SECTION 7

ELECTRICAL EQUIPMENT, INSTRUMENTS AND PROTECTIVE SYSTEMS

CONTENTS

ELECTRICAL SYSTEM

A typical engine electrical system generally consists of a starting motor, a battery–charging alternator, a storage battery and the necessary wiring.

Additional equipment such as an engine protective system may also be included.

Detailed information on maintenance and repair of the specific types of electrical equipment can be found in the service manuals and bulletins issued by the equipment manufacturer..

In most instances, repairs and overhaul work on electrical equipment should be referred to an authorized repair station of the manufacturer of the equipment. Replacement parts for electrical equipment should be ordered through the equipment manufacturer's outlets, since these parts are not normally stocked by Detroit Diesel Corporation. For electrical equipment manufactured by Delco–Remy Division, repair service and parts are available through AC–Delco branches and repair stations.

BATTERY–CHARGING ALTERNATOR

The battery–charging circuit consists of an alternator, battery and the wiring. The battery–charging alternator (Figs. 1 or 2) is introduced into the electrical system to provide a source of electrical current for maintaining the storage battery in a charged condition and to supply sufficient current to carry any other electrical load requirements up to the rated capacity of the alternator.

HINGE–MOUNTED ALTERNATOR (BELT–DRIVEN)

The hinge–mounted alternating current self–rectifying alternator (Fig. 1), mounted at the rear of the engine, is belt–driven. The alternator drive pulley is keyed to a shaft which is coupled to the blower drive gear.

An adequate alternator drive ratio is necessary for an engine equipped with extra electrical accessories and one that has to operate for extended periods at idle speeds. Diodes, built into the slip ring end frame, rectify the three phase A.C. voltage to provide D.C. voltage at the battery terminal of the alternator, thereby eliminating the need for an external rectifier. The alternator is also available in various sizes and types, depending upon the specific application.

The access hole permitting the external adjustment of the voltage regulator has been eliminated on current alternators. To adjust the voltage setting on the current alternators, refer to the manufacturer's Service Bulletin for complete adjustment procedure.

Alternator Maintenance

1. Maintain proper drive belt tension as noted in Section 15.1. Replace worn or frayed belts. Belts should be replaced as a set when there is more than one belt on the alternator drive.

   NOTICE: When installing or adjusting an alternator drive belt, be sure the bolt at the alternator pivot point is properly tightened, as well as the bolt in the adjusting slot.

2. Alternator bearings are permanently lubricated. There are no external oiler fittings.

Remove Alternator

1. Disconnect the cables at the battery supply. If the alternator has a separately mounted regulator and field relay, disconnect all other leads from the alternator and tag each one to ensure correct reinstallation.

2. Loosen the mounting bolts and the adjusting strap bolt. Then remove the drive belts.

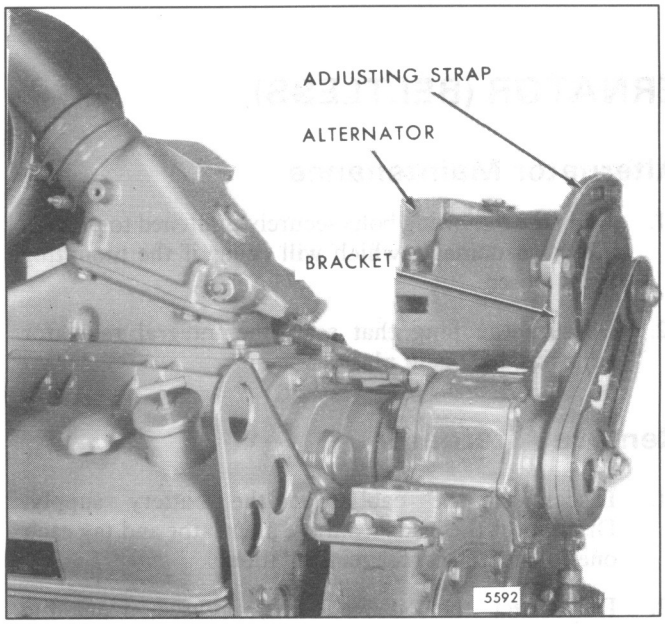

Fig. 1 – Typical Hinge–Mounted Alternator (Belt–Driven)

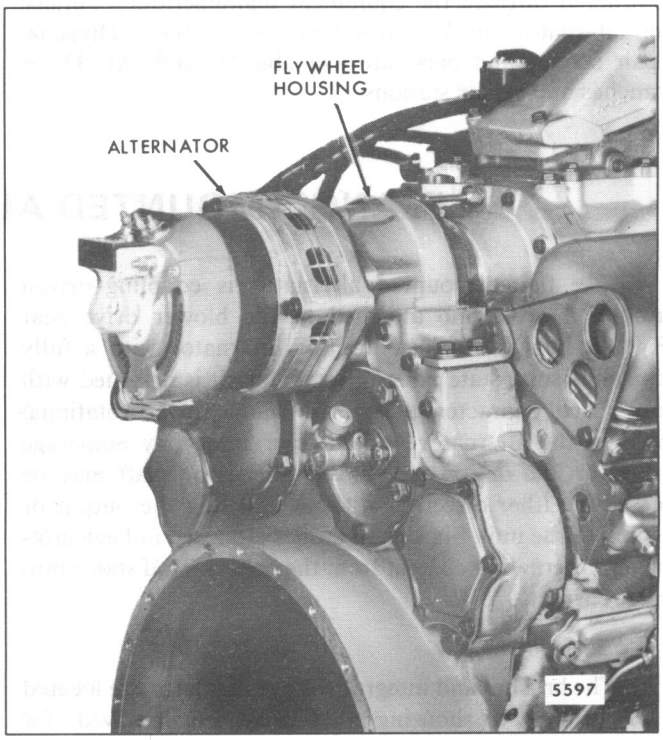

Fig. 2 – Typical Flange–Mounted Alternator (Beltless)

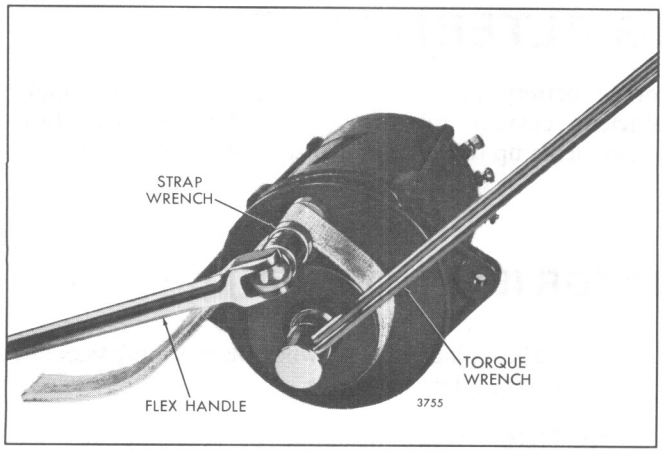

Fig. 3 – Tightening Alternator Pulley Retaining Nut

3. While supporting the alternator, remove the adjusting strap bolt, hardened washer and lock washer. Then remove the mounting bolts, hardened washer, lock washer and nuts. Remove the alternator carefully and protect it from costly physical damage.

4. Remove the pulley assembly if the alternator is to be replaced.

Alternator Service

Repairs and overhaul work on alternators should be referred to an authorized repair station of the manufacturer of this equipment. Replacement parts for alternators should be ordered through the equipment manufacturer's outlets. For alternators manufactured by Delco–Remy Division, repair service and parts are available through AC Delco branches and repair stations.

Install Alternator

1. Install the drive pulley, if it was removed. Tighten the pulley retaining nut to 50–60 lb–ft (68–81 N•m) torque.

   NOTICE: If the pulley was not removed, check the retaining nut for proper torque.

2. Position the alternator on the mounting brackets and start the bolts, with lock washers and hardened washers in place, through the bolt holes in the alternator end frames. If nuts are used, insert the bolts through the bolt holes in the mounting bracket and alternator end frame and make sure that the lock washers, hardened washers and nuts are in their proper locations.

3. Align the threaded hole in the adjusting lug of the drive end frame with the slot in the adjusting strap. Start the bolt, with the lock washer and hardened washer, through the slot of the adjusting strap and into the threaded hole in the alternator end frame.

4. Place the drive belts in the grooves of the pulleys.

5. Adjust the alternator belt tension as outlined in Section 15.1. Tighten all of the bolts after belt tightening is completed.

6. Attach the wires and cables. Be sure that each one is correctly installed in accordance with its previous location on the alternator. Keep all connections clean and tight.

FLANGE–MOUNTED ALTERNATOR (BELTLESS)

The flange–mounted alternator is coupling–driven through a drive hub attached to the blower drive gear (Fig. 2). It is a self load limiting alternator with a fully adjustable solid state integral regulator. It is designed with slow speed characteristics which allow lower rotational speed of the alternator without sacrificing any amperage output at idle or top speed. The alternator shaft may be rotated in either direction without affecting the output or cooling of the unit. Six silicon diodes mounted in heat sinks convert alternating current from the delta wound stator into direct current.

The brushes and integral voltage regulator are located in a waterproof housing that may be removed for replacement or inspection.

Alternator Maintenance

1. Keep the mounting bolts securely tightened to prevent vibration damage, which will occur if the mounting bolts loosen.

2. Be sure the plug that seals the integral regulator adjusting hole is in place.

Remove Alternator

1. Disconnect the cables at the battery supply. Disconnect the leads from the alternator and tag each one to ensure correct reinstallation.

2. Disconnect the oil feed line, if used, from the alternator.

3. Loosen the three alternator mounting bolts.

4. While supporting the alternator, remove the mounting bolts, hardened washers and lock washers and lift the alternator and fan guard as a unit from the mounting adaptor. Protect the alternator and fan guard assembly from physical damage following removal from the engine.

   NOTICE: The fan guard, which includes an oil seal, should not be separated from the alternator until the alternator half of the coupling is removed. Any attempt to separate the fan guard from the alternator could damage the oil seal.

5. Loosen the retaining nut and remove the coupling hub keyed to the alternator shaft.

6. If the alternator is to be replaced, separate the fan guard from the alternator.

7. Remove the alternator flange mounting adaptor from the flywheel housing, if necessary.

Alternator Service

To service the alternator, contact the alternator manufacturer.

Inspection

Inspect the drive coupling and hub for wear at the seal surface and the drive tangs. If worn excessively, replace them with new parts.

Oil leaks indicate a worn or damaged oil seal. Replace the oil seal in the fan guard, if necessary.

Inspect the alternator housing and flange adaptor at the mounting bolt holes for cracks and the pilot diameters for damage, cracks or distortion. Replace if necessary.

Install Alternator

1. If removed, attach the alternator mounting adaptor, using a new gasket, to the flywheel housing. The adaptor is secured to the engine by two short bolts into the flywheel housing and four long bolts through the flywheel housing, end plate and blower drive support.

   Make sure the alternator is properly fitted to the adaptor before it is bolted in place. Improper installation of the alternator can disturb adaptor alignment and cause gear train damage. See Section 1.7.7 for alignment procedure.

   NOTICE: Special hardened, plain washers seat in the six counterbored bolt holes in the adaptor. Also, the current gasket has a positioning identification tab.

2. If the fan guard and hub were removed, locate the fan guard on the alternator by engaging the mating pilot diameters. Lubricate the seal diameter on the coupling hub and the seal lip. Install the coupling hub on the shaft. Be careful not to damage the lip of the oil seal. Install the retaining nut on the shaft and tighten it to 70–80 lb–ft (95–108 N•m) torque. If the fan guard and hub were not removed, check the retaining nut for proper torque.

   NOTICE: Do not support the alternator on the fan guard.

3. Place the slotted drive coupling on the drive hub.

   NOTICE: Align the slotted drive coupling with the blower drive coupling when attaching the alternator assembly.

4. Align the bolt holes in the fan guard with the mounting holes in the alternator housing. Support the alternator assembly against the mounting flange adaptor, using a new gasket, and install the three 3/8"–16 x 3 1/2" bolts, lock washers and hardened washers through the alternator housing and fan guard mounting holes into the mounting adaptor. Tighten the bolts to 30–35 lb–ft (41–47 N•m) torque.

5. Attach the wires and cables. Be sure each one is correctly installed in accordance with its previous location on the alternator. Keep all connections clean and tight.

6. Connect the oil feed line, if used, to the alternator.

Oil Return Line

Distributor–provided Delco–Remy oil–cooled alternators formerly required a retrofit kit and customer–supplied oil supply and return lines. Because *the oil return line is no longer required* the oil return drain in the rectifier end frame of current 32SI alternators has been eliminated. The oil supply line is not affected by this change.

When an alternator having an oil return line is being serviced with a new rectifier end frame which does not have the oil return hole, or when an alternator assembly without the oil return hole is installed, perform the following steps:

1. Remove and discard the oil return line.

2. Remove the oil drain tube from the engine star cover.

3. Seal the hole in the engine star cover with the plug provided with the rectifier end frame or the complete alternator. This plug is also available from authorized Detroit Diesel or AC–Delco Parts Distributors.

ALTERNATOR PRECAUTIONS

Precautions must be taken when working on or around alternators. The diodes and transistors in the alternator circuit are very sensitive and can be easily destroyed.

Avoid grounding or shorting the output wires or the field wires between the alternator and the regulator. Never run an alternator on an open circuit.

Grounding an alternator's output wire or terminals, which are always "hot" regardless of whether or not the engine is running, or accidental reversing of the battery polarity will destroy the diodes. Grounding the field circuit will also result in the destruction of the diodes. Some voltage regulators provide protection against some of these circumstances. However, it is recommended that extreme caution be used.

