check Air Piping And Vent Tube (C Check)

Check Air Piping

Check air intake piping from air cleaner to carburetor. Check for loose clamps or connections, cracks, punctures, or tears in hose or tubing, collapsing hose or other damage. Tighten clamps or replace parts as necessary to insure an airtight air intake system. Make sure that all air goes through the air cleaner.

Check Air And Vapor Line Connections

Check all air and vapor lines and connections from 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.

Check Inlet Air Restriction (D Check)

The best method for determining dry-type air cleaner maintenance periods is through air restriction checks.

Air restriction readings may be taken at the air cleaner outlet pipe or cleaner body tap, if so equipped.

The adapter must be mounted perpendicular to air flow, and the restriction must not exceed 20 inches of water or 1.5 inches of mercury when checked at this location.

A mechanical restriction gauge is available to indicate excessive air restriction. This gauge can be mounted in the air cleaner outlet or on the instrument panel. The gauge shows completely red in the indicator window when restriction reaches 20 inches of water. Fig. 3-13.

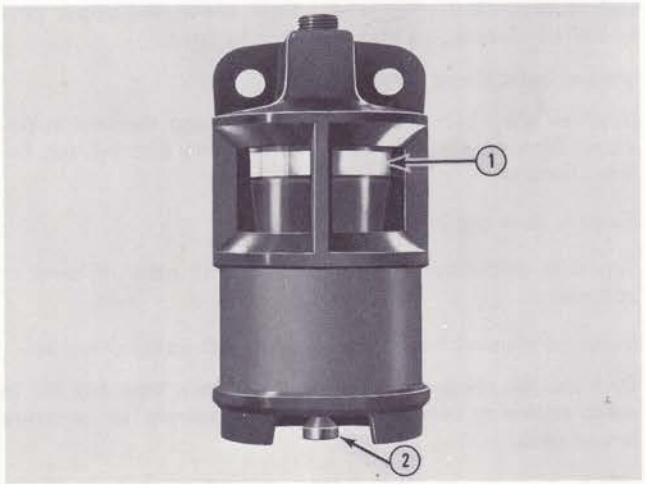


Fig. 3-13. Mechanical air inlet restriction gauge CGS20

Vacuum switches are available which actuate a warning light on the instrument panel when air restriction becomes excessive.

Note: Air restriction checks should not be used to determine maintenance periods for oil-bath air cleaners. Before dirt build-up reaches ½ inch maximum height, perform maintenance as described under "Change Air Cleaner Oil".

Replace Composite/Dry-Type Cleaner Element (D Check)

Composite-Type Cleaner Element

Replace the paper element in composite-type air cleaners when breaks appear or if air restriction is still excessive after element has been cleaned. To change element:

1. Remove cover; lift out element. Do not allow dust from element to fall back into air cleaner. Discard element.
2. Inspect "O" rings or gaskets. Replace as needed.
3. Insert new element and tighten cover securely.

Dry-Type Cleaner Element

Elements that have been cleaned several times will finally clog and air flow to the engine will be restricted. After cleaning, check restriction as previously described and replace the element if necessary.

Holes, loose end seals, dented sealing surfaces and other forms of damage require immediate element replacement.

Clean Oil Bath Air Cleaner (E Check)

Perform At D Check Under Extreme Dusty Conditions

Steam

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

Solvent-Air Cleaning

This method of cleaning requires a 55 gallon drum and a source of air pressure. Any good commercial solvent may be used.

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

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

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

   If the screens cannot be thoroughly cleaned by either of the above methods, or if body is pierced or otherwise damaged, replace with new air cleaner.

Power Generator Maintenance

Caution: Always shut down unit and be sure main disconnect switch is open. Disable automatic starting circuits on units so equipped before performing any maintenance operations.

Clean Exciter Regulator (B Check)

Dirt and dust, especially with iron content, will conduct electricity between two points of different electrical potential. Therefore the exciter regulator must be kept free from excessive amounts of dirt and dust.

Remove cover and blow out dirt and dust with low-pressure moisture-free compressed air or by carefully wiping with a clean lint-free cloth.

Check Connections And Gauges (B Check)

Check all wires for frayed or damaged insulation. Replace as necessary.

Check all connections to be sure they are tight.

Check all gauges for proper operation. Replace any defective gauge.

Check For Dust (B Check)

Inspect generator winding, brushes, brush holders and slip rings for dirt and dust. Blow out contamination with moisture-free compressed air. Wipe slip rings with a lint-free cloth.

Check Intake And Exhaust Openings (B Check)

Check area around generator air intake and exhaust openings to be sure no foreign material has dropped where it can be drawn into intake or block air exhaust.

Check Bearing Temperatures (B Check)

Place hand on bearing hub. If hub is too hot to touch, check temperature with thermometer. If temperature exceeds 195° F, shut down generator and replace bearing.

Check Slip Rings And Brushes (C Check)

If slip rings are dirty, clean with lint free cloth. Check brushes for cracks, wear, loose connections and free movement in brush holder. Correct as necessary.

Check Brush Pressure

Brush pressure is applied by the adjusting spring on the brush holder. Pressure should be maintained at from 9 to 12 ounces for the 400 and 500 generators, and from 16 to 20 ounces for the 680 generators. Check with a spring scale.

Replace Brushes (If Necessary)

If brushes are worn shorter than 5/8 inch, replace with new brushes. Replacement brushes must be fitted to the curvature of slip rings before placing unit in operation, as follows:

1. Place fine sandpaper (#0 or #00) with back held firmly to the slip rings and allow the brush to ride on the cutting side.
2. Pull the sandpaper around the slip rings, making sure that where it passes under the brush it follows exactly the slip ring contour. The last few passes should be taken in the same direction in which the unit rotates.
3. Blow out excessive carbon dust.

Electrical Connections

Inspect for loose electrical connections. Inspect generator wires for cracked, frayed, or oil-soaked insulation. Tighten or replace as necessary.

Mounting Bolts

Tighten all mounting nuts and bolts.

Inspect Windings

If inspection shows that varnish coatings on the windings

have deteriorated, they should be recoated with insulating varnish.

Flush Grease Cavity

The generator is equipped with a single-row, deep-groove double-shielded, grease-lubricated ball bearing which requires relubricating infrequently.

Add Or Renew Grease

1. Stop unit.
2. Wipe clean the grease plugs and surrounding area of generator.
3. Remove filter and drain plugs.
4. Free drain hole of any hard grease.
5. Start unit and add grease while unit is running.
6. Permit unit to run with the drain plug removed until old grease has been flushed out and new grease is discharged through drain. Then allow to run for 15 to 20 minutes before replacing drain plug. The grease cavity is then approximately one-third full.

   Use lubricant from clean, closed containers, and keep it from being contaminated during regreasing operations. Care should be taken in greasing bearings, as overgreasing is just as detrimental as undergreasing. Specify grease Socony Vacuum B.R.B. — 1 or Beacon No. 325, or equal.

Other Maintenance

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 temperature.
4. Unusual engine noises.
5. Excessive smoke.

Check Vibration Damper Alignment (D Check)

Damper hub and inertia member are stamped with an index mark to permit detection of movement between the two components. Fig. 3-14. There should be no relative rotation (index marks more than ¼ inch out of alignment) between hub and inertia member resulting from engine operation.

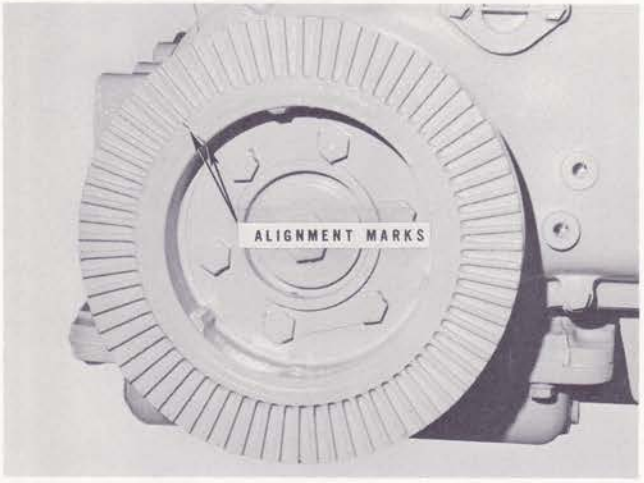


Fig. 3-14. Vibration damper alignment marks N11931

Clean Electric Units And Tighten Connections

Dust and dirt, if allowed to accumulate in the generator/alternator and cranking motor, will cause excessive wear of bearings, brushes and commutator.

Remove the cover band and blow out dust and dirt with compressed air.

Tighten Electric Connections

Hard starting is often traceable to loose or corroded battery connections. A loose connection will overwork the battery-charging generator/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 battery tested periodically. Follow battery manufacturer's instructions for maintenance.

Check Battery-Charging Generator/Alternator Brushes And Commutator (D Check)

The failure of a generator/alternator may cause unit downtime and nearly always results in expensive replacement.

1. Clean dirty commutators with No. 00 sandpaper; never use emery cloth.
2. Replace worn brushes Fig. 3-15. If brushes wear rapidly, check for incorrect brush spring tension or high mica on the commutator. Check output and action on an ammeter indicator after brush replacement.
3. Shorts and incorrect generator polarization can be detected at the ammeter. Incorrect polarization is indicated by a minus reading when generator is in operation. Take unit to an electric service station for immediate correction.

Clean Engine (D Check)

Dirt from the outside will find its way into the lubricating oil filter cases and into the rocker housings when the covers are removed unless dirt is removed first.

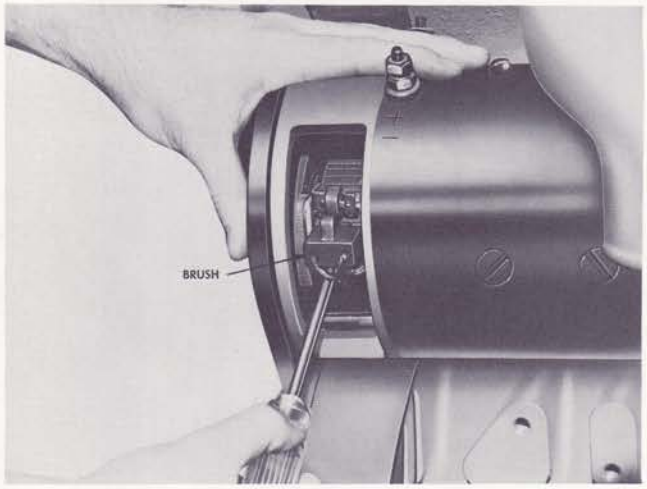


Fig. 3-15. Replacing generator brushes N11308

Steam is the most satisfactory method of cleaning a dirty engine or piece of equipment. If steam is not available, use mineral spirits or some other solvent to wash down the engine.

All electrical components and wiring should be protected from the full force of the steam jet or cleaning solvent.

Tighten Mounting Bolts And Nuts (D Check)

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 (E Check)

Engine blow-by, or escape of combustion gases past 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 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 Distributors are equipped to check engines for blow-by under loaded conditions, with special tools, to determine if blow-by is excessive.

Check Crankshaft End Clearance (E Check)

The crankshaft of a new or newly rebuilt engine must have end clearance as listed for that model in Table 3-5. A worn engine must not be operated with more than the worn limit end clearance shown in the same table.

Table 3-5: Crankshaft End Clearance

Engine Series	New Min.	New Max.	Worn Limit
GNH	0.007″	0.015″	0.035″
GV12	0.006″	0.013″	0.035″

The check can be made by attaching an indicator to rest against the flywheel or on a crankshaft throw while prying against a crankshaft throw through an inspection plate, (Fig. 3-16) if the oil pan is not removed. End clearance must be present with engine mounted in the unit and assembled to generator.

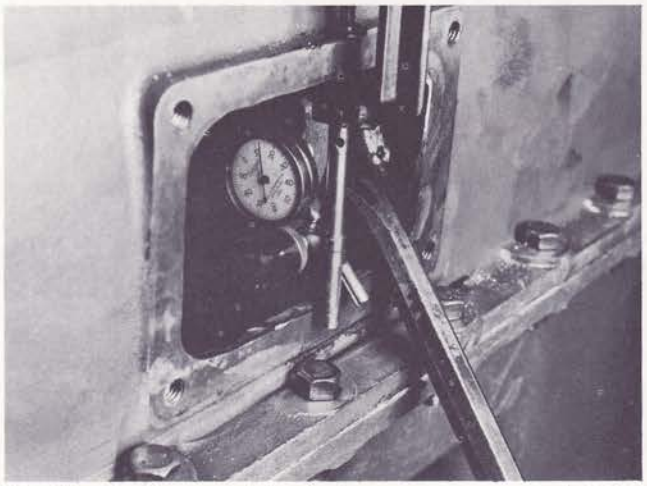


Fig. 3-16. Checking crankshaft end clearance N11905

Major Inspection

After the engine has had four "E" checks, it should have a major inspection to determine whether it may be operated for another service period, or whether it should be overhauled. Oil consumption, oil pressure at idling, dilution and other signs of wear should be analyzed as part of the inspection.

Since the major inspection requires partial disassembly of the engine, it should be done only in a well-equipped shop

by mechanics thoroughly familiar with worn replacement limits and with disassembly and assembly procedures. This information is avaliable in all Cummins Shop Manuals which can be purchased from any Cummins Distributor.

Inspect the following items at this period:

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)

"Mag-tronic" Ignition and Spark Plugs

Battery-charging Alternator/Generator and Cranking Motor

Intake and Exhaust System (Clean and Correct Leaks)

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

Engine Rebuild

If, during the 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.

After an engine has been rebuilt it is essentially a new engine and should be treated as such. By treating the rebuilt engine like a new engine and by following the preventive maintenance schedule, the same dependable service can be expected from the engine that it gave during its first service period.

Standard and Optional Component Servicing

For all unit rebuilding or parts installation, see the nearest Cummins Distributor who is equipped to rebuild all Cummins 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 surfaces from contact with corners, edges, rough surfaces, dust, 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 outside of the engine before removing any units.

Clean Engine Exterior

After removal of electrical equipment, but before removal of other components, steam clean engine thoroughly. Refer to Engine Wiring Diagram, Section 5. In addition to actual time saved by engine cleaning, the quality of work will be improved.

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

Spark Plugs

Removal

1. Remove ignition harness wire from transformer terminal.
2. Remove screws securing transformer cover, retainer, spring and transformer ground wire to rocker cover; lift off cover. Fig. 4-1.

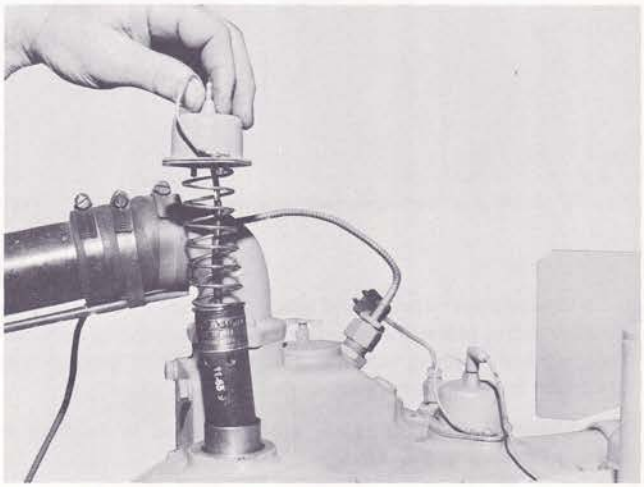


Fig. 4-1. Removing transformer assembly NG9

Caution: Remove transformer assembly cover with care as the transformer assembly is spring loaded to assure contact with spark plug.

3. Lift transformer, spring, spring retainer and cover assembly from the spark plug adapter tube.
4. Using a $^{13}/_{16}$ inch deep-well rubber insert spark-plug socket, remove spark plug from adapter. Lift out spark plug and gasket.

