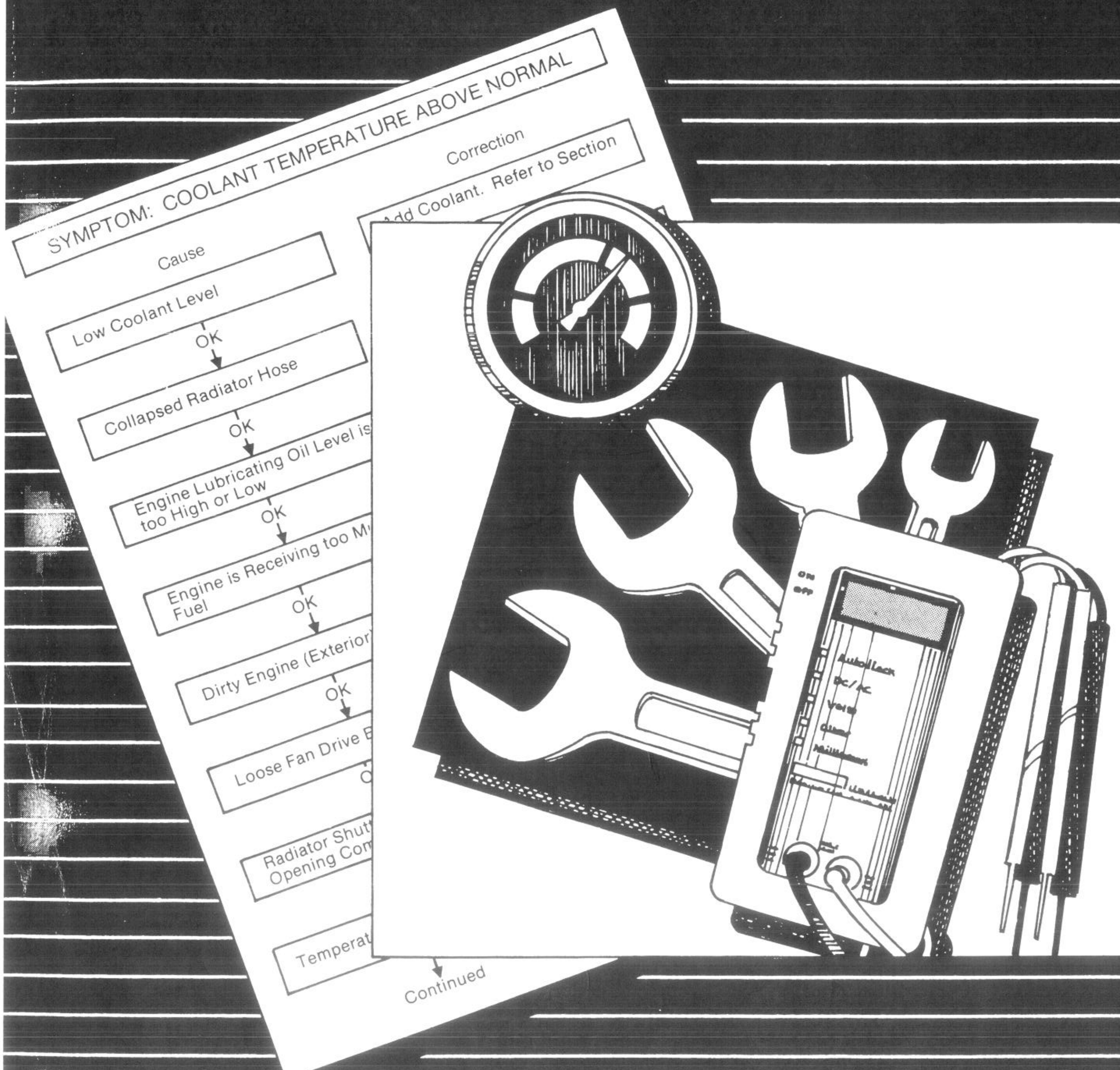
Troubleshooting and Repair Manual Generator Sets



Troubleshooting and Repair Manual Generator Sets

Form 960-0503
11-89
Printed in U.S.A.

Foreword

This manual provides instructions for troubleshooting and repairing Cummins generator sets that use the Cummins 14 litre (NT-855) displacement and larger engines.

The engine models included in this manual are:

NT-855 GS/GC
NTA-855 GS/GC
NTTA-855 GS/GC
KT-19 GS/GC
KTA-19 GS/GC
KTTA-19 GS/GC
VT-28 GS/GC
VTA-28 GS/GC
KT-38 GS/GC
KTA-38 GS/GC
KTTA-38 GS/GC
KTA-50 GS/GC
KTTA-50 GS/GC

The manual is organized to guide a trained Generator Set Service Technician through logical steps of identifying and correcting problems related to generator sets.

The information, specifications, and recommended repair procedures in this publication are based on the information in effect at the time it was printed. Cummins reserves the right to make changes at anytime without notice.

Specific engine rebuild instructions are covered in separate manuals for each engine and may be ordered by contacting the following locations:

Publications Ordering Locations

Publications may be ordered from the following locations:

Region	Ordering Location
United States and Canada	Cummins Distributors or Cummins Engine Co. Box 3005 M/C 40924 Columbus, IN 47202
U.K., Europe, Mid-East, Africa and Eastern European Countries	Cummins Daventry Royal Oak Way South Northants, England NN11 5 NU
South America and Central America with the exception of Brazil and Mexico	Cummins Americas, Inc. 16085 N.W. 52nd Avenue Hialeah, Florida 33104
Brazil and Mexico	International Parts Order Dept. Cummins Engine Company Box No. 3005 Columbus, Indiana 47202 Mail Code 40931
Far East with the exception of Australia and New Zealand	Cummins Diesel Sales Corporation Literature Center 8 Tanjong Penjuru Jurong Industrial Est. Singapore 2260
Australia and New Zealand	Cummins Diesel Australia Maroondah Highway P.O. Box 139 Ringwood 3134 Victoria, Australia

COMPONENT MANUFACTURERS

UNITED STATES AND UNITED KINGDOM OFFICES

The following list contains addresses and phone numbers of suppliers of accessories used on Cummins engines. Suppliers may be contacted directly for any specifications **not** covered in this manual.

AIR STARTERS

Ingersoll Rand
Chorley New Road
Horwich
Bolton
Lancashire
England
BL6 6JN
Telephone: 0204-65544

Ingersoll-Rand Engine
Starting Systems
651 Park Avenue
King of Prussia, PA 19406
Telephone: (215) 337-5900

ALTERNATORS

A.C. Delco Comp. Group
Civic Offices
Central Milton Keynes
MK9 3EL
England
Telephone: 0908-66001

Delco-Remy
P.O. Box 2439
Anderson, IN 46018
Telephone: (317) 646-7838

Leece-Neville Corp.
1374 E. 51st St.
Cleveland, OH 44013
Telephone: (216) 431-0740

AUXILIARY MAGNETIC SWITCH

Hamilton Standard Controls, Inc.
Essex Products
131 Godfrey St.
Logansport, IN 46947
Telephone: 219-753-7521

BATTERY CHARGERS

Master Control Systems, Inc.
910 North Shore Drive
Lake Bluff, IL 60044
Telephone: 312-295-1010

BELTS

Dayco Rubber U.K.
Sheffield Street
Stockport
Cheshire
SK4 1RV
England
Telephone: 061-432-5163

T.B.A. Ind. Products
P.O. Box 77
Wigan
Lancashire
WN2 4XQ
England
Telephone: 0942-59221

Dayco Corp.
Belt Technical Center
P.O. Box 3258
Springfield, MO 65804
Telephone: (417) 881-7440

Gates Rubber Company
5610 Crawfordsville Road
Suite 2002
Speedway, IN 46224
Telephone: (317) 248-0386

Goodyear Tire and
Rubber Company
49 South Franklin Road
Indianapolis, IN 46219
Telephone: (317) 898-4170

CIRCUIT BREAKERS

Airpax Corp. North American Phillips
Woods Rd., P.O. Box 520
Cambridge, MD 21613
Telephone: 301-228-4600

Heineman Electric Co.
P.O. Box 6800-T
Lawrenceville, NH 08648
Telephone: 609-882-4800

No Fuse Circuit Breaker Co., Ltd.
32 Finlos St.
Glasgow GZ2 5DU
Scotland
Telephone: 041 558-2861

Westinghouse Electric Co.
5881 East 82nd St.
Indianapolis, IN 46250
Telephone: 317-845-1675

COOLANT HEATERS

Watlow Industries, Inc.
401 South Maple St., Box 975
Hannibal, MO 63401
Telephone: 314-878-4600

ELECTRIC STARTERS

A.C. Delco Comp. Group
Civic Offices
Central Milton Keynes
MK9 3EL
England
Telephone: 0908-66001

Delco-Remy
P.O. Box 2439
Anderson, IN 46018
Telephone: (317) 646-7838

Leece-Neville Corp.
1374 E. 51st Street
Cleveland, OH 44013
Telephone: (216) 431-0740

FANS

Aerovent, Inc.
1 Aerovent Drive
Piqua, OH 45356
Telephone: 573-773-4611

Hayes-Albion
1999 Wildwood Avenue
Jackson, MI 49202
Telephone: (517) 782-9421

FILTERS

Fleetguard
Cavalry Hill
Weedon
Northants
NN7 4PP
England
Telephone: 0327-41313

Fleetguard, Inc.
Route 8
Cookeville, TN 38501
Telephone: (615) 526-9551

GAUGES

Datcon Instrument Co.
P.O. Box 128
East Petersburg, PA 17520
Telephone: (717) 569-5713

GOVERNORS

Woodward Governors Ltd.
P.O. Box 15
663/664 Ajax Avenue
Slough
Bucks
SL1 4DD
England
Telephone: 0753-26835

Woodward Governor Co.
1000 E. Drake Road
Fort Collins, CO 80522
Telephone: (303) 482-5811

Barber Colman Co.
1300 Rock Street
Rockford, IL 61101
Telephone: (815) 877-0241

United Technologies
Diesel Systems
1 Diesel Drive
I-77 at Killiam Rd.
Columbia, SC 29204
Telephone: (803) 735-1400

INSTRUMENTS (GENERATOR)

General Electric - CESD
6321 La Pas Trail, P.O. Box 6854
Indianapolis, IN 46268
Telephone: 317-298-2323

OIL HEATERS

Kim Hotstart Co.
West 917 Broadway
Spokane, WA 99210
Telephone: (509) 534-6171

RADIATORS

G & O Radiator Co.
100 Gando Drive
New Haven, CT 06508
Telephone: 203-562-5121

RAW WATER PUMPS

Gilbert Gilkes & Gorden Ltd.
Kendal, Cumbria
England LA9 7BZ
Telephone: 0539 20028

RAW WATER PUMPS (CONTINUED)

I.T.T. Jabsco Ltd.
Bingley Rd., Hoddesdon
Hertfordshire
England EN11 OBU
Telephone: 0924 67191

Jabsco Products ITT
1485 Dale Way
Cosa Mesa, CA 92626
Telephone: 714-545-5251

SAFETY CONTROLS

The Nason Company
10388 Enterprise Drive
Davisburg, MI 48019
Telephone: (313) 625-5381

Robertshaw Controls
Tennessee Div.
2318 Kingston Pike SW
Knoxville, TN 37901
Telephone: 615-546-0550

VIBRATION ISOLATORS

Peabody Noise Control
6300 Ireland Place
P.O. Box 655
Dublin, OH 43017
Telephone: 614-889-0480

Table of Contents

Introduction

Contents

Page Number

How to Use the Manual

The manual is organized to provide an easy flow from problem identification to problem correction. A list of troubleshooting symptoms containing the most common generator set problems is on Page 1-1. Complete the following steps to locate and correct a problem:

(Step 1.) Locate the symptom on the list.

Reference is made to the page number where the "Troubleshooting Logic Chart" is found.

(Step 2.) The left column of the "Troubleshooting Logic Chart" indicates a probable cause. Starting at the top with the simple and easiest to repair, and continuing downward to the most difficult.

The right column provides a brief description of the corrective action with a procedure number reference for the repair procedure where applicable.

(Step 3.) Locate the probable cause in the left column, then turn to the procedure number referenced in the right column.

The repair procedures are listed by system (cooling, lubricating oil, air, fuel, and electrical).

(Step 4.) The following are required when the "Troubleshooting Logic Charts" are used:

1. The generator set has been installed according to Cummins Installation Recommendations.
2. The easiest repairs are done first.
3. "Generic" solutions cover problems with Cummins generator sets. Specific problems (overheating or no generator voltage) usually have a similar solution on generator sets of different ratings.

Generic Symbols

The following group of symbols have been used in this manual to help communicate the intent of the instructions. When one of the symbols appears, it conveys the meaning defined below.

WARNING - Provides a warning to take precaution to avoid bodily injury from electrical shock or electrocution. There is in the vicinity uninsulated high A.C. voltage.

WARNING - Serious personal injury or extensive property damage can result if the warning instructions are not followed.

CAUTION - Minor personal injury can result or a part, an assembly or the engine can be damaged if the caution instructions are not followed.

Indicates a **REMOVAL or DISASSEMBLY** step.

Indicates an **INSTALLATION or ASSEMBLY** step.

INSPECTION is required.

CLEAN the part or assembly.

PERFORM a mechanical or time **MEASUREMENT**.

LUBRICATE the part or assembly.

Indicates that a **WRENCH or TOOL SIZE** will be given.

TIGHTEN to a specific torque.

PERFORM an electrical **MEASUREMENT**.

Refer to another location in this manual or another publication for additional information.

The main circuit breaker is closed and normal power is being supplied to the equipment.

The main circuit breaker must be open so that normal power is **not** being supplied to the equipment.

The generator set is on and supplying power to the equipment.

The generator set **must** be off and **not** supplying power to the equipment.

The wiring harness disconnect plug **must** be disconnected.

The component weighs 23 kg [50 lb] or more. To avoid personal injury, use a hoist or get assistance to lift the component.

Simbolos Usados En Este Manual

Los símbolos siguientes son usados en este manual para clarificar el proceso de las instrucciones. Cuandc aparece uno de estos símbolos, su significado se especifica en la parte inferior.


Proporciona un aviso de precaución para evitar daños corporales causados por choques eléctricos o electrocución. El peligro está en la vecindad del alto voltaje de c.a. sin aislamiento.


ADVERTENCIA - Serios daños personales o daño a la propiedad puede resultar si las instrucciones de Advertencia **no** se consideran.


PRECAUCION - Daños menores pueden resultar, o de piezas del conjunto o el motor puede averiarse si las instrucciones de Precaución **no** se siguen.


Indica un paso de **REMOCION** o **DESMONTAJE**.


Indica un paso de **INSTALACION** o **MONTAJE**.


Se requiere **INSPECCION.**


LIMPIESE la pieza o el montaje.


EJECUTESE una **MEDICION** mecánica o del tiempo.


LUBRIQUESE la pieza o el montaje.


Indica que se dará una **LLAVE DE TUERCAS** o el **TAMANO DE HERRAMIENTA.**


APRIETESE hasta un par torsor específico.


EJECUTESE una **MEDICION** eléctrica.

Para información adicional refiérase a otro emplazamiento de este manual o a otra publicación anterior.


Durante el procedimiento, **EL DISYUNTOR PRINCIPAL ESTA CERRADO.** Se suministra potencia normal al equipo.


Durante este procedimiento, **EL DISYUNTOR PRINCIPAL ESTA ABIERTO.** No se suministra potencia normal al equipo.


Este procedimiento requiere que el **GRUPO ELECTROGENO ESTE CONECTADO** para suministrar potencia al equipo.


Este procedimiento requiere que el **GRUPO ELECTROGENO ESTE DESCONECTADO.** No se suministra potencia al equipo.


Este procedimiento requiere que debe desconectarse el **HAZ PRINCIPAL DE CONDUCTORES PREFORMADO.**


El componente pesa 23 kgs [50 lb] o mas. para evitar dano corporal empleen una cabria obtengan ayuda para elevar el componente.

Symbole

In diesem Handbuch werden die folgenden Symbole verwendet, die wesentliche Funktionen hervorheben. Die Symbole haben folgende Bedeutung:


Unfallgefahr bedingt durch elektrischen Schlag. Nichtisolierte Hochspannungsleitungen in der Nähe.


WARNUNG - Wird die Warnung **nicht** beachtet, dann besteht erhöhte Unfall- und Beschädigungsgefahr.


VORSICHT - Werden die Vorsichtsmassnahmen **nicht** beachtet, dann besteht Unfall- und Beschädigungsgefahr.


AUSBAU bzw. **ZERLEGEN.**


EINBAU bzw. **ZUSAMMENBAU.**


INSPEKTION erforderlich.


Teil oder Baugruppe **REINIGEN.**


DIMENSION - oder **ZEITMESSUNG.**


Teil oder Baugruppe **ÖLEN.**


WERKZEUGGRÖSSE wird angegeben.


ANZUG auf vorgeschriebenes Drehmoment erforderlich.


Elektrische **MESSUNG DURCHFÜHREN.**


Weitere Informationen an anderer Stelle bzw. in anderen Handbüchern.


Während des Arbeitsgangs ist der **HAUPTTRENNSCHALTER GESCHLOSSEN.** Das Gerät wird von der normalen Stromversorgung versorgt.


Während des Arbeitsgangs ist der **HAUPTTRENNSCHALTER GEÖFFNET.** Das Gerät wird nicht von der normalen Stromversorgung versorgt.


Der Arbeitsgang erfordert, daB der **LAUFENDE STROMVERSORGER** das Gerät mit Strom versorgt.


Der Arbeitsgang erfordert, daB der **STROMVERSORGER ABGESCHALTET IST** und das Gerät nicht mit Strom versorgt wird.


Dieser Arbeitsgang erfordert Abklemmen des **HAUPTKABELSTRANGS.**


Das teil weigt 23 kg [50 lb] oder mehr. Zur vermeidung von koerperverletzung winde benutzen oder hilfe beim heben des teils in anspruch nehmen.

Symboles Utilises Dans Ce Manuel

Les symboles suivants sont utilisés dans ce manuel pour aider à communiquer le but des instructions. Quand l'un de ces symboles apparaît, il évoque le sens défini ci-dessous:

Avertit de prendre soin d'éviter des lésions corporelles provenant de décharge électrique ou d'électrocution. Il y a dans le voisinage une haute tension C.A. non isolée.

AVERTISSEMENT - De graves lésions corporelles ou des dommages matériels considérables peuvent survenir si les instructions données sous les rubriques "Avertissement" **ne** sont **pas** suivies.

ATTENTION - De petites lésions corporelles peuvent survenir, ou bien une pièce, un ensemble ou le moteur peuvent être endommagés si les instructions données sous les rubriques "Attention" **ne** sont **pas** suivies.

Indique une opération de **DEPOSE.**

Indique une opération de **MONTAGE.**

L'INSPECTION est nécessaire.

NETTOYER la pièce ou l'ensemble.

EFFECTUER une **MESURE** mécanique ou de temps.

GRAISSER la pièce ou l'ensemble.

Indique qu'une **DIMENSION DE CLE** ou **D'OUTIL** sera donnée.

SERRER à un couple spécifique.

EFFECTUER une **MESURE** électrique.

Se reporter à un autre endroit dans ce manuel ou à une autre publication pour obtenir des informations plus complètes.

Pendant la procédure, le **DISJONCTEUR PRINCIPAL EST FERME.** L'équipement recoit l'alimentation normale.

Pendant cette procédure, le **DISJONCTEUR PRINCIPAL EST OUVERT.** L'équipement ne recoit pas l'alimentation normale.

Cette procédure nécessite que le **GROUPE ELECTROGENE SOIT EN MARCHE** pour alimenter l'équipement.

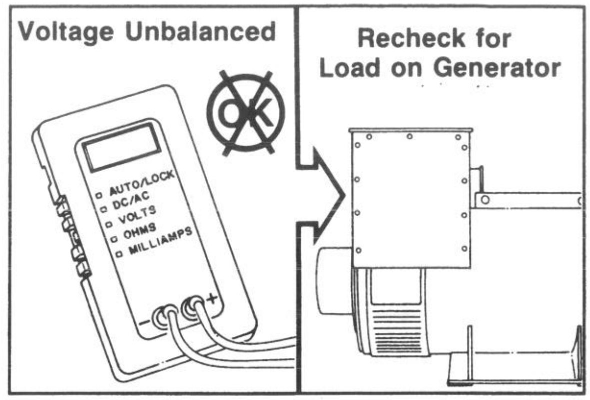
Cette procédure nécessite que le **GROUPE ELECTROGENE SOIT EN ARRET.** L'équipement n'est pas alimenté.