Accidentally reversing the battery connections must be avoided.

Never disconnect the battery while an alternator is in operation. Disconnecting the battery may result in damage to the diodes due to the momentary high voltage and current generated by the rapid collapse of the magnetic field surrounding the field windings.

In marine applications which have two sets of batteries, switching from one set of batteries to the other while the engine is running will momentarily disconnect the batteries and result in damage to the alternator diodes.

If a booster battery is to be used, the batteries must be connected correctly (negative to negative and positive to positive).

Never use a fast charger with the battery connected or as a booster for battery output. Never attempt to polarize the alternator.

The alternator diodes are also sensitive to heat and care must be exercised to prevent damage to them from soldering irons, etc.

If faulty operation of an alternator occurs on an engine equipped with an insulated starting motor, check to be sure that a ground strap is present and is correctly installed.

STORAGE BATTERY

The lead–acid storage battery is an electro–chemical device for converting chemical energy into electrical energy.

Function Of Battery

The battery has three major functions:

1. It provides a source of current for starting the engine.
2. It acts as a stabilizer to the voltage in the electrical system.
3. It can, for a limited time, furnish current when the electrical demands exceed the output of the alternator.

In the selection of a replacement battery, it is always good practice to select one of an "electrical size" (refer to Chart) at least equal to the battery originally engineered for the particular equipment by the manufacturer.

		Minimum Battery Rating	
		SAE Cold Cranking AMPS @ 0°F (– 17.8°C)	
Engine Model	System Voltage	Above 32°F (0°C)	Below 32°F (0°C)
6V-92, 8V-92* 12V-92*	24V, 32V	950	1250
16V-92	#24V, 32V	950	1250

*Must use Delco Remy 50MT cranking motor or equivalent.
#Two cranking motors. Battery recommendation is for each motor.

BATTERY RECOMMENDATIONS

Install Battery

While the battery is built to satisfactorily withstand the conditions under which it will normally operate, excessive mechanical abuse leads to early failure.

Install the battery as follows:

1. Be sure the battery carrier is clean and that the battery rests level when installed.
2. Tighten the hold–down clamps evenly until snug. However, do not draw them down too tight or the battery case will become distorted or will crack.
3. Attach the cable clamps after making sure the cables and terminal clamps are clean and in good condition. To make the cable connections as corrosion resistant as possible, place a felt washer at the base of each terminal beneath the cable clamps. Coat the entire connection with a heavy general–purpose grease. Be sure the ground cable is clean and tight at the engine block or frame.
4. Check the polarity to be sure the battery is not reversed with respect to the generating system.
5. Connect the *grounded* terminal of the battery last to avoid short circuits which will damage the battery.

Servicing The Battery

A battery is a perishable item which requires periodic servicing. Only when the battery is properly cared for as described below can long and trouble–free service be expected.

1. Maintenance–free type batteries.
   a. On batteries equipped with charge indicator "eyes", periodically check for adequate charge.
   b. Although maintenance–free, periodically remove, check and clean battery posts, terminals and connections. Check connections for fraying or loss of insulation coverings and repair or replace.
2. If the batteries that are not the maintenance–free type, check the level of the electrolyte regularly. Add water, if necessary, but do not overfill. Overfilling can cause poor performance or early failure.
   a. Keep the top of the battery clean. When necessary, wash with a baking soda solution and rinse with fresh water. Do not allow the soda solution to enter the cells.
   b. Inspect the cables, clamps and hold–down bracket regularly. Clean and reapply a coat of grease when needed. Replace corroded or damaged parts.
   c. Use the standard battery test as the regular service test to check the condition of the battery.

Check the electrical system if the battery becomes discharged repeatedly. Many electrical troubles caused by battery failures can be prevented by systematic battery service.

Battery Safety Precautions

When batteries are being charged, an explosive gas mixture forms beneath the cover of each cell. Part of this gas escapes through the holes in the vent plugs and may form an explosive atmosphere around the battery itself if ventilation is poor.

CAUTION: Explosive gas may remain in or around the battery for several hours after it has been charged. Sparks or flames can ignite this gas causing an internal explosion which could shatter the battery. Flying pieces of the battery structure and splash of electrolyte can cause personal injury.

STARTING MOTOR

The starting motor (Fig. 1) is mounted on the flywheel housing. When the starting circuit is closed, a small drive pinion on the armature shaft engages with the teeth on the engine flywheel ring gear to crank the engine. When the engine starts, it is necessary to disengage the drive pinion to prevent the armature from overspeeding and damaging the starting motor.

See Section 7.0 for the mounting of a starter auxiliary magnetic switch.

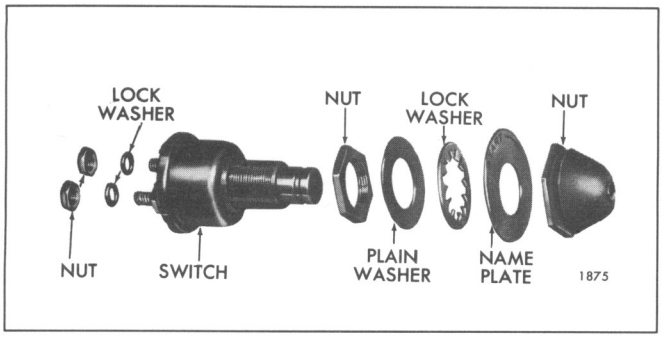

Fig. 1 – Typical Starting Motor

When repositioning of the solenoid is required on a service replacement starting motor, proceed as follows:

1. Remove the six socket head screws (1 short and 5 long) and six neoprene plugs, if a twelve hole starter mounting flange is used.
2. Turn the nose housing to the required position.

   NOTICE: The solenoid must never be located below the centerline of the starter or dust, oil, moisture and foreign material can collect and cause solenoid failures.
3. Install the six socket head screws, with the short screw in the shallow hole nearest the solenoid and six neoprene plugs, if a twelve hole starter mounting flange is used.
4. Tighten the screws to 13–17 lb–ft (18–23 N•m) torque.

Remove Starting Motor

Failure of the starting motor to crank the engine at normal cranking speed may be due to a defective battery, worn battery cables, poor connections in the cranking circuit, defective engine starting switch, low temperature, condition of the engine or a defective starting motor.

If the engine, battery and cranking circuit are in good condition, remove the starting motor as follows:

1. Remove the ground strap or cable from the battery or the cable from the starting motor solenoid. Tape the end of the cable to prevent discharging the battery from a direct short.
2. Disconnect the starting motor cables and solenoid wiring.

   NOTICE: Tag each lead to ensure correct connections when the starting motor is reinstalled.
3. Support the motor and remove the three bolts and lock washers which secure it to the flywheel housing. Then, pull the motor forward to remove it from the flywheel housing.

Check the starting motor in accordance with the Delco–Remy "Cranking Circuit" maintenance handbook.

Install Starting Motor

To install the starting motor, reverse the procedure outlined for removal. Tighten the 5/8"–11 starter attaching bolts to 137–147 lb–ft (186–200 N•m) torque when a cast iron flywheel housing is used or to 95–105 lb–ft (129–143 N•m) torque when an aluminum flywheel housing is used.

Keep all of the electrical connections clean and tight. When installing wiring terminal leads to the starting motor and the solenoid switch, tighten the No. 10–32 connections to 16–30 **lb–in** (2–3 N•m) torque and the 1/2"–13 connections to 20–25 lb–ft (27–34 N•m) torque.

INSTRUMENTS AND TACHOMETER DRIVE

INSTRUMENTS

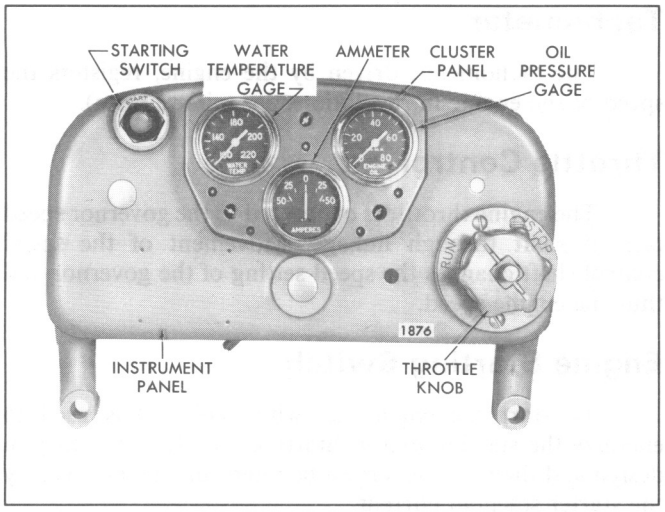

Fig. 1 – Typical Instrument Panel

The instruments generally required in the operation of a diesel engine consist of an oil pressure gage, water temperature gage, an ammeter and a mechanical tachometer. Also, closely related and usually installed in the general vicinity of these instruments are certain controls consisting of an engine starting switch, engine stop knob and an emergency stop knob (Fig. 1).

All Torqmatic converters are equipped with an oil pressure gage and, in some instances, with an oil temperature gage. These instruments are mounted on a separate panel.

Instruments, throttle control and engine starting and stopping controls are mounted in various locations depending upon the particular use of the engine.

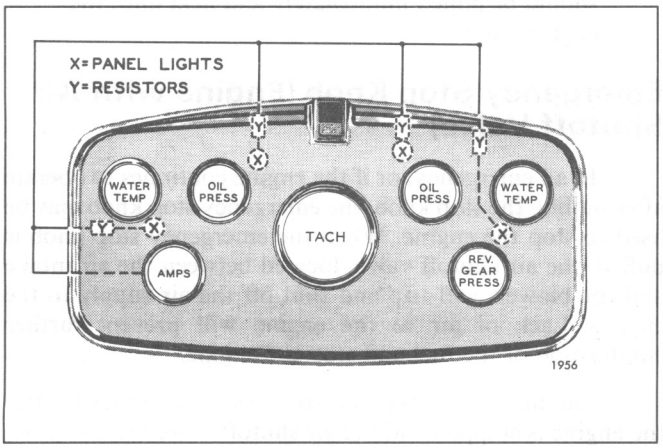

Fig. 2 – Installation of Resistors in Illuminated Instrument Panel

Marine propulsion engines are provided with an instrument panel which usually includes an engine oil pressure gage, reverse gear oil pressure gage, water temperature gage, ammeter and a tachometer. The instrument panels are generally mounted some distance from the engine. Illuminated instrument panels are provided for marine applications which require night operations.

All illuminated instrument panels are wired for a 12 volt lighting circuit. Therefore, when marine propulsion units incorporate either a 24 or 32 volt electrical system, a 12 volt tap–off from the battery may be made, or resistors (Table 1) may be installed in the circuit to protect the instrument panel bulbs. As indicated in Fig. 2, one resistor is used in the lead for each instrument panel bulb.

Resistor Specifications		
Volts	Ohms	Watts
24	50	10
32	100	10

TABLE 1

Whenever performing service or preventive maintenance procedures on marine propulsion engine units which include a 24 or 32 volt electrical system, check the lighting circuit of the instrument panels to determine if either a 12 volt tap–off from the battery or resistors have been installed in the lighting circuit to protect the instrument panel bulbs.

Anti–Vibration Instrument Mountings

Anti–vibration mountings are used in many places to absorb engine vibration in the mounting of instruments, drop relays, tachometers, etc. When it may become necessary to service a part secured by rubber mounts, care should be exercised, during removal and installation of the part, so twist is not imposed into the rubber mount diaphram. At the time the part is removed from the engine for service, the mounts should be inspected for damage and replaced, if necessary.

The attaching screw, through the center of the mount, must be held from turning during final tightening of the nut. Support the screw and tighten the nut only. If this screw turns, it will pre–load the rubber diaphragm in torsion and considerably shorten the life of the mount.

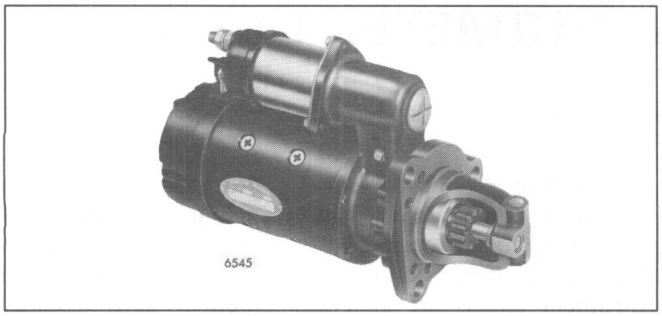

Fig. 3 – Typical Engine Starting Switch

Oil Pressure Gage

The oil pressure gage registers the pressure of the lubricating oil in the engine. As soon as the engine is started, the oil pressure gage should start to register. If the oil pressure gage does not register at least the minimum pressure listed in the *Operating Conditions* in Section 13.2, the engine should be stopped and the cause of the low oil pressure determined and corrected before the engine is started again.

Current oil pressure gages have male threads and require female fittings. When replacing a former gage with female threads, a new mounting clamp and connector must be used.

Water Temperature Gage

The engine coolant temperature is registered on the water temperature gage.

Incorrect coolant temperature readings will be registered if the gage assembly is incorrectly installed or the capillary tube is damaged.

To prevent damage to the gage assembly from vibration, the capillary tube must be securely fastened to the engine the full length with suitable clips at intervals of ten inches or less. Sharp bends in the tube must be avoided, particularly at the gage or bulb connection areas. Where the tube must be bent around any object, the bend must not be less than one inch radius.