Installation

1. Check spark plug gap; it should be 0.018 inch.
2. Inspect spark plug seating area of the adapter and clean to insure a good seating surface for the spark plug.
3. Position new gasket on spark plug; insert spark plug in adapter and tighten to 28 to 30 foot-pounds torque.

Note: If long-body spark plugs are installed, a spacer **must** be used under the transformer to prevent excessive pressure atop spark plug. Fig. 4-2.

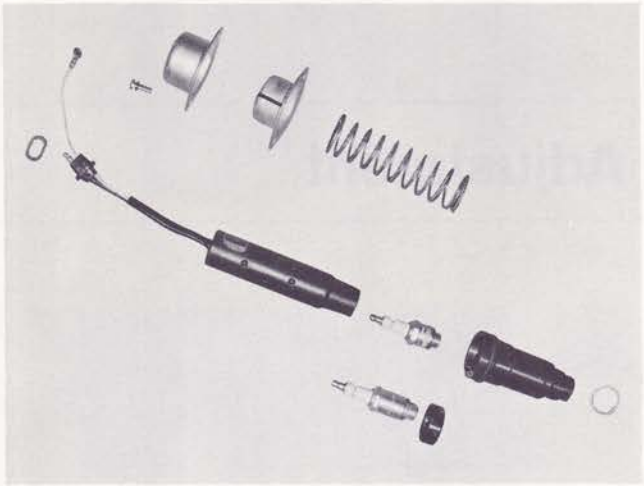


Fig. 4-2. Spark plug, transformer and components NG10

4. Insert transformer spring and spring retainer into spark plug adapter tube; place transformer cover over spring retainer, secure cover, spring retainer and transformer ground wire to rocker cover with screws.

   Note: Ignition harness leads are numbered in relation to the proper engine cylinders.

5. Connect the ignition harness lead to the transformer terminal.

Mag-Tronic Ignition

1. Crank engine in direction of rotation until rotor arm is centered in timing window of "Mag-tronic" distributor head, Fig. 4-3, and engine timing marks are indexed for No. 1 cylinder for GNH Series and No. 1-R for GV12 Series.
2. Disconnect wiring harness from "Mag-tronic".
3. Remove nuts, capscrews, flatwashers and lockwashers securing "Mag-tronic" to drive housing. Fig. 4-4. Lift "Mag-tronic" from drive assembly.

Installation

1. Rotate "Mag-tronic" drive until rotor arm is centered in timing window.
2. Position "Mag-tronic" to drive assembly, engaging drive coupling, Fig. 4-5, and secure with capscrews, lockwashers, flatwashers and nuts. (Do not tighten capscrews.)

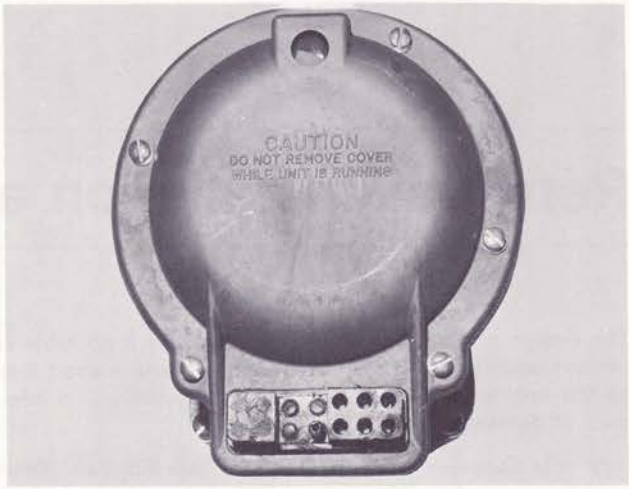


Fig. 4-3. Rotor arm in Mag-tronic timing window NG11

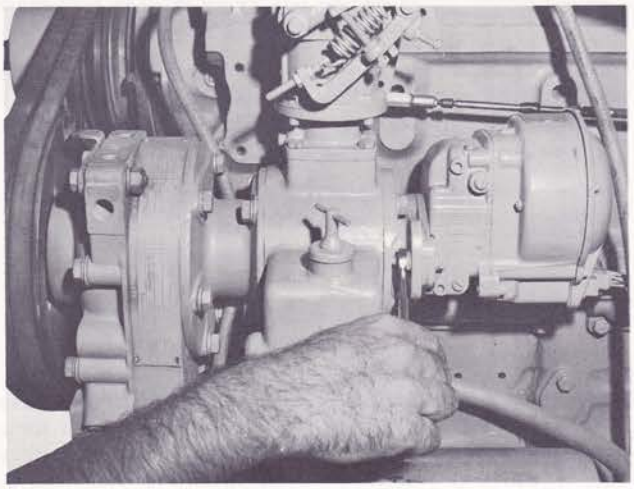


Fig. 4-4. Removing Mag-tronic NG12

3. Plug wiring harness into "Mag-tronic".
4. Attach a timing light to #1 cylinder ignition transformer. If a low-voltage timing light is not available it will be necessary to either: a) Remove the ignition transformer from #1 cylinder and attach timing light to the high-tension terminal. b) If an extra ignition transformer is available it may be connected in parallel with the #1 cylinder ignition transformer to allow use of a high-voltage timing light.
5. Start engine and rotate "Mag-tronic" to obtain correct timing with timing light directed toward timing mark on accessory drive pulley and timing pointer. Fig. 4-6. Secure "Mag-tronic" in desired position.

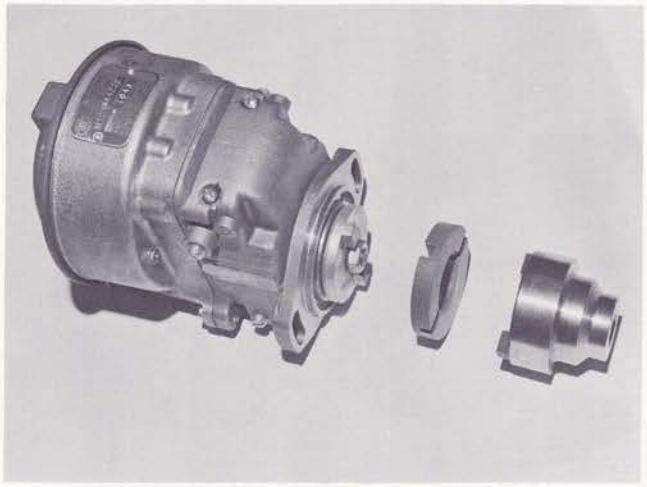


Fig. 4-5. Mag-tronic and drive NG13

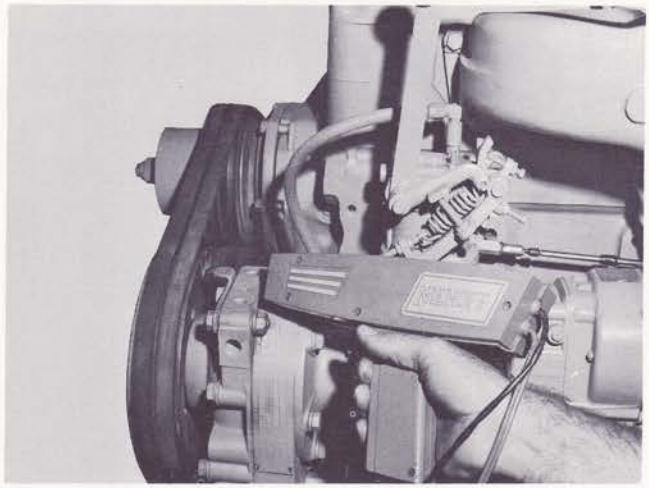


Fig. 4-6. Using timing light NG14

Carburetor and Pressure Reduction Valve

Removal

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

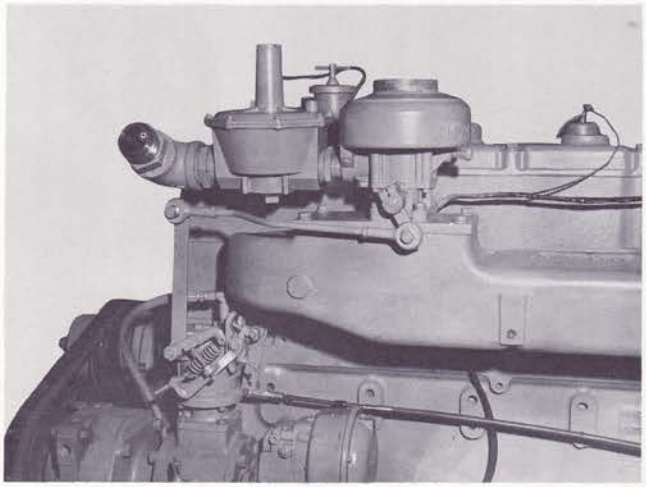


Fig. 4-7. Carburetor linkage NG15

Installation

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

   Note: Install valve with arrow on bottom of pressure reduction valve pointing toward carburetor gas inlet.
3. Position carburetor with new gasket on intake manifold; secure with washers and capscrews.
4. Secure pressure reduction valve to mounting bracket with clamps.
5. Connect gas supply line to pressure reduction valve.
6. Connect throttle linkage to carburetor.
7. Connect air intake piping to carburetor.
8. Open main gas supply valve.

Field Adjustment — Carburetor

1. Close main gas supply valve.
2. Set the carburetor power mixture adjustment valve at center between "R" (Rich) and "L" (Lean) marks. Fig. 4-8.
3. Close the idle adjustment; then open two and one-half turns. Fig. 4-9.
4. Remove pipe plug and attach a pressure gauge (water manometer) between the main line passage 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. See Fig. 4-10 for check points.

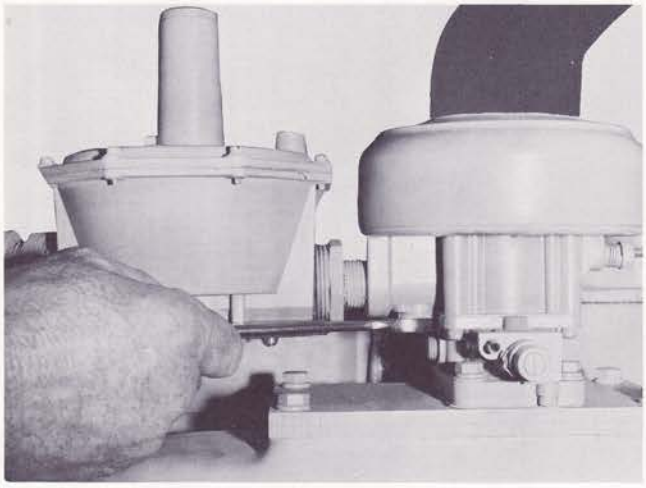


Fig. 4-8. Setting carburetor power mixture NG16

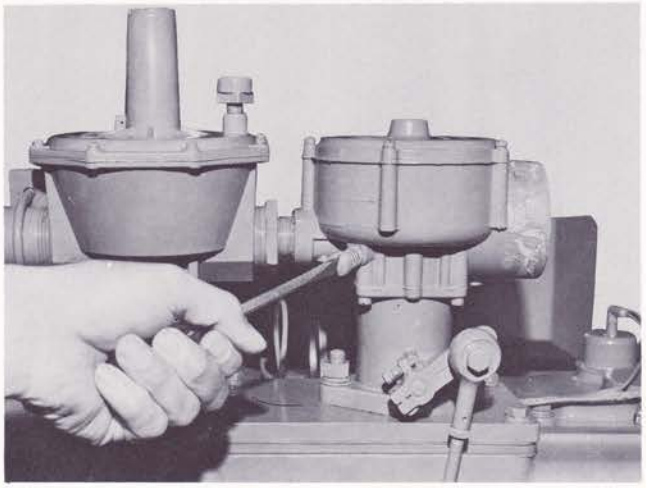


Fig. 4-9. Setting idle adjustment NG17

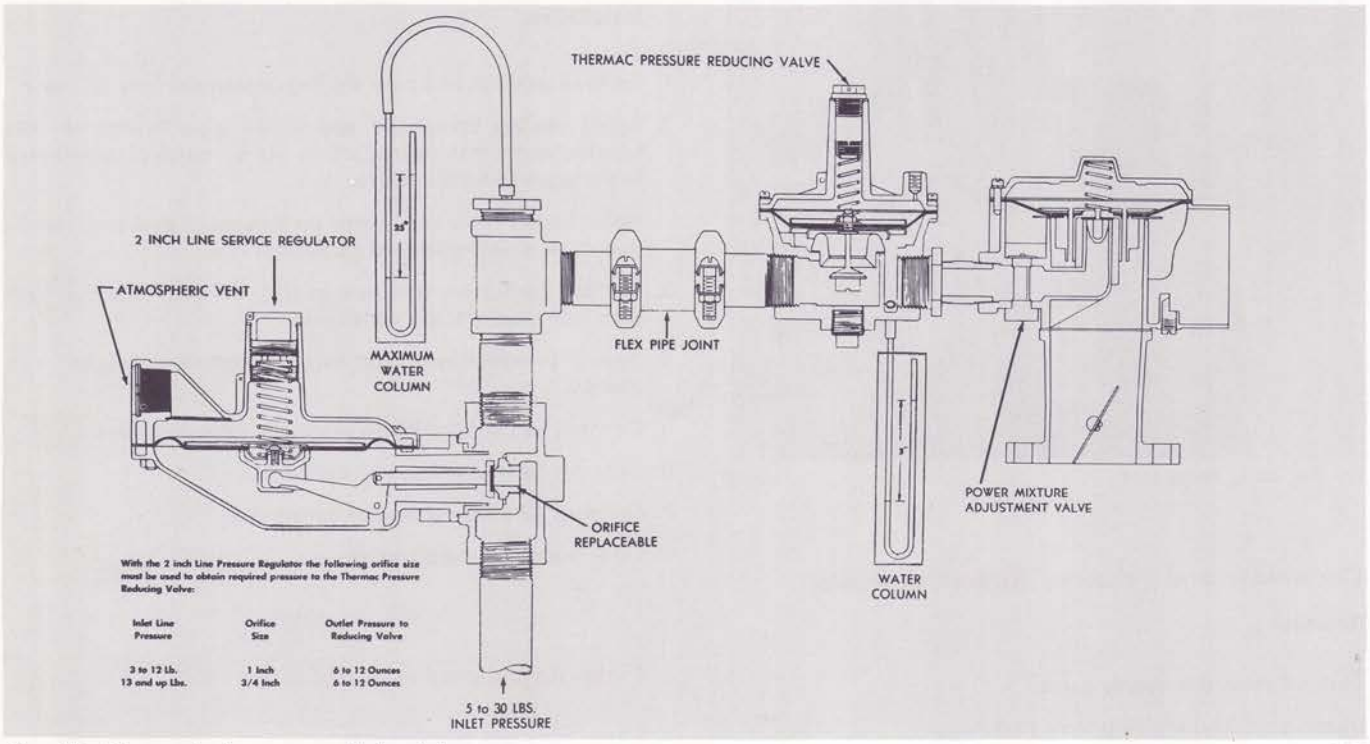


Fig. 4-10. Diagram showing pressure check points NG1

Caution: When using a mercury manometer, the capacity of the manometer should be a minimum of 24 inches of mercury to avoid drawing mercury into the engine at high vacuum conditions such as start-up or idle. If not available, a lower capacity manometer (10 inches of mercury) may be used in combination with a shut-off petcock valve in the manifold vacuum line. The valve is to be open only when the engine is under load and rated speed conditions, i.e. when the manifold vacuum is within the range of the manometer.