Cette procédure nécessite de déconnecter le **CABLAGE PRINCIPAL.**

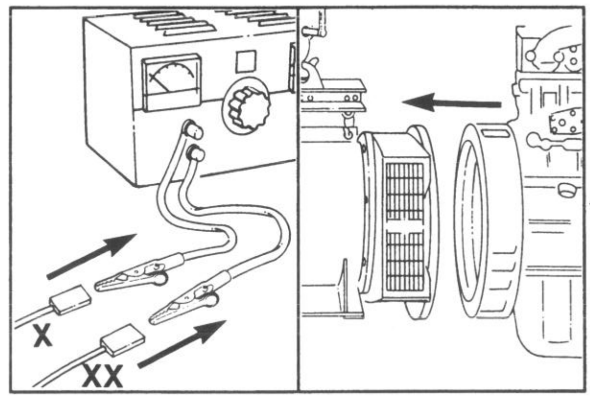
Le Composant pese 23 kg [50 lb] ou davantage. Pour eviter toute blessure, employer un appareil de levage ou demander de l'aide pour le soulever.

Illustrations

The illustrations used in the "Repair Sections" of this manual are intended to give an example of a problem, show what to look for and where the problem can be found. Some of the illustrations are "generic" and might not look exactly like the engine or parts used in your application. The illustrations may contain symbols to indicate an action required along with a corresponding acceptable or not acceptable condition.



The illustrations are intended to show repair or replacement procedures accomplished with the generator set at the installation site. The illustration can differ from your application, but the procedure given will be the same.



Definition of Terms

The following is a list of guidelines for each procedure in the " Repair Sections" of the Troubleshooting and Repair Manual. The procedure will be given first; followed by a definition of the step or steps involved.

Check – Examine a component or system for damage, excessive wear, accuracy, safety, or performance.

Inspection – Examine a component or dimension to make sure it meets the required specifications.

Test – Check or compare the performance of a component or system to established specifications.

Adjust – Complete the necessary steps to set or adjust the component, assemblies, or system in the required setting or position.

Visually Inspect – Look for any obvious damage or problem.

Remove – Take off a component or assembly.

Clean – Remove dirt, grease or other contamination.

Disassemble – Take the component or assembly apart.

Repair – Restore a component or assembly to a serviceable condition within the established specifications.

Note – Only the easiest and simplest repairs will be made to a component or assembly. If a component or assembly must be rebuilt; it must be replaced with a Cummins part replacement or be rebuilt at a Cummins authorized repair location.

Replace – Install a new, properly rebuilt, or Cummins Diesel ReCon, Inc. component or assembly in place of one which is removed when noted in this manual.

Install – Place a component or assembly in the correct position.

Safety Precautions and Warnings

A generator set, like any other electro-mechanical device, contains potential dangers to life and limb if improperly maintained or operated. The best safeguards against accidents are to be ever mindful of the potential dangers and always to use good common sense. Always observe all applicable mechanical and electrical safety precautions. In the interest of safety, some general warnings relating to operation of a generator set are presented below. Keep these in mind.

Warnings

Operation: Before placing a unit in operation, verify the voltage and KW rating of the generator set. Double check to be sure that the generator is properly connected to produce the voltage required by the load. Except for momentary periods such as starting of electrical motors, do not exceed the current or KW rating of any generator. Prime power sets may be overloaded up to the Standby Rating on an Intermittent Basis.

Excessive Noise

Never operate an engine without an adequate muffler or with a faulty exhaust system. Exposure to excessive noise is not only tiring but can lead to loss of hearing.

High Voltage

Remember that the function of a generator set is to produce electricity. Wherever electrical energy is present, there is the potential danger of electrocution. Take precautions to prevent unqualified personnel from tampering with or attempting to operate your generator set. Have the set and electrical circuits serviced only by qualified technicians. Wiring should be inspected frequently -- replace leads that are frayed or in poor condition. Do not operate electrical equipment when standing in water, on wet ground, or when your hands are wet.

Lethal Exhaust Gas

The engine powering your generator discharges deadly carbon monoxide as well as other irritating gases while operating. Carbon monoxide can cause death if inhaled for even a short period of time. Never operate the generator set inside a building unless the exhaust gas is vented safely outside. Never operate in any area where exhaust gas could accumulate and seep back inside an occupied building. Avoid breathing exhaust fumes when working on or near the generator set.

Dangerous Fuels

Use extreme caution when handling, storing, and using fuels -- all fuels are highly explosive in a vapor state. Store fuel in a well ventilated area away from spark producing equipment. To keep spilled fuel from igniting on contact with hot parts or from an electrical spark, do not add fuel to any tank close to the engine while the engine is running. Keep fuel lines and connections tight and in good condition -- do not replace flexible fuel lines with rigid lines. Flexible sections are used to avoid breakage due to vibration.

Battery Precautions

A battery can cause burns and possibly electrical shocks. Remove rings, watches, and jewelry that can cause short circuits. When disconnecting a battery, disconnect ground lead first and reconnect it last to minimize the probability that tools will cause short circuits.

The gases generated by a battery while being charged are highly explosive! Do not smoke or permit flame or spark to occur near a battery, particularly when it is being charged. Any room containing charging batteries should be well ventilated to prevent accumulation of explosive gases. To avoid sparks, do not disturb battery charger connections while battery is charging, and always turn charger off before connecting or disconnecting.

Avoid contact with battery electrolyte. It contains acid which can burn holes in clothing, burn skin, and cause permanent damage to eyes. Always wear splash-proof safety goggles when working around the battery. If battery electrolyte is splashed in the eyes or on skin, immediately flush the affected area for 15 minutes with large quantities of clean water. In the case of eye contact, seek immediate medical aid. Never add acid to a battery once the battery has been placed in service. Doing so may result in dangerous spattering of electrolyte.

Service and Maintenance

Units Start Without Notice: Generator sets with automatic transfer switches can electrically energize a starting sequence even though the system or portions of the system are not operating. Before performing any maintenance operation, be sure that the manual or automatic starting control circuitry has been completely disabled to prevent unexpected generator set start up. Perform positive electrical tests to confirm that any component to be serviced is electrically de-energized. As a final measure of protection, remove the battery cables (ground cable first and reconnect it last) to disable the generator set.

Moving Parts

Keep hands, hair, necktie, loose clothing and test leads well away from moving parts, as serious injury could result from entanglement. Never run the generator set with guards, covers, or screens removed.

Installation

Electrical connections must not be made on operating equipment. Shut the generator set off; make the necessary electrical connections and then restart the engine.

Repairs

Corrective action must only be taken by qualified personnel. If proper equipment and trained personnel are not available, contact the nearest authorized service center to obtain service.

Grounding

Both stationary and portable generator sets must be properly grounded prior to operation to prevent possible injury or death in case of an electrical fault.

The 1987 edition of the National Electric Code, NFPA No. 70-1987, Article 250 list the requirements for grounding generator sets. Read this article carefully.

Article 250, Section 94, is a table listing the minimum acceptable size of grounding conductors based on the size of the "Service Entrance Conductors". Service entrance conductors are equivalent to generator load cables.

The complete National Electric Code, NFPA No. 70-1987 is available from the National Fire Protection Association, 470 Atlantic Avenue, Boston, MA 02210.

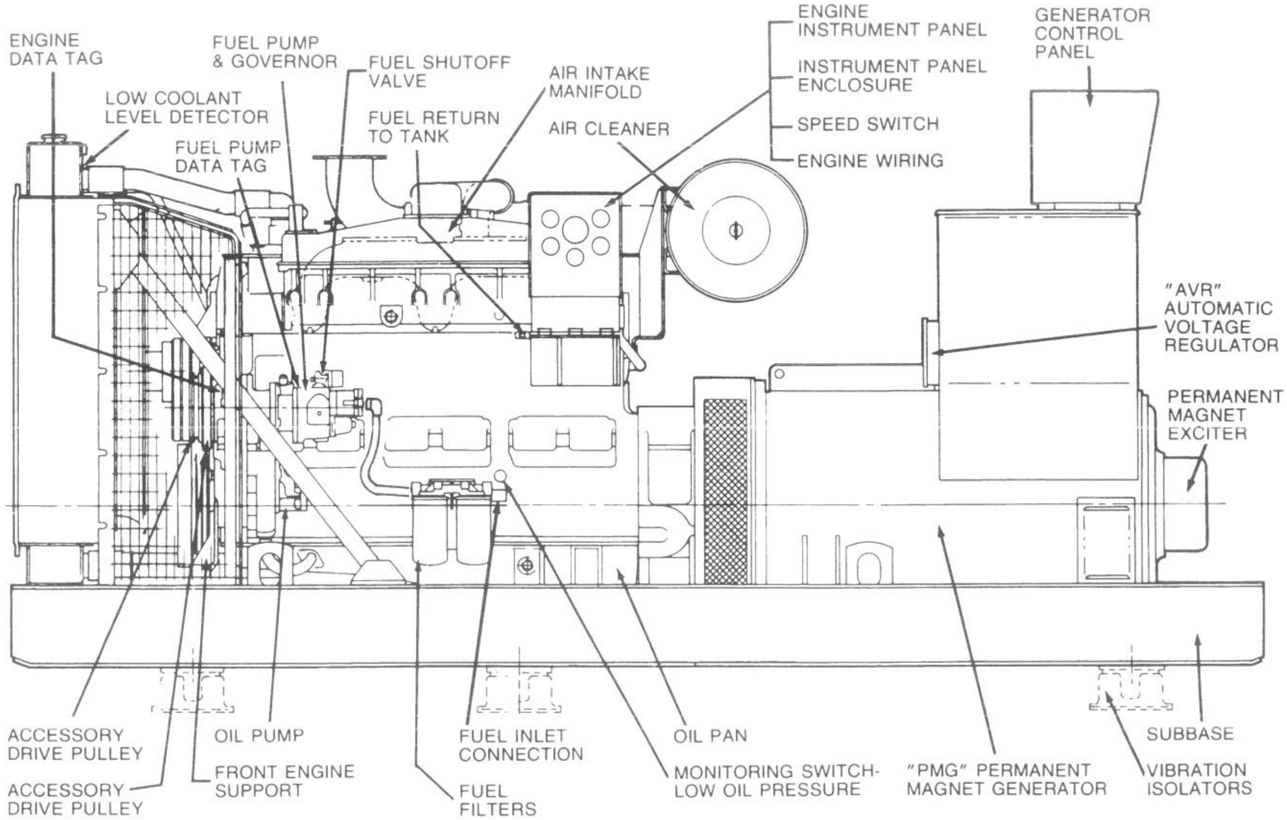
In addition to NFPA No. 70-1987, there may be local codes which also apply. Check with your local agency to become familiar with the local code requirements and fulfill those requirements prior to operating a generator set.

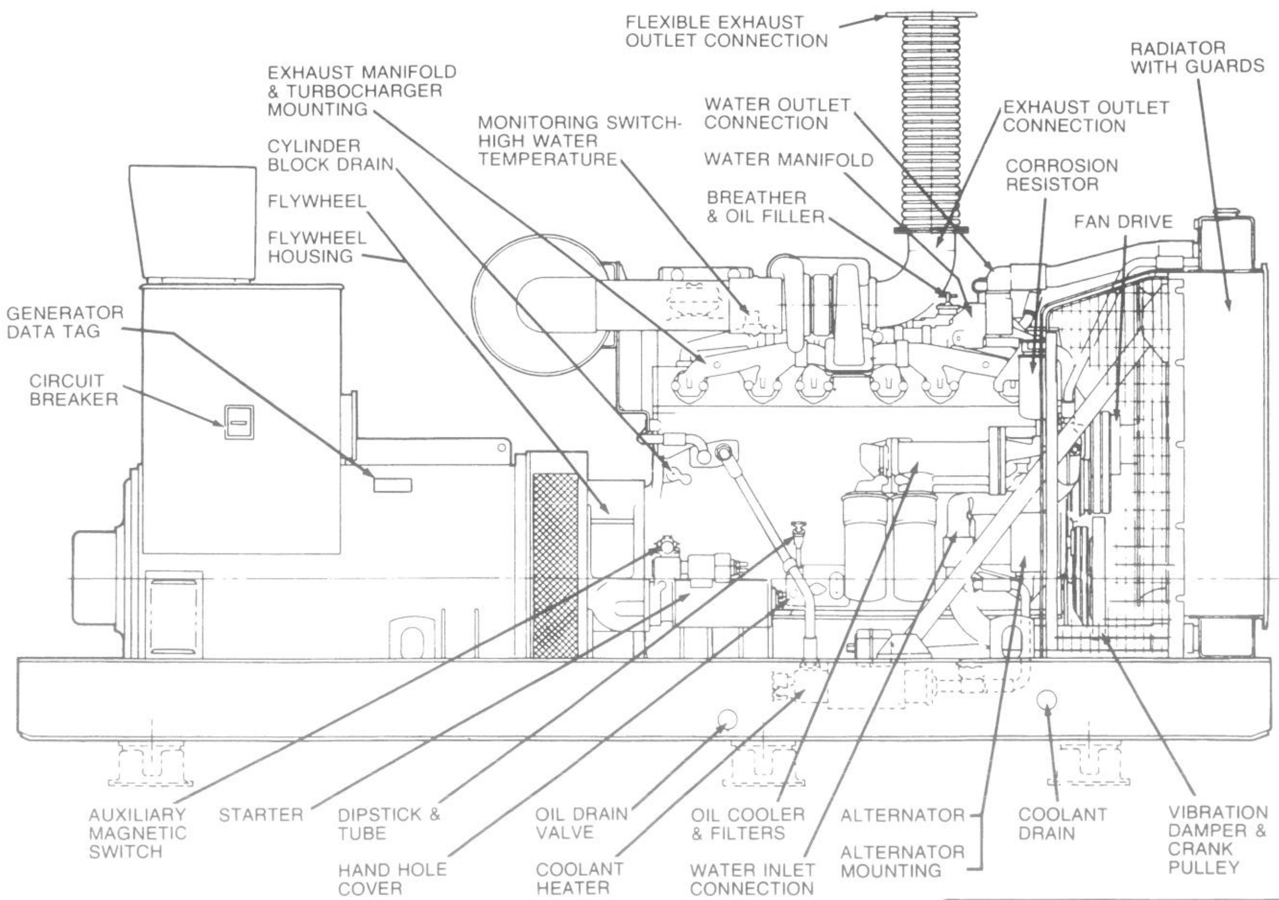
Pictorial Identification

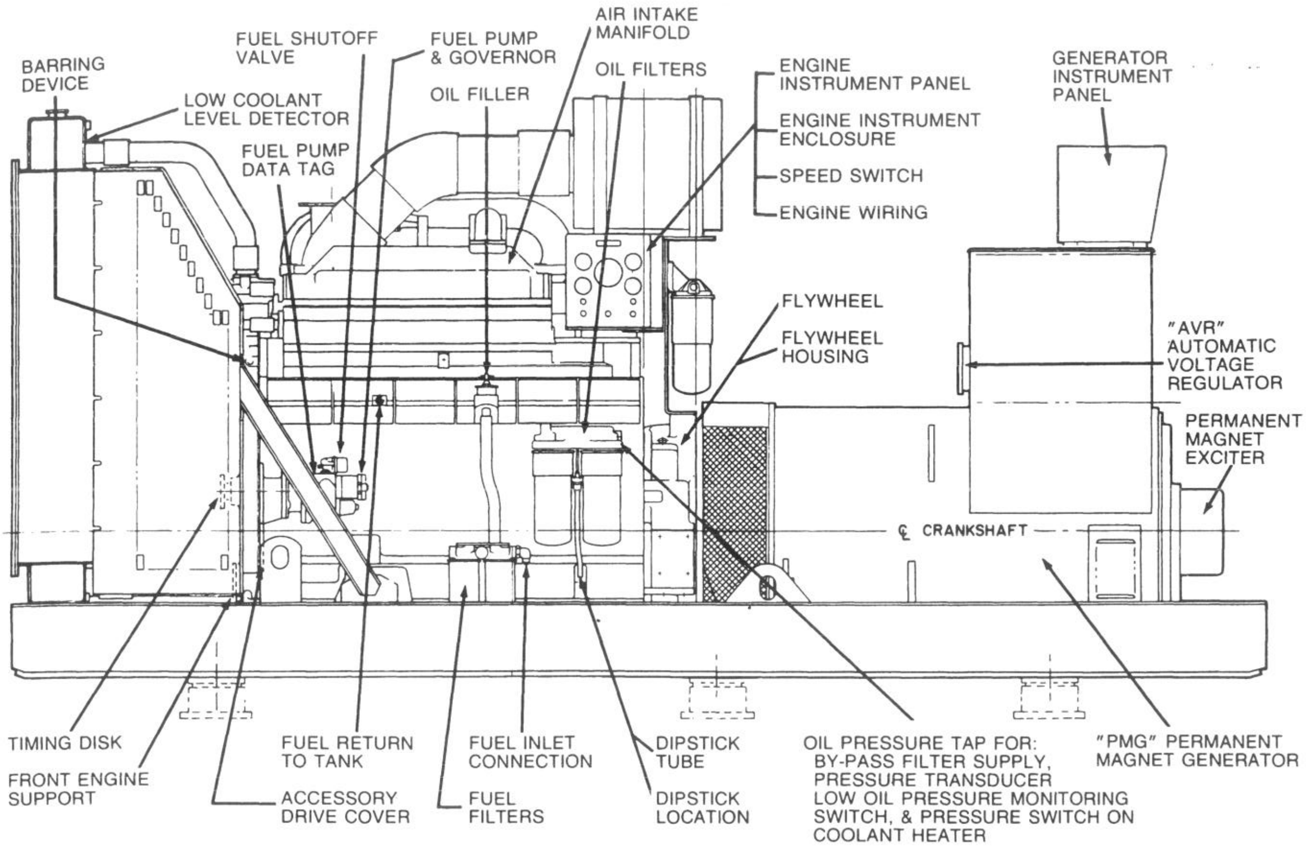
Cummins Generator Sets That Use The Cummins 14 Litre (NT-855) Displacement and Larger Engine Generator Sets, Showing Component Locations

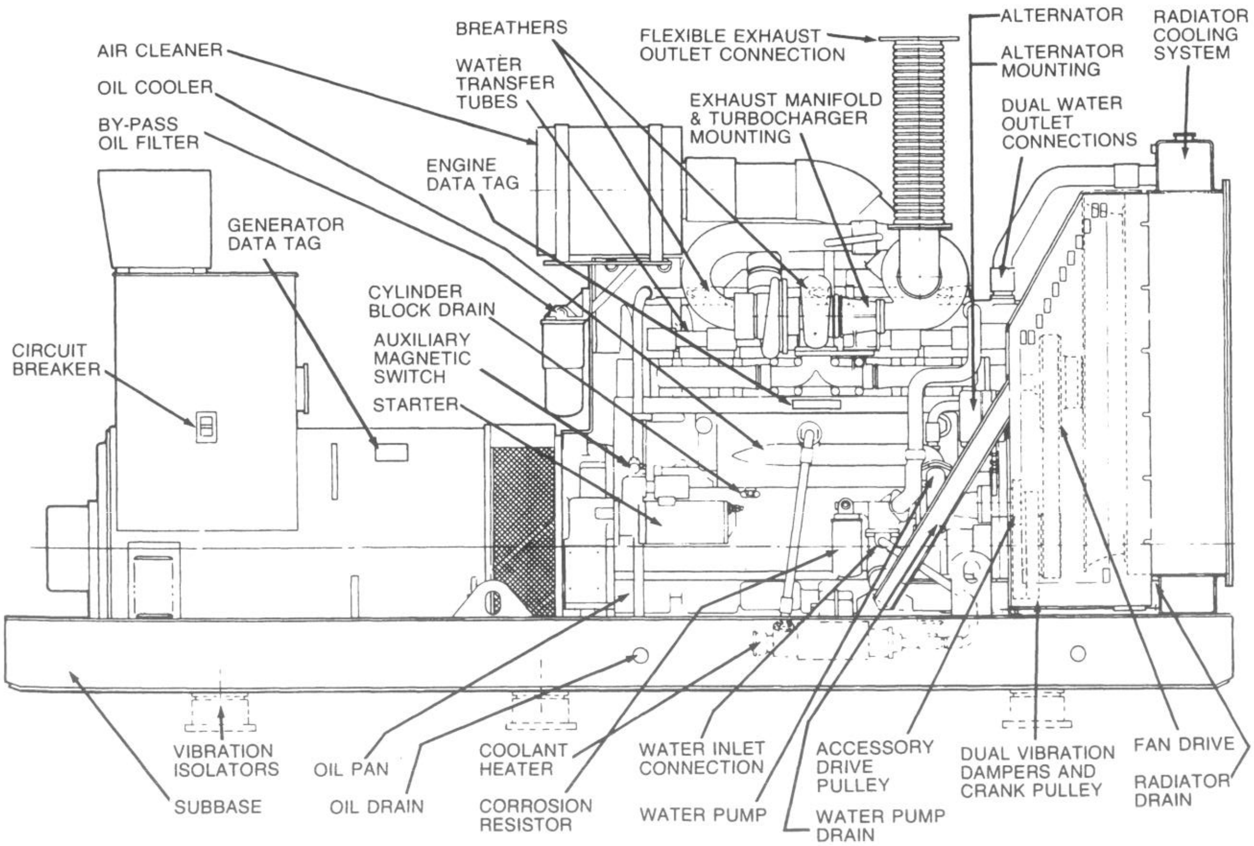
The pictures which follow show the locations of the major generator set components, the filters, and other service and maintenance points. Some external components will be at different locations for different generator set models.