Any extra length can be taken up by coiling, the diameter of which should not be less than two inches. The coils must be located so that they may be securely fastened to prevent vibration.

Ammeter

The ammeter is wired into the electrical circuit to show the current flow to and from the battery. After starting the engine, the ammeter should register a high charge rate at rated engine speed. This is the rate of charge received by the battery to replenish the current used to start the engine. As the engine continues to operate, the ammeter should show a decline in the charge rate to the battery. The ammeter will not show zero charge rate since the regulator voltage is set higher than the battery voltage. The small current registered prevents rapid brush wear in the battery–charging alternator. If lights or other electrical equipment are connected into the circuit, then the ammeter will show discharge when these items are operating and the engine speed is reduced.

Tachometer

The tachometer, driven by the engine, registers the speed of the engine in revolutions per minute (rpm).

Throttle Control

The engine throttle is connected to the governor speed control shaft through linkage. Movement of the speed control shaft changes the speed setting of the governor and thus the engine speed.

Engine Starting Switch

To start the engine, a switch (Fig. 3) is used to energize the starting motor. Starting switches may vary in design and their contacts must be rated sufficiently to carry the starter solenoid current.

NOTICE: Tighten the starting switch mounting nut to 36–48 **lb–in** (4–5.5 N•m) torque.

Engine Stop Knob

A stop knob is used to shut the engine down. When stopping an engine, the engine speed should be reduced to idle and the engine allowed to operate at idle for a few minutes to permit the coolant to reduce the temperature of the engine's moving parts. Then pull the stop knob and hold it until the engine stops. Pulling on the stop knob manually places the injector racks in the no–fuel position. Return the stop knob to its original position after the engine stops.

NOTICE: When an emergency shut down is necessary on a current engine with the spring loaded fuel injector control tubes, the stop knob should be pulled immediately and held until the engine stops.

Emergency Stop Knob (Engine with Air Shutoff Valve)

In an emergency, or if the engine continues to operate after pulling the stop knob, the emergency stop knob may be used to stop the engine. When the emergency stop knob is pulled, the air shutoff valve, located between the air intake and the blower, will trip and shut off the air supply to the engine. Lack of air to the engine will prevent further combustion of the fuel and stop the engine.

The emergency stop knob must be pushed back in after the engine is stopped and the air shutoff valve must be reset manually. The cause of the malfunction should be determined before the engine is started again.

TACHOMETER DRIVE

A tachometer drive shaft may be installed at any one of several locations on the engine.

At the front end of the engine, the tachometer drive shaft is pressed into the end of the right bank camshaft and extends through an adaptor attached to the balance weight cover (Fig. 4).

At the rear of the engine, the tachometer drive shaft may be installed in the end of either camshaft, the blower drive shaft, or the L.H. helix blower rotor shaft (Fig. 5). A tachometer drive shaft adaptor is attached to the flywheel housing cover or the blower rear end plate cover.

When required, a tachometer drive cable adaptor is used to change speed or to change direction of rotation, depending upon the location of the tachometer drive. A special key is used to connect the drive shaft to the tachometer drive cable adaptor.

The cable connection at the current tachometer head is a 5/8" threaded connection in place of the former 7/8" connection. To eliminate possible misalignment, the current tachometer angle drive has a short flexible cable and incorporates an integral oil seal. The output shaft key size has been increased from 5/32" to SAE 3/16". New flexible drive cables are also required with the current tachometers and angle drives.

Remove Tachometer Drive (Camshaft or Blower Drive Shaft Driven)

If replacement is necessary, remove the tachometer drive shaft as follows:

1. Disconnect the tachometer drive cable from the tachometer drive cable adaptor.
2. If used, remove the tachometer drive cable adaptor and key (key and seal assembly if the tachometer drive shaft is driven by the blower drive shaft).
3. Remove the tachometer drive shaft adaptor and gasket from the balance weight cover if the tachometer drive is located at the front of the engine. For a rear mounted tachometer drive, remove the flywheel housing cover and adaptor assembly and gasket. Examine the oil seal(s), if used, for wear or damage. Replace the oil seal (camshaft drive) or oil seal unit (blower drive shaft drive), if necessary.
4. If the tachometer drive shaft is driven by the blower drive shaft, remove the blower drive shaft.
5. Remove a tachometer drive shaft that is pressed into the camshaft as follows:

   a. If the tachometer drive shaft is pressed into the end of the camshaft, it cannot be turned since the end is either square or knurled. If threads (5/16"–24 or 3/8"–24) are provided on the outer end of the tachometer drive shaft to accommodate a removing tool, thread remover J 5901–3 on the shaft. Then attach slide hammer J 23907–1 to the remover. A few sharp blows of the weight against the slide hammer rod will remove the tachometer drive shaft.

   b. If threads are not provided on the outer end of the tachometer drive shaft, or if the end of the shaft is broken off, drill and tap the shaft. Then thread a stud into the shaft and remove the shaft with the remover and slide hammer.

NOTICE: Use adequate protective measures to prevent metal particles from falling into the gear train and oil pan.

Install Tachometer Drive (Camshaft or Blower Drive Shaft Driven)

When installing a tachometer drive cover assembly or a drive adaptor, it is important they be aligned properly with the tachometer drive shaft (Section 7.0).

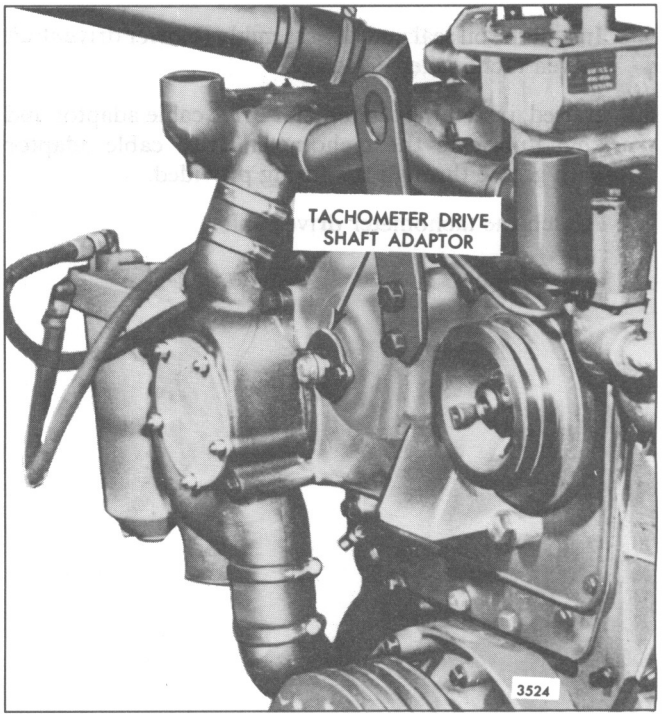

Fig. 4 – Front Mounted Tachometer Drive

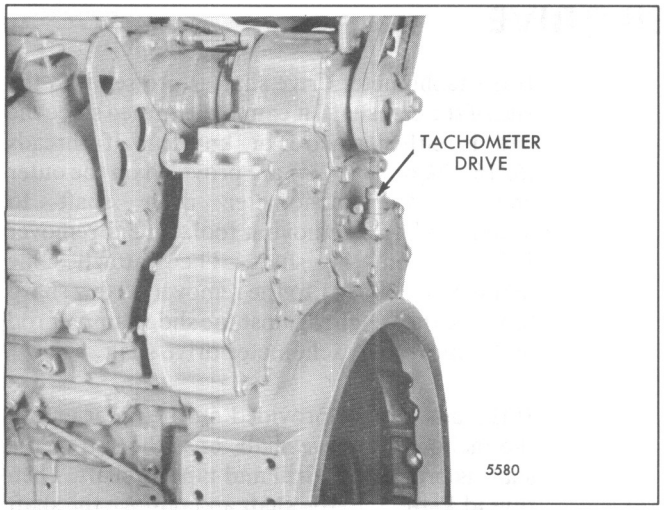

Fig. 5 – Rear Mounted Tachometer Drive

1. Start the tachometer drive shaft in the end of the camshaft or blower drive shaft. Then, using a suitable sleeve, tap or press against the shoulder on the tachometer drive shaft until the shoulder contacts the camshaft or blower drive shaft.
2. Install the blower drive shaft.
3. Use a new gasket and install the tachometer drive cover and adaptor on the balance weight cover or flywheel housing.
4. Check alignment of the tachometer drive shaft as outlined in Section 7.0.
5. Install the oil seal and key assembly (blower drive shaft driven tachometer drive).
6. If used, install the tachometer drive cable adaptor and key. Lubricate the tachometer drive cable adaptor with grease through the fitting provided.
7. Attach the tachometer drive cable.

Remove Tachometer Drive (Driven by Blower Rotor Shaft)

If replacement is necessary, remove the tachometer drive shaft as follows:

1. Disconnect the tachometer drive cable from the tachometer drive cable adaptor.
2. Remove the tachometer drive cable adaptor and key.
3. Remove the blower from the engine as outlined in Section 3.4.
4. Remove the blower rear end plate cover.
5. Remove the tachometer drive shaft, which also functions as the L.H. blower rotor gear retaining bolt, with a 3/4" wrench.

Install Tachometer Drive (Driven by Blower Rotor Shaft)

1. Lubricate the threads with engine oil and install the combination blower rotor retaining bolt and tachometer drive shaft. Tighten it to 55–65 lb–ft (75–88 N•m) torque.
2. Install the blower rear end plate cover.
3. Align the blower rear end plate cover with the tachometer drive shaft. Check the alignment of the drive shaft as outlined in Section 7.0.
4. Install the blower on the engine as outlined in Section 3.4.
5. Install the tachometer drive cable adaptor and key.
6. Attach the tachometer drive cable.

ENGINE PROTECTIVE SYSTEMS

MANUAL SHUTDOWN SYSTEM

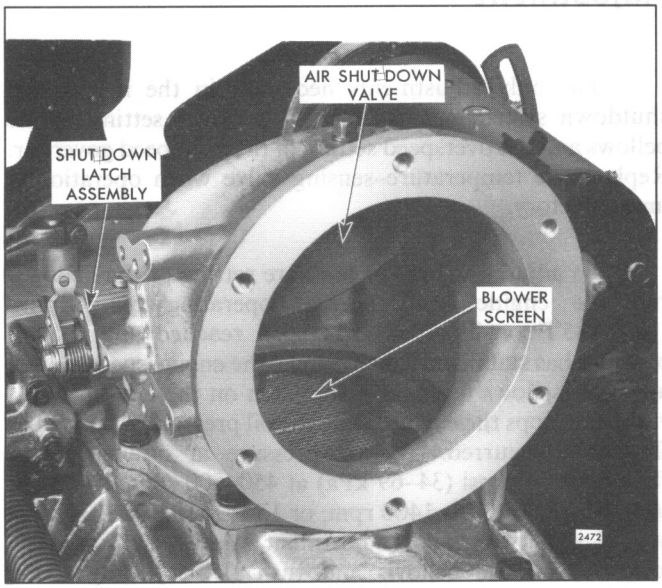

Fig. 1 – Typical Manually Operated Emergency Engine Shutdown Valve Mounting

A manually–operated emergency engine shutdown device, mounted in the air shutdown housing, enables the engine operator to stop the engine in the event an abnormal condition should arise. If the engine continues to run after the engine throttle is placed in the no–fuel position, or if combustible liquids or gases are accidentally introduced into the combustion chamber causing overspeeding of the engine, the shutdown device will prevent damage to the engine by cutting off the air supply and thus stopping the engine. The device consists of a shutdown valve mounted in the air shutdown housing and a suitable operating mechanism (Fig. 1).

The air shutdown valve is retained in the open position by a latch. A Bowden wire or cable assembly is used to trip the latch. Pulling the emergency shutdown knob all the way out will stop the engine. After the engine stops, the operator must push the emergency shutdown knob all the way in and manually reset the air shutdown valve before the engine is started again.

Service

For removal and installation or disassembly and assembly of the manual shutdown device, refer to Section 3.3.

AUTOMATIC MECHANICAL SHUTDOWN SYSTEM

The automatic mechanical shutdown system (Fig. 2) is designed to stop the engine if there is a loss of oil pressure, loss of engine coolant, overheating of the engine coolant or overspeeding of the engine. Engine oil pressure is utilized to activate the components of the system.

A coolant temperature–sensing valve and an adaptor and copper plug assembly are mounted on the exhaust manifold outlet. The power element of the temperature–sensing valve is placed against one end of the copper plug, and the other end of the plug extends into the exhaust manifold. Engine coolant is directed through the adaptor and passes over the power element of the valve. Engine oil, under pressure, is directed through a restricted fitting to the temperature–sensing valve and to an oil pressure actuated bellows located on the air inlet housing.

The pressure of the oil entering the bellows overcomes the tension of the bellows spring and permits the latch to retain the air shutdown valve in the open position. If the oil pressure drops below a pre–determined value, the spring in the bellows will release the latch and permit the air shutdown valve to close and thus stop the engine.

The overspeed governor (Fig. 3), used on certain applications, consists of a valve actuated by a set of spring–loaded weights. Engine oil is supplied to the valve through a connection in the oil line between the bellows and the temperature–sensing valve. An outlet in the governor valve is connected to the engine oil sump. Whenever the engine speed exceeds the overspeed governor setting, the valve (actuated by the governor weights) is moved from its seat and permits the oil to flow to the engine sump. This decreases the oil pressure to the bellows, thus actuating the shutdown mechanism and stopping the engine.