5. Remove pipe plug from intake manifold and install a vacuum gauge or mercury manometer.
6. Open the main line gas supply valve.
7. Adjust line gas pressure to the "Thermac" pressure reduction valve to 10 inches of water.
8. Start the engine, using normal starting procedure.
9. Adjust gas pressure to carburetor to 3 inches of water with engine running at 600 to 700 rpm by adjusting "Thermac"

pressure reduction valve screw. This adjustment is very important and must be accurately accomplished as the engine fuel economy and power output are directly affected by any variation in inlet gas pressure at the carburetor.

a. Remove cap from "Thermac" pressure reduction valve.

b. Insert screw driver in adjusting screw, Fig. 4-11, and adjust to obtain desired pressure on water manometer; replace cap.

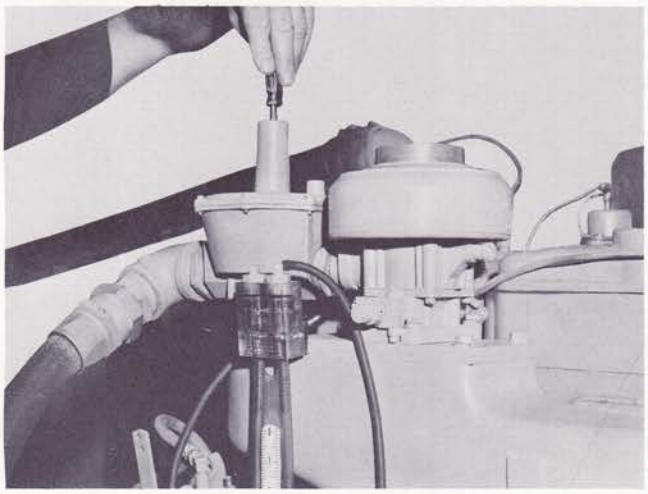


Fig. 4-11. Adjusting pressure-reducing valve NG18

10. After engine coolant attains operating temperature (140° to 160° F), operate the engine at rated rpm and system load.

a. Check the carburetor inlet gas pressure. This pressure must remain between 2 to 3 inches of water when the engine rpm and load varies from rated load and speed to no-load at idle. If gas pressure to carburetor falls below 2 inches of water at full load, this may indicate excessive pipe length, flow restriction between the main line pressure regulator and the "Thermac" pressure reduction valve, defective main line pressure regulator or a defective "Thermac" pressure reduction valve. If this condition exists proceed with the following:

(1) 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 7 above, either the main line pressure regulator is faulty or the main line is undersize. Consult the recommendations and instructions of the main line pressure regulator manufacturer.

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

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

(3) To compensate for flow restriction and pressure loss, the main line pressure regulator outlet pressure may be raised to 11 inches of water and steps 8 and 9 repeated. Continue raising the main line pressure regulator outlet pressure in one-inch increments of water until the 2 to 3 inch "Thermac"-to-carburetor pressure can be maintained at system load and speed.

Caution: The maximum allowable main line pressure outlet pressure setting is 25 inches of water with the engine shut down. If this does not correct the "Thermac"-to-carburetor gas pressure, check the main line pressure regulator for proper operation per the manufacturer's instructions.

b. With engine running at rated rpm and load, move the carburetor power mixture adjustment valve slowly toward the "L" position. Fig. 4-8. Check the intake manifold vacuum reading. Continue to "lean" the gas mixture until intake manifold vacuum reading corresponds with values shown on the following charts for a specific engine at specified speed and horsepower.

11. Shut down engine.

12. Close the main gas supply valve.

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

Derating Procedure

To compensate for intake air temperatures above 60° F and altitude above sea level, the naturally aspirated gas engine must be derated as follows:

1% per each 10° F above 60° F plus 3% for each 1000 ft altitude above sea level.

An example of this derating and its application to the charts is as follows:

Assume an air temperature of 80° F with engine located in area 1000 ft. above sea level.

The derating would be 2% for temperature plus 3% for altitude. If a GNHC-4 were operating here and 100 HP output at 1800 rpm was required, Chart 1 would be read horizontally from 100 HP to the 5% derating line, then down to the manifold vacuum at 1800 rpm which is 5 in. Hg. This is the required manifold vacuum to be used in Step 10 of the preceding instructions.

Cylinder Heads — GNH Series

Removal

1. Shut off gas supply and remove gas lines.

2. Remove ignition harness by disconnecting at "Mag-tronic", at each ignition transformer connector, and at ignition switch if necessary.

3. Remove ignition transformers.

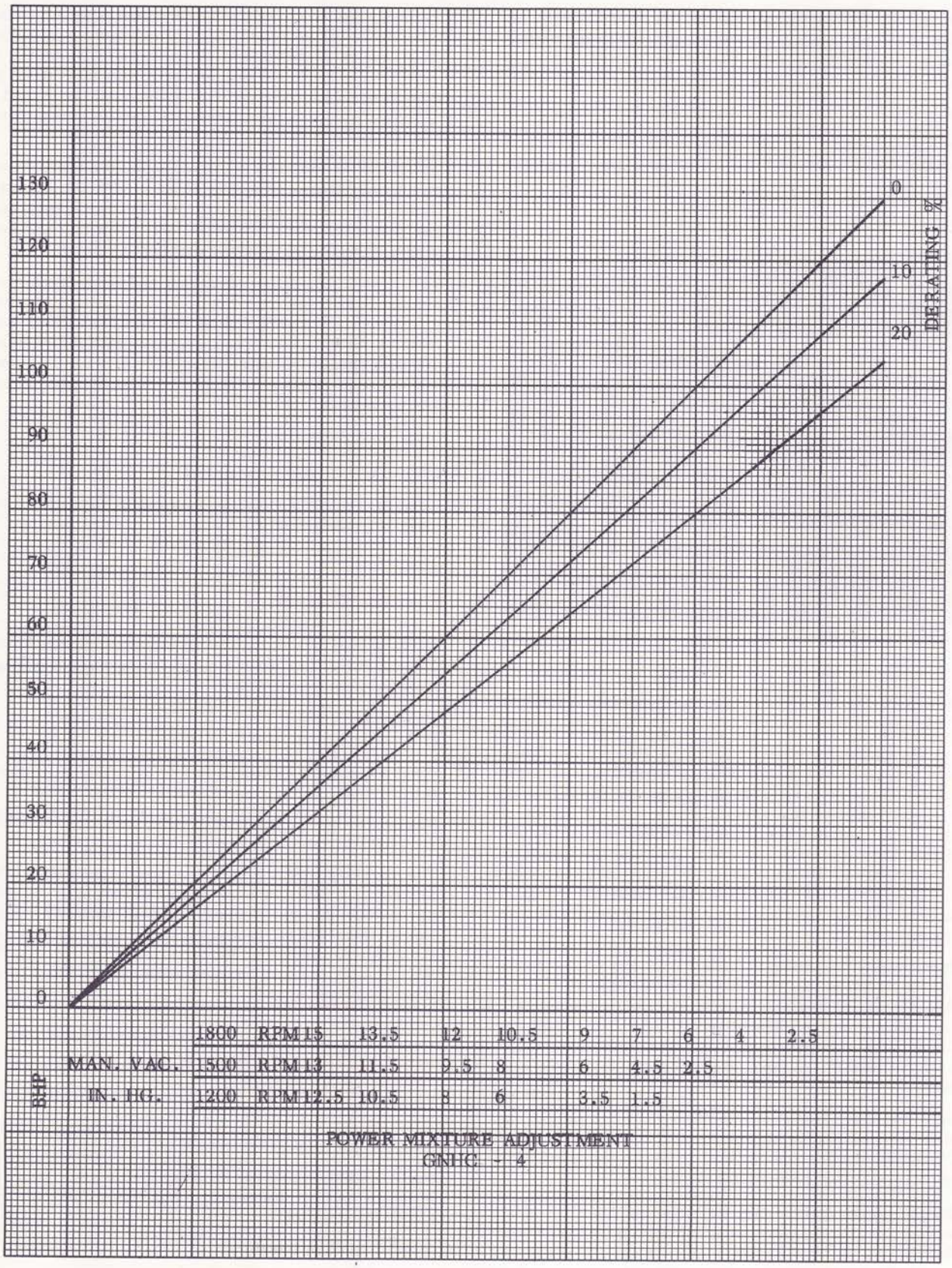

130
120
110
100
90
80
70
60
50
40
30
20
10
0
0
10
20
DERATING %
MAN. VAC. IN. HG.
1800 RPM 15 13.5 12 10.5 9 7 6 4 2.5
1500 RPM 13 11.5 9.5 8 6 4.5 2.5
1200 RPM 12.5 10.5 8 6 3.5 1.5
POWER MIXTURE ADJUSTMENT
GNHC - 4

Chart 1

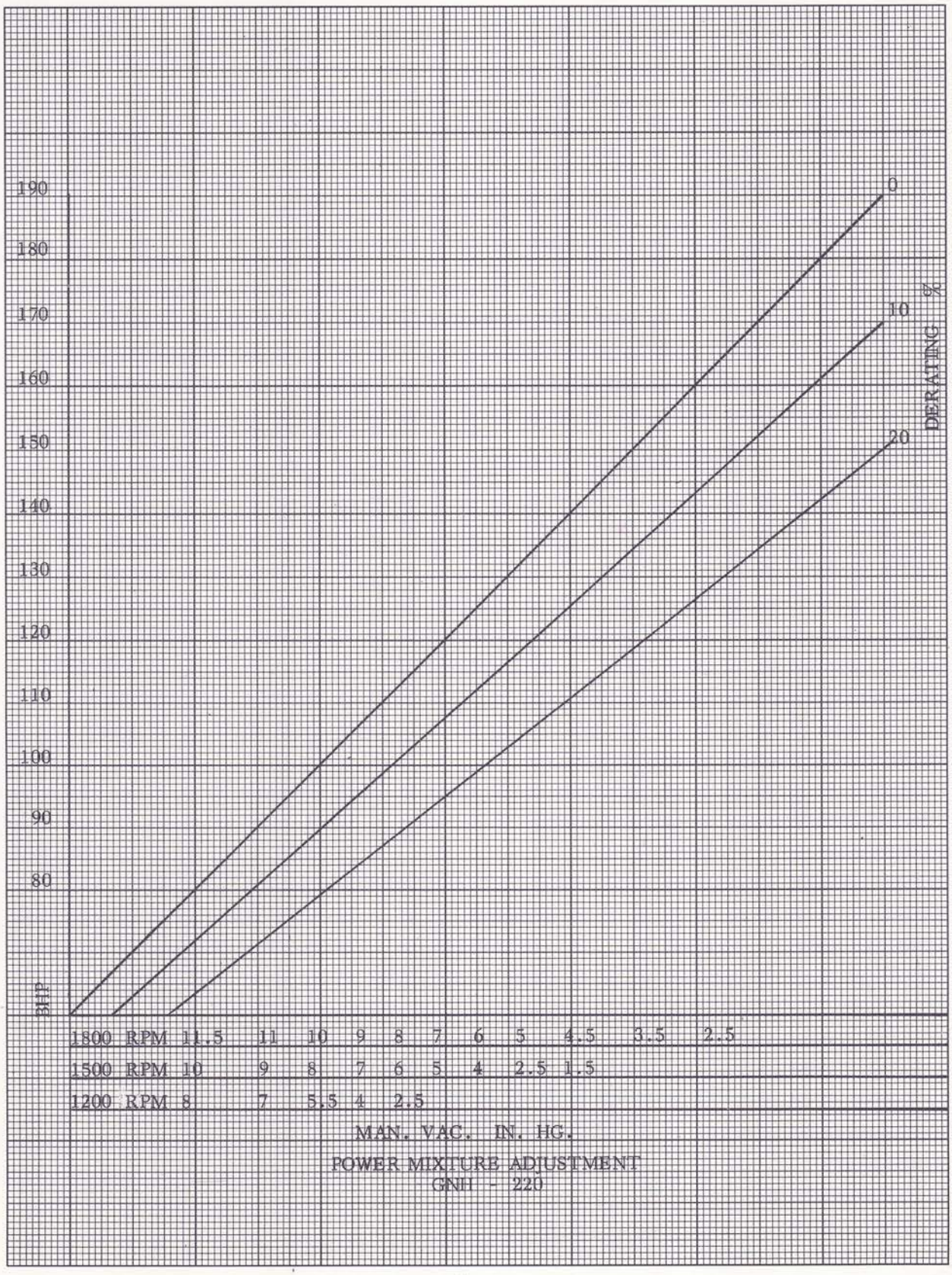

190
180
170
160
150
140
130
120
110
100
90
80
BHP
0
10
20
DERATING %
1800 RPM 11.5 11 10 9 8 7 6 5 4.5 3.5 2.5
1500 RPM 10 9 8 7 6 5 4 2.5 1.5
1200 RPM 8 7 5.5 4 2.5
MAN. VAC. IN. HG.
POWER MIXTURE ADJUSTMENT
GNH - 220

Chart 2

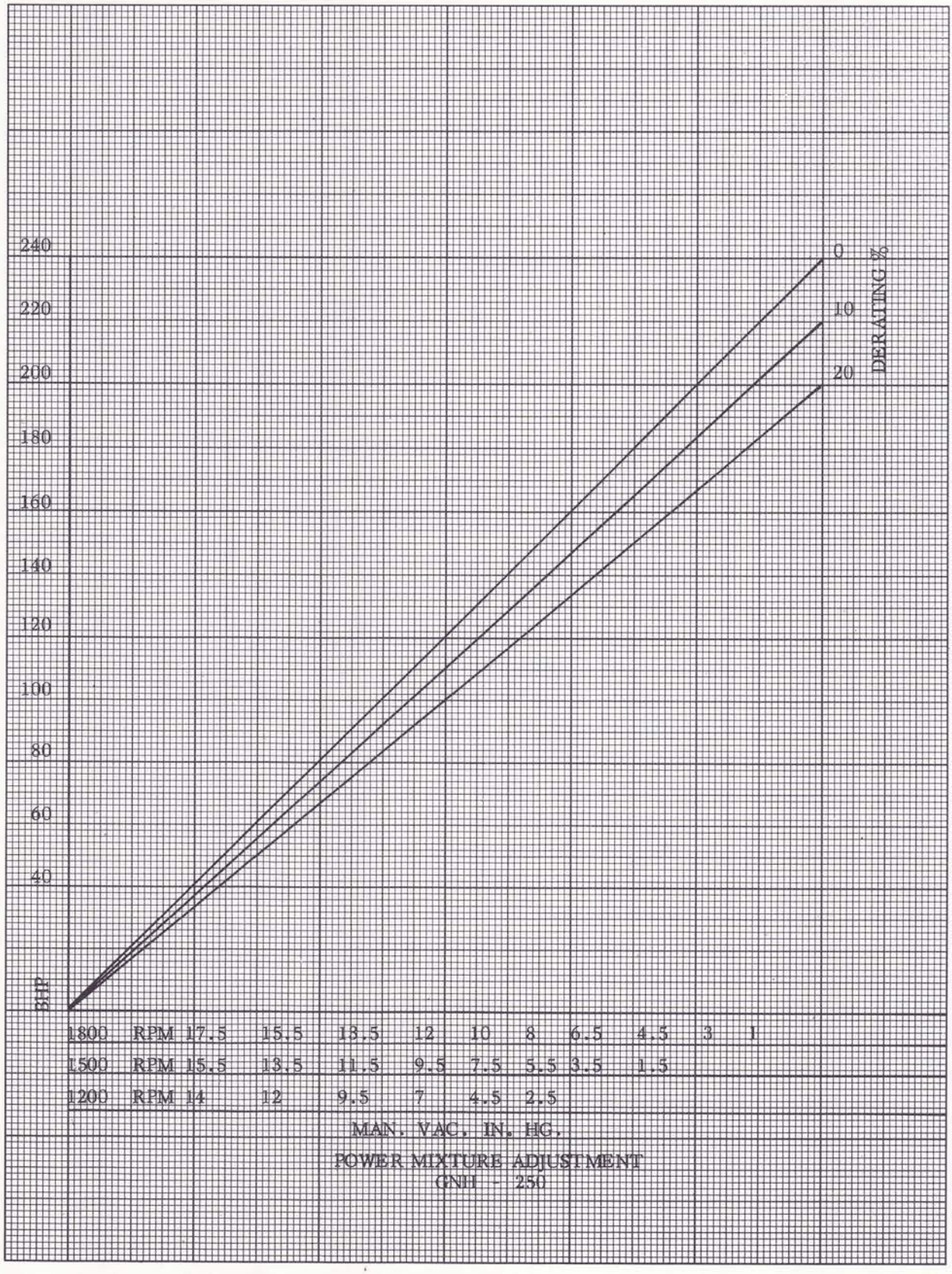

240
220
200
180
160
140
120
100
80
60
40
BHP
0
10
20
DERATING %
1800 RPM 17.5 15.5 13.5 12 10 8 6.5 4.5 3 1
1500 RPM 15.5 13.5 11.5 9.5 7.5 5.5 3.5 1.5
1200 RPM 14 12 9.5 7 4.5 2.5
MAN. VAC. IN. HG.
POWER MIXTURE ADJUSTMENT
GNH - 250