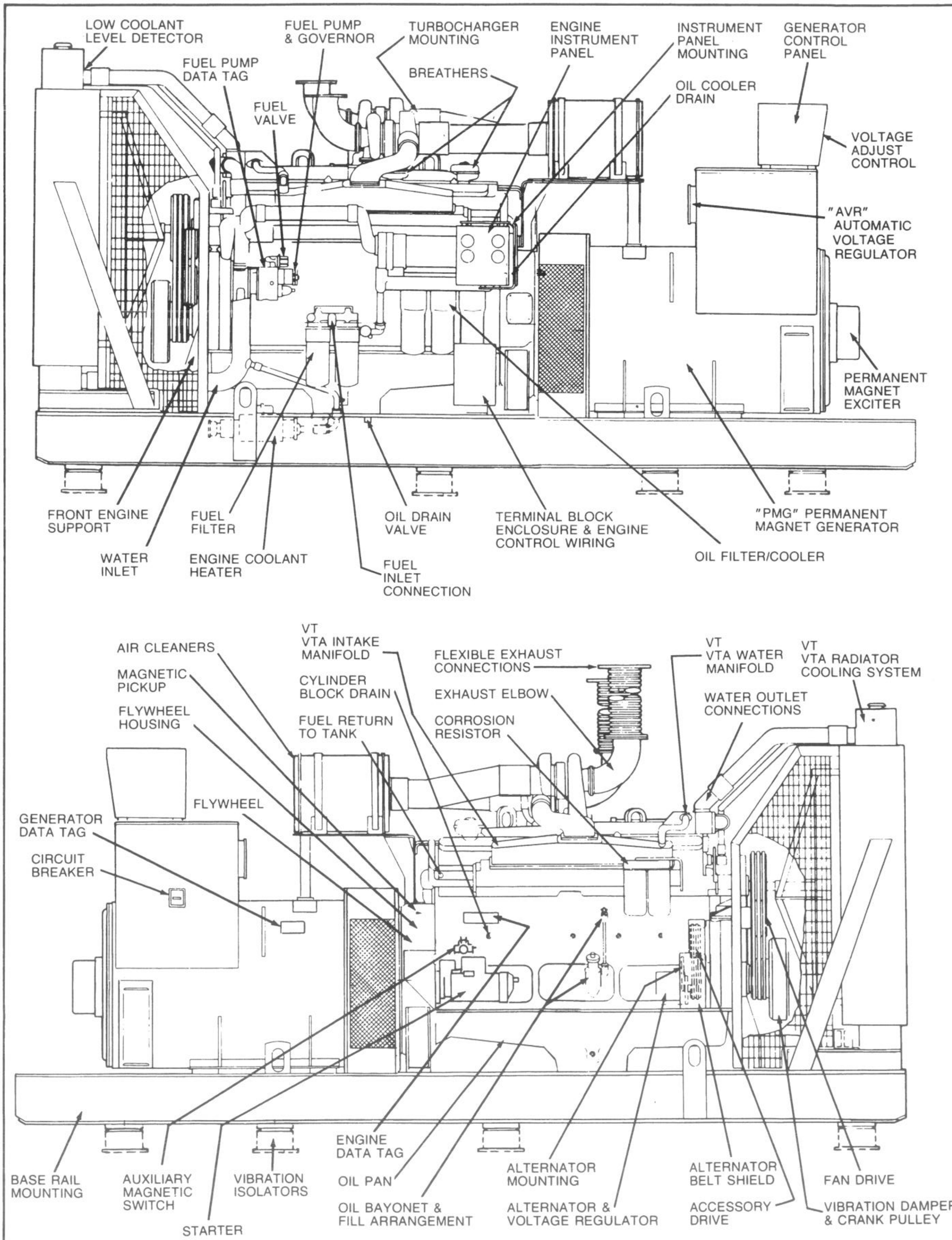
The pictures are only a reference to show a typical generator set model with most of the possible options available.


ENGINE DATA TAG
FUEL PUMP & GOVERNOR
FUEL SHUTOFF VALVE
LOW COOLANT LEVEL DETECTOR
FUEL PUMP DATA TAG
FUEL RETURN TO TANK
AIR INTAKE MANIFOLD
AIR CLEANER
ENGINE INSTRUMENT PANEL
INSTRUMENT PANEL ENCLOSURE
SPEED SWITCH
ENGINE WIRING
GENERATOR CONTROL PANEL
"AVR" AUTOMATIC VOLTAGE REGULATOR
PERMANENT MAGNET EXCITER
ACCESSORY DRIVE PULLEY
ACCESSORY DRIVE PULLEY
OIL PUMP
FRONT ENGINE SUPPORT
FUEL INLET CONNECTION
FUEL FILTERS
OIL PAN
MONITORING SWITCH-LOW OIL PRESSURE
"PMG" PERMANENT MAGNET GENERATOR
SUBBASE
VIBRATION ISOLATORS

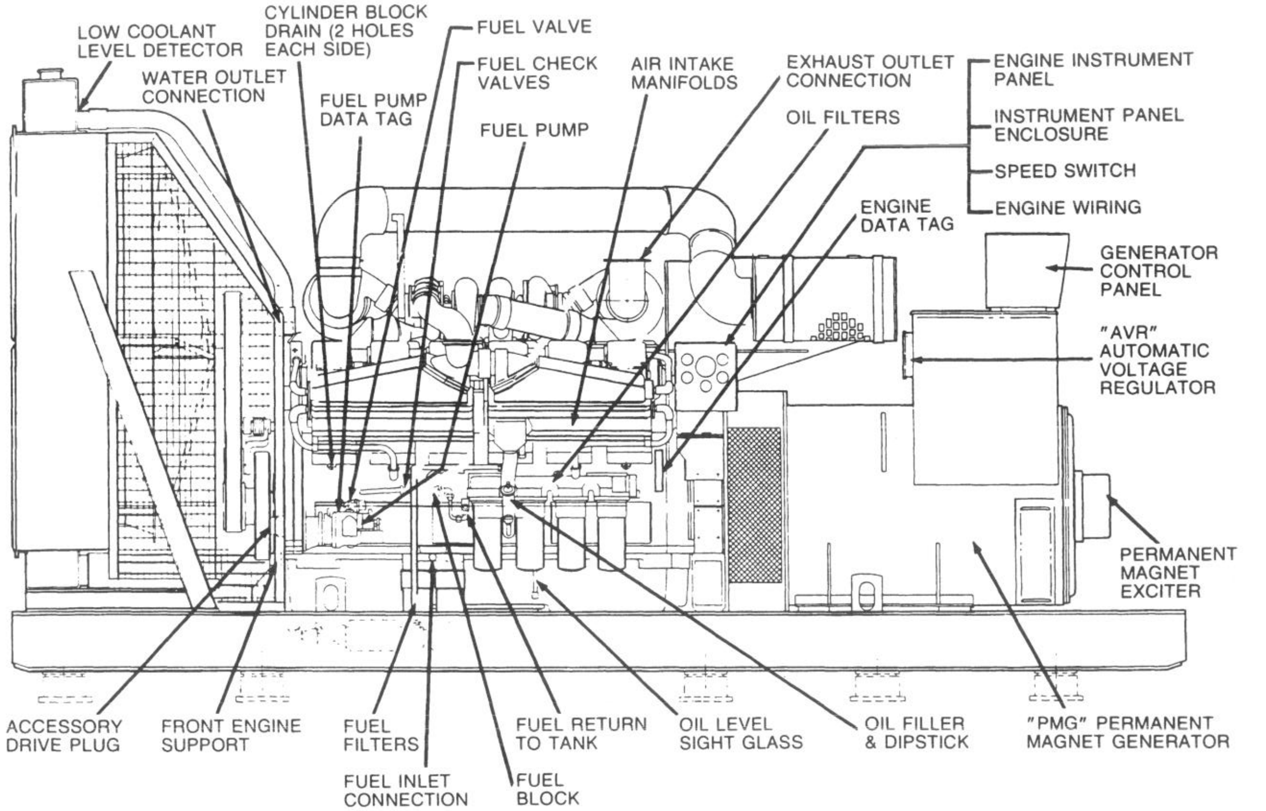

FLEXIBLE EXHAUST OUTLET CONNECTION
RADIATOR WITH GUARDS
EXHAUST MANIFOLD & TURBOCHARGER MOUNTING
CYLINDER BLOCK DRAIN
FLYWHEEL
FLYWHEEL HOUSING
MONITORING SWITCH-HIGH WATER TEMPERATURE
WATER OUTLET CONNECTION
WATER MANIFOLD
BREATHER & OIL FILLER
EXHAUST OUTLET CONNECTION
CORROSION RESISTOR
FAN DRIVE
GENERATOR DATA TAG
CIRCUIT BREAKER
AUXILIARY MAGNETIC SWITCH
STARTER
DIPSTICK & TUBE
HAND HOLE COVER
OIL DRAIN VALVE
COOLANT HEATER
OIL COOLER & FILTERS
WATER INLET CONNECTION
ALTERNATOR
ALTERNATOR MOUNTING
COOLANT DRAIN
VIBRATION DAMPER & CRANK PULLEY

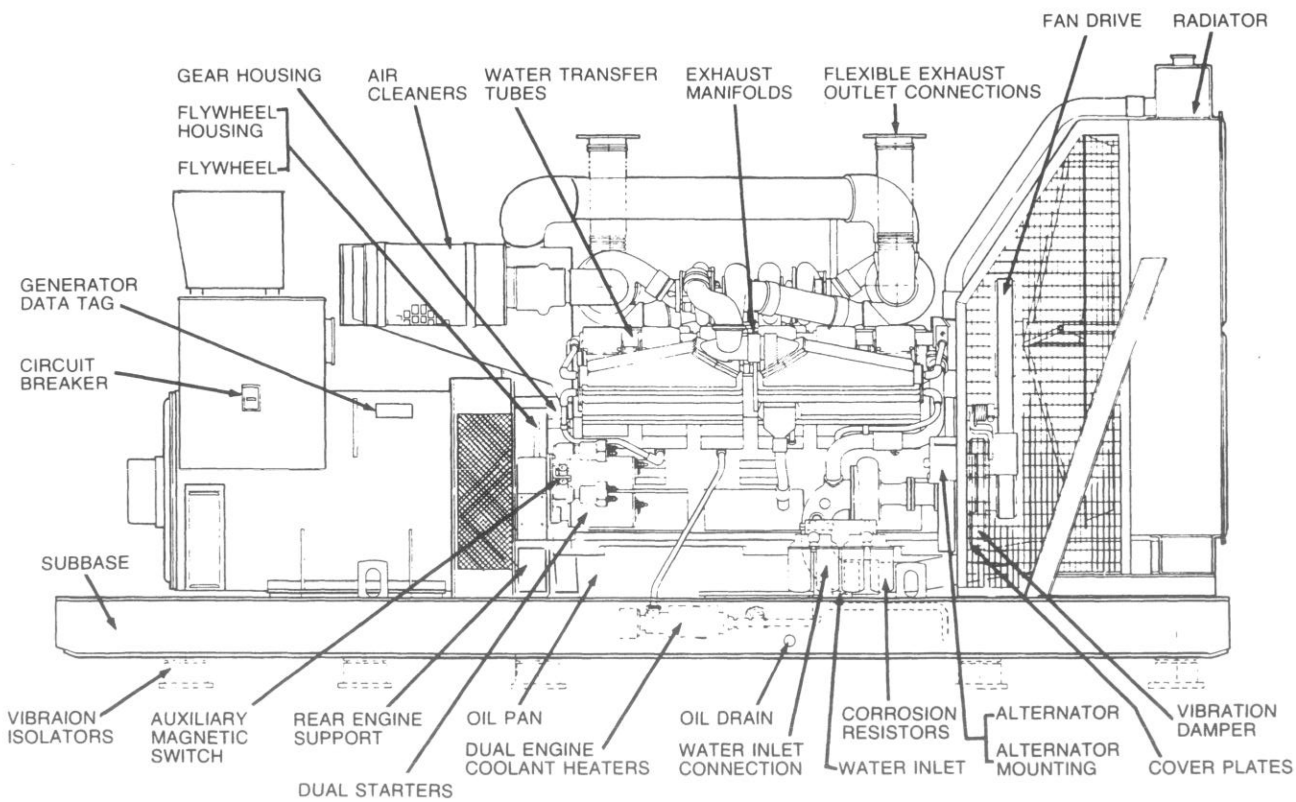

BARRING DEVICE
LOW COOLANT LEVEL DETECTOR
FUEL SHUTOFF VALVE
FUEL PUMP DATA TAG
FUEL PUMP & GOVERNOR
OIL FILLER
AIR INTAKE MANIFOLD
OIL FILTERS
ENGINE INSTRUMENT PANEL
ENGINE INSTRUMENT ENCLOSURE
SPEED SWITCH
ENGINE WIRING
GENERATOR INSTRUMENT PANEL
FLYWHEEL
FLYWHEEL HOUSING
"AVR" AUTOMATIC VOLTAGE REGULATOR
PERMANENT MAGNET EXCITER
℄ CRANKSHAFT
TIMING DISK
FRONT ENGINE SUPPORT
FUEL RETURN TO TANK
ACCESSORY DRIVE COVER
FUEL INLET CONNECTION
FUEL FILTERS
DIPSTICK TUBE
DIPSTICK LOCATION
OIL PRESSURE TAP FOR: BY-PASS FILTER SUPPLY, PRESSURE TRANSDUCER LOW OIL PRESSURE MONITORING SWITCH, & PRESSURE SWITCH ON COOLANT HEATER
"PMG" PERMANENT MAGNET GENERATOR


AIR CLEANER
OIL COOLER
BY-PASS OIL FILTER
BREATHERS
WATER TRANSFER TUBES
ENGINE DATA TAG
FLEXIBLE EXHAUST OUTLET CONNECTION
EXHAUST MANIFOLD & TURBOCHARGER MOUNTING
ALTERNATOR
ALTERNATOR MOUNTING
DUAL WATER OUTLET CONNECTIONS
RADIATOR COOLING SYSTEM
GENERATOR DATA TAG
CIRCUIT BREAKER
CYLINDER BLOCK DRAIN
AUXILIARY MAGNETIC SWITCH
STARTER
VIBRATION ISOLATORS
SUBBASE
OIL PAN
OIL DRAIN
COOLANT HEATER
CORROSION RESISTOR
WATER INLET CONNECTION
WATER PUMP
ACCESSORY DRIVE PULLEY
WATER PUMP DRAIN
DUAL VIBRATION DAMPERS AND CRANK PULLEY
FAN DRIVE
RADIATOR DRAIN

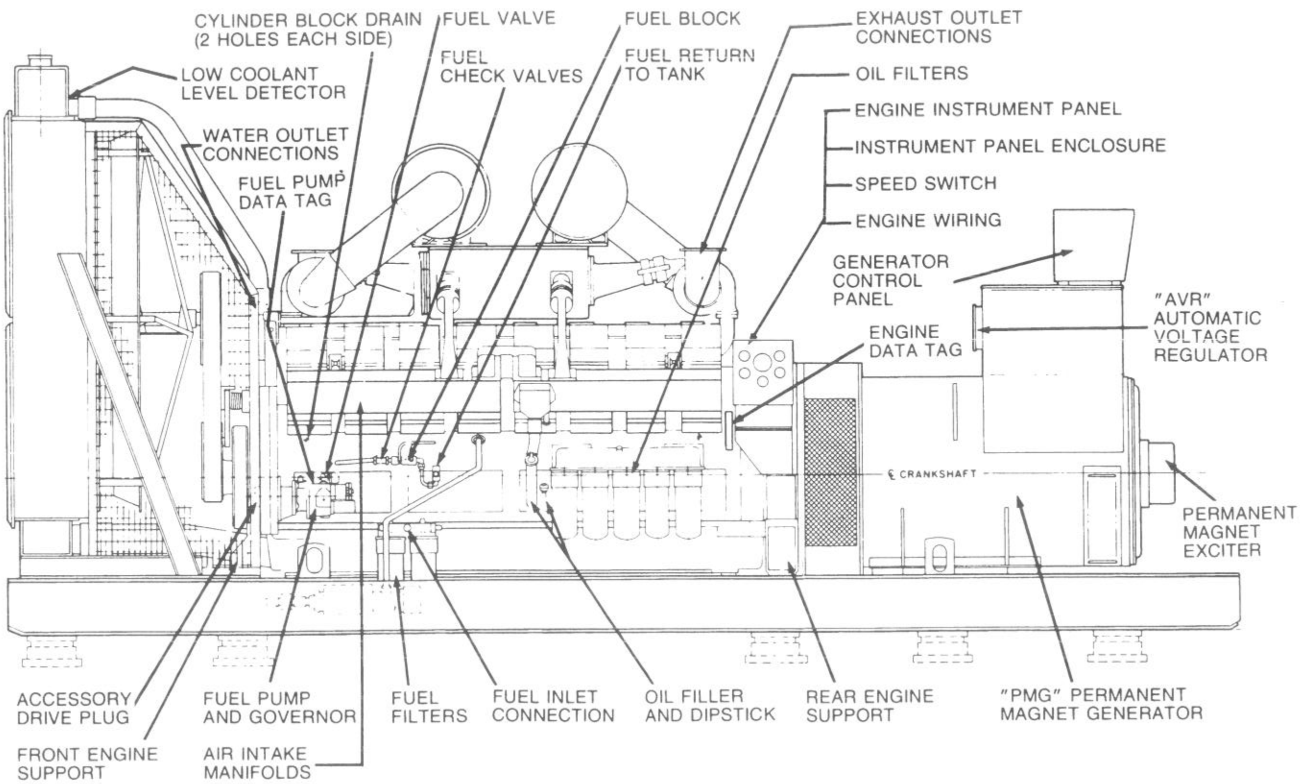


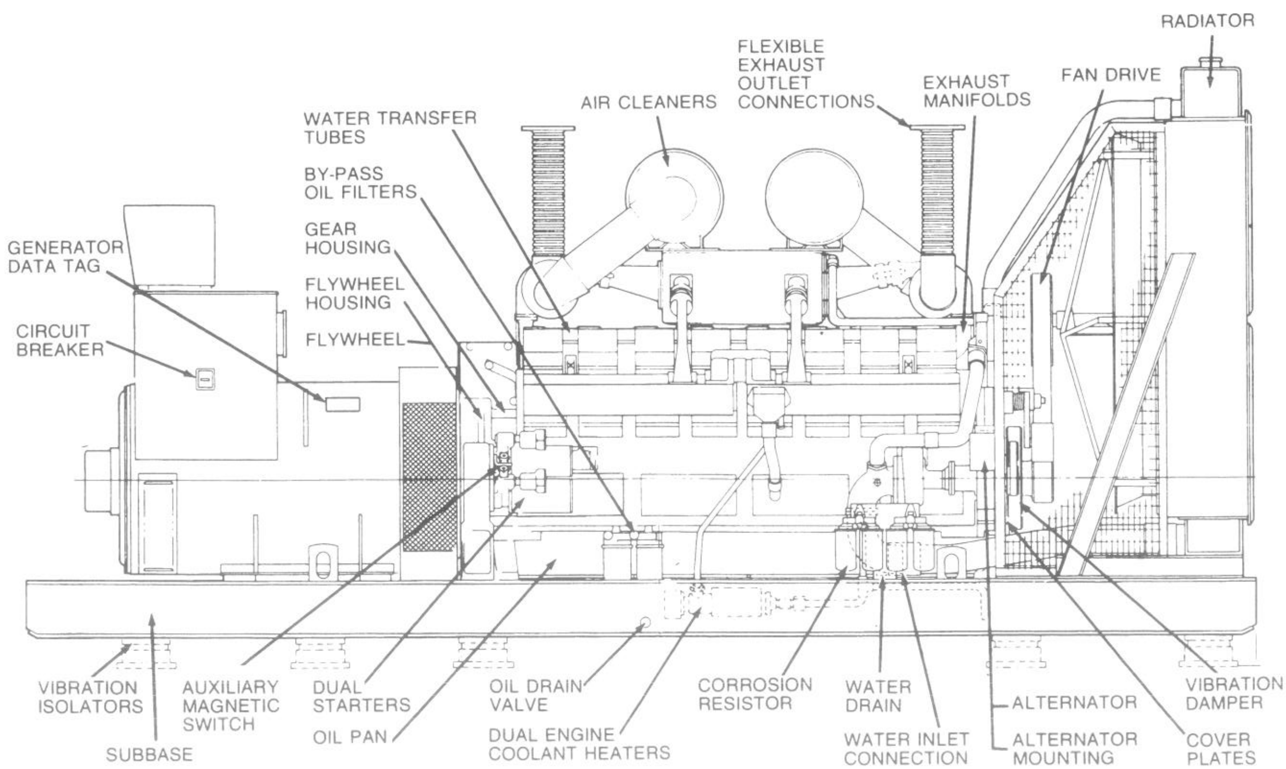
VT/VTA28-GS/GC


LOW COOLANT LEVEL DETECTOR
CYLINDER BLOCK DRAIN (2 HOLES EACH SIDE)
FUEL VALVE
FUEL CHECK VALVES
AIR INTAKE MANIFOLDS
EXHAUST OUTLET CONNECTION
ENGINE INSTRUMENT PANEL
WATER OUTLET CONNECTION
FUEL PUMP DATA TAG
FUEL PUMP
OIL FILTERS
INSTRUMENT PANEL ENCLOSURE
SPEED SWITCH
ENGINE WIRING
ENGINE DATA TAG
GENERATOR CONTROL PANEL
"AVR" AUTOMATIC VOLTAGE REGULATOR
PERMANENT MAGNET EXCITER
ACCESSORY DRIVE PLUG
FRONT ENGINE SUPPORT
FUEL FILTERS
FUEL RETURN TO TANK
OIL LEVEL SIGHT GLASS
OIL FILLER & DIPSTICK
"PMG" PERMANENT MAGNET GENERATOR
FUEL INLET CONNECTION
FUEL BLOCK