Operation

To start an engine equipped with a mechanical shutdown system, first manually open the air shutdown valve and then press the engine starting switch. As soon as the engine starts, the starting switch may be released, but the

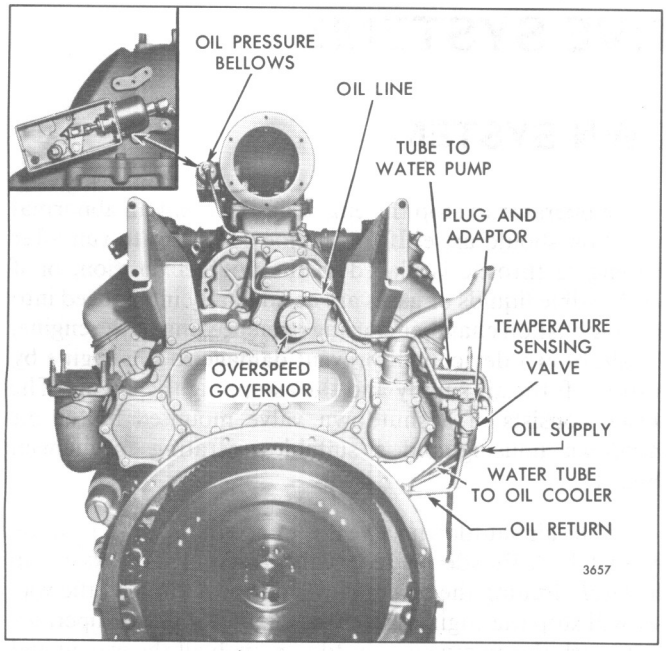

Fig. 2 – Typical Automatic Mechanical Shutdown System Mounting

air shutdown valve must be held in the open position until the engine oil pressure increases sufficiently to permit the bellows to retain the latch in the open position.

During operation, if the engine oil pressure drops below the setting of the pressure sensitive bellows, the spring within the bellows will release the latch and permit the air shutdown valve to close, thus stopping the engine.

If the engine coolant overheats, the temperature–sensing valve will open and permit the oil in the protective system to flow to the engine crankcase.

The resulting decrease in oil pressure will actuate the shutdown mechanism and stop the engine. Also, if the engine loses its coolant, the copper plug will be heated by the hot exhaust gases passing over it and cause the temperature–sensing valve to open and actuate the shutdown mechanism.

Whenever the engine speed exceeds the overspeed governor setting, the oil in the line flows to the sump, resulting in a decrease in oil pressure. The oil pressure bellows then releases the latch and permits the air shutdown valve to close.

When an engine is stopped by the action of the shutdown system, the engine cannot be started again until the particular device which actuated the shutdown mechanism has returned to its normal position. The abnormal condition which caused the engine to stop must be corrected before attempting to start it again.

Adjustment

The only adjustments necessary in the mechanical shutdown system are the low oil pressure setting of the bellows and the overspeed setting of the overspeed governor. Replace the temperature–sensing valve when operation is unsatisfactory.

To adjust the low oil pressure setting of the bellows, run the engine until normal operating temperature (160°–185°F or 71°–85°C) has been reached and the oil pressure has stabilized. Then reduce the engine speed slowly until the bellows disengages the latch on the air shutdown valve and stops the engine. Note the oil pressure at which the shutdown occurred. The oil pressure at disengagement should be 5–10 psi (34–69 kPa) at 450–600 rpm; 10–15 psi (69–103 kPa) at 601–1400 rpm; or 15–20 psi (103–138 kPa) at 1401 and above rpm. If adjustment is necessary, loosen the lock nut on the bellows and turn the adjusting screw clockwise to increase the oil pressure setting or counterclockwise to decrease the setting. Hold the adjusting screw and tighten the lock nut when the proper setting has been obtained.

NOTICE: Set the bellows disengagement pressure as near as possible to the high end of the pressure range for the low engine speed specified for the engine.

Check the operation of the engine coolant temperature–sensing valve by placing a cover over the radiator while the engine is operating at part load and note the coolant outlet temperature at which the bellows disengages the air shutdown latch. The air shutdown valve should close and stop the engine within a temperature range of 200°–210°F (93°–99°C). If the engine is not shutdown in this range, replace the temperature–sensing valve. If the engine is shutdown below 200°F (93°C), check the coolant flow through the plug and adaptor assembly and, if circulation is satisfactory, replace the temperature–sensing valve.

NOTICE: If the temperature sensing valve is removed, examine the temperature shutdown valve plunger in the copper probe (Fig. 3). If it is not free in the probe and adaptor, install a new plunger, spring and adaptor. Deposits from the engine coolant building up between the plunger, spring and plug can cause the plunger to stick in the probe.

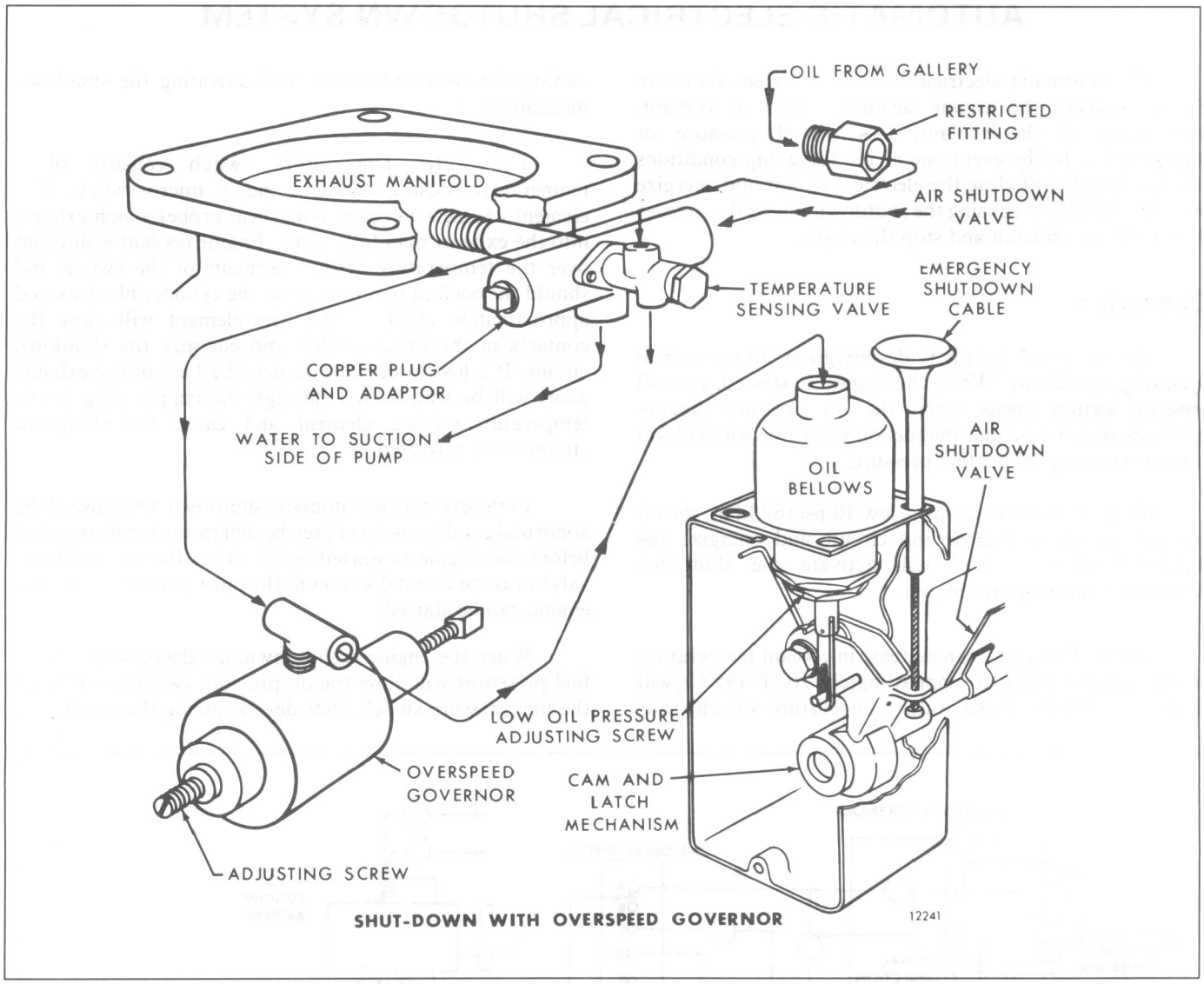

Fig. 3 – Schematic Drawing of Automatic Mechanical Shutdown System with Overspeed Governor

The temperature–sensing valve can be bench tested by attaching an air hose (40 psi or 276 kPa) air supply to the oil inlet side and installing a tube from the outlet side to a can of water. Then immerse the power element of the valve in a container of water that is heated and agitated. Check the temperature of the water with a thermometer. Apply air to the valve. The valve should be open, as indicated by the flow of air, at a water temperature of 195°–206°F (91°–96°C).

To adjust the overspeed governor, run the engine until normal operating temperature is reached. Then increase the engine speed to the desired overspeed shutdown speed. At this speed, the bellows should disengage the air shutdown latch and stop the engine. If necessary, adjust the overspeed governor setting by loosening the lock nut on the adjusting screw at the rear of the governor and turn the screw clockwise to increase the shutdown speed or counterclockwise to decrease the shutdown speed. Then tighten the lock nut, while holding the adjusting screw, when the proper setting is obtained.

AUTOMATIC ELECTRICAL SHUTDOWN SYSTEM

The automatic electrical shutdown system shown in Fig. 4 protects the engine against a loss of coolant, overheating of the coolant, loss of oil pressure or overspeeding. In the event one of the foregoing conditions arises, a switch will close the electrical circuit and energize the solenoid switch, causing the shutdown solenoid to release the air shutdown latch and stop the engine.

Operation

The electrical circuit is de–energized under normal operating conditions. When the engine is started, one oil pressure switch opens when the oil pressure reaches approximately 10 psi and the fuel oil pressure switch closes at approximately 20 psi fuel pressure.

If the oil pressure drops below 10 psi (69 kPa), the oil pressure switch will close the circuit and energize the shutdown solenoid. This will activate the shutdown mechanism and stop the engine.

A loss of coolant or an increase in coolant temperature in the cylinder block to approximately 203°F (95°C) will close the contacts in the water temperature switch, thus closing the electrical circuit and activating the shutdown mechanism.

The water temperature switch consists of a temperature–sensing element and a micro–switch. The element contacts a copper plug (heat probe) which extends into the exhaust manifold outlet. Engine coolant is directed over the temperature–sensing element of the switch and should the coolant temperature in the cylinder block exceed approximately 203°F (95°C), the element will close the contacts in the micro–switch and energize the shutdown circuit. If a loss of coolant occurs, the heat of the exhaust gases will be transmitted through the copper plug to the temperature–sensing element and cause the shutdown circuit to be activated.

In the event of an automatic shutdown, the cause of the abnormal conditions must then be determined and corrected before the engine is started again. Also, the air shutdown valve must be manually reset in the open position before the engine can be started.

When the engine is shutdown, the decrease in oil and fuel pressures will close the oil pressure switches and open the fuel pressure switch, thus de–energizing the circuit.