Chart 3

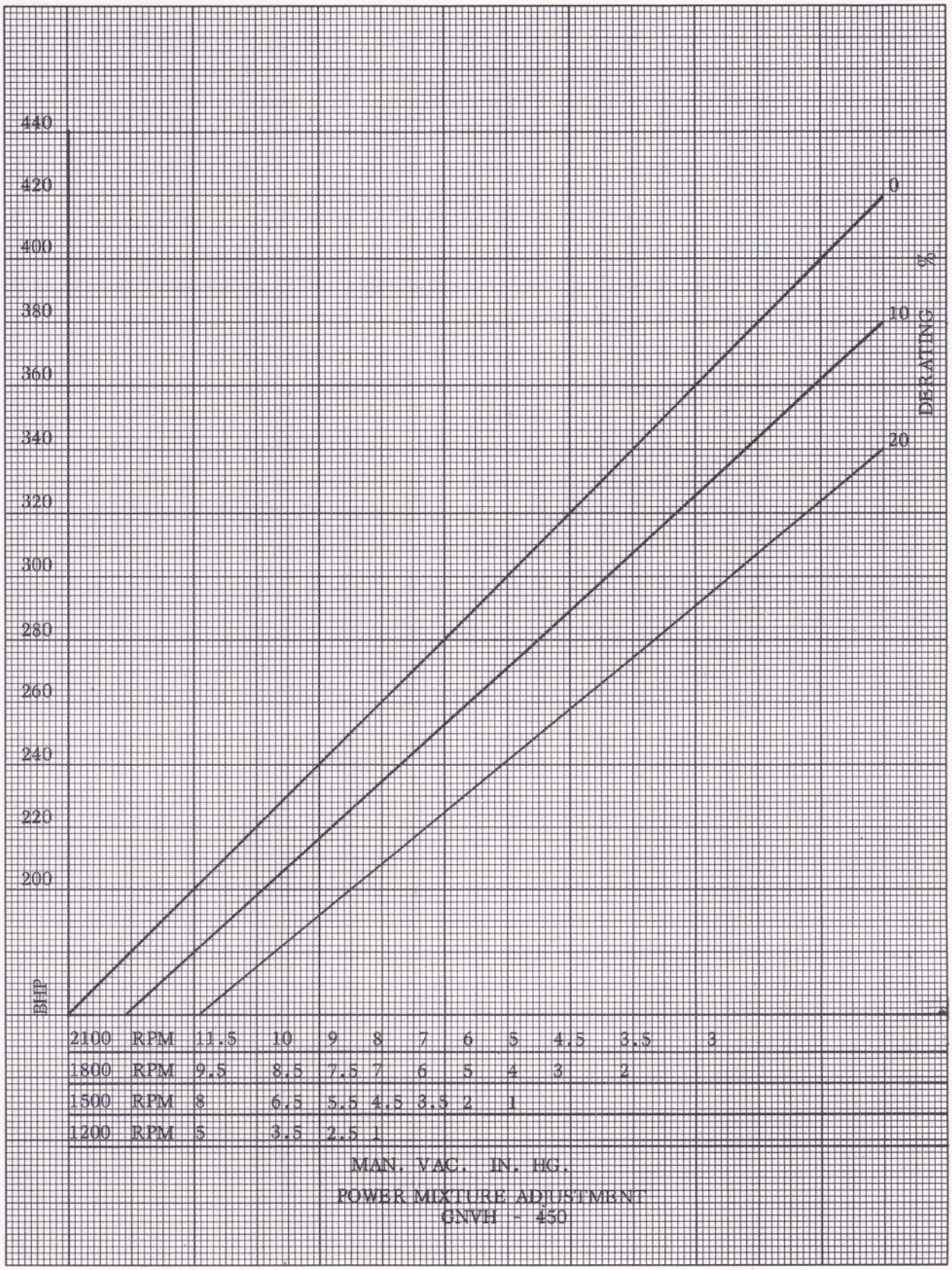

440
420
400
380
360
340
320
300
280
260
240
220
200
BHP
0
10
20
% DERATING
2100 RPM 11.5 10 9 8 7 6 5 4.5 3.5 3
1800 RPM 9.5 8.5 7.5 7 6 5 4 3 2
1500 RPM 8 6.5 5.5 4.5 3.5 2 1
1200 RPM 5 3.5 2.5 1
MAN. VAC. IN. HG.
POWER MIXTURE ADJUSTMENT
GNVH - 450

Chart 4

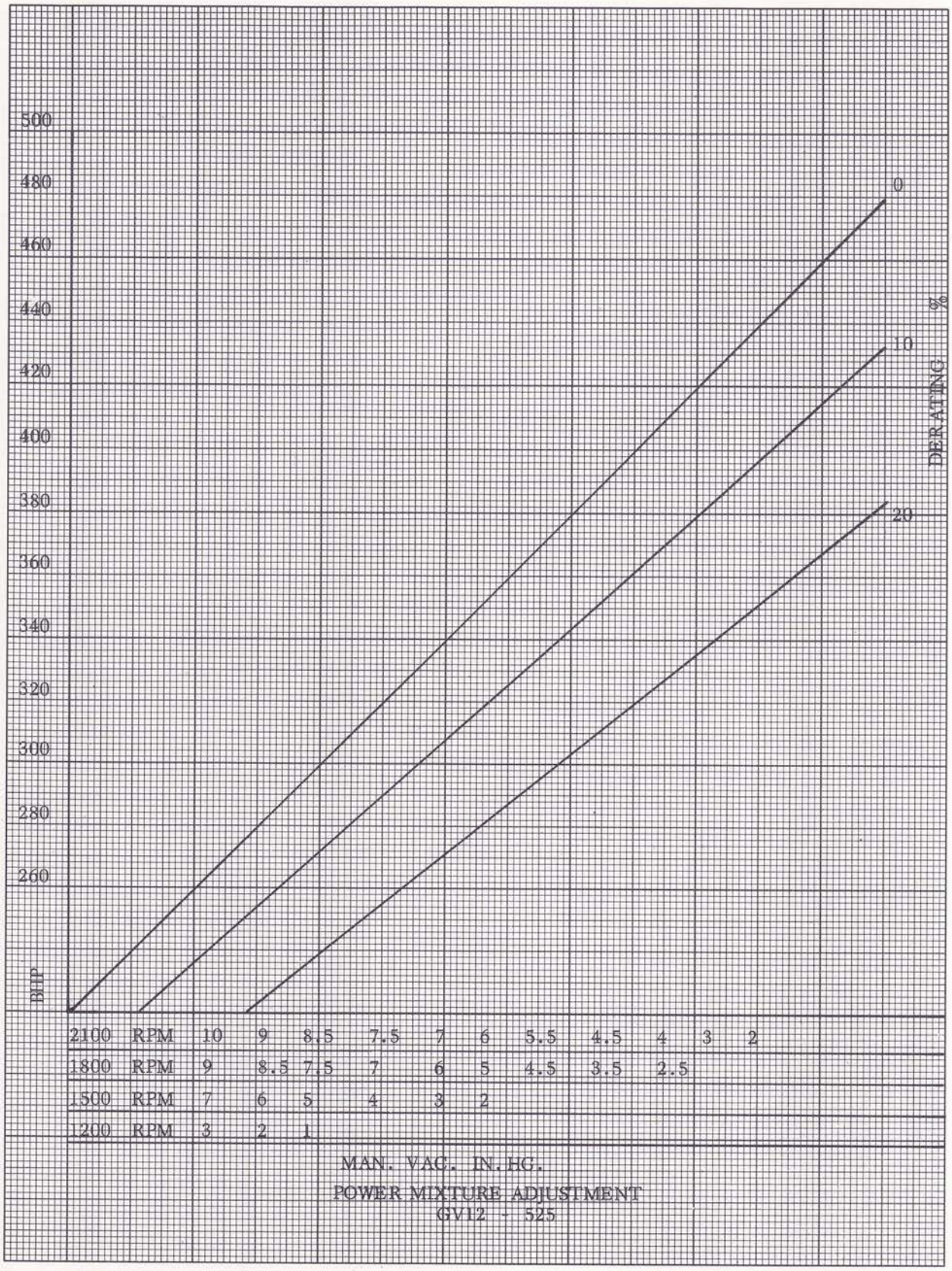

500
480
460
440
420
400
380
360
340
320
300
280
260
BHP
0
10
20
DERATING %
2100 RPM 10 9 8.5 7.5 7 6 5.5 4.5 4 3 2
1800 RPM 9 8.5 7.5 7 6 5 4.5 3.5 2.5
1500 RPM 7 6 5 4 3 2
1200 RPM 3 2 1
MAN. VAC. IN. HG.
POWER MIXTURE ADJUSTMENT
GV12 - 525

Chart 5

4. Remove air piping or air cleaner to facilitate removal of intake manifold.
5. Remove throttle linkage at carburetor lever, intake manifold capscrews, lockwashers and flatwashers; lift off manifold and carburetor assembly; discard gaskets.
6. Disconnect exhaust piping; remove capscrews and lockplates at each exhaust port; lift exhaust manifold(s) from 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.
7. Remove capscrews and lockwashers from water by-pass connection; remove capscrews and lockwashers from each foot of water manifold assembly and lift from engine; remove steel retainers and seal rings; discard seal rings.
8. Remove rocker housing cover capscrews and lift off covers; discard gaskets.
9. Remove lubricating oil pipe cap and gasket.
10. Remove capscrews from each rocker housing. Remove lifting brackets, when used, and lift housings from engine; discard gaskets.
11. Remove screws and yokes; lift out spark plug adapter tubes and discard "O" rings.
12. Lift push tubes from sockets.
13. Remove spark plugs.
14. Remove cylinder head capscrews and lift heads from 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 ST-890 Adapter Wrench, remove spark plug adapters from heads. Fig. 4-12. Remove and discard gaskets and "O" rings.
2. Clean and lubricate 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 build-up, etc., and to insure proper seating of the adapter "O" ring.
3. Using a piloted cutter, clean up spark plug adapter seating areas. Fig. 4-13.
4. Clean threads and gasket seating area of the adapters.
5. Lubricate "O" rings and "O" ring seating areas in bores in head with clean engine oil. Position new gaskets and "O" rings on spark plug adapters. Using ST-890 Wrench, screw adapters into cylinder head and tighten to 70/80 ft. lbs.

Fig. 4-12. Spark plug adapter with ST-890 Wrench NG19

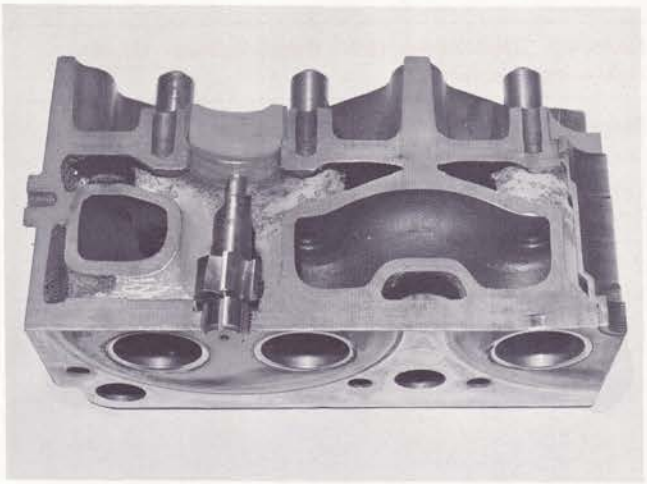


Fig. 4-13. Cleaning spark plug adapter seat NG20

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 top of cylinder head.
2. Wipe cylinder block and cylinder head mating surfaces clean.
3. Install new grommets and retainers. Be sure grommets are not twisted and are in seats.
4. Place grommet retainers with grommets in water passages in block, small end up.
5. Install head gasket, stamped word "TOP" to top, over oil pipes. Be careful not to dislodge grommets as gasket is lowered over grommet retainers.

6. Lower head into place and install new cork washers on oil pipes after cylinder heads have been placed on block (5⅛" Bore).
7. Lubricate capscrews with Shell Rust Preventive — ENSIS-105 or equivalent and tighten each slightly in sequence shown in Figs. 4-14, and 4-15. Complete tightening procedure, following steps outlined in Table 4-1 or 4-2.

Table 4-1: GNH Series (5⅛" Bore) Cylinder Head Tightening Sequence

Step	Procedure	Torque
1	Tighten in sequence	225-275 ft. lbs.
2	Tighten in sequence	350-400 ft. lbs.
3	Tighten in sequence	460-480 ft. lbs.

Table 4-2: GNH Series (5½" Bore) Cylinder Head Tightening Sequence

Steps	Torque
1 — Tighten in sequence	25 ft. lbs.
2 — Tighten in sequence	100 ft. lbs.
3 — Tighten in sequence	200 ft. lbs.
4 — Tighten in sequence	280/300 ft. lbs.

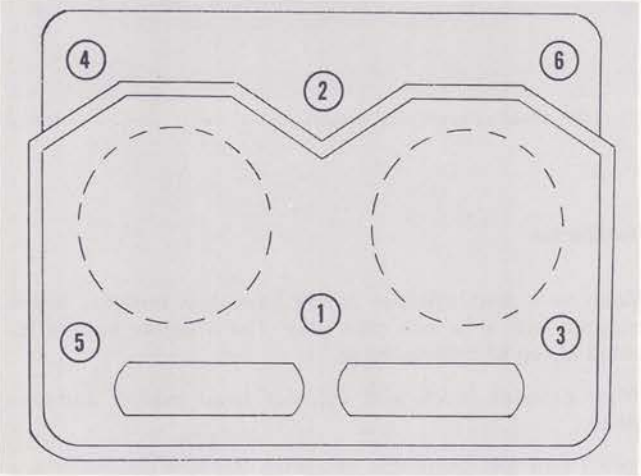


Fig. 4-14. Cylinder head capscrews tightening sequence — GNH 5⅛" bore N11426

8. Insert push tubes in sockets of cam follower levers.
9. On four-valve head engines, assemble crossheads with adjusting screws toward water manifold assembly. Adjust as described in Section 3.