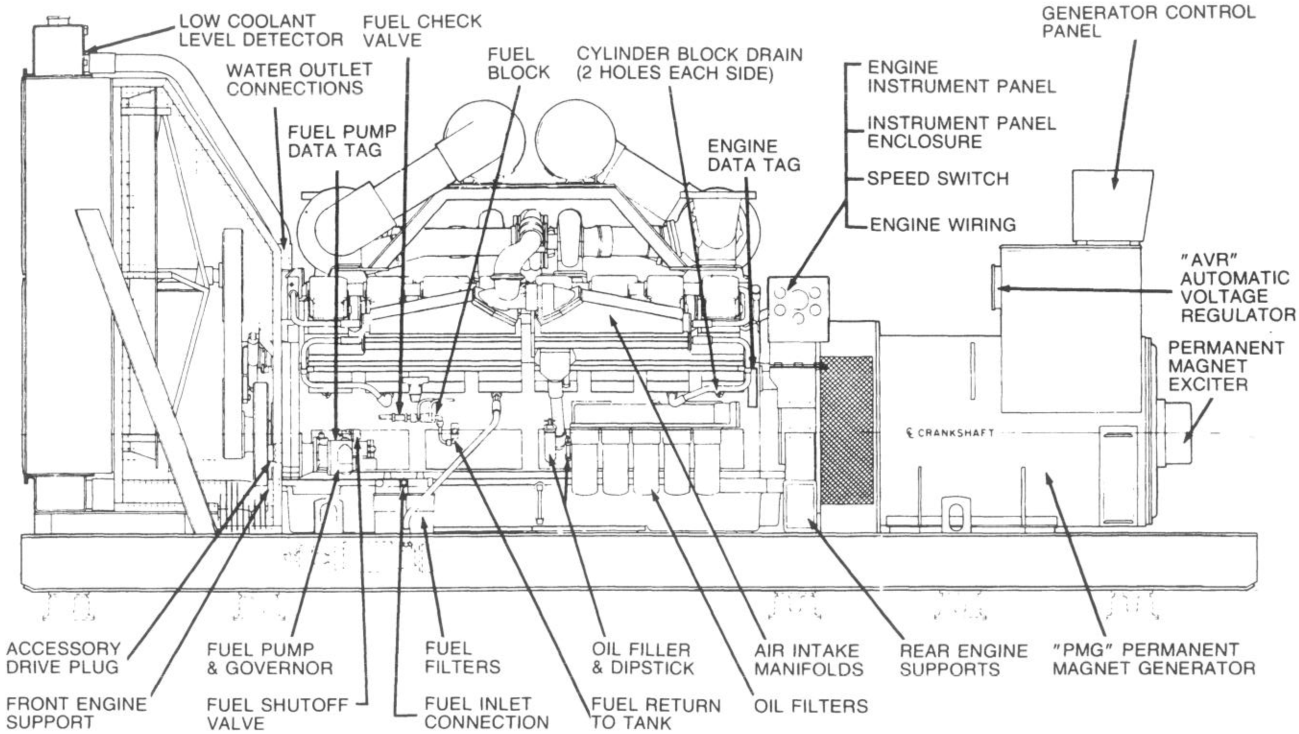

FAN DRIVE
RADIATOR
GEAR HOUSING
AIR CLEANERS
WATER TRANSFER TUBES
EXHAUST MANIFOLDS
FLEXIBLE EXHAUST OUTLET CONNECTIONS
FLYWHEEL HOUSING
FLYWHEEL
GENERATOR DATA TAG
CIRCUIT BREAKER
SUBBASE
VIBRAION ISOLATORS
AUXILIARY MAGNETIC SWITCH
REAR ENGINE SUPPORT
OIL PAN
OIL DRAIN
CORROSION RESISTORS
ALTERNATOR
VIBRATION DAMPER
DUAL ENGINE COOLANT HEATERS
WATER INLET CONNECTION
WATER INLET
ALTERNATOR MOUNTING
COVER PLATES
DUAL STARTERS

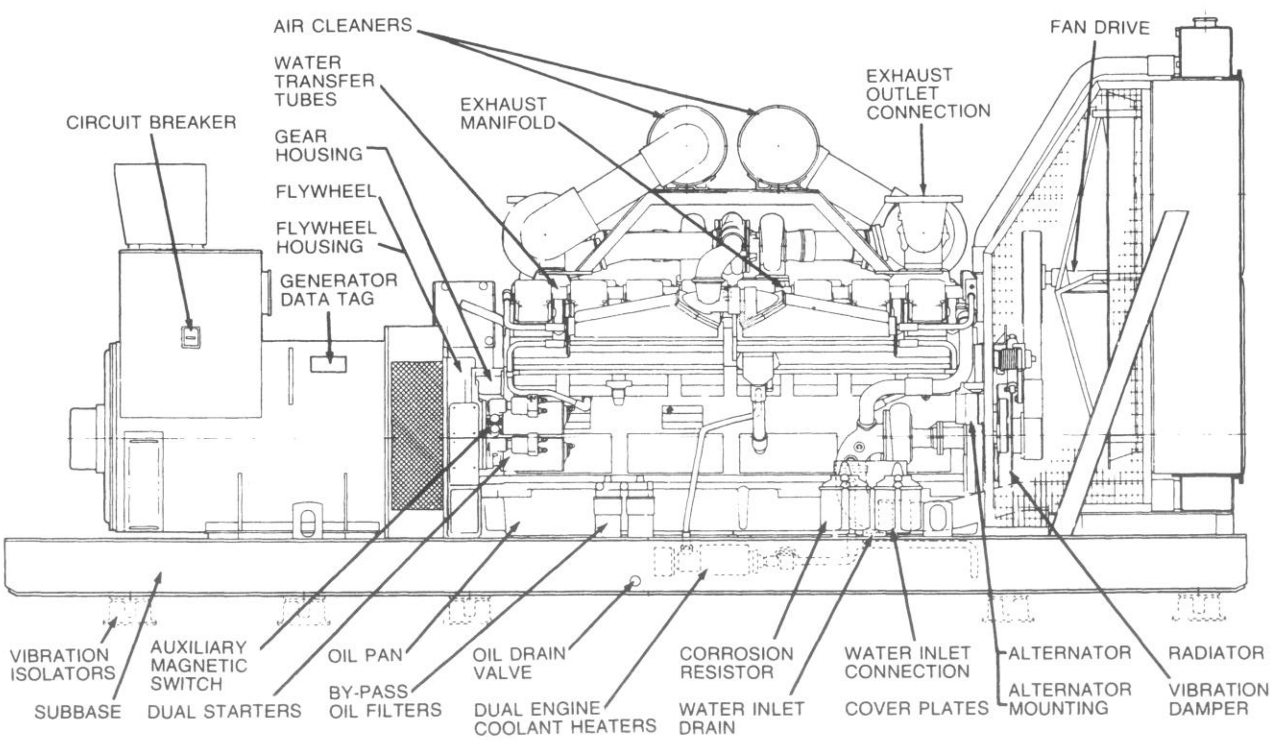
KTTA 38-GS/GC


CYLINDER BLOCK DRAIN
(2 HOLES EACH SIDE)
FUEL VALVE
FUEL BLOCK
EXHAUST OUTLET
CONNECTIONS
LOW COOLANT
LEVEL DETECTOR
FUEL
CHECK VALVES
FUEL RETURN
TO TANK
OIL FILTERS
ENGINE INSTRUMENT PANEL
WATER OUTLET
CONNECTIONS
INSTRUMENT PANEL ENCLOSURE
FUEL PUMP
DATA TAG
SPEED SWITCH
ENGINE WIRING
GENERATOR
CONTROL
PANEL
"AVR"
AUTOMATIC
VOLTAGE
REGULATOR
ENGINE
DATA TAG
℄ CRANKSHAFT
PERMANENT
MAGNET
EXCITER
ACCESSORY
DRIVE PLUG
FUEL PUMP
AND GOVERNOR
FUEL
FILTERS
FUEL INLET
CONNECTION
OIL FILLER
AND DIPSTICK
REAR ENGINE
SUPPORT
"PMG" PERMANENT
MAGNET GENERATOR
FRONT ENGINE
SUPPORT
AIR INTAKE
MANIFOLDS


RADIATOR
FLEXIBLE
EXHAUST
OUTLET
CONNECTIONS
EXHAUST
MANIFOLDS
FAN DRIVE
AIR CLEANERS
WATER TRANSFER
TUBES
BY-PASS
OIL FILTERS
GEAR
HOUSING
GENERATOR
DATA TAG
FLYWHEEL
HOUSING
CIRCUIT
BREAKER
FLYWHEEL
VIBRATION
ISOLATORS
AUXILIARY
MAGNETIC
SWITCH
DUAL
STARTERS
OIL DRAIN
VALVE
CORROSION
RESISTOR
WATER
DRAIN
ALTERNATOR
VIBRATION
DAMPER
SUBBASE
OIL PAN
DUAL ENGINE
COOLANT HEATERS
WATER INLET
CONNECTION
ALTERNATOR
MOUNTING
COVER
PLATES

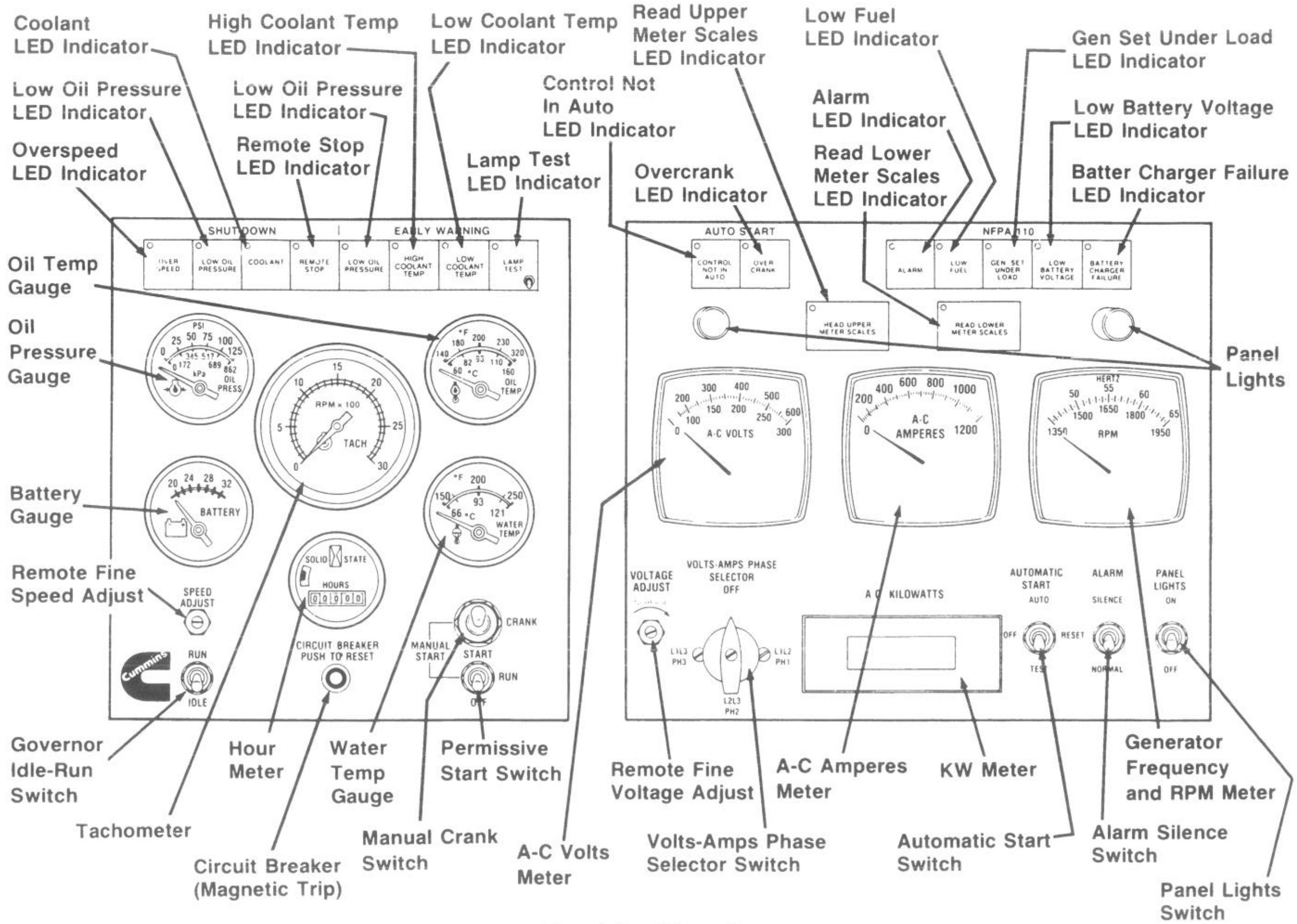
KTA50-GS/GC


LOW COOLANT LEVEL DETECTOR
FUEL CHECK VALVE
WATER OUTLET CONNECTIONS
FUEL BLOCK
CYLINDER BLOCK DRAIN (2 HOLES EACH SIDE)
FUEL PUMP DATA TAG
ENGINE DATA TAG
ENGINE INSTRUMENT PANEL
INSTRUMENT PANEL ENCLOSURE
SPEED SWITCH
ENGINE WIRING
GENERATOR CONTROL PANEL
"AVR" AUTOMATIC VOLTAGE REGULATOR
PERMANENT MAGNET EXCITER
℄ CRANKSHAFT
ACCESSORY DRIVE PLUG
FRONT ENGINE SUPPORT
FUEL PUMP & GOVERNOR
FUEL SHUTOFF VALVE
FUEL FILTERS
FUEL INLET CONNECTION
OIL FILLER & DIPSTICK
FUEL RETURN TO TANK
AIR INTAKE MANIFOLDS
OIL FILTERS
REAR ENGINE SUPPORTS
"PMG" PERMANENT MAGNET GENERATOR

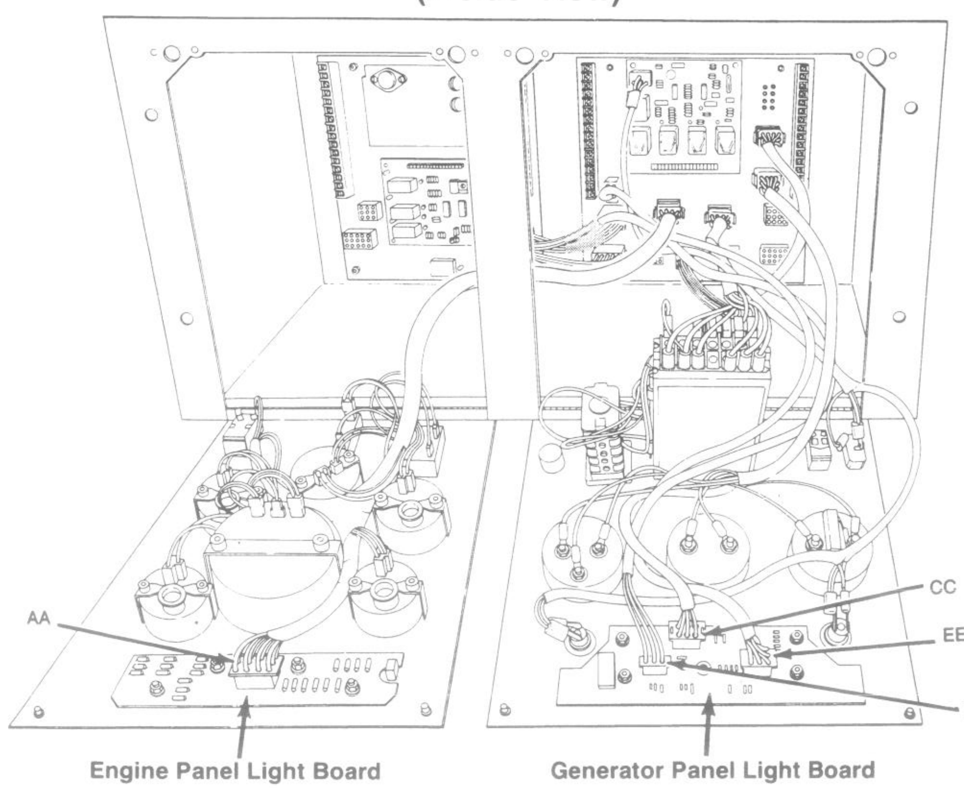

AIR CLEANERS
WATER TRANSFER TUBES
EXHAUST MANIFOLD
EXHAUST OUTLET CONNECTION
FAN DRIVE
CIRCUIT BREAKER
GEAR HOUSING
FLYWHEEL
FLYWHEEL HOUSING
GENERATOR DATA TAG
VIBRATION ISOLATORS
SUBBASE
AUXILIARY MAGNETIC SWITCH
DUAL STARTERS
OIL PAN
BY-PASS OIL FILTERS
OIL DRAIN VALVE
DUAL ENGINE COOLANT HEATERS
CORROSION RESISTOR
WATER INLET DRAIN
WATER INLET CONNECTION
COVER PLATES
ALTERNATOR
ALTERNATOR MOUNTING
RADIATOR
VIBRATION DAMPER