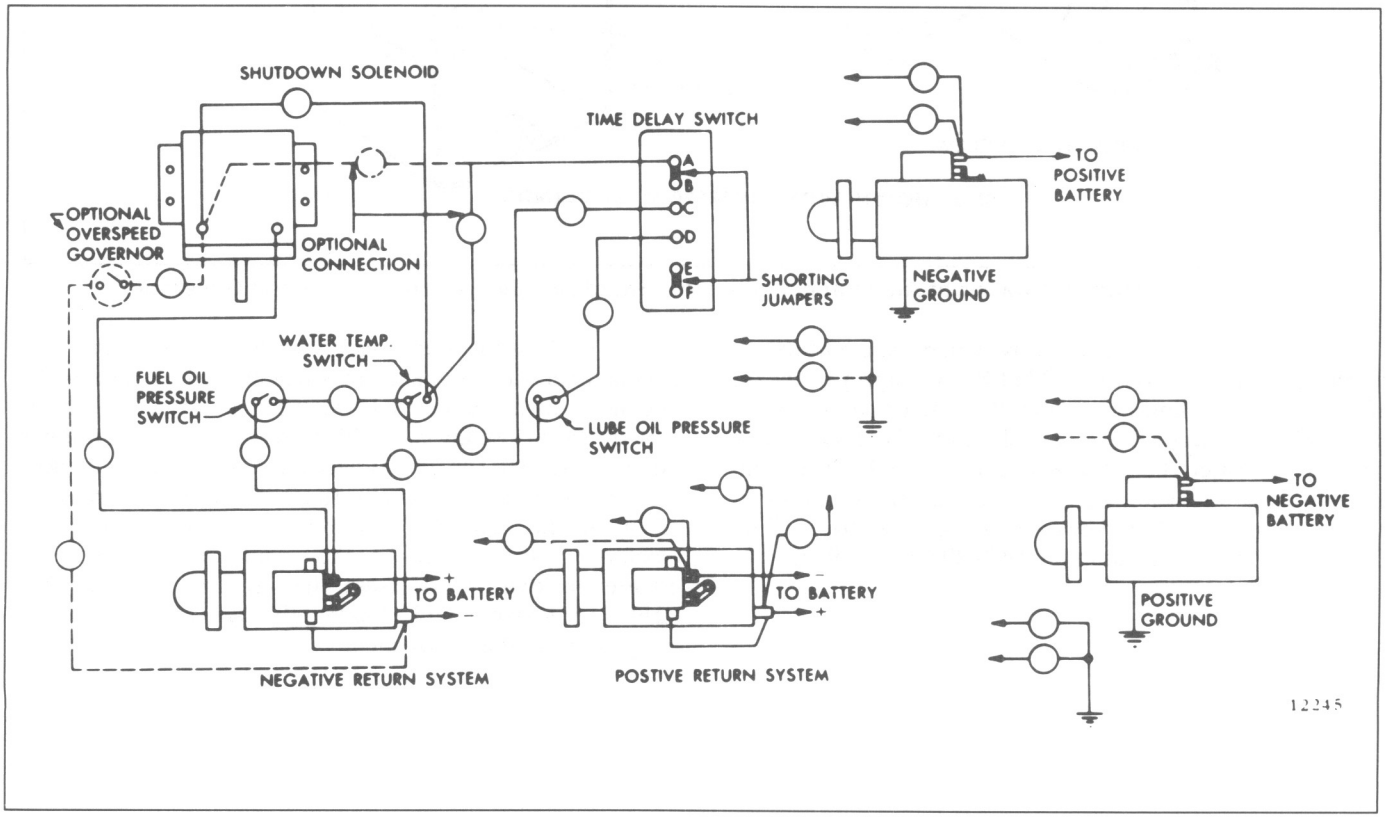

Fig. 4 – Automatic Electrical Shutdown System Diagram

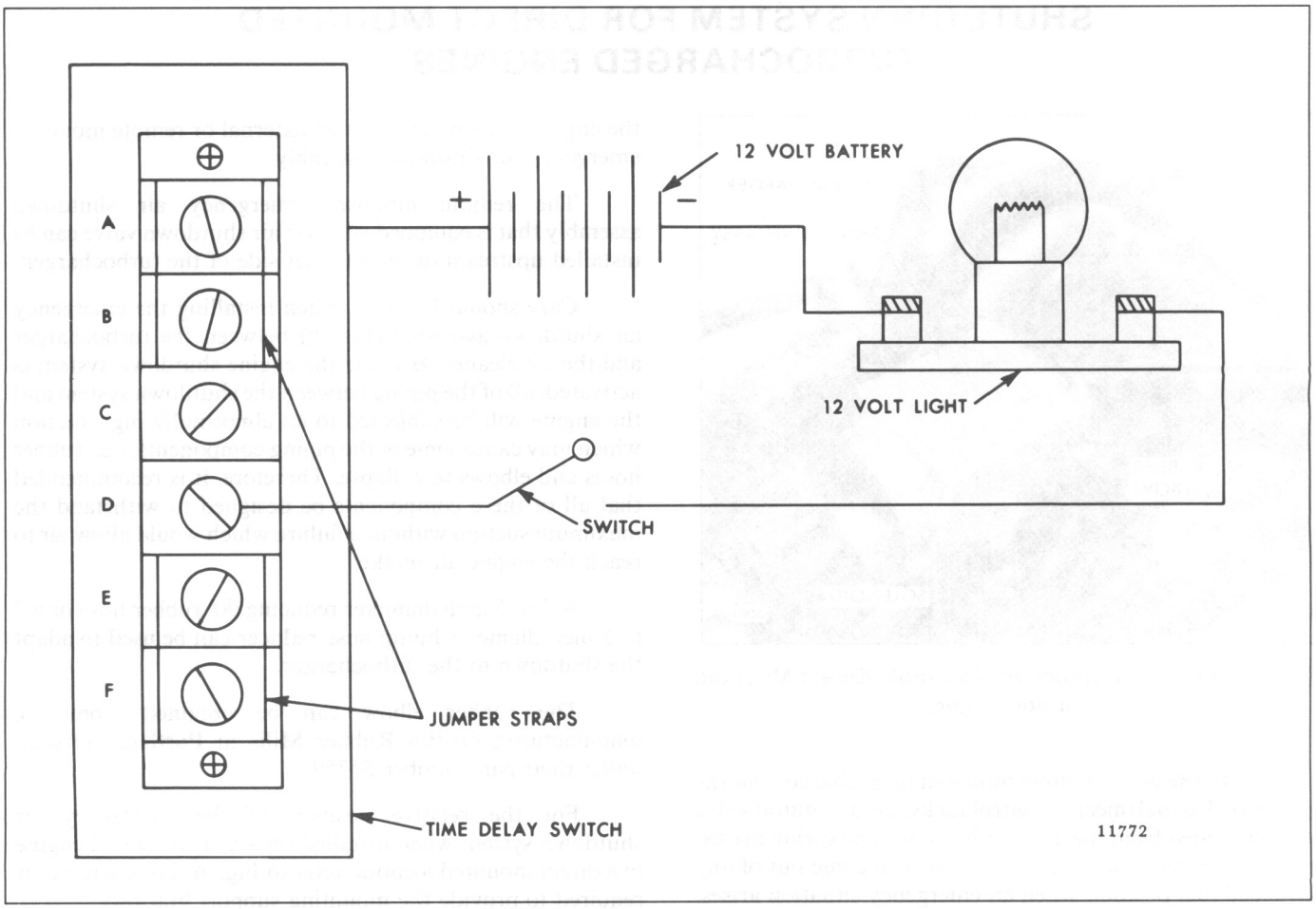

Fig. 5 – Solid State Time Delay Switch Testing Diagram

Some engines are equipped with an electrically operated automatic shutdown system which incorporates a time delay switch (Fig. 4).

Since the fuel pressure builds up rapidly, the fuel oil pressure switch could close before the lubricating oil pressure switch opens, thereby effecting a shutdown of the engine. The time delay switch, however, delays operation of the solenoid for 3 to 10 seconds to enable the lubricating oil pressure to build up and open the oil pressure switch contacts.

When the lubricating oil pressure falls below 10± 2 psi 69 ± 7 kPa), the contacts in the oil pressure switch used in this system will close and current will flow to the time delay switch. The few seconds required to heat the time delay switch provides sufficient delay to avoid an engine shutdown when low oil pressure is caused by a temporary condition such as an air bubble or a temporary overlap in the operation of the oil pressure switch and the fuel oil pressure switch when starting or stopping the engine.

Solid State Time Delay Switch

A bench test procedure for the solid state time delay switch is as follows:

1. Refer to Fig. 4 and remove the time delay switch from the engine.
2. Refer to Fig. 5 and install the jumper straps on terminals A to B and E to F.
3. Install a positive battery lead to terminal A.
4. Install a negative battery lead to one side of a 12 volt light.
5. Install a lead from the opposite side of the light to terminal D. A switch may be used in this lead, if desired.
6. After the negative lead is connected to terminal D or the switch is closed, the lamp should light in 8 to 10 seconds. If not, the time delay switch must be replaced.

SHUTDOWN SYSTEM FOR DIRECT MOUNTED TURBOCHARGED ENGINES

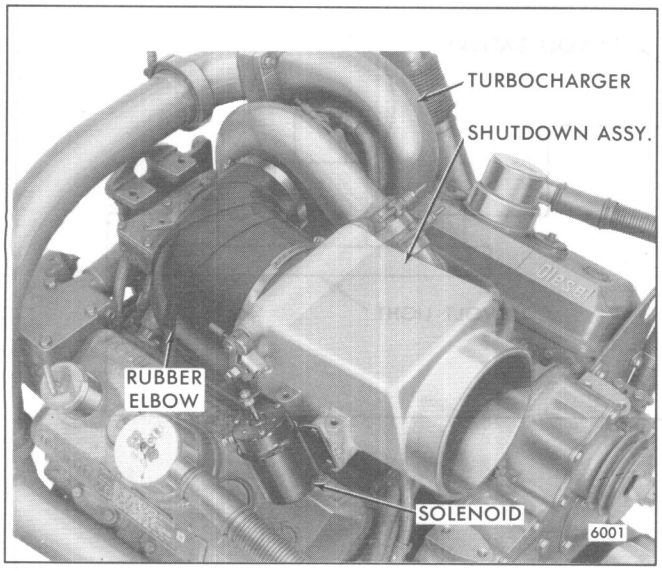

Fig. 6 – Emergency Shutdown Assembly (Direct Mounted Turbocharger)

With the use of a direct mounted turbocharger and the spring loaded fuel injector control racks, the air shutoff valve was eliminated from the air inlet housing. The spring loaded injector control racks enable the engine to come out of any advanced fuel position when an emergency situation arises.

When an engine is operating in an atmosphere subject to volatile fuel and is equipped with an air inlet housing without the air shutdown valve, a customer may request that the engine be equipped with an external or remote mounted emergency air shutdown assembly.

The remote mounted emergency air shutdown assembly that is equipped with the air shutdown valve can be installed upstream of the air inlet side of the turbocharger.

Care should be taken when installing the emergency air shutdown assembly (Fig. 6) between the turbocharger and the air cleaner. Because the engine shutdown system is activated, all of the piping between the shutdown system and the engine will be subjected to an abnormally high suction which may cause some of the piping components, i.e., rubber hoses and elbows to collapse. Therefore, it is recommended that all of these components be designed to withstand the maximum suction without a failure which would allow air to reach the engine air intake.

A 7 to 5 inch diameter reducing 90° rubber hose or a 7 to 5 inch diameter hump hose reducer can be used to adapt the shutdown to the turbocharger.

The rubber elbow can be obtained from the manufacturer; Griffin Rubber Mills in Portland, Oregon under their part number 51759.

For the relative position of the emergency air shutdown system when installed on a Detroit Diesel engine in a direct mounted location refer to Fig. 6. The customer is required to provide the mounting support brackets.

The emergency air shutdown assembly is manually operated. To be an automatic shutdown system, it will be necessary to install a solenoid.

ALARM SYSTEM

The alarm system shown in Figs. 1 and 2 is similar to the automatic electrical shutdown system, but uses a warning bell in place of the air shutdown valve solenoid. The bell warns the engine operator if the engine coolant overheats or the oil pressure drops below the oil pressure switch setting.

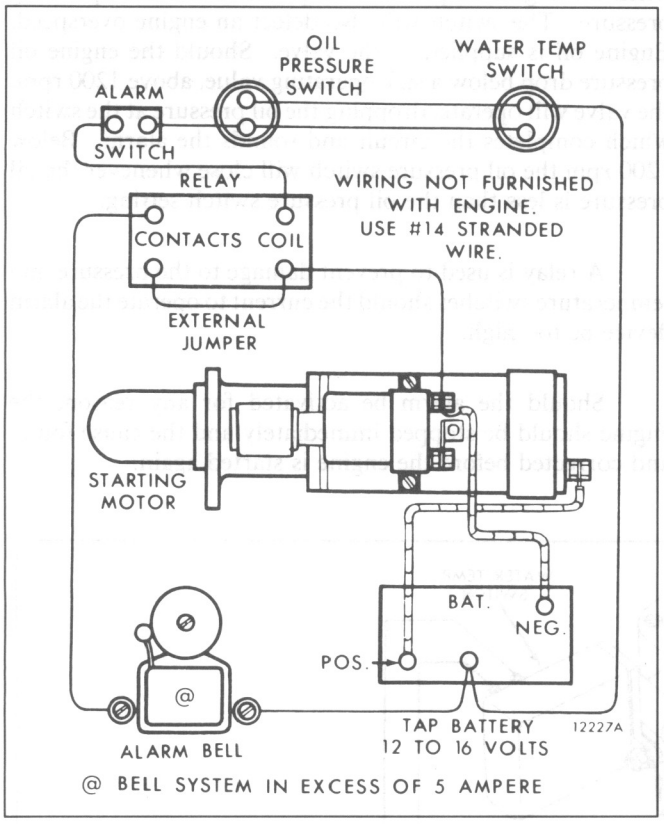

Fig. 1 – Former Alarm System Wiring Diagram

When the engine is started and the oil pressure is sufficient to open the oil pressure switch contacts (opening pressure is stamped on the switch cover), the alarm switch must be turned on manually to put the system in operation. The water temperature switch is normally open. Should the engine coolant exceed 215±5°F (102 ± 3°C), the water temperature switch will close the electrical circuit and sound the alarm bell. Likewise, if the oil pressure drops below the setting of the oil pressure switch, the switch will close and cause the bell to ring. The bell will continue to ring until the engine operator turns the alarm switch off. The alarm switch must also be turned off before a routine stop since the decreasing oil pressure will close the oil pressure switch and cause the bell to ring.

Current Bell System requires less than 5 ampheres to ring the bell (Fig. 2). The former Bell System requires more than 5 ampheres to ring the bell (Fig. 1).

If the alarm bell rings during engine operation, stop the engine immediately and determine the cause of the abnormal condition. Make the necessary corrections before starting the engine again.