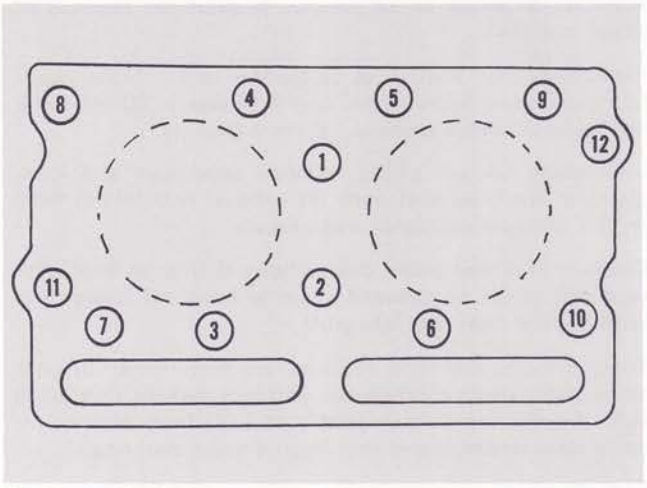


Fig. 4-15. Cylinder head capscrew tightening sequence — GNH 5½" bore N11427

10. Install new rocker housing gaskets on cylinder heads.
11. 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.
12. Place new gasket on each lubricating oil pipe; tighten caps to 55 to 75 foot-pounds torque.
13. Replace and tighten rocker housing capscrews to 55 to 75 ft. lbs. in sequence shown in Fig. 4-16.

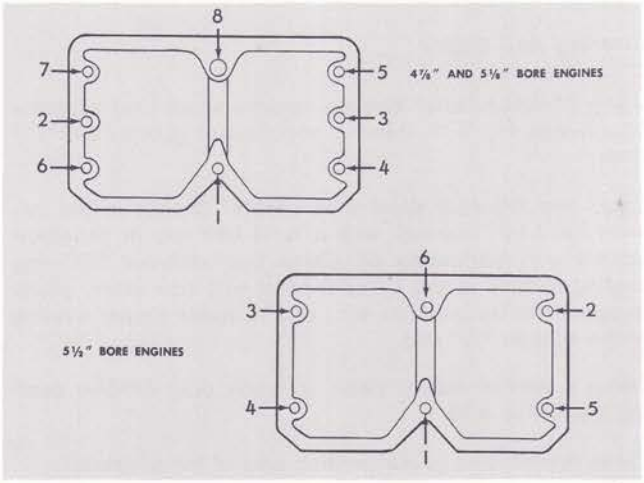


Fig. 4-16. Rocker housing capscrew tightening sequence N11463

14. Adjust valves; see Section 3.

15. Lubricate "O" rings and position red "O" ring in bottom groove and black "O" ring in top groove of each spark plug adapter tube. Insert spark plug adapter tubes in heads and secure with yokes and screws.
16. Carefully position rocker housing covers over the adapter tubes, with new gaskets, on rocker housings; secure with flatwashers, lockwashers and capscrews. Torque to 55/75 ft. lbs.
17. Coat new water manifold sealing rings with clean engine oil; position steel retainers with new sealing rings on cylinder heads. Position water manifolds on cylinder heads and secure with lockwashers and capscrews.
18. Position exhaust manifold(s) with new steel gaskets on cylinder heads; secure with lockplates and capscrews.

    Note: Side of manifold gaskets stamped "OUT" must be facing manifold flanges.
19. Install intake manifolds, using new gaskets. Secure with flatwashers, lockwashers and capscrews.

    Caution: Keep outlets covered until connected to mating parts.
20. Install ignition transformers.
21. Install ignition harness. Refer to wiring diagrams, Section 5.
22. Install air intake and exhaust piping.
23. Install gas line.

Cylinder Heads — GV12 Series

Removal

1. Shut off gas supply and remove gas lines to the pressure reduction valves.
2. Remove ignition harness by disconnecting at "Mag-tronic", at each ignition transformer connector, and at safety switch adapter if necessary.
3. Remove ignition transformers and spark plugs.
4. Remove throttle linkage and cross shaft; disconnect air intake and exhaust piping.
5. Remove capscrews, lockwashers and flatwashers at each intake port; lift intake manifolds from engine and discard gaskets.
6. Close shut-off valves in corrosion resistor inlet and outlet lines; remove drain plug and drain coolant. Disconnect inlet and outlet lines.
7. Remove capscrews and lockwashers securing corrosion resistor to mounting bracket. Remove stud nuts securing bracket to exhaust manifold; remove mounting bracket.
8. Loosen clamps and remove water connections from thermostat housings. Remove stud nuts securing thermostat housing to exhaust manifold; lift off housing and discard gaskets.
9. Remove stud nuts securing lifting eyes to exhaust manifold; lift off lifting eyes.
10. Remove stud nuts, capscrews and lockwashers securing exhaust manifolds to cylinder heads. Lift manifolds from heads and discard gaskets. If manifold is stuck on gasket, use extreme caution in prying against cylinder head. Never use a screwdriver or wedge between machined surfaces.
11. Remove rocker housing covers and discard gaskets.
12. On 5⅛" bore engine, remove lubricating oil pipe caps and gaskets; discard gaskets.
13. Remove stud nuts, capscrews and lockwashers from each rocker housing and lift off rocker housings; discard gaskets.
14. Remove push tubes.
15. Lift crossheads from guides.
16. Remove screws and yokes securing spark plug adapter tubes in heads; lift out tubes and discard "O" rings.
17. Remove cylinder head capscrews; using a chain hoist, lift cylinder heads from engine. Discard grommets, retainers and gaskets.

Cleaning And Repair

1. Using ST-890 Adapter Wrench, remove spark plug adapters from heads; remove and discard gaskets and "O" rings.
2. Clean and lubricate spark plug adapter threads in the cylinder head by "chasing" with a ⅞-14 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 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 spark plug adapters. Using ST-890 Wrench, screw adapters into cylinder heads and tighten to 70/80 ft. lbs.

Installation

1. Cylinder heads should have valve guides, valves and springs assembled in position.
2. Clean mating surfaces of cylinder block and cylinder heads. See that cylinder walls are clean and lubricated with clean lubricating oil.
3. Install new grommets and retainers. Be sure grommets are not twisted and that they are in seats.
4. Place cylinder head gaskets on block with stamped work "TOP" up.
5. Lubricate capscrews with Shell Rust Preventive ENSIS —

105 or equivalent and tighten to values shown in Tables 4-3 and 4-4, and in sequence shown in Figs. 4-17 and 4-18.

Table 4-3: GV12 Cylinder Head (5⅛" Bore) Tightening Sequence

Step	Procedure	Torque
1	Tighten in sequence	25 ft. lbs.
2	Tighten in sequence	125/150 ft. lbs.
3	Tighten in sequence	150/300 ft. lbs.
4	Tighten in sequence	450 ft. lbs.

Table 4-4: GV12 Cylinder Head Tightening Sequence (5½" Bore)

Step	Procedure	Torque
1	Tighten in sequence	95/105 ft. lbs.
2	Tighten in sequence	195/205 ft. lbs.
3	Tighten in sequence	295/305 ft. lbs.
4	Tighten in sequence	315/335 ft. lbs.

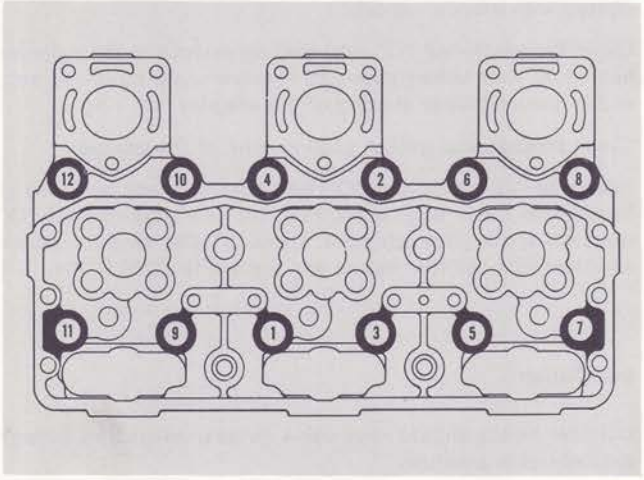


Fig. 4-17. Cylinder head capscrew tightening sequence — GV12 5⅛" bore V41422

6. On 5⅛" Bore, place two gaskets over each lubricating oil pipe into bores in cylinder head.
7. Position crossheads on guides.
8. Install push tubes in proper positions.

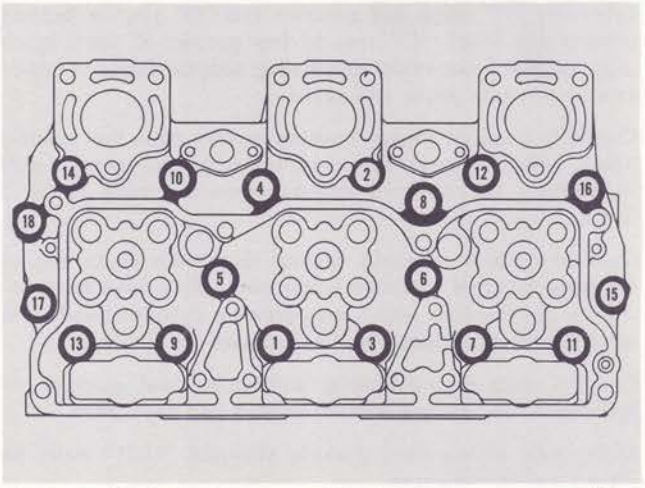


Fig. 4-18. Cylinder head capscrew tightening sequence — GV12 5½" bore V41423

9. Lubricate "O" rings and position red "O" ring in bottom groove and black "O" ring in top groove of each spark plug adapter tube. Insert spark plug adapter tubes in heads and secure with yokes and screws.
10. Install spark plugs with new gaskets. See Section 3.
11. Install new rocker housing gaskets on cylinder heads.
12. 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.
13. Place new gasket on each lubricating oil pipe; tighten caps.

    Note: Tighten oil pipe caps so hex side is parallel with sides of engine to eliminate interference.
14. Secure rocker housings with lockwashers and capscrews; torque to 55/75 ft. lbs.
15. Position new exhaust manifold gaskets on cylinder heads; install exhaust manifolds over studs to cylinder heads. Position lifting eyes on studs provided and secure manifolds and lifting eyes with lockwashers and stud nuts.
16. Position thermostat housings with new gaskets to exhaust manifolds; secure with lockwashers and capscrews.
17. Position corrosion resistor mounting bracket to exhaust manifold and secure; position corrosion resistor to mounting bracket and secure with lockwashers and capscrews.
18. Connect inlet and outlet lines to corrosion resistor and open shut-off valves.
19. Bar engine to appropriate valve set markings and adjust valves. See Section 3.
20. Carefully position rocker housing covers over spark plug adapter tubes, install with new gaskets and secure with flatwashers, lockwashers and capscrews.
21. Install ignition transformers (see Section 3).

22. Install intake manifolds, cross shaft, and throttle linkages.
23. Install ignition harness. Refer to wiring diagrams for proper wiring of ignition ground leads and safety switch adapter. (Section 5).
24. Install air intake and exhaust piping.
25. Install gas line.

Hydraulic Governor

Removal

1. Disconnect and tag electrical wiring from motor-driven head, if used.
2. Draw scribe mark on the governor terminal lever and governor terminal shaft to assist in assembly alignment.
3. Disconnect carburetor linkage from governor speed control lever. Do not remove lever from speed-adjusting shaft without first scribing position to assist in assembly alignment.
4. Remove stud nuts securing governor assembly to governor drive housing; lift off governor and discard gasket.

Installation

1. Position governor assembly with new gasket over studs of governor drive assembly. Take care to align splines of drive in drive coupling while positioning governor on housing.
2. Align scribe marks and install governor speed control lever on speed-adjusting shaft; connect speed-adjusting linkage to governor speed control lever.
3. Align scribe marks and install governor lever on governor terminal shaft; connect linkage from governor terminal to carburetor.
4. Remove tags from electrical wiring; connect wires to their respective terminals of motor-driven head, if used.

Hydraulic Governor Adjustment

Carburetor Throttle Travel

Carburetors on Cummins Gas Engines have a throttle travel of about 65 degrees 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 installation of governor lever and linkage to 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 screw rests against stop pin.

Manually lift governor lever through 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 engine and adjust low-speed stop screw (atop governor head) for desired idling speed, approximately 600 rpm.

With Motorized Head

1. The governor can be fitted with a speed-adjusting motor to enable the switchboard operator to match the frequency of a generator with that of other units or a system before synchronizing, and to change load distribution after synchronizing.
2. The motor used is of the split-field, series-wound, reversible type.
3. A manual speed-adjusting knob with friction clutch assembly is included on units fitted with a speed-adjusting motor.
4. When used on generator set applications, set the high-speed setting stop screw at approximately 1854 rpm for 60-cycle units and 1545 rpm for 50-cycle units to obtain 3% speed regulation.
5. Adjust the rated speed to 1800 rpm for 60-cycle units and 1500 rpm for 50-cycle units by means of the motor control at full load.

Speed Droop Adjustment

1. Remove the top cover from governor to expose speed droop mechanism and adjustments.
2. The speed droop bracket is clamped to terminal lever by the slotted hexagonal head screw. When loosened, it can be moved to the front or rear. Moving bracket to the rear produces more speed droop.
3. This 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 bottom of governor to 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).

SG-Type Woodward Governor

Follow Step 3 under PSG Type.

Constant-Speed Mechanical Governor (Pierce) Fig. 4-20

Removal

1. Disconnect governor speed control linkage.
2. Disconnect linkage from governor throttle control lever to carburetor.

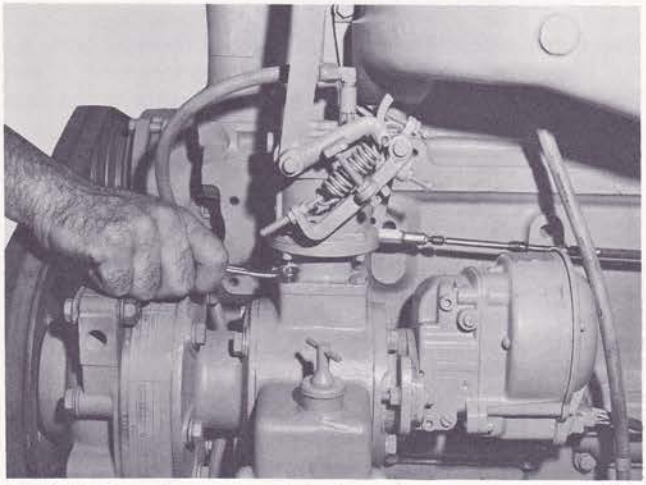


Fig. 4-19. Removing governor stud nut NG21

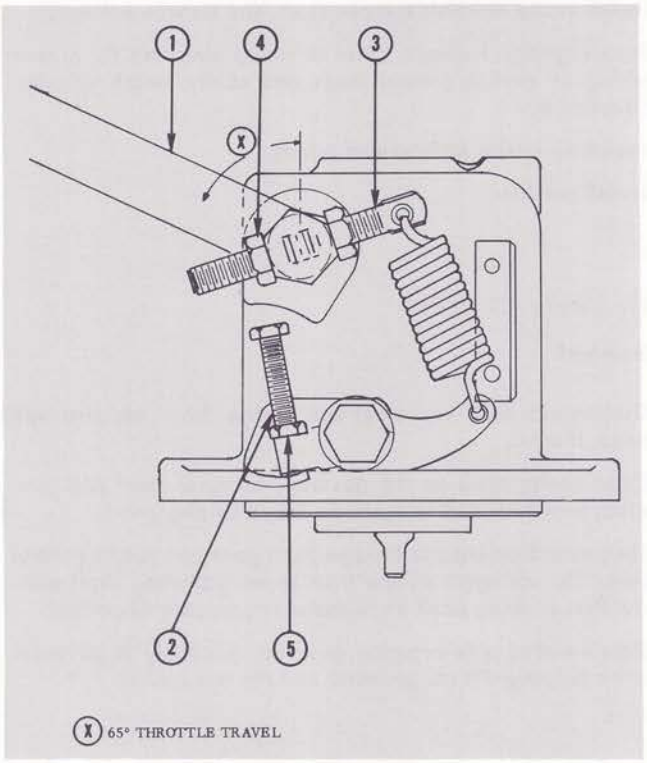


Fig. 4-20. Constant-Speed Governor (Pierce) NG22

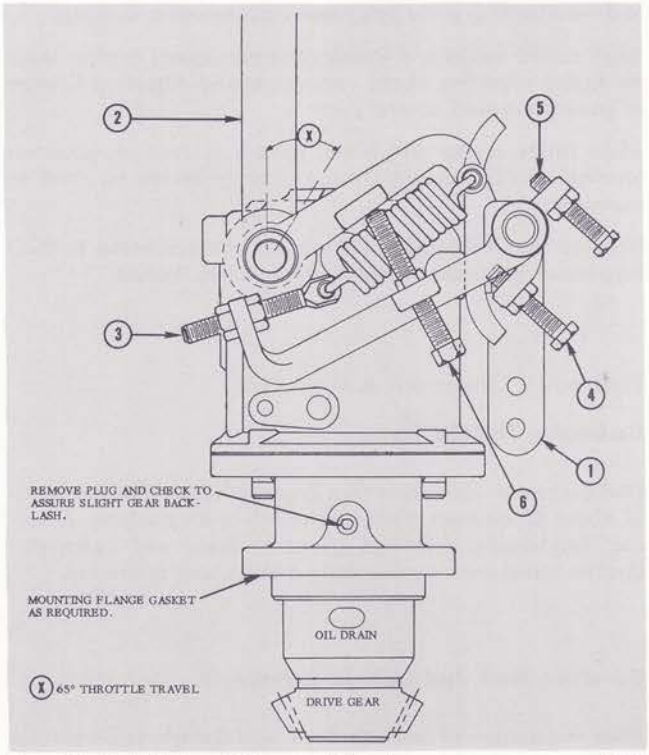


Fig. 4-21. Variable-Speed Governor (Pierce) NG23

3. Remove nuts, lockwashers and flatwashers securing governor to drive housing. Fig. 4-19. Lift off governor assembly and discard gasket.