KTTA50-GS/GC

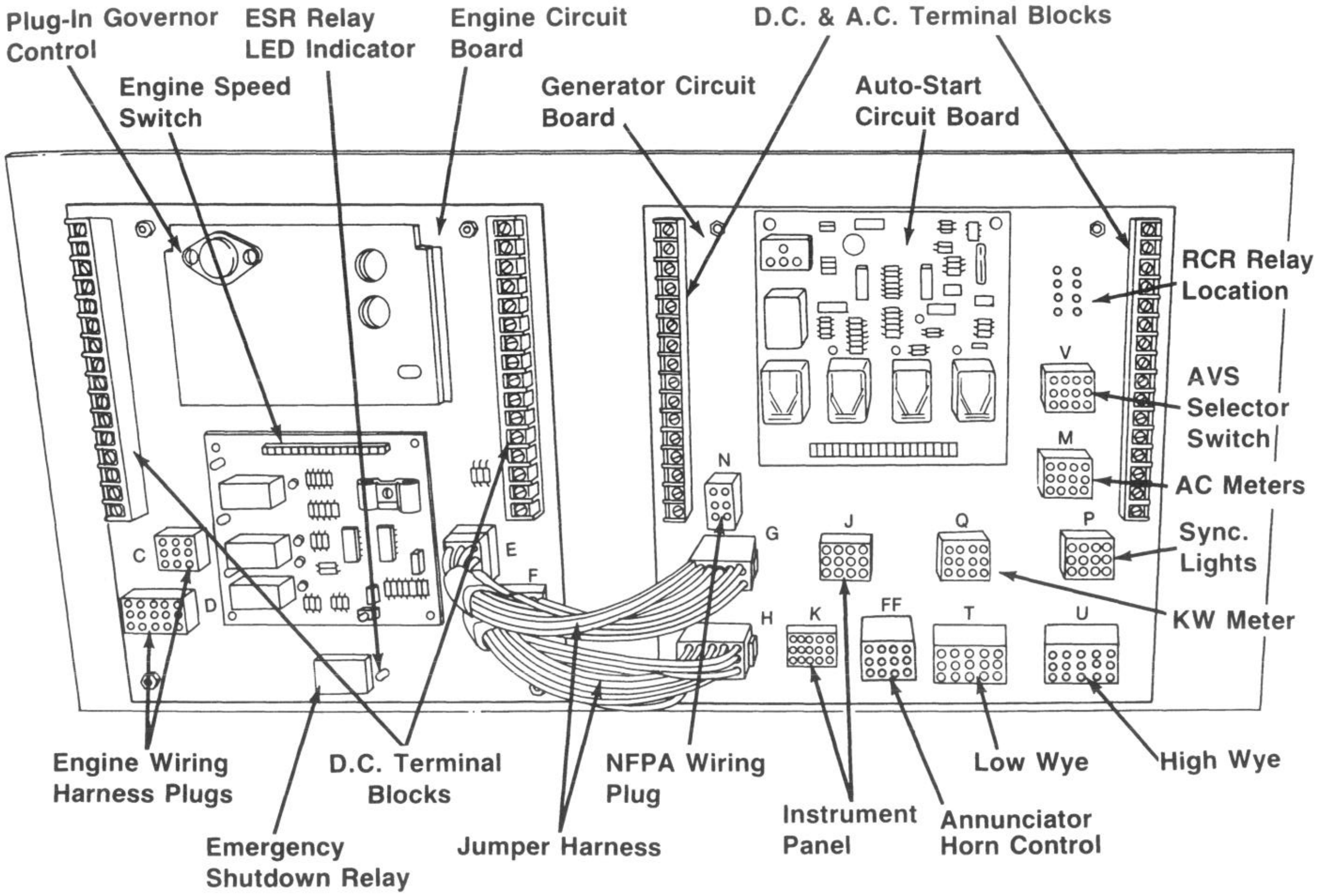
Generator Control Panel
(Front View)



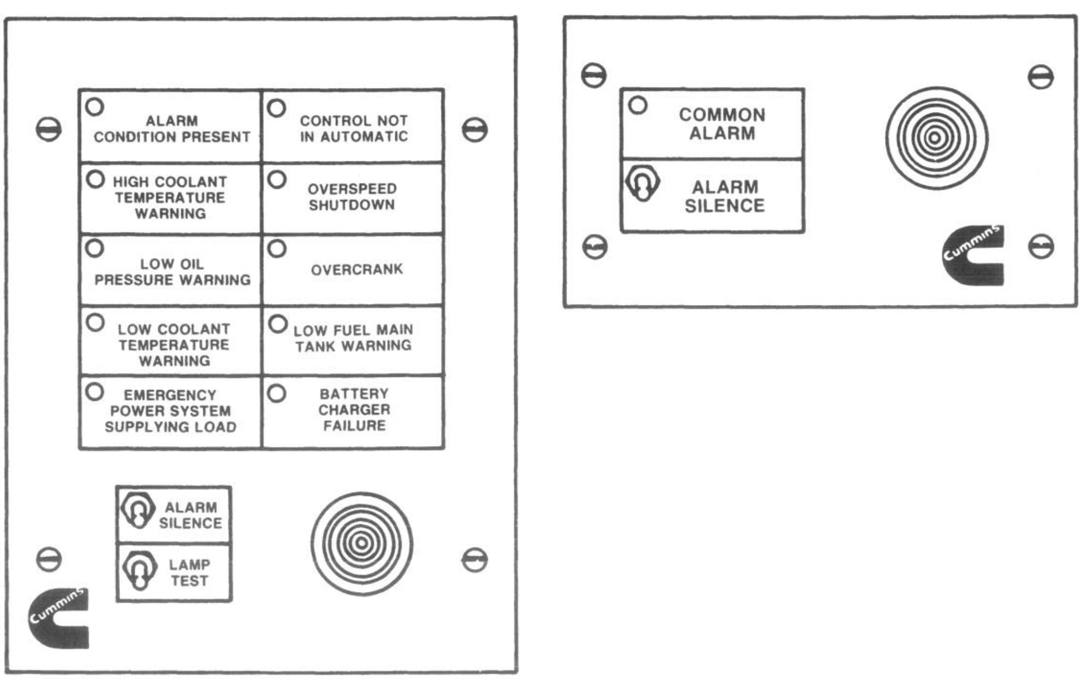
(Inside View)



Generator Set Control Panel (Inside View)



Remote Annunciator Panels



Section T - Troubleshooting

Procedures and Techniques

A thorough analysis of the customer's complaint is the key to successful troubleshooting. The more information known about a complaint, the faster and easier the problem can be solved.

The "Troubleshooting Symptoms Charts", beginning on page t-3, are organized so that a problem can be located and corrected by doing the easiest and most logical things first. Complete all steps in the sequence shown from top to bottom.

It is not possible to include all the possible solutions to problems that can occur; however, these charts should stimulate a thought process that will lead to the cause and correction of the problem.

Follow these basic troubleshooting steps:

- **Get all the facts concerning the complaint.**
- **Analyze the problem thoroughly.**
- **Relate the symptoms to the basic engine generator set systems and components.**
- **Consider any recent maintenance or repair action that may relate to the problem.**
- **Double-check before beginning any disassembly.**
- **Solve the problem by using the logic charts and doing the easiest things first.**
- **Determine the cause of the problem and make a thorough repair.**
- **After repairs have been made, operate the generator set to make sure the cause of the problem has been corrected.**

Troubleshooting Symptoms

Engine Symptoms **Page Number**

Generator Symptoms

Symptom: Engine Will Not Crank or Cranks Slowly

Cause	Correction
External or Internal Conditions Affecting Engine Crankshaft Rotation	Check engine for ease of crankshaft rotation.
OK ↓	
Verify Starting Procedure	1. Manual Refer to Procedure 5-08 2. Test Refer to Procedure 5-09 3. Auto Refer to Procedure 5-10
OK ↓	
Engine Control Panel Breaker Open	Reset Breaker. Refer to Procedure 5-07
OK ↓	
Battery Connections Broken, Loose, Or Corroded	Check Battery Connections. Refer to Procedure 5-05
OK ↓	
Battery Condition Indicator Low	Check Specific Gravity Of Batteries. Charge Batteries If Below 1.160
OK ↓	
Battery Voltage Low While Attempting To Crank	Check Electrolyte Level, Starter Cables, Terminals, And Connections. Refer to Procedure 5-04, 5-05
OK ↓	
Starting Circuit Component Defective - Remote Start Contacts, AMS, Starter	Check Starting Circuit Components. Refer to Section 5.
OK ↓	
Control Panel Circuit Defective	Refer To Schematic Diagrams. Refer to Section 7

Symptom: Engine Cranks But Will Not Start

Cause	Correction
Incorrect Starting Procedure	1. Manual Refer to Procedure 5-08 2. Test Refer to Procedure 5-09 3. Auto Refer to Procedure 5-10
OK	
Overspeed Stop Tripped	Reset Overspeed Stop. (Turn Off-Run-Start Switch to "Off", Then to "Run").
OK	
No Fuel in Supply Tank or Tank Valve Closed	Add Fuel To Tank Or Open Tank Valve
OK	
No Fuel to Cylinder Head	Loosen fuel line at cylinder head while cranking engine. Check fuel line check valves.
OK	
No Fuel Through Shutoff Valve	Manually open shutoff valve. Refer to Procedure 4-10.
OK	
No Voltage At The Fuel Solenoid Valve Coil	Check Electrical Circuit. Refer to Section 5.
OK	
Fuel Solenoid Valve Coil Defective	Check Solenoid Coil Resistance. Refer to Procedure 4-11. Manually Open Solenoid Valve. Refer to Procedure 4-10. Replace Coil If Necessary.
OK	
No Fuel to Shutoff Valve	Loosen pipe plug in shutoff valve and crank engine.
OK	

(Continued)

Symptom: Engine Cranks But Will Not Start (Continued)

Cause	Correction
No Fuel In Pump	Fill Fuel Pump With Fuel. Refer to Procedure 4-06. Fill Fuel Filter With Fuel. Refer to Procedure 4-05.
OK ↓	
Air Leak In Fuel Supply Line	Tighten All Fuel Supply Line Fittings. Fill and Tighten Fuel Filter. Refer to Procedure 4-05. Check Fuel Supply Line Restriction. Refer to Procedure 4-07.
OK ↓	
Fuel Filter Plugged Or Fuel Supply Line Restricted	Verify Restriction On Inlet Side Of Fuel Pump. Refer to Procedure 4-07. Replace Fuel Filter and Lines If Required. Refer to Procedure 4-05. Run From a Temporary Fuel Supply.
OK ↓	
Loss Of Magnetic Pick-Up Signal With Normally Closed EFC Governor System Or United Technologies Governor System	Check Magnetic Pick-Up Voltage to Engine Terminal Board, Terminals 13 and 14 For Plug-In Governor Controls, Or Remote EFC Governor Terminals 5 and 6 Or United Technologies ECD 67-5111 Terminals C & D. Check Wires From Magnetic Pick-Up To Governor Control.
OK ↓	
Normally Closed EFC Or United Technologies Actuator Lead(s) Disconnected	Check Actuator Lead(s). Refer to Procedure 4-13
OK ↓	
Normally Closed EFC Actuator Stuck In Closed Position	Check Actuator Installation In EFC Fuel Pump Housing. Refer to Procedure 4-14.
OK ↓	
Normally Closed EFC Governor System, No Battery Supply Voltage To Governor Control	Verify That Battery Voltage Is Present At Engine Terminal Board Terminal 5. Check Wiring and Connections.
OK ↓	
Defective Normally Closed EFC Governor Operation	Check EFC Governor Operation. Refer to Procedure 4-14.
OK ↓	

(Continued)

Symptom: Engine Cranks But Will Not Start (Continued)

Cause	Correction
Defective United Technologies Governor Operation	Check United Technologies Governor Operation. Refer to Procedure 4-16, 17 Or 18
OK ↓	
Foreign Material (Brass Or Aluminum Threads, Teflon Tape, Etc.) In Fuel Solenoid Valve	Disassemble Fuel Solenoid Valve. Refer to Procedure 4-11. Remove Any Foreign Material. Assemble Fuel Solenoid Valve. Refer to Procedure 4-12
OK ↓	
Cold Starting Aid Needed Or Not Working	Check Operation Of Coolant Heater. Check Operation Of Fluid Starting Aid (Prime Power Generator Sets Below 10° C (50° F) Ambient).
OK ↓	
Installation Of Normally Open EFC Actuator With A Normally Closed EFC Governor Control	Use Correct Normally Closed EFC Actuator With Normally Closed EFC Governor Control. Refer to Procedure 4-14
OK ↓	
Installation Of Normally Closed EFC Actuator With A Normally Open EFC Governor Control AND Loss Of Magnetic Pick-Up Signal	Use Correct Normally Open EFC Actuator With Normally Open EFC Governor Control. AND Check Magnetic Pick-Up Output. Refer to Procedure 4-14
OK ↓	
Low Cetane (Furnace Type) Fuel	Verify By Cranking Engine On Recommended Fuel From A Temporary Supply Tank.
OK ↓	
Defective Fuel Pump	Refer To Appropriate Engine T&R Manual For Further Diagnosis.

Symptom: Engine Overspeed, Shutoff Or Operates At High Idle

Cause	Correction
Governor Speed Set Too High	See EFC Governor Adjustments. Refer to Procedure 4-14. See United Technologies Governor Adjustments. Refer to Procedure 4-16, 17, 18 Or 19. Woodward PSG Or 2301 Linkage. See Refer to Procedure 4-20. See Woodward PSG Adjustments. Refer to Procedure 4-22. See Woodward 2301 Adjustments. Bulletin 3379179.
OK ↓	
Governor Gain/Stability Adjustments Incorrect	EFC Governor Adjustments. Refer to Procedure 4-14, Pg. (24) United Technologies Governor Adjustments. Refer to Procedure 4-16, 17, Or 18. Woodward PSG Adjustments, Refer to Procedure 4-22. See Woodward 2301 Adjustments, Bulletin 3379179.
OK ↓	
Overspeed Stop Set Too Low	Adjust Overspeed Stop. Refer to Procedure Page 5-11
OK ↓	
Actuator Lead(s) Disconnected On Normally Open EFC Governor System	Connect Actuator Leads. Refer to Procedure 4-13
OK ↓	
Normally Open EFC Governor System, Magnetic Pick-Up Voltage Less Than 1.5 Volts AC At Governor Control	Check Magnetic Pick-Up Voltage to Engine Terminal Board Terminal 13 And 14 For Plug-In Governor Control or Remote Governor Control Terminals 5 And 6. Refer to Procedure 4-14. Check Wires From Magnetic Pick-Up To Governor Control.
OK ↓	
Normally Open EFC Governor System Voltage AT ACTUATOR TERMINALS Above 16 Volts	Replace Normally Open Actuator. Refer to Procedure 4-14.
OK ↓	

(Continued)

Symptom: Engine Overspeed, Shutoff Or Operates At High Idle (Continued)

Cause	Correction
Normally Open EFC Governor System Voltage AT GOVERNOR CONTROL TERMINALS TO ACTUATOR Above 16 Volts	Check Wiring And Connections
OK ↓	
Normally Open EFC Governor System, No Voltage Supply To Governor Control	Check Wiring And Connections. Verify That Battery Voltage Is Present On Engine Terminal Board Terminal 5. Check Battery Voltage. Refer to Procedure 5-04.
OK ↓	
Normally Closed EFC Governor Control System, Voltage At Governor Control Output To Actuator Above 19-20 Volts.	Check Wiring To Normally Closed EFC Governor Control. Replace Normally Closed EFC Governor Control.
OK ↓	
Normally Closed Or Normally Open EFC Governor Control System, Defective O-Rings On Actuator Shaft	Remove EFC Actuator From Fuel Pump. Refer to Procedure 4-14. Install New O-Rings. Install EFC Actuator In Fuel Pump. Refer to Procedure 4-14.
OK ↓	
Normally Open EFC Governor Control Used With Normally Closed EFC Actuator	Use Normally Closed EFC Governor Control With Normally Closed EFC Actuator. Refer to Procedure 4-14
OK ↓	
Normally Open EFC Governor Control Failures	Replace Normally Open EFC Governor Control.
OK ↓	
Woodward 2301 Electric Governor EG-1PC Actuator, Magnetic Pick-Up Fail-Safe Defeated AND Loss Of Magnetic Pick-Up Signal	Install Fail-Safe Jumper. See Cummins Bulletin No. 3379179.
OK ↓	
Excessive Motoring Power From Induction Motor	Revise Loading Sequence. Add Load Bank To System.

Symptom: High Coolant Temperature With Set Mounted Radiator

Cause	Correction
Low Coolant Level	Check/Replenish Coolant. Refer to Procedure 1-06 & 1-05.
OK ↓	
Defective Coolant Temperature Gauge/Sender	Check/Replace Coolant Temperature Gauge/Sender. Refer to Procedure 1-11, 1-12, & 1-13.
OK ↓	
Inadequate Air Flow Through The Radiator	1. Inspect And Clean Radiator Fins. Refer to Procedure 1-14. 2. Inspect And Correct Intake And Exhaust Air Shutters And Ducts If Equipped. 3. Inspect And Adjust Fan And Shroud. Refer to Procedure 1-15. 4. Check For Recirculation Of Air Around Radiator. Install Baffles If Required. Refer to Procedure 1-17.
OK ↓	
Loose Drive Belt On Fan Or Coolant Pump (On NT-855 And VT-28 Series Only)	Check/Correct Belt Tension. Refer to Procedure 1-22.
OK ↓	
Generator Set Overload	Verify Generator Load Applied With Generator Data Plate Rating.
OK ↓	
Collapsed Coolant Hose	Check/Replace Coolant Hose. Refer to Procedure 1-10.
OK ↓	
Incorrect Engine Oil Level	1. Check Oil Temp. 121° C [250° F] Max. 2. Check Oil Level. 3. Add Or Drain Oil To Correct Level. Refer to Procedure 2-04 & 2-05.
OK ↓	
Thermostat Incorrect Or Defective	Check And Replace Engine Thermostat. Refer To Appropriate Engine T&R Manual.
OK ↓	

(Continued)

Symptom: High Coolant Temperature With Set Mounted Radiator (Continued)

Cause	Correction
Water Pump Defective	Check and Replace Engine Water Pump. Refer to Appropriate Engine T&R Manual.
OK ↓	
Air In Cooling System	Check And Correct. Refer to Procedure 1-09.
OK ↓	
Obstructed Or Damaged Radiator Core Tubes. Check For Excessive Differential Across Core	Inspect Radiator. Clean And Flush If Necessary. Refer to Procedure 1-08 & 1-14.
OK ↓	
Plugged Cooling Passages In The Engine	Flush The System And Fill With Clean Coolant. Refer to Procedure 1-08.

Symptom: High Coolant Temperature With Remote Mounted Radiator

Cause	Correction
Low Coolant Level	Check And Replenish Coolant. Refer to Procedure 1-06.
OK ↓	
Remote Fan Not Operating Correctly	1. Verify That Power Is Available At Motor. 2. Determine That Fan Runs In Correct Rotation. Correct If Required. Refer to Procedure 1-16. 3. Check And Correct Fan Belt Tension. Refer to Procedure 1-22.
OK ↓	
Inadequate Air Flow Through Radiator	1. Inspect And Clean Radiator Fins. Refer to Procedure 1-14. 2. Inspect And Adjust Fan And Shroud. Refer to Procedure 1-15. 3. Check For Recirculation Of Air Around Radiator. Install Baffles If Required. Refer to Procedure 1-17.
OK ↓	
Generator Set Overload	Verify Generator Load Applied With Generator Data Plate Rating.
OK ↓	
Loose Engine Water Pump Drive Belt.NT-855 And VT-28 Series Only	Check And Correct Water Pump Drive Belt Tension. 1. NT-855 Series Refer to Procedure 1-22 2. VT-28 Series Refer to Procedure 1-22
OK ↓	
Collapsed Coolant Hose	Check And Replace Coolant Hose. Refer to Procedure 1-10.
OK ↓	
Incorrect Engine Oil Level	1. Check Oil Temp. 121° C [250° F] Max. 2. Check Oil Level. 3. Add Or Drain Oil To Correct Level. Refer to Procedure 2-04 & 2-05.
OK ↓	
Thermostat Incorrect Or Defective	Check And Replace Engine Thermostat. Refer To Appropriate Engine T&R Manual.
OK ↓	

(Continued)

Symptom: High Coolant Temperature With Remote Mounted Radiator (Continued)

Cause	Correction
Water Pump Defective	Check And Replace Engine Water Pump. Refer To Appropriate Engine T&R Manual.
OK ↓	
Air In The Cooling System	1. Check Engine Coolant Lines For Unvented High Points. 2. Check And Correct For Air In Cooling System. Refer to Procedure 1-09.
OK ↓	
Obstructed Or Damaged Radiator Core	Inspect Radiator. Clean If Necessary. Refer to Procedure 1-14.
OK ↓	
Plugged Cooling Passages In The Engine	1. Flush The System. Refer to Procedure 1-08. 2. Fill The System With Clean Coolant.

Symptom: High Coolant Temperature With Heat Exchanger

Cause	Correction
Low Engine Coolant Level	Check And Add Engine Coolant. Refer to Procedure 1-06.
OK ↓	
Generator Set Overloaded	Verify Generator Load Applied With Generator Nameplate Rating.
OK ↓	
Raw Water Strainers Plugged	Check And Clean Raw Water Strainer. Refer to Procedure 1-24.
OK ↓	
Raw Water Pump Defective	Check Raw Water Pump. Check And Correct Raw Water Pump Belt Tension (NT-855 And VT-28 Series Only). Refer to Procedure 1-23 & 1-22.
OK ↓	
Loose Engine Water Pump Drive Belt NT-855 And VT-28 Engines Only	Check And Correct Engine Water Pump Drive Belt. Refer to Procedure 1-22.
OK ↓	
Incorrect Engine Oil Level	1. Check Oil Temperature 121° C [250° F] Max. 2. Check Oil Level. 3. Add Or Drain Oil To Correct Level. Refer to Procedure 2-04 & 2-05.
OK ↓	
Thermostat Incorrect Or Defective	Check Thermostat(s) And Replace If Necessary. Refer To Appropriate Engine T&R Manual.
OK ↓	
Engine Water Pump Defective	Remove And Check. Replace – Refer To Appropriate Engine T&R Manual.
OK ↓	

(Continued)

Symptom: High Coolant Temperature With Heat Exchanger (Continued)

Cause	Correction
Air In Engine Cooling System	1. Check For Air In Engine Cooling System. Refer to Procedure 1-09.
OK ↓	
Heat Exchanger Element Dirty	Clean Heat Exchanger Element. Refer to Procedure 1-25.