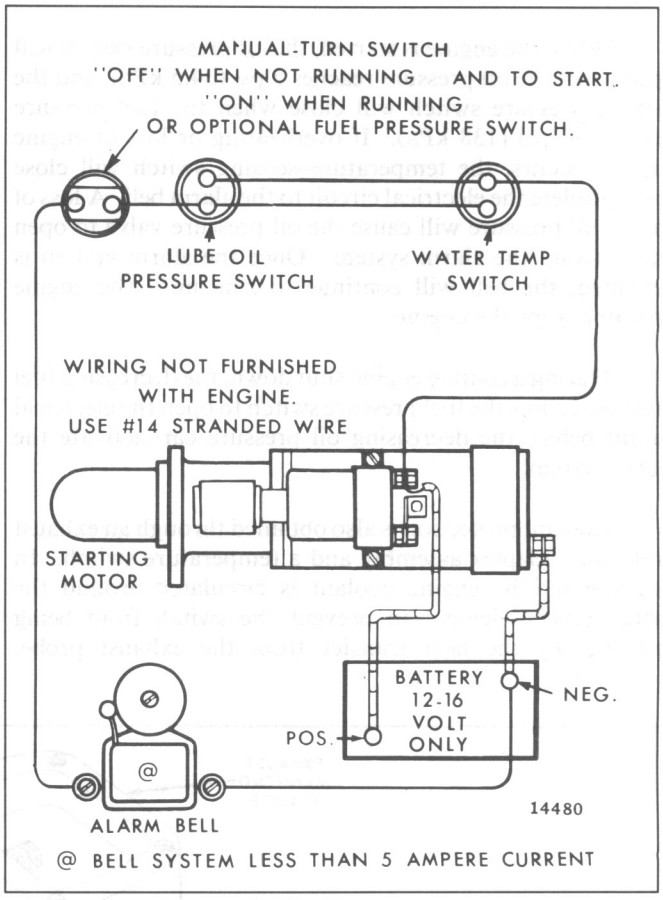

Fig. 2 – Current Alarm System Wiring Diagram

An alarm bell may be connected to the electrical shutdown system (Fig. 3). In this system, if an abnormal condition occurs, the engine will be stopped automatically and the alarm bell will ring to notify the operator. The bell will continue to ring until the operator pushes the reset button on the drop relay.

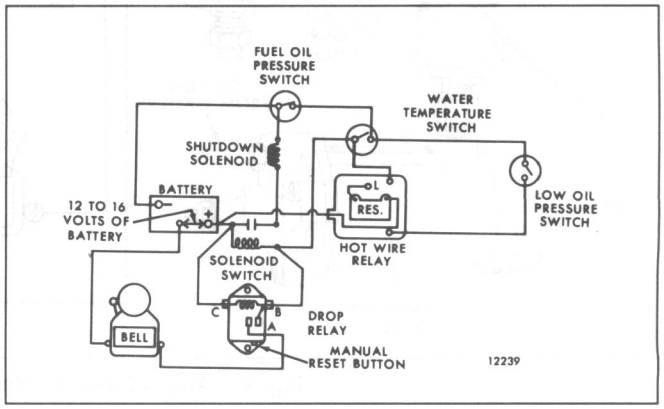

Fig. 3 – Alarm Bell Connected to Electrical Shutdown System

The alarm system illustrated in Fig. 4 utilizes the temperature–sensing switch and the low oil pressure valve.

When the engine is started, the oil pressure switch will open when the oil pressure reaches 5 psi (34.5 kPa), and the fuel oil pressure switch will close when the fuel pressure reaches 20 psi (138 kPa). If overheating or loss of engine coolant occurs, the temperature–sensing switch will close and complete the electrical circuit to the alarm bell. A loss of engine oil pressure will cause the oil pressure valve to open and activate the alarm system. Once the alarm system is activated, the bell will continue to ring until the engine operator stops the engine.

During a routine engine shut down, the decreasing fuel pressure causes the fuel pressure switch to open the electrical circuit before the decreasing oil pressure can activate the alarm system.

Coolant protection is also obtained through an exhaust probe and adaptor assembly and a temperature switch. In this system, the engine coolant is circulated around the switch power element to prevent the switch from being activated by the heat transfer from the exhaust probe. Therefore, an alarm will occur if coolant flow through the adaptor is interrupted for any reason. The switch will also operate when the engine coolant discharge temperature exceeds 205°–215°F (96°–102°C).

The oil pressure switch, mounted in the low oil pressure valve (Fig. 5), will be activated to sound the alarm when the engine oil pressure drops below the safe operating pressure. The switch will also detect an engine overspeed. Engine oil is supplied to the valve. Should the engine oil pressure drop below a safe operating value, above 1200 rpm, the valve will operate, dropping the oil pressure at the switch which completes the circuit and sounds the alarm. Below 1200 rpm the oil pressure switch will close whenever the oil pressure is less than the oil pressure switch setting.

A relay is used to prevent damage to the pressure and temperature switches should the current to operate the alarm device be too high.

Should the alarm be activated for any reason, the engine should be stopped immediately and the cause found and corrected before the engine is started again.

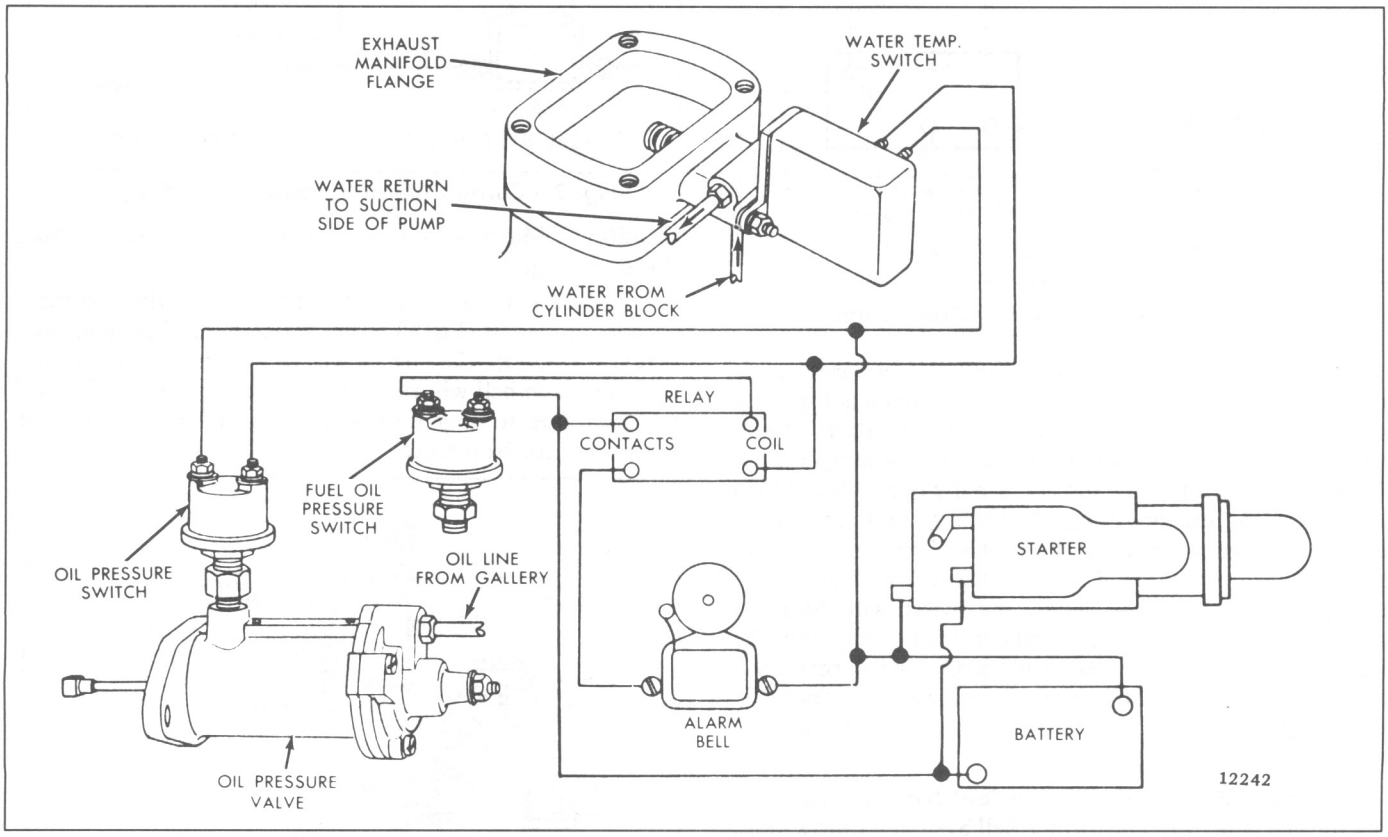

Fig. 4 – Alarm System With Mechanical Sensing Units

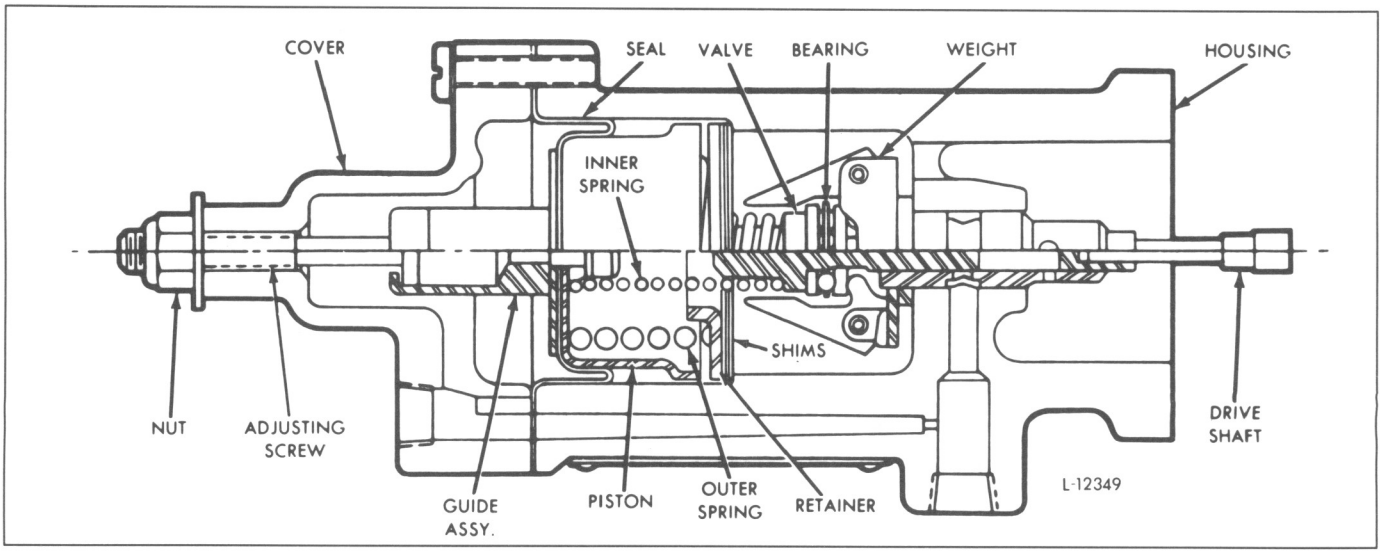

Fig. 5 – Typical Low Oil Pressure Valve

OVERSPEED GOVERNOR

The series GW–2 Synchro–Start overspeed governor (Fig. 1) contains two separate snap action switches with single–pole double–throw contacts which operate at two different speeds. The governor is adjusted by the manufacturer to trip at the speeds required as indicated on the name plate. Unless otherwise specified, the name plate indicates trip points on increasing speed. The contacts will return to normal when the speed is decreased approximately 100 rpm below the trip speed, except on the high speed switch of those models having a manual reset button. The letter "M" after any model number indicates the high speed switch must be reset manually.

Service

1. The snap action switches may be replaced as follows:
   a. Mark the position of the dust cover and remove both hold–down screws.
   b. Observe the position of the switches. Usually they are positioned with 1/64" clearance between the switch button and the lifters. If the lifters are replaced, make certain that the long lifter is placed beneath the low speed switch and the short lifter is placed beneath the high speed switch.
   c. Install the new switches by reversing the above procedure.

   NOTICE: When replacing the dust cover on a governor with a manual reset, make certain the switch wiring does not interfere with the reset mechanism.

   d. Adjust the speed as outlined under *Speed Adjustment.*
2. Remove the governor cap as follows:
   a. Observe the marking on the cap and the body and remove the three holding screws.
   b. Remove the cap assembly, being careful not to damage the seal ring.
   c. Replace any internal parts as required and reassemble and return the cap to the original position. A light coat of grease will facilitate assembly of the seal ring to the body.

   NOTICE: The position of the cap is very critical on governors in which the difference in trip points between the two switches is more than 1000 rpm and the trip point of the high speed switch is above 2100 rpm. These governors use elongated loop flyweight springs. If, after assembly, the No. 1 switch trips at a far higher point than normal, lower the cap position slightly. If the No. 2 switch trips at a very low speed, raise the cap position slightly. If difficulty arises, refer to step 5 below.

   d. Adjust the speed as outlined under *Speed Adjustment.*
3. Replace the speed adjusting springs as follows:
   a. Hold the speed adjusting stud with a 5/16" open end wrench and loosen the adjusting stud nut with a 3/8" open end wrench.
   b. After the above nut is removed, the adjusting spring and related parts may be removed and replaced as necessary. Exercise care to prevent particles of dirt from accumulating on the parts.
4. Replace the flexible drive shaft as follows:
   a. Insert a sharp pointed instrument in the loop of the spring clip and pull it from the shaft as far as possible and remove the shaft assembly.
   b. Upon reassembly, first install the spring clip in the groove of the fitting on the end of the governor shaft.
   c. Push the shaft assembly into the square end of the governor shaft and the spring clip will snap in place.