Installation And Adjustment

1. Position governor with new gasket to governor drive housing, engaging tang of governor shaft in slot of drive shaft; secure with flatwashers, lockwashers and nuts.
2. Place tension on governor spring.
3. Install linkage from throttle lever (1) to carburetor; adjust length of linkage to hold carburetor throttle at wide-open position. Release all spring tension and operate throttle lever manually to check for bind in linkage.
4. Start engine and idle until engine coolant is at operating temperature.
5. Obtain no-load speed by adjusting spring tension with adjusting screw (2).
6. Check regulation by applying and removing engine load. If regulation is too broad, adjust screw (3) to move spring nearer throttle lever hub. If governor surges under load, adjust screw (3) to move spring away from throttle lever hub. Lock in desired position with locknut (4).
7. Recheck speed adjustment after making regulation adjustment. Lock adjusting screw in place with locknut (5).

Variable-Speed Mechanical Governor (Pierce) Fig. 4-21

Removal

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

Installation And Adjustment

1. Position governor with new gaskets to drive housing, engaging governor gear in gear of drive shaft; secure with flatwashers, lockwashers and nuts.
2. Remove 1/8 pipe plug from governor base and bar engine until hole in governor drive shaft is visible through governor base. Insert 3/16 diameter pin in shaft hole and check gear play for slight backlash. Gasket governor flange as required. Replace pipe plug.

   Note: Pin movement of the governor housing should be approximately .005 inches.
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. Start engine, operate at idle until engine coolant is at operating temperature.
7. Move speed change lever (1) to a point approximately three-fourths of the travel toward wide open position.
8. Obtain no-load speed by adjusting spring tension with adjusting screw (3).
9. Check regulation by applying and removing engine load. If regulation is too broad, move speed change lever (1) approximately 1/4" toward closed position and increase spring tension with adjusting screw (3). If governor surges under load, decrease spring tension with screw (3) and move speed change lever (1) toward open position to again obtain top no-load speed. Repeat until desired performance is obtained.
10. Recheck speed by applying and removing load. Set high speed stop screw (5) and lock with locknut.
11. Idle engine and set low speed stop screw (4) and idle speed over-ride screw (6) to maintain desired idle speed. Lock screws with locknuts.
12. Recheck no-load speed and load-speed as set in 9.

Engine Safety Control — Fig. 4-22

Removal

1. Drain cooling system.
2. Disconnect and tag all electrical wiring.
3. Disconnect lubricating oil pressure line from controller.
4. Remove clamps (if used) securing capillary tube to engine block.
5. Loosen packing nut securing temperature-sensing bulb in cooling system; remove bulb, packing nut and brass washers.
6. Remove mounting hardware securing assembly to engine; lift off assembly.

Installation

1. Position assembly on bracket and secure with mounting hardware.
2. Insert sensing bulb in engine cooling system; secure with brass washers and packing nut.
3. Secure capillary tube to engine block with clamps (if required).

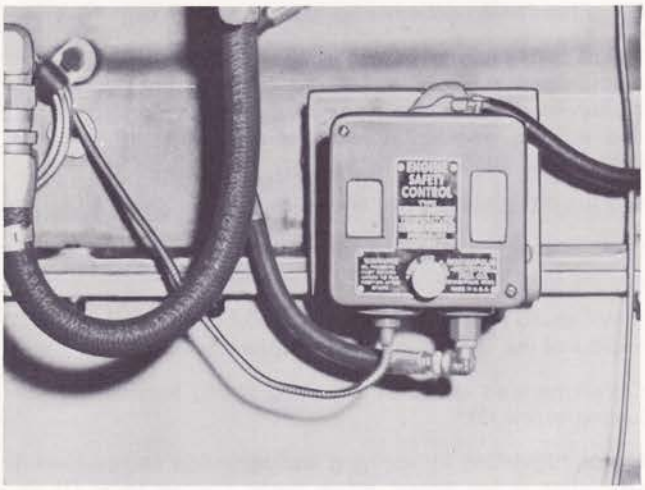


Fig. 4-22. Engine safety control CGS24

4. Connect engine lubricating oil line to oil pressure side of controller.
5. Remove tags and connect electrical wiring to designated terminals.
6. Fill cooling system and check for leaks.

Adjustments

1. Remove operation selector knob and cover.
2. Loosen two hex nuts that lock adjusting screws to top of controller case.
3. Adjust right-hand (facing controller) screw at top of case until pressure indicator on scale inside of case is at desired pressure cut-out point.
4. Adjust left-hand screw at top of case until temperature indicator on scale inside case is at desired temperature cut-out point.

   Note: If the temperature sensing bulb and controller are not mounted on the same level, the temperature trip setting must be adjusted to compensate for the difference in level. For every foot the sensing bulb is above controller, temperature trip setting should be raised 3° F. Example: sensing bulb 2 feet above controller, desired temperature trip setting 200° F. Temperature trip setting should be 206° F. The temperature scale is adjustable. The setting of the scale plate may be made against engine coolant temperature gage or a thermometer.
5. Tighten the two hex nuts loosened in Step 2 above.
6. Replace cover and knob.

Engine Instrument Panel

Instruments normally mounted in the engine panel are the hourmeter, lubricating oil pressure gauge, coolant temperature gauge, battery-charging ammeter and engine stop-start switch. Fig. 4-23.

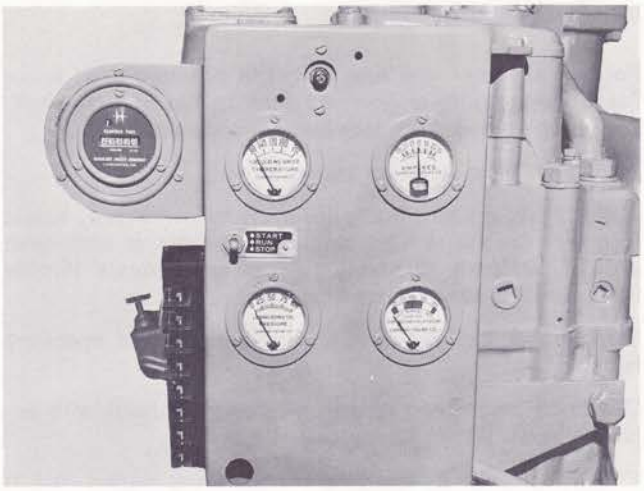


Fig. 4-23. Engine instrument panel NG24

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

Speed Switch

Removal

1. Disconnect and tag all electrical wiring from terminals of speed switch.
2. Unscrew speed switch from tachometer drive adapter; lift off switch.

Installation

1. Position speed switch over tachometer drive, inserting mating drive couplings; screw switch on adapter.
2. Remove tags from electrical wiring and connect to corresponding terminals.

Testing And Adjustment

The testing and adjusting procedure can best be accomplished if the switch is mounted on a test stand.

Single Switch (Fig. 4-24)

Single engine speed switch. (Generator Set Field Flashing)

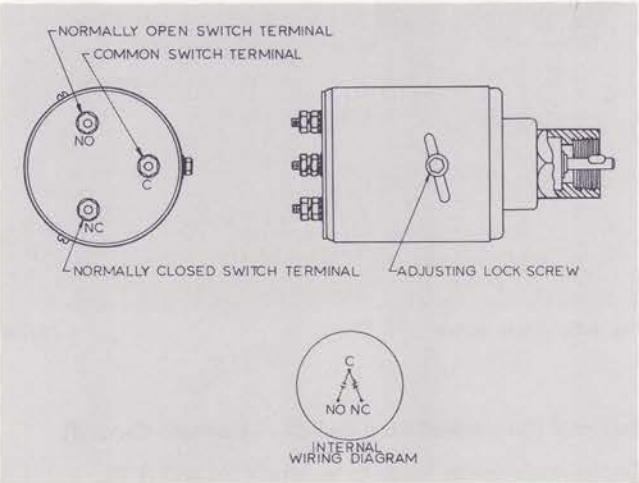


Fig. 4-24. Single switch CGS26

Test

1. Connect ohmmeter leads to the terminals C and NO.
2. Advance test stand rpm and observe ohmmeter. Ohmmeter should indicate switch closes its contacts at 1450 ± 40 rpm.
3. Decrease test stand rpm and observe ohmmeter. Ohmmeter should indicate switch opens its contacts above 1200 rpm.
4. Should switch not open or close at above rpm adjust as follows:

Adjustment

1. Remove lockwire from metal screws in the diagonal slots securing outer case to inner case.
2. Loosen screws and rotate outer case counterclockwise to increase or clockwise to decrease switch actuating or closing rpm.
3. Connect ohmmeter leads to terminals C and NO to indicate switch action and turn the switch outer case counterclockwise to set switch action above desired rpm.
4. Advance test stand to 1450 ± 40 rpm. Slowly turn outer case clockwise while observing ohmmeter until switch is actuated, closing its contacts.
5. Decrease test stand rpm and observe ohmmeter. Switch should open above 1200 rpm.
6. Recheck switch closure at 1450 ± 40 rpm and opening above 1200 rpm.
7. After Step 6 has been obtained, tighten metal screws and insert lockwire.

   Should either Steps 4 or 5 not be obtained, the switch is defective and must be replaced.

Double Switch (Fig. 4-25)

Test

1. Switch 1. (Generator Set Field Flashing)

a. Connect ohmmeter leads to terminals C1 and NO1.

b. Advance test stand rpm and observe ohmmeter. Ohmmeter should indicate switch closes the contacts at 1450 ± 40 rpm.

c. Decrease test stand rpm and observe ohmmeter. Ohmmeter should indicate switch opens its contacts above 1200 rpm.

2. Switch 2. (Overspeed Stop Switch — Magneto Ground).

a. Connect ohmmeter leads to terminals C2 and NO2.

b. Advance test stand rpm and observe ohmmeter. Ohmmeter should indicate switch closes its contacts at 2070 ± 40 rpm.

c. Switch 2 only must be manually reset (closed) by pressing reset button in center of switch when speed is below 1700 rpm.

3. Should either switch not open or close at specified rpm, adjust faulty switch as follows:

Adjustment

1. Switch 1.

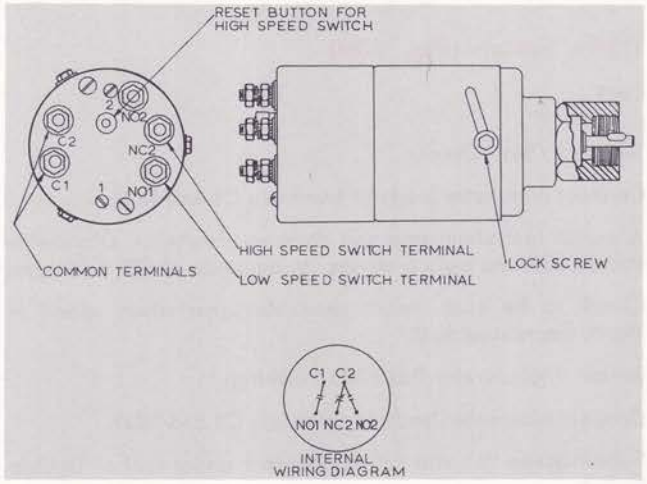


Fig. 4-25. Double switch CGS27

a. Remove slotted screw marked No. 1, insert an Allen wrench through opening into speed-adjusting screw. Turn speed-adjusting screw clockwise to increase or counterclockwise to decrease switch actuating rpm.

b. Connect ohmmeter leads to terminals C1 and NO1; turn speed adjusting screw clockwise to set switch action above 1500 rpm.

c. Advance test stand to 1450 ± 40 rpm. Slowly turn speed-adjusting screw counterclockwise, while observing ohmmeter, until switch is actuated, closing its contacts.

d. Decrease test stand rpm and observe ohmmeter. Switch should open above 1200 rpm.

e. Recheck switch closure at 1450 ± 40 rpm and opening above 1200 rpm.

f. After Step "e" has been obtained, remove Allen wrench and install slotted screw. Should either Step "c" or "d" not be obtained, the switch is defective and must be replaced.

2. Switch 2.

a. Remove slotted screw marked No. 2; insert an Allen Wrench through opening into speed adjusting screw. Turn adjusting screw clockwise to increase or counterclockwise to decrease switch actuating rpm.

b. Connect ohmmeter leads to terminals C2 and NO2; turn speed-adjusting screw clockwise to set switch action above desired rpm.

c. Advance test stand to 2070 ± 40 rpm. Slowly turn speed-adjusting screw counterclockwise while observing ohmmeter, until switch is actuated, closing its contacts.

d. Slow down test stand rpm, push down on re-set button, advance test stand rpm and check ohmmeter for switch closing at specified rpm (2070 ± 40).

e. After Steps "c" and "d" have been obtained, remove Allen wrench and install slotted screw. Should either Step "c" or "d" not be obtained, the switch is defective and must be replaced.

Triple Switch (Fig. 4-26)

Test

1. Switch 1 (Stop Crank).

a. Connect ohmmeter leads to terminals C1 and NO1.

b. Advance test stand rpm and observe ohmmeter. Ohmmeter should indicate switch closes its contacts at 575 ± 20 rpm.

c. Check to be sure switch contacts open when speed is slowly decreased to 0.

2. Switch 2 (Generator Set Field Flashing),

a. Connect ohmmeter leads to terminals C2 and NO2.

b. Follow Steps "b" and "c" of Switch 1 under test of Double Switch.