Symptom: Low Oil Pressure/Alarm/Shutoff

Cause	Correction
Low Oil Level	Add Engine Oil. Refer To Engine T&R Or O&M Manual.
OK ↓	
Oil Pressure Gauge Defective	Check Oil Pressure. Refer to Procedure 2-06.
OK ↓	
Oil Pressure Sending Unit Defective	1. Check Oil Pressure. Refer to Procedure 2-06. 2. Check Sending Unit Resistance. Refer to Procedure 2-08.
OK ↓	
Low Oil Pressure Switch Defective	Check Oil Pressure Switch. Refer to Procedure 2-12.
OK ↓	
Oil Diluted With Fuel	Refer To Engine T&R Manual.
OK ↓	
Incorrect Oil Specification	Check Oil Specification. Refer to Procedure 2-01.
OK ↓	
Oil Temperature Above Normal 120° C [250° F]	Refer To Engine T&R Manual.
OK ↓	
Internal Engine Component Defective	Refer To Specific Engine T&R Manual.

Symptom: Engine Will Not Stop

Cause	Correction
Fuel Solenoid Valve Held Open By Manual Override	Check To Be Sure Manual Override Screw Is In The Maximum CCW Position. Refer to Procedure 4-10.
OK ↓	
Voltage At Fuel Pump Solenoid	1. Check With Voltmeter. Refer to Procedure 4-10. 2. If Voltage Is Present, Disconnect Fuel Solenoid Wire.
OK ↓	
Fuel Pump Shutoff Valve Disc Stuck	1. Remove fuel line from fuel pump 2. Disassemble Valve Refer to Procedure 4-11 3. Check For Missing Parts 4. Reassemble Valve Refer to Procedure 4-12
OK ↓	
Fuel Drain Line Restricted (Engine Decelerates Slowly)	Check Line From Head To Tank. Refer to Procedure 4-08.
OK ↓	
Engine Running On Fumes Drawn Into Air Intake	Locate And Isolate The Source Of Fumes.

Symptom: Low Power

Cause	Correction
Normally Closed EFC Or United Tech. Gov. Actuator Not Fully Open	Check Actuator Voltage and Coil Resistance EFC Gov. Refer to Section 4-14 United Tech. Gov. United Tech. Gov. Push Actuator Lever Down. Refer to Section 4-15.
OK ↓	
Woodward PSG Or 2301 Governor – Throttle Linkage Not Set Correctly	Set Throttle Linkage. Refer to Procedure 4-20.
OK ↓	
Normally Closed EFC Or United Tech. Gov. Low Battery Voltage	Battery Charging System Malfunction. Nominal 24 Volt System Minimum Is 24 Volts.
OK ↓	
Control Output Below 19-20V on EFC Normally Closed System	Replace Controller.
OK ↓	
Fuel Suction Line Or Fuel Filter Restricted	Replace Filter. Refer to Procedure 4-05. Check Fuel. Inlet Restriction. Refer to Procedure 4-07.
OK ↓	
Air Leaks Into Fuel System	Check For Air In Fuel System. Tighten Fuel Fittings And Filter. Refer to Procedure 4-09.
OK ↓	
High Engine Oil Level High Oil Temp. Is Symptom	Check Oil Temp. 121° C [250° F] Max. Check Oil Level. Drain Oil To Correct Level. Check Dipstick Calibration. Refer to Procedure 2-04 & 2-05.
OK ↓	
Engine Room Air Inlet Restriction	Verify That Room Air Inlet Is Open When Engine Is Running.
OK ↓	

(Continued)

Symptom: Low Power (Continued)

Cause	Correction
Engine Air Inlet Restriction	Inspect and Replace Engine Air Filter
OK ↓	
Exhaust System Restriction	Check Exhaust System For Restriction. Refer to Procedure 3-04.
OK ↓	
Automotive Throttle Lever Not Locked In Maximum Fuel Position	Lock Lever In Maximum Fuel Position
OK ↓	
Defective Fuel Pump Or Incorrect Calibration	Check Fuel Pump Calibration.
OK ↓	
Valves Or Injectors Adjusted Wrong	Refer To Specific Engine Manual.

Symptom: Engine Has Rough Performance Or Surge

Cause	Correction
Air In Fuel	Tighten Fuel Line Fittings And Fuel Filter. Install Sight Glass And Check For Air. Refer to Procedure 4-09. Raise Fuel Float Tank And/Or Lower Fuel Filter To Provide Slight Pressure On Fuel Filter At All Times.
OK	
Cold Engine	Standby Units, Verify That Coolant Heaters Are Operating. Reduce Electric Governor Gain And/Or Stability Settings.
OK	
Low Cetane (Furnace Type) Fuel	Operate Engine From A Temporary Supply Of Fuel Known To Be Within Recommended Specifications, Refer to Procedure 4-02. A Cetane Improver Additive May Improve Engine Operation On Low Cetane Fuel. See Serv. Bulletin 3379001.
OK	
Electric Governor Controls Adjusted Incorrectly	EFC Governor Control, Sec. 4-14. Turn Gain CCW. United Technologies Governor Controls. Refer to Procedure 4-16, 17, 18 and 19. Turn Gain And/Or Stability CCW. Woodward 2301 Governor Control. See Bulletin 3379179. Turn Gain And/Or Stability CCW. Check Linkage For Travel And Binding. Refer to Procedure 4-22.
OK	
Battery Charger Not Connected Direct to Batteries	Connect battery charger directly to battery terminals.
OK	
Woodward PSG Hydraulic Governor	Check Linkage For Travel And Binding. Refer to Procedure 4-21. Close Compensating Needle Valve Slightly. Refer to Procedure 4-22.
OK	
EFC Actuator Sticking	Loosen Actuator Capscrews And Tighten Again. Refer to Procedure 4-14. Apply And Remove Battery Voltage To Actuator. Sec. 4-14.
OK	
Defective EFC Actuator O-Rings, Broken Or Missing Spring	Remove Actuator. Replace O'Rings. Install Spring If Required. Install Actuator. Refer to Procedure 4-14.
OK	
Fuel Pump Housing Defective	Replace Fuel Pump

Symptom: High Generator Voltage

Cause	Correction
Incorrect AVR (Automatic Voltage Regulator) Adjustment	1. Reset remote voltage adjust rheostat 2. Reset voltage adjust rheostat on AVR
OK ↓	
Defective Panel Voltmeter	Check with auxiliary test meter. Adjust or replace panel voltmeter.
OK ↓	
Remote Voltage Adjust Rheostat Open or Disconnected	1. Turn remote voltage adjust rheostat. 2. If no change in output voltage, check for broken or disconnected leads 1 and 2 at remote voltage adjust rheostat and auxiliary terminal block. 3. Replace remote voltage adjust rheostat.
OK ↓	
AVR Sensing Circuit Open	1. Repair or replace sensing leads 2 and 3 from AVR to auxiliary terminal block. 2. Repair or replace leads on dropper transformer, if supplied.
OK ↓	
Dropper Transformer Winding Open (if Supplied)	Replace dropper transformer.
OK ↓	
Defective Three Phase Sensing Module (Three Phase Sensing Regulator Only)	1. Visually check for burned resistor or transformer. 2. Check for faulty diode D1 through D6. 3. Replace defective three phase sensing module. Refer to procedure.
OK ↓	
Generator Connected High Wye (Series Star) When Delta or Low Wye (Parallel Star) Is Required	Re-connect generator. Refer to Wiring Diagrams 3052054, 5, & 6.
OK ↓	
Defective AVR	1. Check AVR. Refer to Procedure 6-17. 2. Replace if defective.

Symptom: No or Low Generator Voltage

Cause	Correction
Engine Operating at Less Than Rated Speed	Adjust engine speed to rated RPM.
OK ↓	
Overvoltage Module (OVM) Tripped	1. Move overvoltage module switch to "ON" position. 2. Recalibrate overvoltage module. Refer to Procedure 6-15. 3. See high generator voltage, T-17. 4. See AVR notes. Refer to Procedure 6-17.
OK ↓	
Defective Panel Voltmeter	1. Check with auxiliary test voltmeter. 2. Replace or recalibrate.
OK ↓	
Incorrect Automotive Voltage Regulator (AVR) Adjustment	1. Reset remote voltage adjust rheostat. 2. Reset voltage adjust rheostat on AVR. Refer to Procedure 6-17. 3. Turn AVR gain control clockwise. Refer to Procedure 6-18.
OK ↓	
AVR Leads 1 and 2 Interchanged at AVR or Auxiliary Terminal Block	Check. Connect AVR and auxiliary terminal block per drawings No. 3052054, 3052055, 3052056.
OK ↓	
Field Overexcitation (Protection) Circuit in AVR Actuated	1. Stop unit. Wait 10 seconds. Reset unit. 2. Verify that top AVR jumper is connected from "C" terminal to "60 volts" terminal. 3. Check for open or shorted diode on rotor. Refer to Procedure 6-11. 4. Perform No load d.c. excitation test. Refer to procedure 6-14.
OK ↓	
K1, K2 Jumper in AVR Omitted (for Generator Without OVM or Other Disabling Relays Such as Over Temperature or Overcurrent Relays).	Install K1, K2 jumper in AVR (K1, K2 jumper is used only on generators without OVM or other disabling relays).
OK ↓	
AVR Connected to Wrong Terminals	1. Re-connect AVR. Refer to drawing Nos. 3052054, 3052055 or 3052056.
OK ↓	

(Continued)

Symptom: Low Generator Voltage (Continued)

Cause	Correction
Permanent Magnet Exciter Defective, or Leads P2, P3 and P4 Damaged or Disconnected.	1. Check permanent magnet exciter output. Refer to Procedure 6-10. 2. Repair or replace damaged or defective permanent magnet exciter or leads.
OK ↓	
Control System Component Incorrectly Connected, Adjusted or Defective	1. Adjust, repair or replace system component. a. Paralleling module resistor or choke or leads open. b. Three phase sensing module voltage rheostat R13 adjusted too far CCW. c. Circuit breaker auxiliary switches reversed, defective or mis-wired. d. Regulator control relay defective.
OK ↓	
Defective Component in Generator.	1. Perform No load d.c. excitation test. Refer to Procedure 6-14. 2. Repair or repalce defective component as indicated.
OK ↓	
Defective AVR	Replace AVR.

Symptom: Unstable Voltage

Cause	Correction
Engine Speed Not Constant	Adjust governor stability. Refer to Procedure 4-14 through 4-22.
OK ↓	
AVR Stability Control	Adjust stability control on AVR. Refer to Procedure 6-18.
OK ↓	
Permanent Magnet Generator Set for too Much Gain (Single Phase Sensing AVR Only).	Adjust permanent magnet stator housing orientation. Refer to Procedure 6-06.
OK ↓	
Excessive SCR Type Loads	1. Add motor or heating load. 2. Add 5 to 10% max. KVAR capacitor load. 3. Use three phase sensing AVR. 4. Contact Cummins Service Engineering.
OK ↓	
Defective AVR	Replace AVR.

Symptom: Voltage Rises As Load Increases

Cause	Correction
Unity Power Factor Load	The PMG generator typically has a voltage rise of less than 1% at full load, 1.0 power factor. Set no load voltage 1% low.
OK ↓	
Droop CT (in Paralleling Module) Connection Reversed.	Reverse droop CT connections. Refer to Procedure 6-15.
OK ↓	
Too Much Capacitive (Leading Power Factor) Load.	1. Add inductive (motor) load. 2. Reduce number of capacitors in load.
OK ↓	
Line Current Unbalanced by More Than 30 Percent.	Redistribute single phase loads.

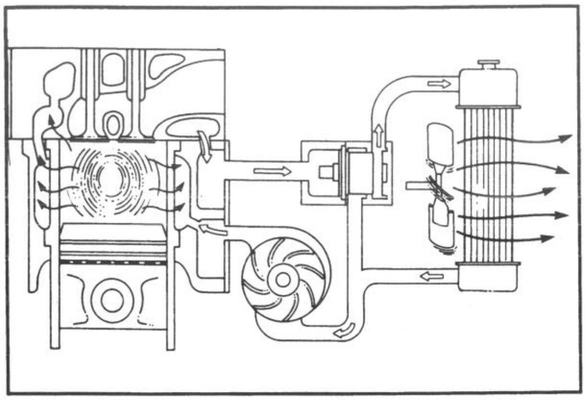
Symptom: Battery Charging Alternator Malfunction

Cause	Correction
Gauge Defective	Measure voltage at gauge with 3376898 Multitester. Replace gauge if required.
OK	
Alternator Belt Loose	Check belt tension. Refer to Procedure 1-22.
OK	
Engine Idle Speed Too Low	Check engine idle speed. Refer to Procedure 4-14, pgs. 39 and 40. Refer to Procedures 4-16, 4-17, 4-18, 4-19, and 4-22.
OK	
Alternator Malfunctioning	Have alternator checked at an automotive electrical service shop.
OK	
System Electrically "Open" (Broken Wires, Loose Connections, Etc.)	Check connections and wiring. Refer to manufacturer's wiring diagrams.

Section 1 - Cooling System

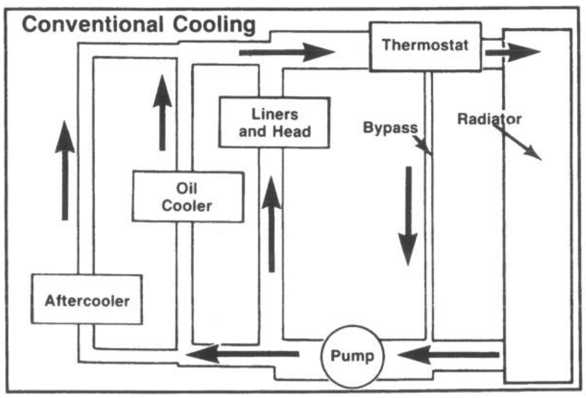
Table of Contents

System Troubleshooting and Repair List

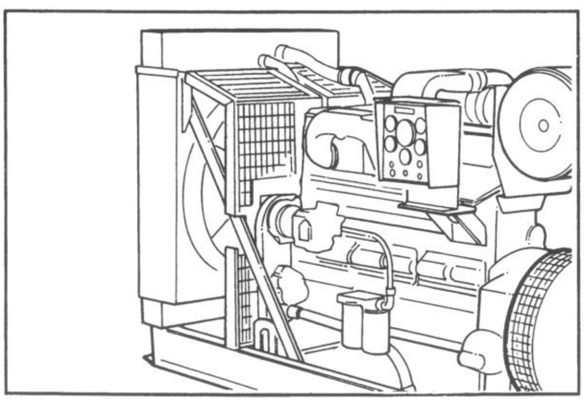


General Information (1-01)

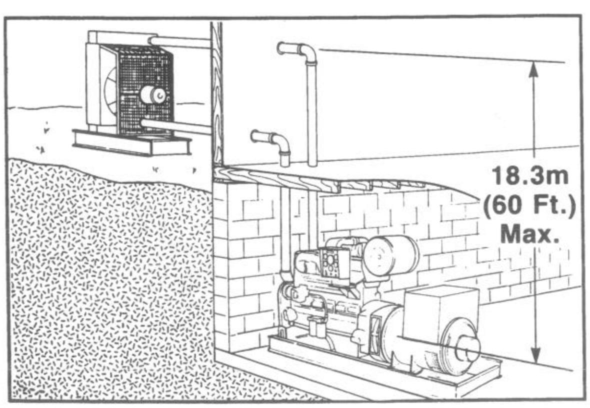
The primary function of the cooling system is to remove the heat created by the engine and its support components. The excess heat energy that is not removed by the cooling system, is carried away by exhaust gases and radiated into the atmosphere.



The chart illustrates the coolant flow through the engine. (For more detail, refer to the coolant flow diagrams in the specific engine T&R manuals.)

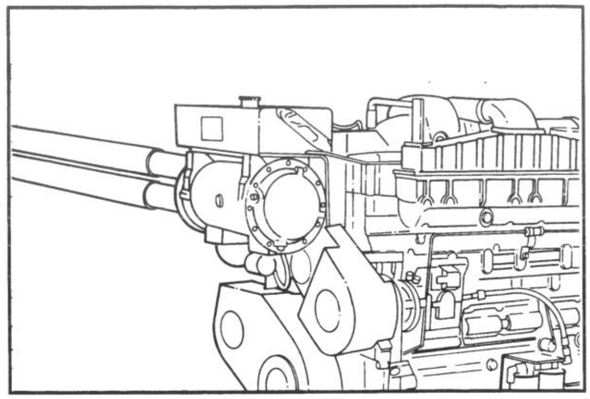


A radiator mounted on the generator set subbase is th most common means of cooling Cummins Generato Sets. The radiator, mounted on the generator set, use a blower fan in order to avoid excessive ambient tem peratures around the main generators.



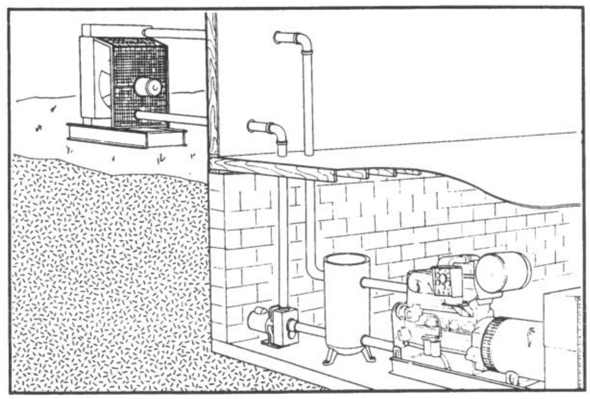
Remote mounted radiators are frequently used fc Standby Generator Sets, usually when the Generator Se is located in a basement. The radiator is usually muc higher than the engine. With a high mounted radiator, th coolant usually enters the bottom of the radiator and exit at the top of the radiator. The maximum coolant heigh above the crankshaft must not exceed 18.3m [60 ft.].

Heat exchanger cooling is sometimes used on inland applications where there is an abundance of cool water. Heat exchangers are used in most marine applications.



Combination heat exchanger with a remote radiator are usually avoided.

Hot well-remote radiator systems are rarely installed on Cummins Generator Sets after January, 1984 when the pressure balanced water pump seal was introduced.



Water

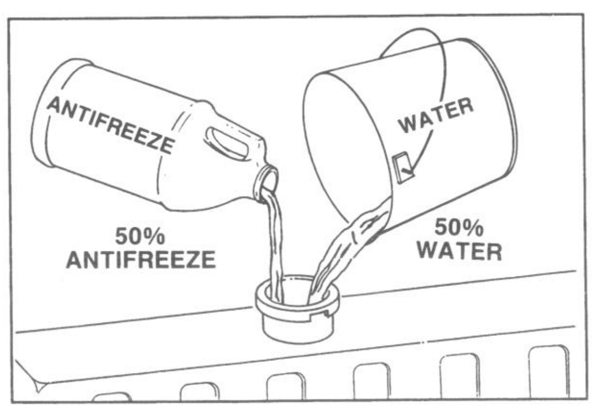
Makeup water must meet the specifications given in the accompanying chart.

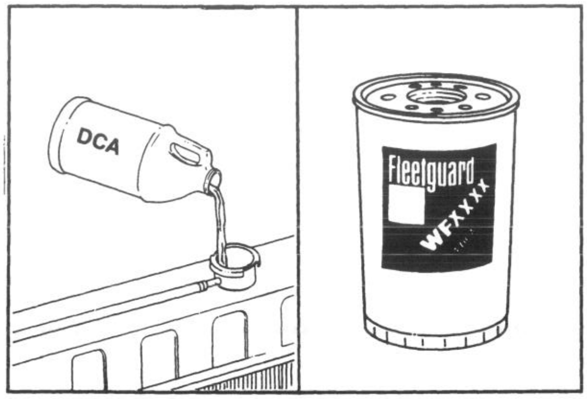
Mineral	Problem Cause	Max. Limit
Calcium Magnesium (hardness)	Deposits on Liners/Heads/ Coolers	300 PPM
Chloride	General Corrosion	100 PPM
Sulfate	General Corrosion	100 PPM

Antifreeze

Use 50-50 ethylene glycol antifreeze year around to provide freeze point and boil over protection.

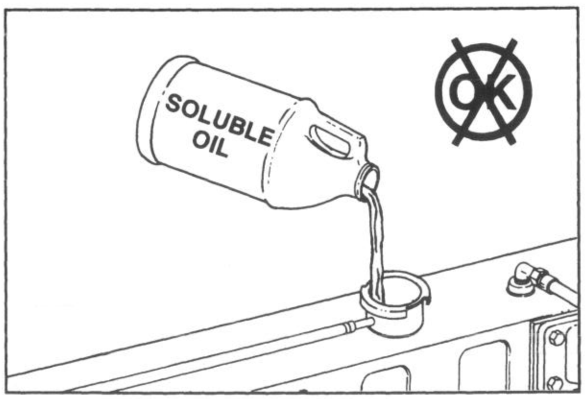
Caution: Antifreeze overconcentration reduces freeze protection. Do not use more than 68 percent antifreeze. Minimum freeze point is at 68 percent ethylene glycol.