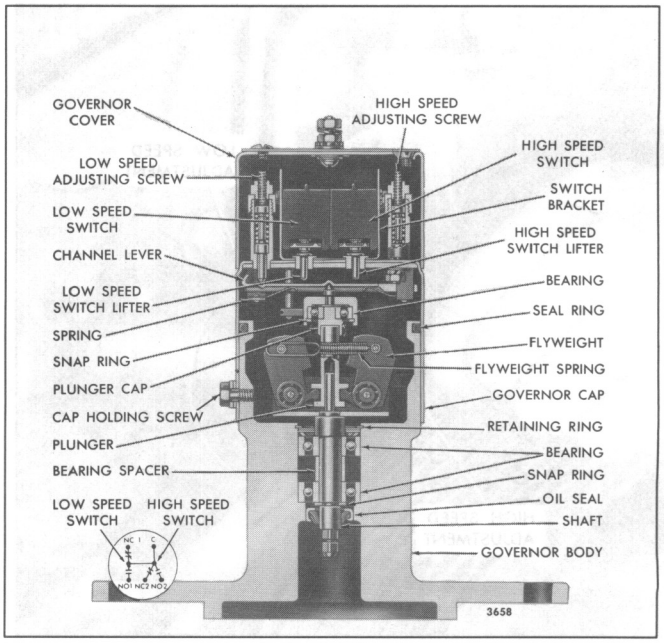

Fig. 1 – Cross–Section of Overspeed Governor

NOTICE: Check the position of the spring clip. If the clip has sprung out of position, use a small screwdriver and push it into place.

5. Adjust the governor cap (with the dust cover in place):

   a. Turn the low speed adjusting screw out for minimum speed adjustment. In this position, the top of the adjusting screw is approximately 1/8" from the top of the dust cover.

   b. Turn the high speed adjusting screw in for almost maximum speed adjustment. In this position, the top of the adjusting screw is approximately 5/16" from the top of the dust cover.

   c. With partial tension on the cap holding screws, turn the governor cap to the maximum extended position.

   d. Operate the governor at 200 rpm above the trip point of the low speed switch.

   e. Rotate the cap slowly in a clockwise direction until the low speed switch trips, mark the cap position and stop the governor. Then turn the cap another 1/16" and lock the holding screws securely.

   f. Complete the operation as outlined under *Speed Adjustment.* Generally, the trip point of the low speed switch will have to be increased and the high speed switch decreased.

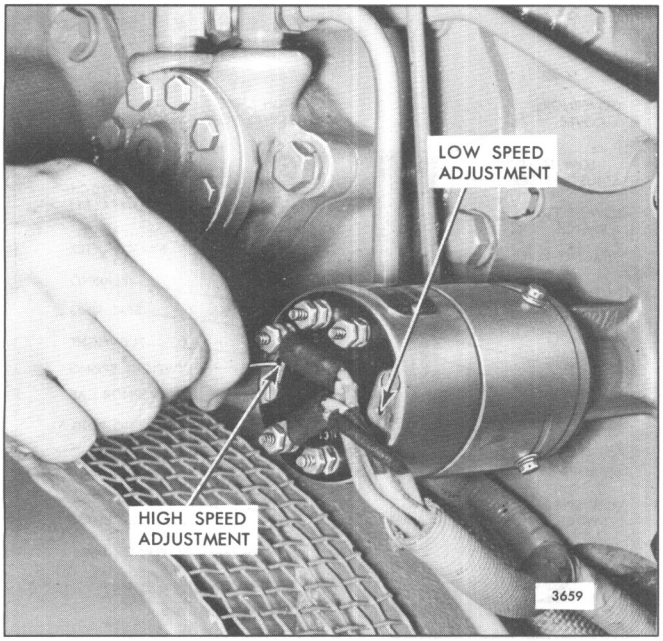

Fig. 2 – Adjusting Trip Speed of Overspeed Governor

Maintenance

• All Synchro–Start two switch electric overspeed governors contain sealed ball bearings which have sufficient grease for their useful life, except Model GT governors. *For GT units only,* add Aeroshell 7A grease (or equivalent) to the open upper shaft bearing every 2500 operating hours. Apply grease sparingly with a hand operated low pressure gun. Grease the upper governor shaft bearing as follows:

1. Remove the governor cap.

2. Apply grease sparingly to the bearing.

   NOTICE: Do not overgrease or use a power gun, since the bearing seals will be damaged, forcing grease onto the weights and springs.

3. Replace the cap.

4. The oil seal may be inspected and if necessary replaced as follows:

   1. Place the governor body in an arbor press with the mounting flange toward the bottom and use a 9/16" diameter rod to press out the oil seal.

   2. Press a new oil seal in place 3/64" from the bottom of the bearing cavity.

   3. Reassemble the governor by reversing the procedure for disassembly and adjust the trip speeds as outlined below.

Speed Adjustment

Both switches may be individually adjusted. Dust cover screw marked "1" covers the low speed adjuster; screw marked "2" covers the high speed adjuster. Proceed as follows:

1. Remove the appropriate dust cover screw.

2. Insert a 1/16" Allen wrench into the adjusting screw.

3. Turn the screw clockwise to increase the trip speed, or counterclockwise to decrease.

   NOTICE: If the adjusting screws are turned in too far, the switch will no longer operate. Do not attempt to use the slots in the cap for normal speed adjustments. This position is set and marked by the manufacturer for operation in the speed range required.

HYDRAULIC OVERSPEED GOVERNOR

The hydraulic governor which contains a set of spring loaded weights, prevents excessive engine speeds.

The overspeed governor is mounted in an adaptor which is mounted on the rear of the flywheel housing. A seal ring in the adaptor end of the governor housing prevents oil seepage from the flywheel housing. The governor is driven by a flexible drive assembly from the blower drive shaft. Oil under pressure is supplied to the governor by a tube which is connected to the oil gallery in the cylinder block.

Operation

When the engine speed reaches the value for which the overspeed governor is set, the centrifugal force of the weights in the overspeed governor overcomes the spring tension and opens a pilot valve in the governor. The pilot valve dumps oil from the oil tube, lowering the pressure at the engine oil pressure switch, thus closing the switch and energizing the shutdown solenoid and closing the shutdown valve.

Lubrication

The overspeed governor is lubricated by oil from the engine crankcase.

Adjustment

The engine shutdown speed is determined by the position of the adjusting screw in the overspeed governor cover. To change the setting, loosen the locknut and turn the adjusting screw in to increase the speed and out to decrease the speed. When the proper setting is obtained, tighten the adjusting screw locknut.

SHOP NOTES - TROUBLESHOOTING SPECIFICATIONS - SERVICE TOOLS

SHOP NOTES

PROPER OPERATION OF THE SWITCHES OR ALARM SYSTEM FOR TESTING THE ELECTRICAL SHUTDOWN

The protective system is activated whenever low lubricating oil pressure, high coolant temperature, engine overspeed or any other abnormal condition develops that could damage the engine.

In a properly maintained installation, the shutdown system seldom has cause to function. Therefore, it is advisable to check the system periodically to be sure that it will function when needed.

Check each component of the shutdown system as outlined below. It is important to thoroughly warm–up the engine before any component of the shutdown system is checked.

Overspeed Governor

1. Remove the valve rocker cover. Discard the gasket.
2. Start the engine and move the speed control lever to the *full–speed* position.
3. While watching a tachometer, manually move the control tube slowly towards the *increased fuel* position until the air shutoff valve closes, stopping the engine. Do not exceed the engine no–load operating speed by more than 10%.
4. Note the speed at which the engine stops and adjust the overspeed governor, if necessary, as outlined in Section 7.4.3.
5. Using new gaskets reinstall the valve rocker cover.

Water Temperature Switch

The terminals of the water temperature switch are connected into the shutdown system and when the engine water temperature reaches 210°F (99°C), the switch closes and completes the circuit in the shutdown or alarm system.

1. Cover the radiator with a sheet of cardboard to prevent circulation of air.
2. Remove the radiator cap, if the engine is operating near sea level, and insert a steel jacketed thermometer.

The boiling point of water lowers approximately 2° for each 1000 foot rise in altitude. As an example, water boils at approximately 203°F (95°C) at 5000 feet and at 195°F (91°C) at 9000 feet altitude. It is necessary to retain the radiator pressure cap on engines which operate in excess of 1000 feet altitude to prevent the coolant from boiling while performing this test. The engine temperature gage, if it is found to be accurate, may be used when performing this test.

Do not exceed 210°F (99°C) when performing this test.

3. Start and run the engine at rated speed and with enough load to raise the water temperature gradually until the air shutoff valve closes. The water temperature switch will usually be set at 210°F (99°C).
4. Note the temperature at which the air shutoff valve closed.
5. Remove the radiator cover and start the engine without load immediately after the engine stops. This will permit the engine to cool down to normal operating temperature.

Fuel Oil Pressure Switch

The fuel oil pressure switch is set to make contact at an increasing fuel pressure of 20 psi (138 kPa), and the phrase "20–MAKE" is stamped on the switch cover.

As the fuel pressure increases upon starting the engine, a diaphragm in the switch body expands and forces the plunger upwards (Fig. 1). Since the bottom of the adjusting screw bears against this plunger, the adjusting screw and the lower breaker point are also forced upwards. When the fuel pressure reaches 20 psi (138 kPa), the breaker points close and current flows to the terminals of the lubricating oil pressure switch and the water temperature switch.

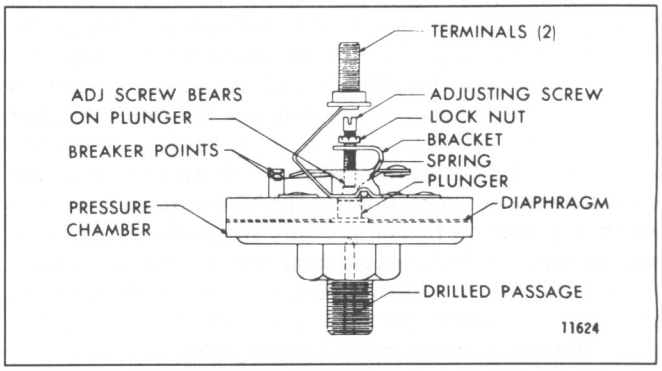

Fig. 1 – Fuel Oil Pressure Switch

When the engine is stopped, the fuel pressure decreases and the diaphragm in the switch body contracts. This action causes the plunger to lower and, when the fuel pressure decreases to 20 psi (138 kPa), permits the lower breaker point arm to lower and break the electrical circuit. The bracket to which the lower breaker point arm and the adjusting screw are attached is spring–loaded, which provides for positive breaking of the connection when the fuel pressure decreases sufficiently.

1. Insert a pressure gage on the discharge side of the fuel strainer.
2. Remove one of the leads from the lubricating oil pressure switch while this test is being performed, to prevent the engine from being shut down.
3. Start and run the engine at idle speed.
4. Slow the engine down by moving the speed control lever towards the *no–fuel* position until the fuel pressure is approximately 15 psi (103 kPa), with the engine barely turning over.
5. Place a jumper wire across the water temperature switch terminals.
6. Raise the engine speed slowly and watch the fuel oil pressure gage until the air shutoff valve closes.
7. Note the fuel pressure at which the air shutoff valve closed and, if necessary, replace the switch.
8. Remove the jumper wire from the water temperature switch and reconnect the lubricating oil pressure switch.

Lubricating Oil Pressure Switch

The construction of the lubricating oil pressure switch is very similar to that of the fuel oil pressure switch, except that the lubricating oil pressure switch is calibrated to break contact when the lubricating oil pressure increases to 10 psi (69 kPa). The phrase "10 BREAK" is stamped on the switch cover.

A 20 psi (138 kPa) break switch is used on some engines whose predominant operation is constant speed.

As the lubricating oil pressure increases upon starting, the diaphragm in the switch body expands and forces the plunger upwards (Fig. 2). Since the bottom of the adjusting screw bears against the plunger, and the adjusting screw is attached to the bracket which controls the upper breaker point arm, the arm is also forced upwards. When the lubricating oil pressure increases to 10 psi (69 kPa), the points separate. Current flows to the lubricating oil pressure switch only after the fuel oil pressure switch closes, at which time the points of the lubricating oil switch are open. Should the lubricating oil pressure decrease to 10 psi (69 kPa) during operation, the breaker point will close and either the alarm bell or shutdown solenoid will be energized.

1. Start and run the engine at idle speed.

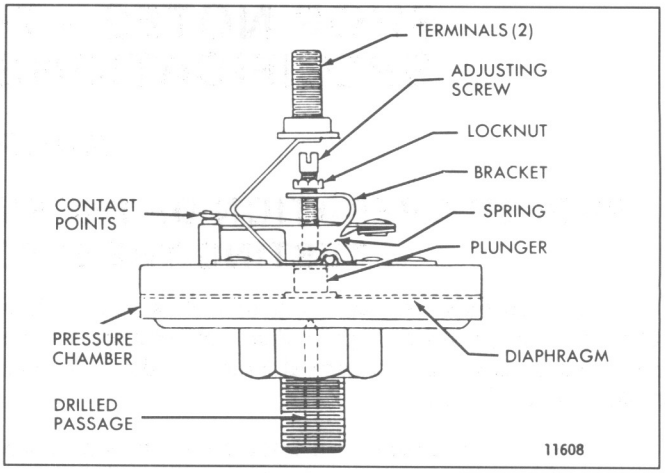

Fig. 2 – Lubricating Oil Pressure Switch

2. Place a jumper wire on the hot wire relay between the "1" and "S" terminals.
3. Place a jumper wire across the fuel oil pressure switch terminals.
4. Reduce the engine speed by moving the control lever towards the *no–fuel* position while watching the lubricating oil pressure gage.
5. Note the oil pressure at which the switch stops the engine and, if necessary, replace the switch.
6. Remove the jumper wire.

Hot Wire Relay

1. Start and operate the engine at idle speed.
2. Place the jumper wire across the terminals of the lubricating oil pressure switch while watching a second hand of a clock.
3. Not more than three (3) to ten (10) seconds should elapse between the time the jumper wire is placed across the terminals of the lubricating oil pressure switch and the air shutoff valve closes.

The above procedures completely test the normally open electrical shutdown system on an engine.