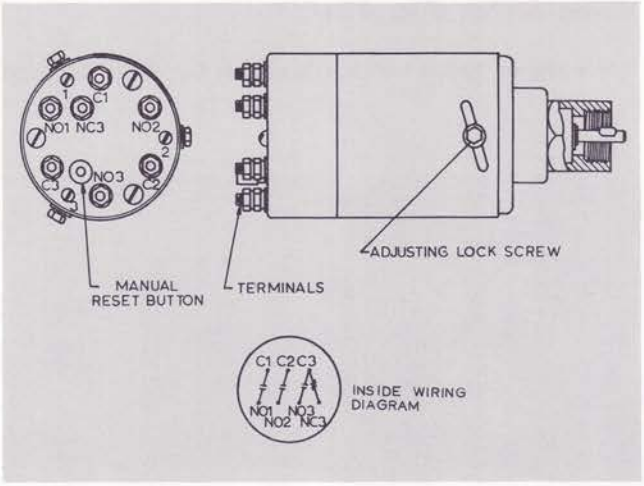


Fig. 4-26. Triple switch CGS28

3. Switch 3 (Overspeed Stop Switch — Magneto Ground).

a. Connect ohmmeter leads to terminals C3 and NO3.

b. Follow Step "b" of Switch 2 under test of Double Switch.

4. Should any switch not open or close at specified rpm, adjust faulty switch as follows:

Adjustment

1. Switch 1.

a. Remove slotted screw marked No. 1; insert an Allen wrench through opening into speed-adjusting screw. Turn adjusting screw clockwise to increase or counterclockwise to decrease switch actuating rpm.

b. Connect ohmmeter leads to terminals C1 and NO1 to indicate switch action. Turn speed adjusting-screw clockwise to set switch action above 650 rpm.

c. Advance test stand to 575 ± 20 rpm. Slowly turn speed-adjusting screw counterclockwise while observing ohmmeter, until switch is actuated, closing its contacts.

d. Shut down test stand, then advance test stand rpm and observe ohmmeter. When switch is actuated, check rpm, (575 ± 20).

e. Check to be sure switch contacts open when the speed is slowly decreased to 0.

f. After Steps "c" and "d" have been obtained, remove Allen wrench and install slotted screw. Should Steps "c" or "d" not be obtained, switch is defective and must be replaced.

2. Switch 2.

a. Connect ohmmeter leads to terminals C2 and NO2.

b. Follow procedure of adjustment for switch No. 1 under Double Switch.

3. Switch 3.

a. Connect ohmmeter leads to terminals C3 and NO3.

b. Follow procedure of adjustment for switch No. 2 under Double Switch.

Repair

Return defective switches to Manufacturer. Synchro-Start Products, Inc., Skokie, Ill., for repair as required.

Auxiliary Engine Coolant Heater

Removal

1. Disconnect heater electrical supply.
2. Drain engine cooling system.
3. Remove coolant inlet and outlet connection from heater body.
4. Remove capscrews and lockwashers securing heater assembly to mounting brackets; lift off heater assembly.

Installation

1. Position heater assembly to mounting brackets; secure with lockwashers and capscrews.
2. Connect water inlet and outlet connections to heater body. Check for correct coolant flow.
3. Fill cooling system with proper coolant mixture.
4. Connect heater electrical leads to electric supply.
5. Start engine and check for leaks.

Specifications

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

Coolant Specifications

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 range of 8.3 to 9.5. Any water which is suitable for drinking can be treated as described in the following paragraphs for use in an engine.

Install and/or maintain the Cummins Corrosion Resistor on the engine. The resistor by-passes a small amount of coolant from the system via a filtering and treating element which must be replaced periodically. In addition, a sacrificial metal plate arrests pitting of metals in the system by electro-chemical action. The resistor is available from any Cummins Distributor or Dealer.

In Summer (No Anti-freeze):

1. Use the corrosion resistor with a chromate element(s), Part No. 132732. Do not use element 168481 (PAF) with plain water.
2. Replace corrosion resistor element(s) as recommended in "Maintenance Section" of this manual.
3. If no corrosion resistor is used, add ½ oz [14.1747 g] chromate compound in the system for every U.S. gal [3.785 lit] of water or until the coolant mixture meets requirements indicated in Maintenance Section under "Check Engine Coolant".

In Winter (Using Anti-freeze):

1. Select an anti-freeze known to be satisfactory for use with the chromate element of the corrosion resistor and continue to use the 132732 resistor element or;
2. If you are not sure the anti-freeze is compatible with the chromate resistor element 132732:

a. Use anti-freeze, in percentage to prevent freezing, with a PAF (168481) element in the corrosion resistor.

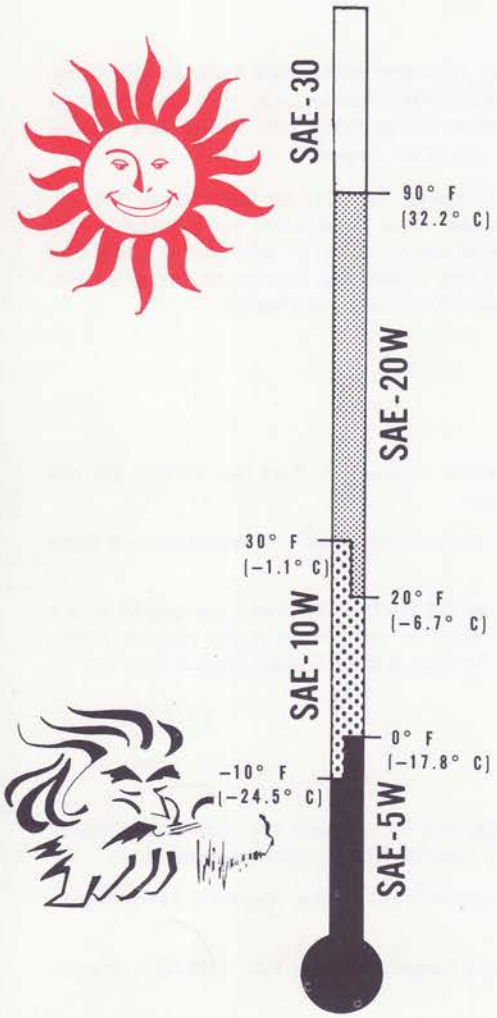
b. Use only anti-freeze, with compounded inhibitors, in proper percentage and follow anti-freeze suppliers recommendation to prevent corrosion.

c. Check corrosion control by draining a sample of coolant from the system as described in Maintenance Section under "Check Engine Coolant".

d. If there has been a loss of corrosion control, renew anti-freeze.

Caution: Never use soluble oil in the cooling system when a Cummins Resistor is being used.

Lubricating Oil Specifications



Cummins Engine Company, Inc., recommends that owners of Cummins Engines give special consideration to use of heavy-duty engine oils. Under normal conditions, the oil used should meet the requirements of U. S. Military Specifications Mil-L-2104-A. The responsibility for meeting these specifications, the quality of the product and its performance must necessarily rest with the oil supplier. Cummins Engine Company, Inc., does not recommend any specific brand of lubricating oil. Many brands which meet specifications following are listed in the "Lubricating Oils for Industrial Engines" booklet published by The Internal Combustion Engine Institute (Chicago 6, Illinois).

Mil-L-2104-A and/or British Defense Spec. DEF-2101B

Recommended for engines operating under normal conditions.

Supplement 1 (SI)

These oils have a higher additive level than Mil-L-2104-A.

Mil-L-2104-B

These oils meet or exceed the levels of Supplement 1 oils and may be used in Cummins Engines to provide additional sludge and rust protection.

Series 3 (Mil-L-45199)

These are premium oils and are not required for Cummins Engines except under very unusual operating conditions. Do not use in applications where exhaust valve deposits are encountered.

Viscosity Recommendations

Except in extreme climates most engine operation will be in the range of — 10° F [— 23° C] to 90° F [32.2° C], oil viscosity should be as follows:

SAE 10W — temperatures consistently between — 10° F [— 23° C] and 30° F [— 1.1° C].

SAE 20 — temperatures consistently between 20° F [— 6.7° C] and 90° F [32.2° C].

SAE 30 — temperatures above 90° F [32.2° C].

Where temperatures are not above 0° F [— 17.8° C], SAE 5W oils meeting the requirements of Mil-L-10295 may be used. However, in heavily loaded applications it may be necessary to use one grade heavier oil to maintain minimum recommended oil pressures of engine being operated.

Oil which is best for general operation is also best for the "break-in" period. No change in oil viscosity or type is needed for new or newly rebuilt engines. Do not mix brands or grades of oil in the engine. Choose carefully the best oil available and continue to use that brand consistent with above conditions and engine wear.

Grease Specifications

Longer service, less maintenance and more effective lubrication are possible when a high-quality engine accessory grease is used. Cummins Engine Company, Inc., recommends use of grease meeting the specifications of Mil-G-3545, excluding those of sodium or soda soap-type thickeners. Contact your lubricant supplier for grease meeting these specifications.

High-Temperature Performance		
Dropping point, °F	ASTM D 2265	350 min.
Bearing life, hours at 300° F., 10,000 rpm	*FTM 331	600 min.
Low-Temperature Properties		
Torque, GCM	ASTM D 1478	
Start at 0°F.		15,000 max.
Run at 0°F.		5,000 max.
Rust Protection and Water Resistance		
Rust test	ASTM D 1743	Pass
Water Resistance, %	ASTM D 1264	20 max.
Stability		
Oil separation, % 30 Hours @ 212° F.	*FTM 321	5 max.
Penetration		
Worked	ASTM D 217	250-300
Bomb Test, PSI Drop	ASTM D 942	
100 Hours		10 max.
500 Hours		25 max.
Copper Corrosion	*FTM 5309	Pass
Dirt Count, Particles/cc	*FTM 3005	
25 Micron +		5,000 max.
75 Micron +		1,000 max.
125 Micron +		None
Rubber Swell	*FTM 3603	10 max.

*Federal Test Method Standard No. 791a.

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 rotative speed.

Standard Capscrew Markings and Torque Specifications

Current Usage	Much Used	Much Used	Used at Times	Used at Times
Minimum Tensile Strength psi	To 1/2 — 69,000 To 3/4 — 64,000 To 1 — 55,000	To 3/4 — 120,000 To 1 — 115,000	To 5/8 — 140,000 To 3/4 — 133,000	150,000
Quality of Material	Indeterminate	Minimum Commercial	Medium Commercial	Best Commercial
SAE Grade Number	1 or 2	5	6	8
Capscrew Head Markings Manufacturer's marks may vary. These are all SAE Grade 5 (3-line). 				
Capscrew 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]

1. Always use the torque values listed above when specific specifications are not available.

   Note: Do not use above values in place of those specified in this manual as a part of Cummins assembly procedures.

2. The above is based on use of clean and dry threads.

3. Reduce torque by 10% when engine oil is used as a lubricant.

4. Reduce torque by 20% if new plated capscrews are used.

   Caution: Capscrews threaded into aluminum may require reductions in torque of 30% or more, unless inserts are used.

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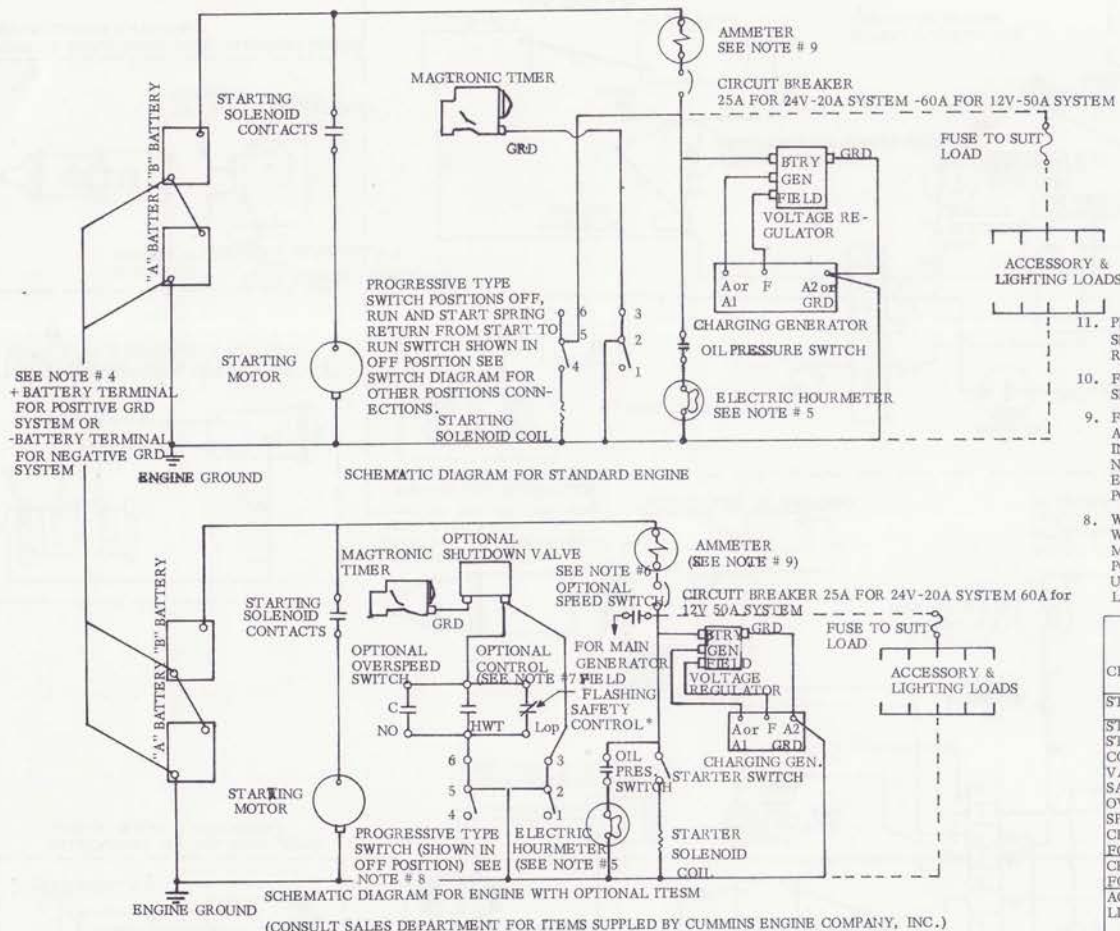

*SHOWN IN ENGINE NOT RUNNING POSITION

11. PROGRESSIVE TYPE SWITCH DIAGRAM SHOWS SWITCH CONNECTIONS FOR OFF, RUN, & START POSITIONS.
10. FOR ACTUAL WIRING DIAGRAM SEE SHEET 2.
9. FOLLOW WIRING DIAGRAM THEN REVERSE AMMETER CONNECTION IF AMMETER INDICATES DISCHARGE WITH ENGINE RUN-NING AND INDICATES CHARGE WITH ENGINE STOPPED AND SWITCH IN ON POSITION.
8. WHEN PROGRESSIVE TYPE SWITCH IS WIRED FOR SAFETY CONTROL SWITCH MUST BE MANUALLY HELD IN START POSITION UNTIL ENGINE OIL PRESS-URE RISES TO NORMAL OPERATING LEVEL.