Supplemental Coolant Chemicals

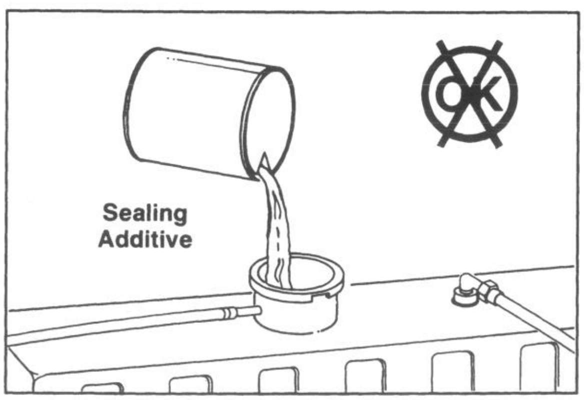
Diesel Coolant Additives (DCA) and filters are required to protect the cooling system from oil contamination, corrosion, scale and dirt. Refer to Diesel Coolant Additives Section 1-07.



Soluble Oils

Do not use soluble oils in cooling systems. Soluble oils will:

- cause cylinder liner pitting.
- corrode brass and copper.
- damage heat transfer surfaces.



Sealing Additives

Do not use sealing additives in cooling systems. Sealing additives will:

- buildup in coolant low flow areas.
- clog coolant filters.

Cooling System Specifications (1-02)

GENERATOR SET ENGINES COOLING SYSTEMS		COOLANT	CAPACITY	
	Engine Only L (U.S. qt.)	Engine With 38° C (100° F) Radiator L (U.S. qt.)	Engine With 52° C (125° F) Radiator L (U.S. qt.)	Engine With Heat Exchanger L (U.S. qt.)
NT-855-2 Dry Exhaust Manifold	19 (20)	59 (62)	60 (63)	38 (40)
Wet Exhaust Manifold	25 (26)	67 (71)	68 (72)	44 (46)
NT-855-3 Dry Exhaust Manifold	19 (20)	59 (62)	60 (63)	38 (40)
Wet Exhaust Manifold	25 (26)	67 (71)	68 (72)	44 (46)
NT-855-4 Dry Exhaust Manifold	19 (20)	59 (62)	60 (63)	38 (40)
Wet Exhaust Manifold	N.A.	N.A.	N.A.	N.A.
NT-855-5 Dry Exhaust Manifold	19 (20)	62 (65)	62 (65)	38 (40)
Wet Exhaust Manifold	N.A.	N.A.	N.A.	N.A.
NTA-855-1 Dry Exhaust Manifold	21 (22)	63 (67)	64 (68)	40 (42)
Wet Exhaust Manifold	26 (28)	72 (76)	N.A.	45 (48)
NTA-855-2 Dry Exhaust Manifold	21 (22)	66 (70)	66 (70)	40 (42)
Wet Exhaust Manifold	N.A.	N.A.	N.A.	N.A.
NTTA-855-2 Dry Exhaust Manifold	21 (22)	66 (70)	66 (70)	40 (42)
Wet Exhaust Manifold	N.A.	N.A.	N.A.	N.A.
KT-19 Dry Exhaust Manifold	26 (28)	108 (114)	108 (114)	66 (70)
Wet Exhaust Manifold	31 (33)	113 (119)	113 (119)	71 (75)
KTA-19-1&2 Dry Exhaust Manifold	30 (32)	112 (118)	119 (126)	66 (70)
Wet Exhaust Manifold	35 (37)	116 (123)	124 (131)	71 (75)
KTTA-19 Dry Exhaust Manifold	30 (32)	112 (118)	119 (126)	66 (70)
Wet Exhaust Manifold	N.A.	N.A.	N.A.	N.A.
VT-28 Dry Exhaust Manifold	75 (79)	165 (174)	165 (174)	106 (112)
Wet Exhaust Manifold	82 (87)	172 (182)	177 (187)	114 (120)
VTA-28-1 Dry Exhaust Manifold	80 (85)	170 (180)	175 (185)	102 (108)
Wet Exhaust Manifold	88 (93)	178 (188)	178 (188)	110 (116)
VTA-28-3 Dry Exhaust Manifold	80 (85)	180 (190)	180 (190)	102 (108)
Wet Exhaust Manifold	N.A.	N.A.	N.A.	N.A.
KT-38 Dry Exhaust Manifold	111 (117)	318 (336)	318 (336)	183 (193)
Wet Exhaust Manifold	120 (127)	327 (346)	327 (346)	192 (203)
KTA-38-1&2 Dry Exhaust Manifold	118 (125)	325 (344)	333 (352)	190 (201)
Wet Exhaust Manifold	128 (135)	335 (354)	342 (362)	200 (211)
KTTA-38 Dry Exhaust Manifold	118 (125)	333 (352)	333 (352)	194 (205)
Wet Exhaust Manifold	N.A.	N.A.	N.A.	N.A.
KTA-50-1 Dry Exhaust Manifold	153 (162)	383 (405)	383 (405)	229 (242)
Wet Exhaust Manifold	166 (176)	408 (431)	408 (431)	242 (256)
KTA-50-2 Dry Exhaust Manifold	153 (162)	383 (405)	395 (417)	229 (242)
Wet Exhaust Manifold	166 (176)	408 (431)	423 (447)	242 (256)
KTTA-50 Dry Exhaust Manifold	153 (162)	383 (405)	395 (417)	229 (242)
Wet Exhaust Manifold	N.A.	N.A.	N.A.	N.A.

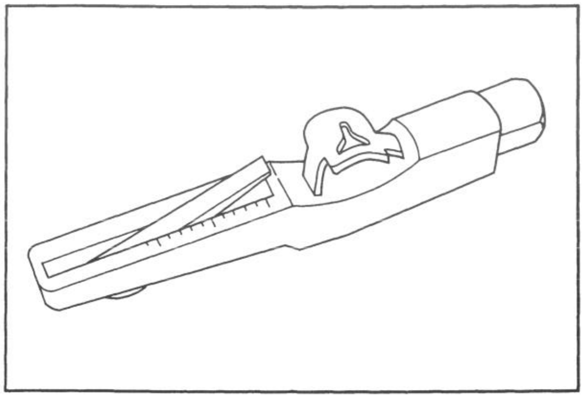
N.A. = Not Available

Standard Modulating Thermostat Range	82° C - 94° C (180° F - 200° F) (start opening - full open)
Maximum Static Head of Coolant	18.3m (60 ft.)
Maximum Allowable Engine Coolant Outlet Temperature	104° C (220° F)
Minimum Recommended Engine Coolant Outlet Temperature	71° C (160° F)
Recommended Pressure Cap.	50 kPa (7 psi)

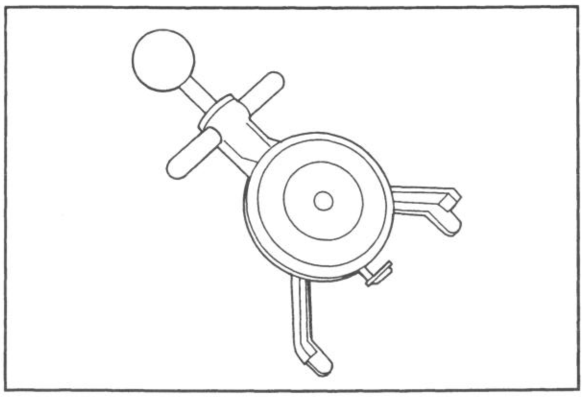
For further system specification, refer to the specific Generator Set Engine Data Sheet.

Cooling System Service Tools (1-03)

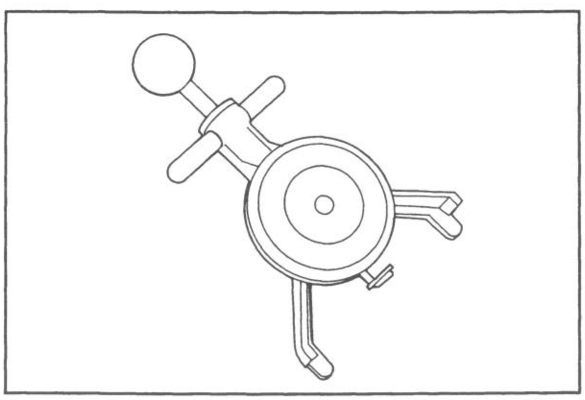
The following service tools are recommended to perform generator set cooling system troubleshooting and repair.



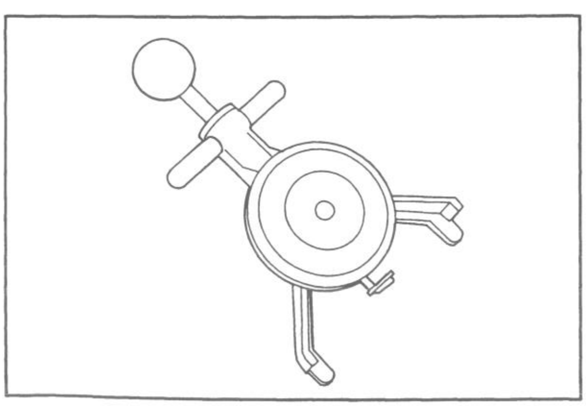
Belt Tension Gauge Part No. ST-1274. Use to check the belt tension on 9.5 mm [3/8 inch] to 12.7 mm [1/2 inch] top width belt.



Belt Tension Gauge Part No. ST-1138. Use to check the belt tension on 17.5 mm [11/16 inch] to 22.2 mm [7/8 inch] top width belts.

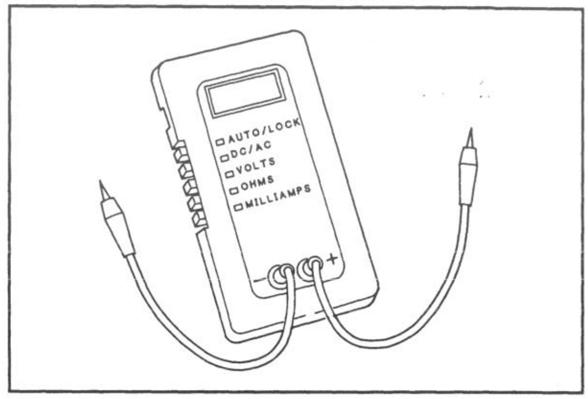


Belt Tension Gauge Part No. ST-1293. Use to check the belt tension on poly " V" rib belts on L-10 and K-19 series engines.

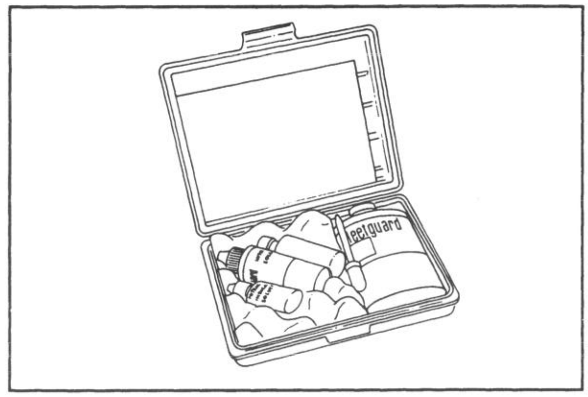


Belt Tension Gauge Part No. 3376344. Use to check 45.3 to 227 kg [100 to 500 lbs] of tension on V-28 series engines.

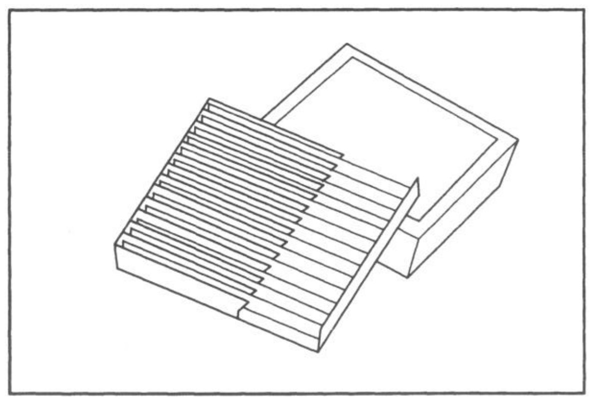
Multitester Part No. 3376898. Use to measure Volts, Ohms, and Milliamperes.



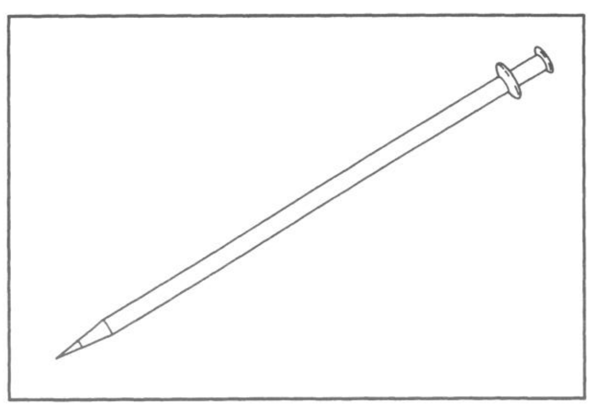
DCA Coolant Test Kit Part No. 3375208. Fleetguard® Part No. 3008465.

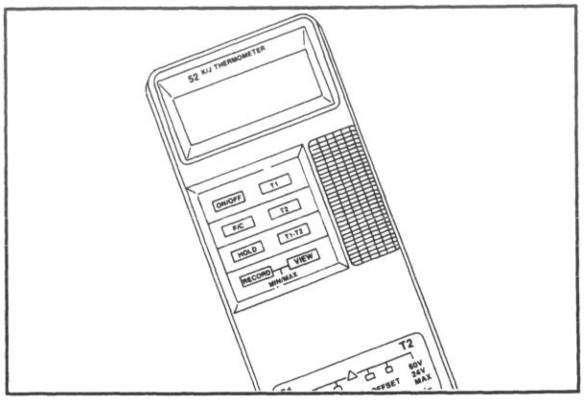


Fleetguard® Spot Check Test Kit. Fleetguard Part No. CC-2530.



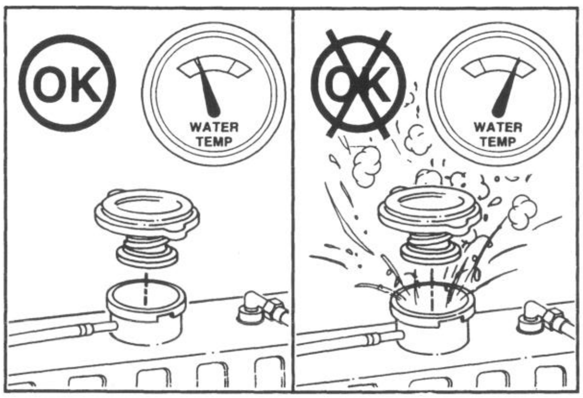
Fleetguard® Spot Check Test Kit, Reusable Plunger Type Sampler. Fleetguard Part No. CC-2535.





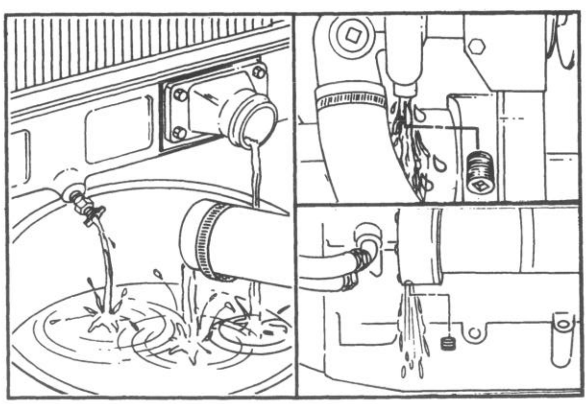
Digital Thermometer, Fluke Model No. 51 or 52 is for temperature measurements.

Drain The Cooling System (1-04)



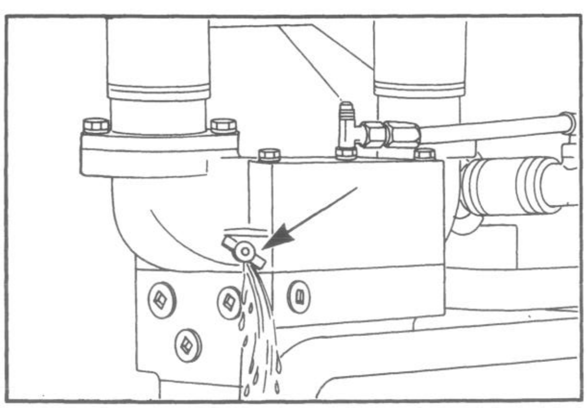
Remove the radiator cap after the engine is cool.

Warning: Do not remove the radiator cap from a hot engine. Hot steam will cause serious personal injury. Wait until the coolant temperature is below 70° C [160° F] before removing the radiator cap.



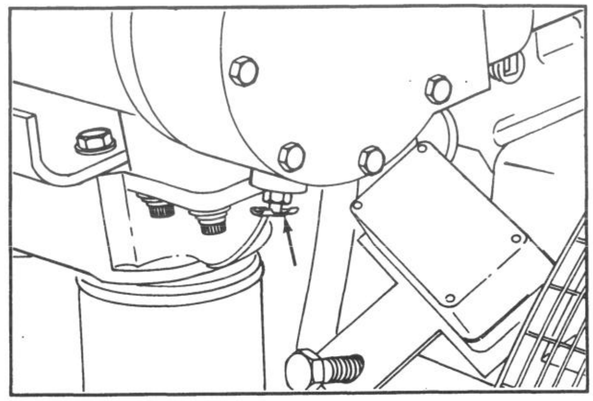
To drain the cooling system;

1. Open the radiator draincock.
2. Remove the lower radiator hose.
3. Remove the pipe plug in the water pump body.
4. If the engine has one or more tank type coolant heaters, remove the pipe plug from the bottom of each coolant heater.



KT(A) 19 series engines only. Open the draincock at the bottom of the thermostat housing. This draincock drains the coolant which is trapped on the engine side of the thermostat in the thermostat housing.

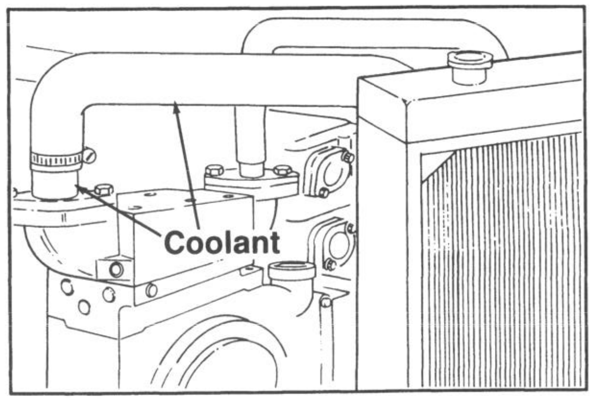
VT(A) 28 series engines only. Open the draincock at the rear of the oil cooler. This draincock drains the coolant which is trapped in the rear of the oil cooler.



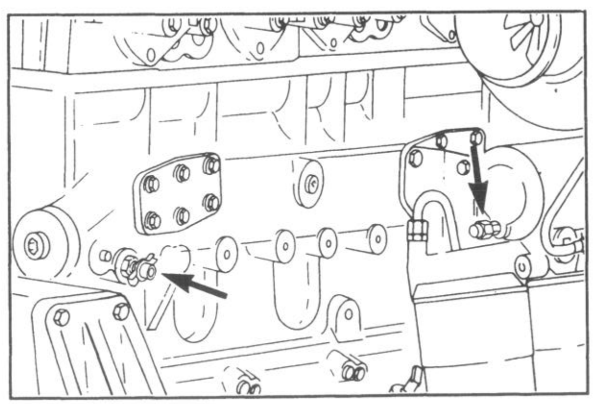
Caution: The coolant in the thermostat housing(s) on the radiator side of the thermostat(s) and in the line(s) between the thermostat housing(s) and the radiator is not drained from any of these locations. This is not normally a concern unless:

1. The radiator is to be removed, or
2. Antifreeze has **not** been used **and** the generator set will be stored in sub-freezing temperatures.