NOTICE: When the engine is operating at idle speed or above, the air shutoff valve will completely close off the air from the engine causing it to stop. However, when the engine is operating at the very low speeds that are necessary when performing the test on the fuel shutdown switch and the lubricating oil shutdown switch, the air damper solenoid will close the air shutoff valve, but the engine may continue to run very slowly. This may be due to insufficient force exerted by the low air flow on the back of the shutoff valve to completely close it.

Solid State Time Delay Switch 12, 24 or 32 Volts–Direct Current

A solid state time delay switch is used on current engines in place of the former hot wire relay.

A bench test procedure for the solid state time delay switch (Fig. 3) is as follows:

1. Remove the time delay switch from the engine.
2. Install the jumper straps on terminals "A" to "B" and "E" to "F", if they have been removed. Normally, the jumper straps are on the Time Delay Switches as supplied.
3. Install a positive battery lead to terminal "A".
4. Install a negative battery lead to one side of a 12 volt light which is a known good test lamp.
5. Install a lead from the opposite side of the light to terminal "D". A switch may be used in this lead, if desired.
6. After the negative lead is connected to "D" or the switch is closed, the lamp should light in eight (8) to ten (10) seconds. If not, the time delay switch must be replaced.

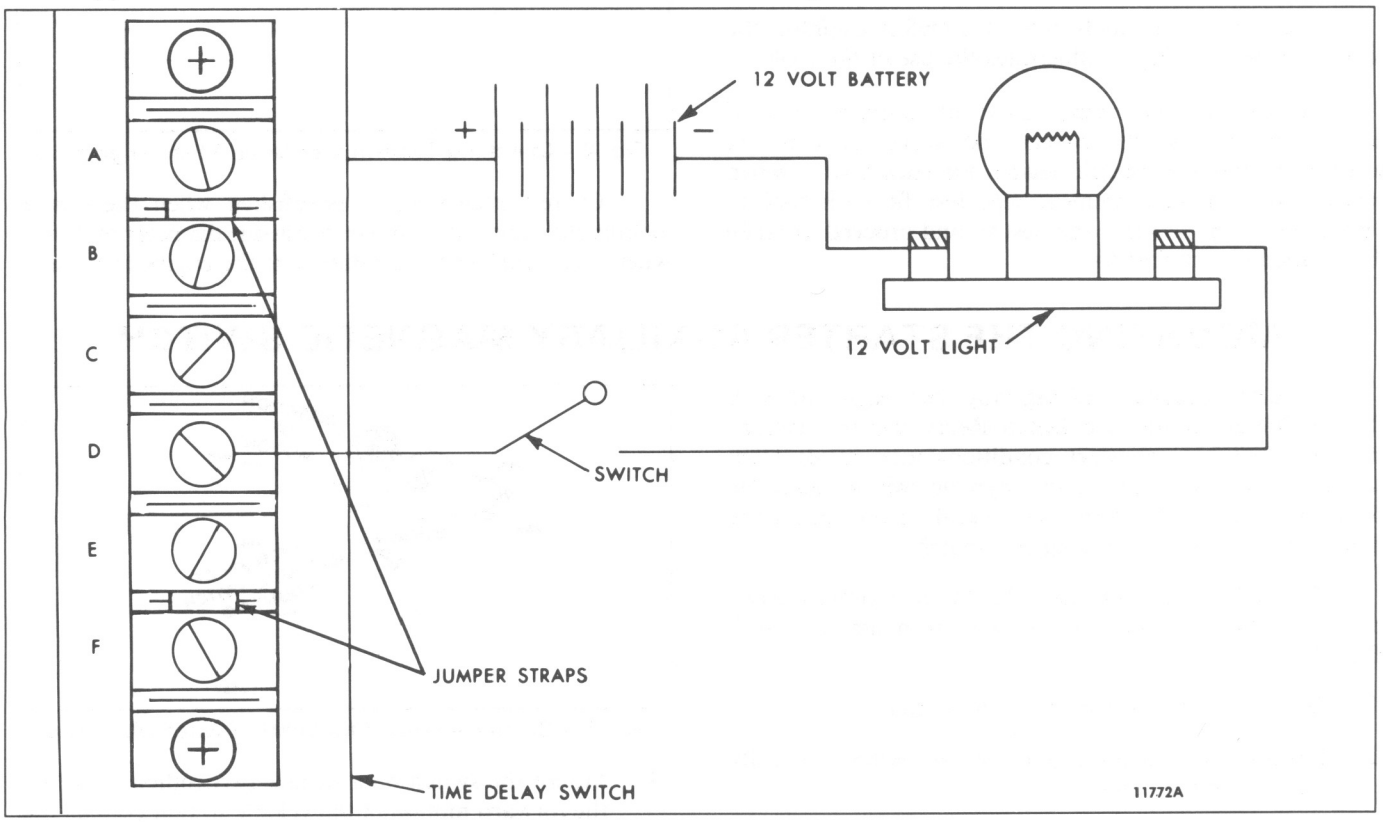

Fig. 3 – Time Delay Switch Testing Diagram

CHECK ENGINE STARTING SWITCH

If difficulty in starting motor engagement has been experienced in a vehicle which has been repowered by a diesel engine, check to see if the key–type starting switch on the instrument panel has been retained.

Key–type starting switches are usually not capable of carrying the current required for heavy–duty diesel engine starter solenoids. The excessive voltage drop in the solenoid circuit restricts the solenoid pull and results in failure of the starter to engage and crank. When tooth abutment occurs and the switch is turned off and on several times, breaking of the solenoid current causes burning or welding of the switch contacts.

Install a push button type starting switch which is capable of making, breaking and carrying the solenoid current without damage (refer to *Engine Starting Motor Switch* in Section 7.4). Otherwise, a heavy–duty magnetic switch should be used in the solenoid control circuit in addition to the key–type switch. The magnetic switch must be capable of making and breaking at least 90 amperes in a 12 volt system; the key switch would then carry no more than one ampere, which is sufficient to operate the magnetic switch.

ALIGNMENT TOOLS FOR TACHOMETER DRIVE COVERS AND ADAPTORS

Whenever a tachometer drive cover assembly or a tachometer drive adaptor is installed on a engine, it is important that the cover assembly or adaptor be aligned properly with the tachometer drive shaft.

Misalignment of a tachometer drive shaft can impose a side load on a tachometer drive cable adaptor resulting in possible gear seizure and damage to other related components.

Use one of three tools in set J 23068 to establish the proper alignment. Fig. 4 illustrates the use of the tools.

Because of the many different combinations of tachometer drive shafts, covers and adaptors, it is not practical to itemize specific usages for each tool. When confronted with an alignment job, test fit each tool to determine which provides the best fit and proceed to make the alignment with that tool.

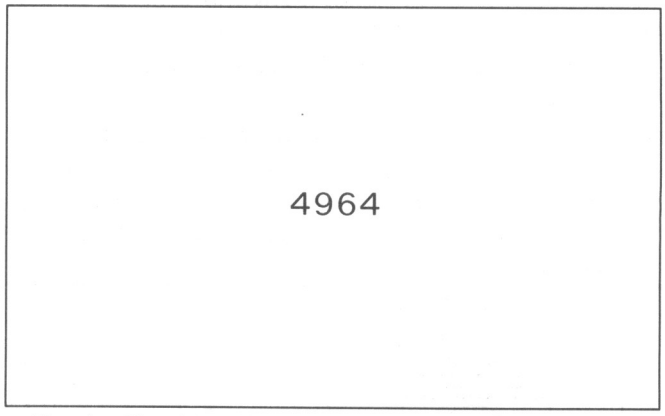

Fig. 4 – Checking Tachometer Drive Shaft Alignment

Correct alignment is established when there is no tachometer drive shaft bind on the inside diameter of the tool when one complete hand rotation of the engine is made.

MOUNTING THE STARTER AUXILIARY MAGNETIC SWITCH

On certain railcar and highway units equipped with Detroit Diesel engines and Delco–Remy starter auxiliary magnetic switches, no–start conditions may result from damage to the starter auxiliary magnetic switch caused by vibration. The vibration may result from improper mounting of the auxiliary magnetic switch.

The following guidelines should be followed when mounting a Delco–Remy starter auxiliary magnetic switch (Fig. 5):

1. Do not mount the switch on the engine.
2. Position the mounting pads of the switch vertically (one above the other).
3. Mount the switch on a rigid bracket, base rail or fire wall.

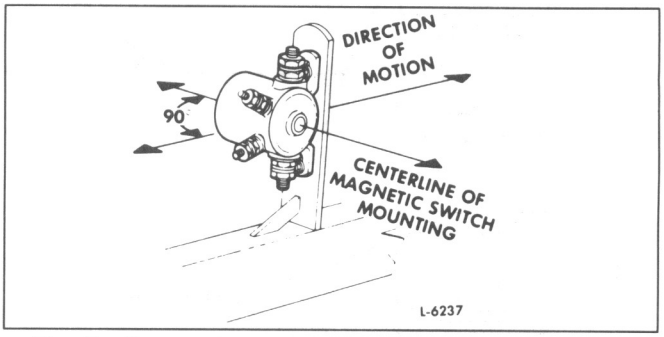

Fig. 5 – Starter Auxiliary Magnetic Switch Mounting

4. Mount the switch on a surface perpendicular (90°) to the forward motion of the vehicle so that contact disc movement is not in line with gravity or vehicle movement.

TROUBLESHOOTING

CHECKING ENGINE ELECTRICAL GENERATING SYSTEM

Whenever trouble is indicated in the electrical generating system, the following quick checks can be made to assist in localizing the cause.

A *fully charged battery and low charging rate* indicates normal alternator–regulator operation.

A *low battery and high charging rate* indicates normal alternator–regulator operation.

A *fully charged battery and high charging rate* condition usually indicates the voltage regulator is set too high or is not limiting the alternator output. A high charging rate to a fully charged battery will damage the battery and other electrical components.

A *low battery and low or no charging rate* condition could be caused by: Loose connections or damaged wiring, defective battery or alternator and defective regulator or improper regulator setting.

SPECIFICATIONS

STANDARD BOLT AND NUT TORQUE SPECIFICATIONS

THREAD SIZE	260M BOLTS TORQUE (lb–ft)	260M BOLTS TORQUE N•m	THREAD SIZE	280M OR BETTER TORQUE (lb–ft)	280M OR BETTER TORQUE N•m
1/4–20	5–7	7–9	1/4–20	7–9	10–12
1/4–28	6–8	8–11	1/4–28	8–10	11–14
5/16–18	10–13	14–18	5/16–18	13–17	18–23
5/16–24	11–14	15–19	5/16–24	15–19	20–26
3/8–16	23–26	31–35	3/8–16	30–35	41–47
3/8–24	26–29	35–40	3/8–24	35–39	47–53
7/16–14	35–38	47–51	7/16–14	46–50	62–68
7/16–20	43–46	58–62	7/16–20	57–61	77–83
1/2–13	53–56	72–76	1/2–13	71–75	96–102
1/2–20	62–70	84–95	1/2–20	83–93	113–126
9/16–12	68–75	92–102	9/16–12	90–100	122–136
9/16–18	80–88	109–119	9/16–18	107–117	146–159
5/8–11	103–110	140–149	5/8–11	137–147	186–200
5/8–18	126–134	171–181	5/8–18	168–178	228–242
3/4–10	180–188	244–254	3/4–10	240–250	325–339
3/4–16	218–225	295–305	3/4–16	290–300	393–407
7/8–9	308–315	417–427	7/8–9	410–420	556–569
7/8–14	356–364	483–494	7/8–14	475–485	644–657
1–8	435–443	590–600	1–8	580–590	786–800
1–14	514–521	697–705	1–14	685–695	928–942

Grade identification markings are normally stamped on the heads of the bolts. To aid identification of the various bolts used in Detroit Diesel engines, refer to the following chart.

Grade Identification Marking on Bolt Head	GM Number	SAE Grade Designation	Nominal Size Diameter (inch)	Tensile Strength Min. (psi)
None	GM 255-M	1	No. 6 thru 1 1/2	60,000
None	GM 260-M	2	No. 6 thru 3/4 over 3/4 to 1 1/2	74,000 60,000
 Bolts and Screws	GM 280-M	5	No. 6 thru 1 over 1 to 1 1/2	120,000 105,000
 Hex Head Sems Only	GM 275-M	5.1	No. 6 thru 3/8	120,000
 Bolts and Screws	GM 290-M	7	1/4 thru 1 1/2	133,000
 Bolts and Screws	GM 300-M	8	1/4 thru 1 1/2	150,000
 Bolts and Screws	GM 455-M	None	No. 6 thru 1 1/2	55,000

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BOLT IDENTIFICATION CHART

EXCEPTIONS TO STANDARD BOLT AND NUT TORQUE SPECIFICATIONS

APPLICATION	THREAD	(lb–ft)	(N•m)
Flange mounted alternator adaptor nut	3/8–24	15–20	20–27
Tachometer drive cover bolt	7/16–14	30–35	41–47
Tachometer drive cover bolt	1/2–13	30–35	41–47
Tachometer drive shaft (blower)	1/2–20	55–65	75–88
Starting motor switch mounting nut	5/8–32	*	*
Starting motor attaching bolts (alum. flywheel hsg.)	5/8–11	95–105	129–143

*36–48 **lb–in** (4–5.5 N•m)

SERVICE TOOLS

TOOL NAME	TOOL NO.
Slide hammer	J 23907–1
Tachometer drive alignment tool set	J 23068
Tachometer drive shaft remover	J 5901–3