CIRCUIT	MINIMUM U.S. WIRE GAGE B&S SIZE
STARTING MOTOR	SEE NOTE # 4
STARTING SWITCH, STARTING SOLENOID COIL, SHUTDOWN VALVE, HOURMETER, SAFETY CONTROL, OVERSPEED SWITCH, SPEED SWITCH	#14
CHARGING CIRCUIT FOR 24V-20A	#10
CHARGING CIRCUIT FOR 12V-50A	#6
ACCESSORY & LIGHTING LOADS	#14 OR LARGER AS REQ. BY LOADS

7. WHEN SAFETY CONTROL IS USED PLACE CONTROL KNOB IN RUN POSITION AND REMOVE KNOB (SO SAFETY CONTROL IS ALWAYS IN RUN POSITION).
6. SPEED SWITCH REQUIRED WHEN USING STANDARD CUMMINS MAIN GENERATORS REQUIRING FIELD FLASHING CONNECT TO GENERATOR LEAD #15 AND TO FO (FIELD FLASHING CIRCUIT).
5. USE 24 VOLT ELECTRIC HOURMETER ON 24 VOLT SYSTEM AND 12 VOLT ELECTRIC HOURMETER ON 12 VOLT SYSTEM.
   OBSERVE POLARITY WHEN CONNECTING HOURMETER + ON HOURMETER MUST BE CONNECTED TO GROUND POSITIVE GROUND SYSTEM.
   -ON HOURMETER MUST BE CONNECTED TO GROUND ON NEGATIVE GROUND SYSTEM.
4. CONSULT SERVICE BULLETIN #985006 FOR BATTERY CABLE REQUIREMENTS AT VARIOUS CRANKING TEMPERATURES.
3. CONSULT SALES DEPARTMENT FOR PARTS SUPPLIED BY CUMMINS ENGINE CO.'PANY, INC.
2. THIS DIAGRAM IS APPLICABLE TO EITHER LEECE-NEVILLE OR DELCO-REMY ELECTRICAL EQUIPEMENT.
1. THIS DIAGRAM IS APPLICABLE TO ALL GNHC-4, GNH-220 & GNH-250 ENGINES USING 24V-20A CHARGING SYSTEM WITH POSITIVE OR NEGATIVE GROUND AND HAVING EITHER A BENDIX TYPE OR POSITIVE ENGAGEMENT TYPE STARTER WITH STARTING SOLENOID MTD. ON START-MOTOR.

ENGINE WIRING DIAGRAM (NATURAL GAS ENGINE) GNH SERIES (SHEET 1)

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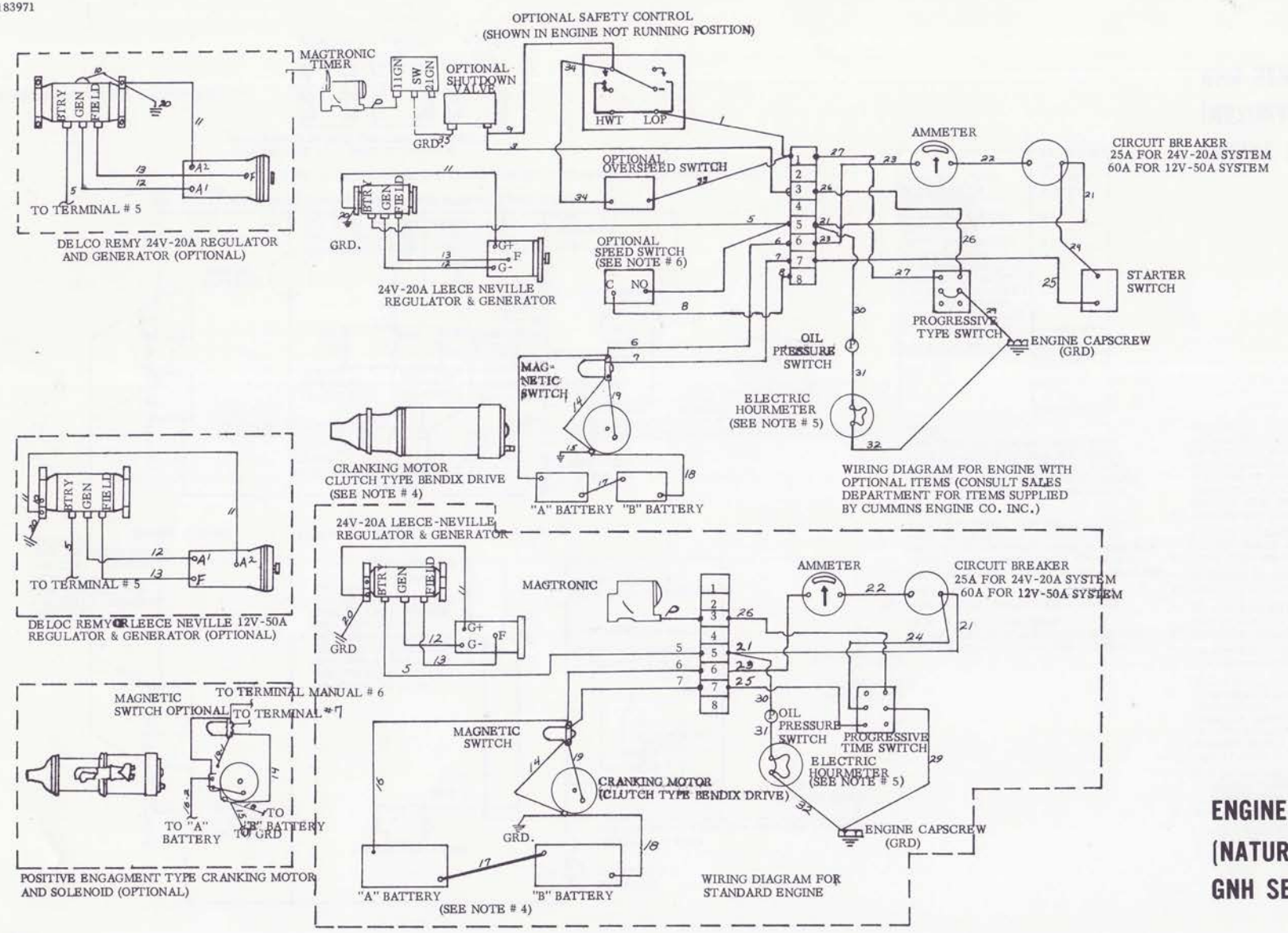
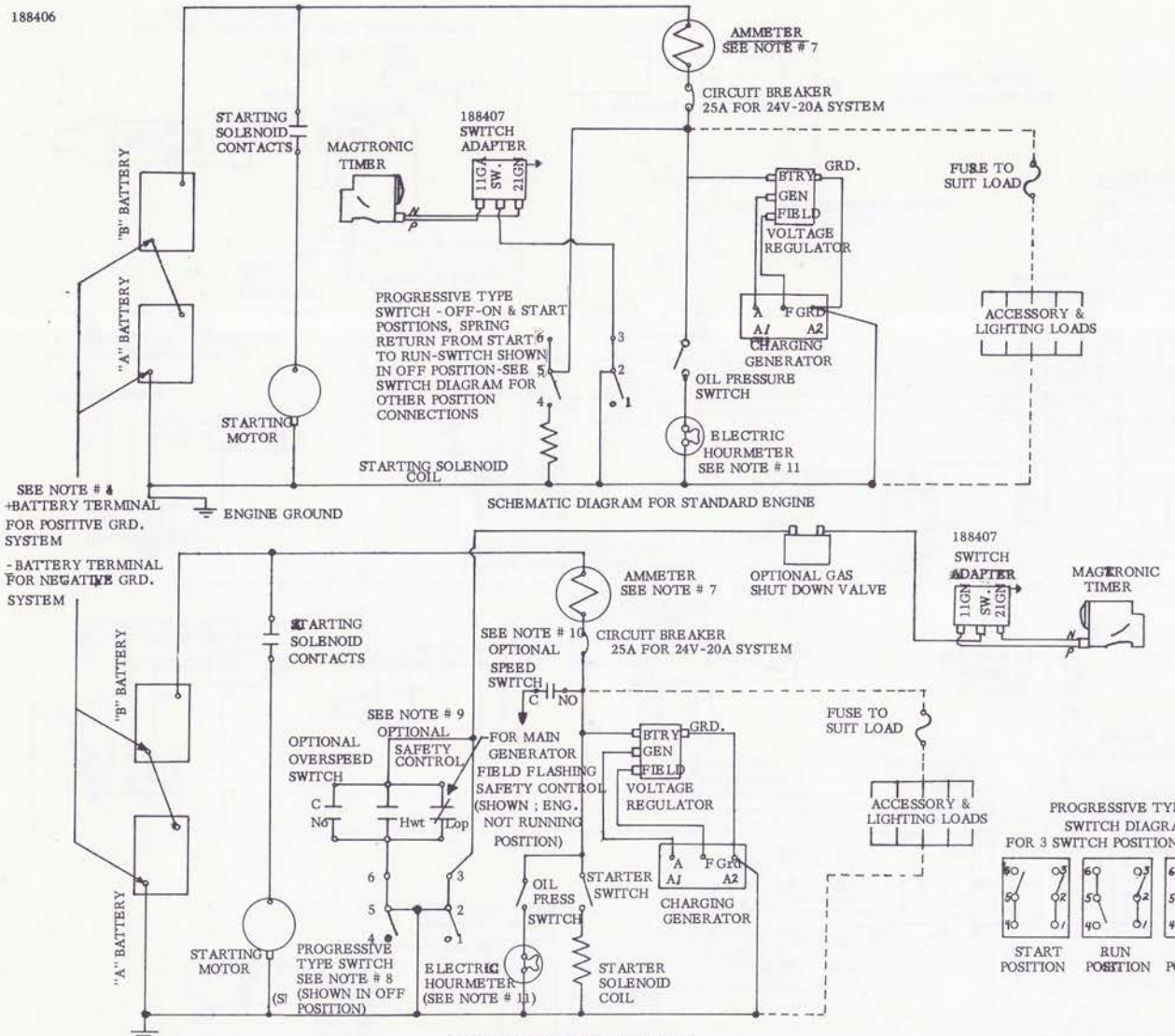


ENGINE WIRING DIAGRAM (NATURAL GAS ENGINE) GNH SERIES (SHEET 2)

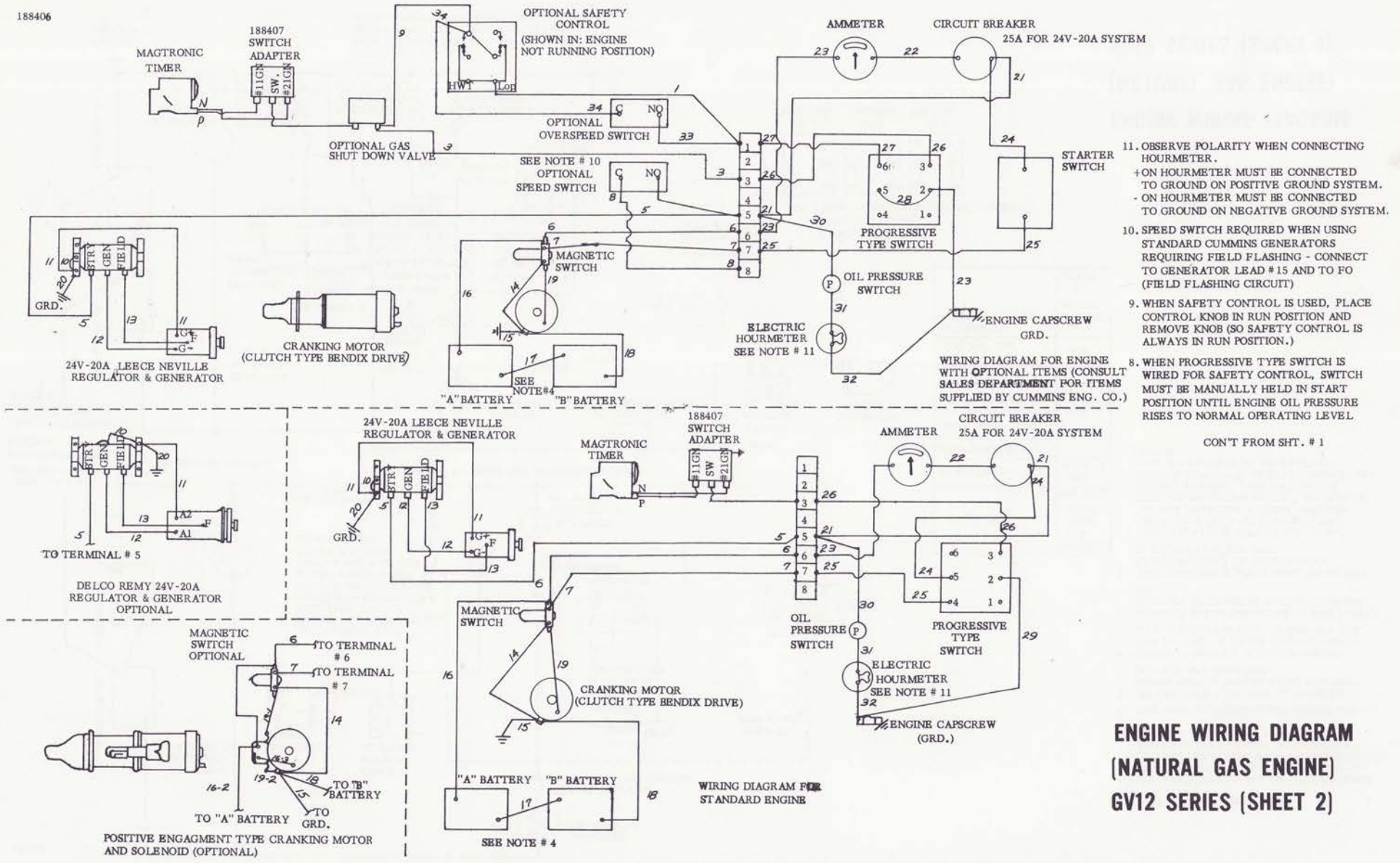


CIRCUIT	MINIMUM U.S. WIRE GAGE B&S SIZE
STARTING MOTOR	SEE NOTE #4
STARTING SWITCH STARTING SOLENOID COIL, SHUT DOWN VALVE, HOURMETER SAFETY CONTROL, OVERSPEED SWITCH, SPEED SWITCH	#14
CHARGING CIRCUIT FOR 24V-20A	#10
ACCESSORY & LIGHTING LOADS	#14 or LARGER AS REQ. BY LOADS

NOTES CONT. ON SHT. #2

7. FOLLOW WIRING DIAGRAM THEN REVERSE AMMETER CONNECTION IF AMMETER INDICATES DISCHARGE WITH ENGINE RUNNING AND INDICATES CHARGE WITH ENGINE STOPPED AND SWITCH IN ON POSITION.
6. FOR ACTUAL WIRING DIAGRAM SEE SHT. 2.
5. PROGRESSIVE TYPE SWITCH DIAGRAM SHOWS SWITCH CONNECTIONS FOR OFF RUN & START POSITIONS.
4. CONSULT SERVICE BULLETIN #985006 FOR BATTERY & CABLE REQUIREMENTS AT VARIOUS CRANKING TEMPERATURES.
3. CONSULT SALES DEPARTMENT FOR PARTS SUPPLIED BY CUMMINS ENGINE COMPANY, INC.
2. THIS DIAGRAM IS APPLICABLE TO EITHER LEECE NEVILLE OR DELCO-REMY ELECTRICAL EQUIPMENT.
1. THIS DIAGRAM IS APPLICABLE TO ALL GNVH-450 & GV12-525 ENGINES USING 24V-20A CHARGING SYSTEM WITH POSITIVE OR NEGATIVE GROUND AND HAVING EITHER A BENDIX TYPE OR POSITIVE ENGAGEMENT TYPE STARTER WITH STARTING SOLENOID MTD. ON STARTING MOTOR.

ENGINE WIRING DIAGRAM (NATURAL GAS ENGINE) GV12 SERIES (SHEET 1)



ENGINE WIRING DIAGRAM (NATURAL GAS ENGINE) GV12 SERIES (SHEET 2)

Cummins Engine Company, Inc.
Columbus, Indiana, U.S.A. 47201

Cummins Diesel International, Ltd.
Bowater House, Knightsbridge, London, England
Cable: INTCUMLON

Overseas Factories:
Cummins Engine Company, Ltd.
Shotts, Lanarkshire, Scotland
Cable: CUMSCOT SHOTTS

Cummins Engine Company, Ltd.
Yarm Road, Darlington, County Durham, England
Cable: CUMDAR DARLINGTON

Cummins Diesel Australia
Ringwood, Victoria
Cable: CUMAUS

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