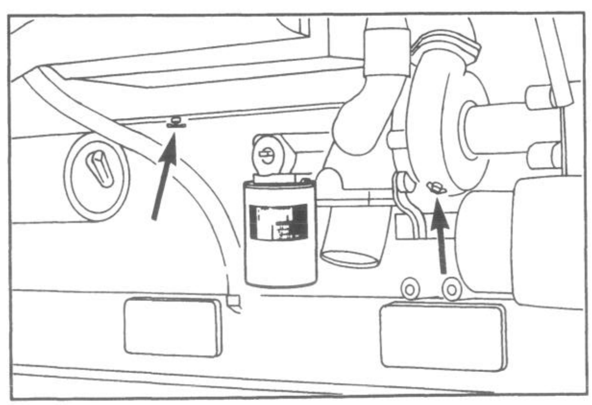
In these cases, the coolant line(s) must be removed from the thermostat housing(s) and the coolant removed from the thermostat housing(s) with a sponge.

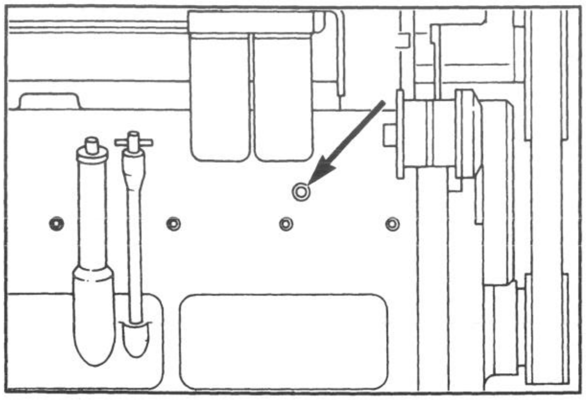


Cylinder block drain location on an NT-855 series engine.

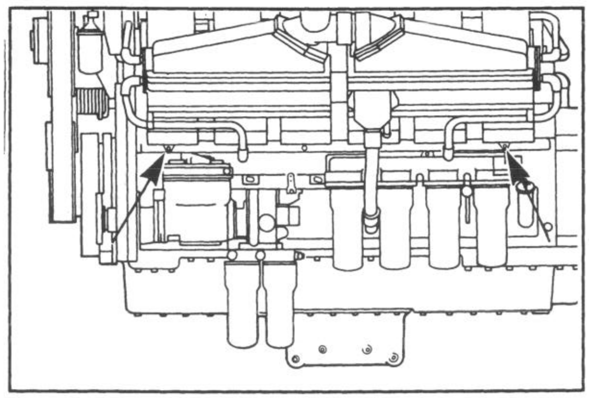


Cylinder block drain location on a KT-19 series engine.

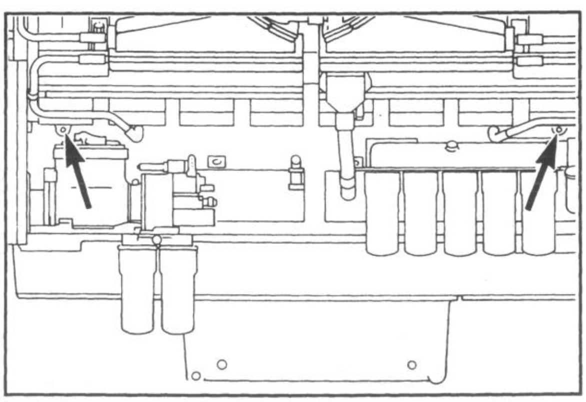




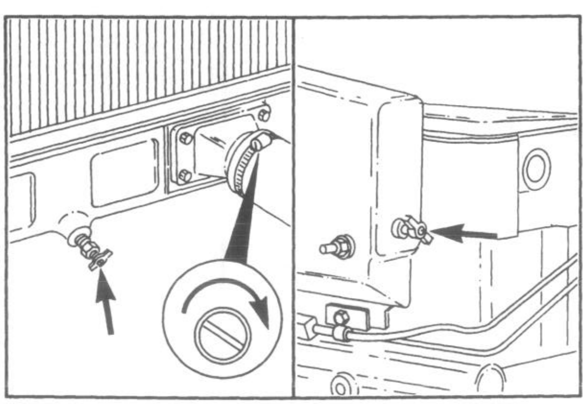
Cylinder block drain location on a VT-28 series engine.



Cylinder block drain location on a KT-38 series engine.



Cylinder block drain location on a KTA-50 series engine.



Fill The Cooling System (1-05)

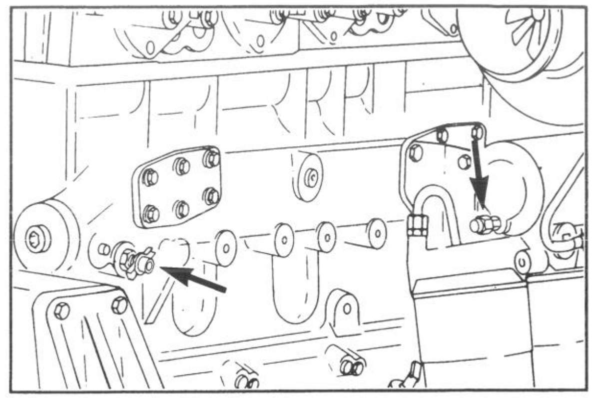
Close the radiator draincock. Close the thermostat housing or oil cooler draincock, if required.

Install the lower radiator hose.

Tighten the hose clamp to 5N•m [40 in-lbs] torque.

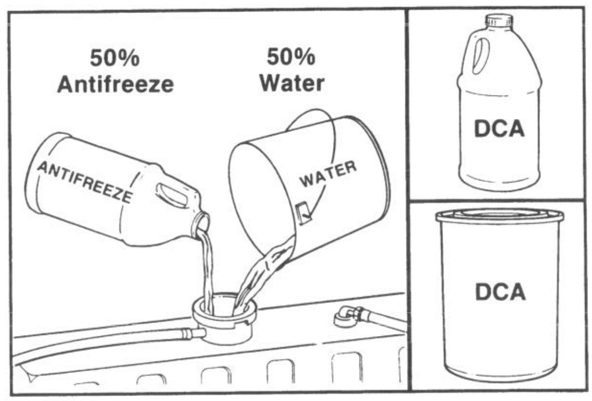
Install the pipe plug in the water pump body. Install the pipe plugs in the cylinder block, if required.

Tighten the pipe plug to 20 N•m [15 ft-lbs] torque. Close the cylinder block drains.

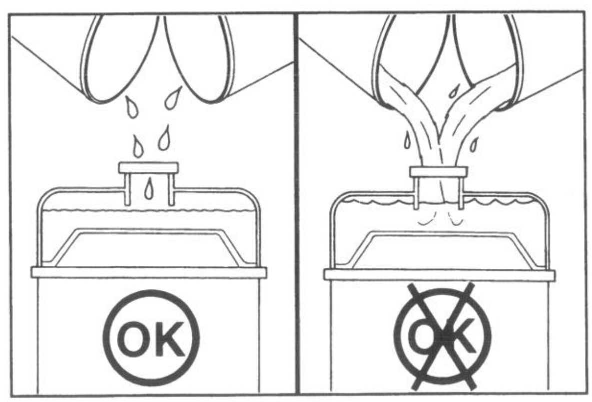


Use a mixture of 50 percent clean water and 50 percent ethylene glycol base antifreeze to fill the cooling system.

NOTE: Add the correct amount of DCA to the cooling system. Refer to Section 1-07.

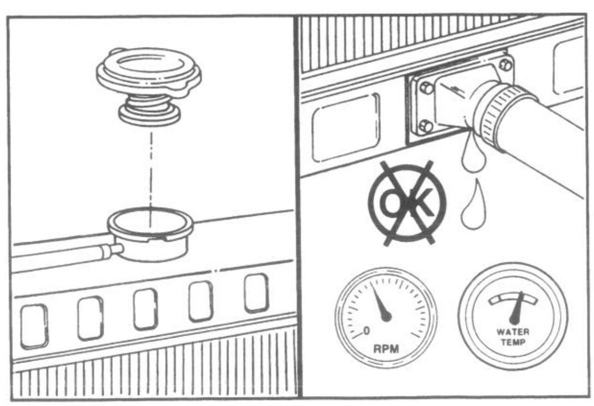


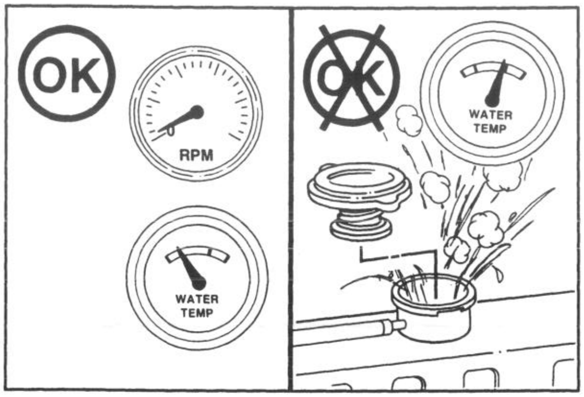
Fill the system with enough coolant to cover the baffle in the radiator top (expansion) tank. Do not overfill, leave space for coolant expansion.



Install the radiator or fill cap.

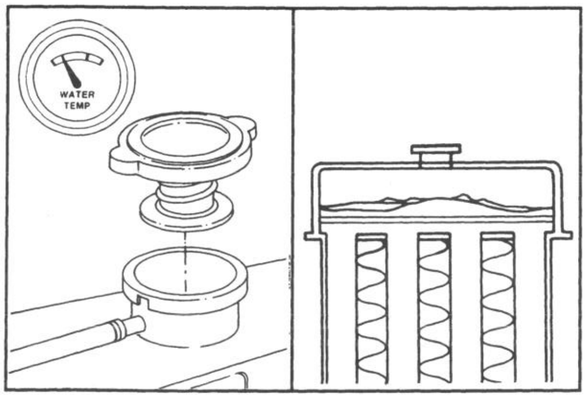
Operate the engine to 90° C [194° F] temperature and check for leaks.





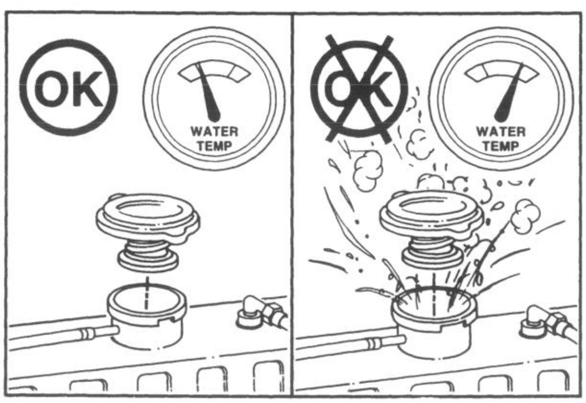
Stop the engine and allow it to cool.

Warning: Do not remove the radiator cap from a hot engine. Hot steam will cause serious personal injury. Wait until the coolant temperature is below 70° C [160° F] before removing the radiator cap.



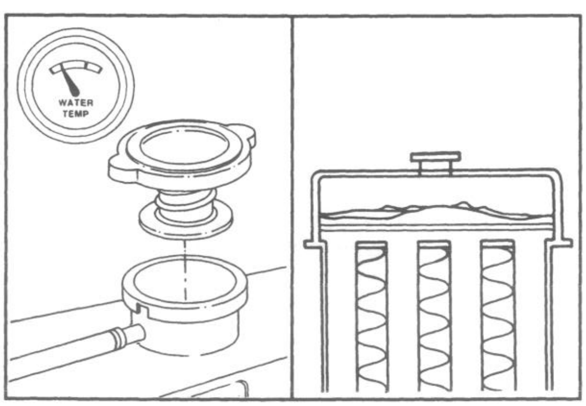
Remove the radiator or fill cap and check the coolant level. Add coolant if necessary.

Coolant Level - Check (1-06)



Remove the radiator cap after the engine is cool.

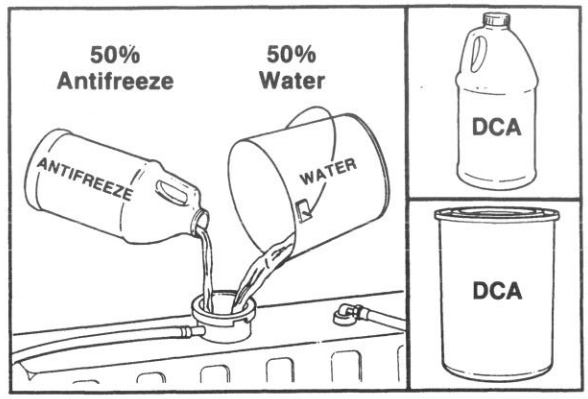
Warning: Do not remove the radiator cap from a ho engine. Hot steam will cause serious personal injury Wait until the coolant temperature is below 70° C [160° F before removing the radiator cap.



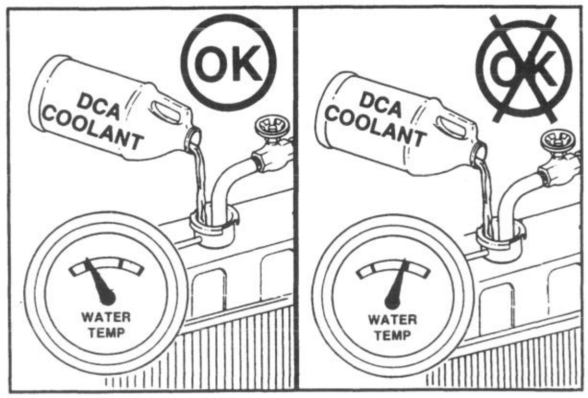
Check the coolant level. Add coolant if necessary.

Use a mixture of 50 percent clean water and 50 percent ethylene glycol base antifreeze to fill the cooling system.

NOTE: Add the correct amount of DCA to the cooling system. Refer to Section 1-07.

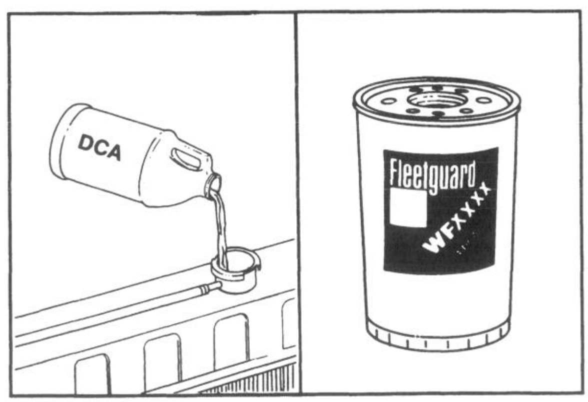


Caution: Do not add cold coolant to a hot engine. Engine castings may be damaged. Allow the engine to cool below 70° C [160° F] before adding coolant.

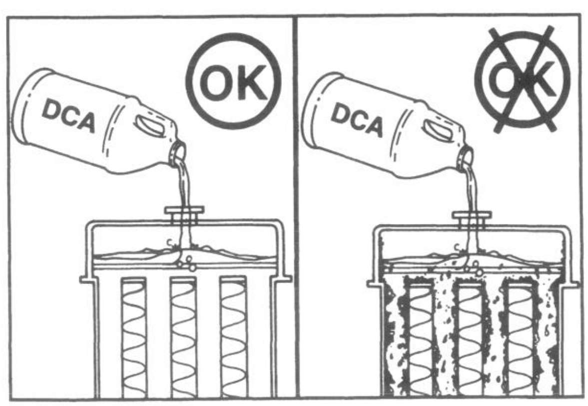


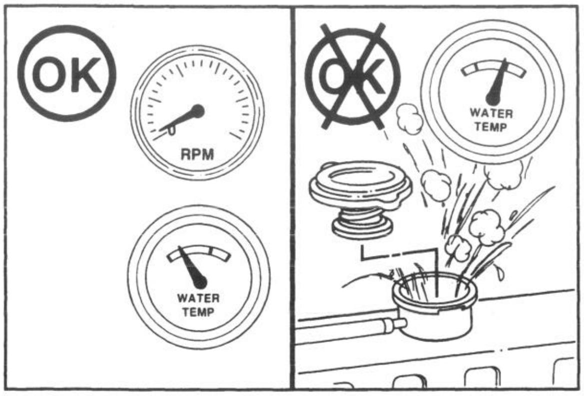
Coolant Additives (1-07)

Add DCA (Diesel Coolant Additive) to the cooling system to prevent the build up of corrosion and scale deposits.



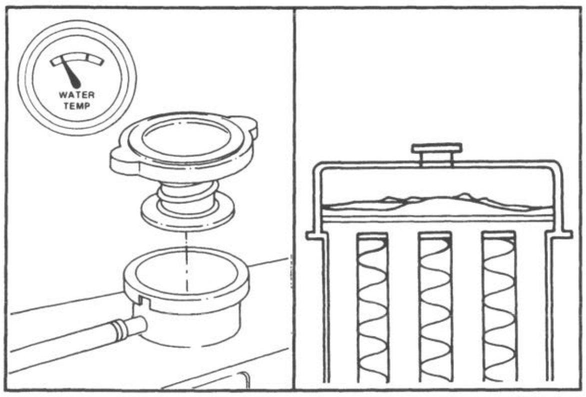
Caution: The cooling system must be clean before adding DCA. Refer to Section 1-08 to clean the cooling system.



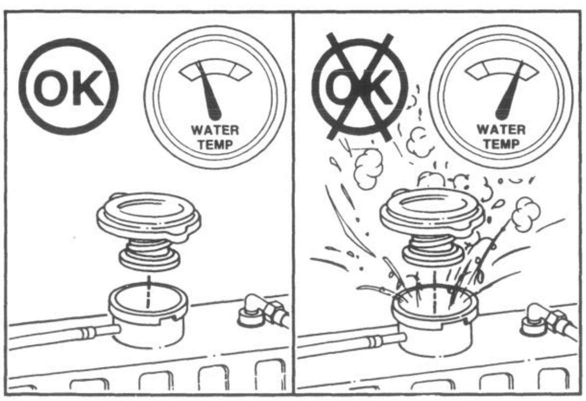


Stop the engine and allow it to cool.

Warning: Do not remove the radiator cap from a hot engine. Hot steam will cause serious personal injury. Wait until the coolant temperature is below 70° C [160° F] before removing the radiator cap.



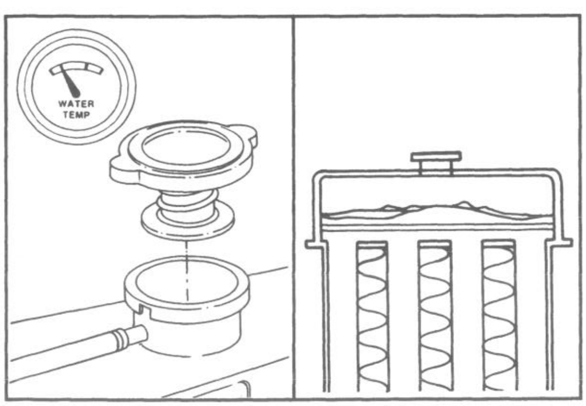
Remove the radiator or fill cap and check the coolant level. Add coolant if necessary.



Coolant Level - Check (1-06)

Remove the radiator cap after the engine is cool.

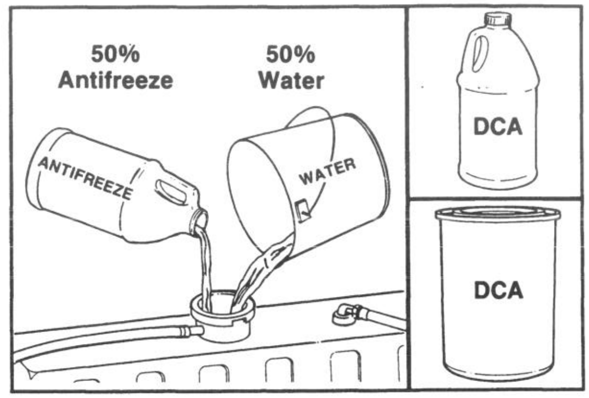
Warning: Do not remove the radiator cap from a ho engine. Hot steam will cause serious personal injury Wait until the coolant temperature is below 70° C [160° F before removing the radiator cap.



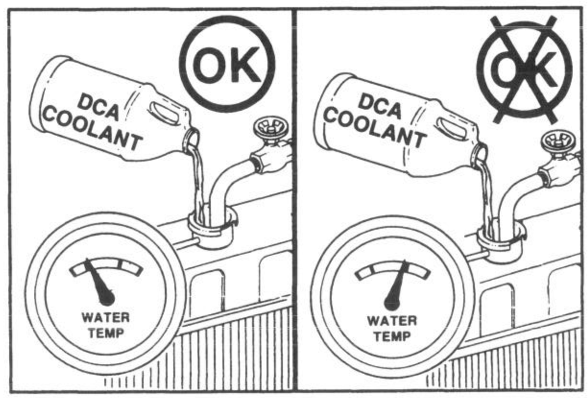
Check the coolant level. Add coolant if necessary.

Use a mixture of 50 percent clean water and 50 percent ethylene glycol base antifreeze to fill the cooling system.

NOTE: Add the correct amount of DCA to the cooling system. Refer to Section 1-07.



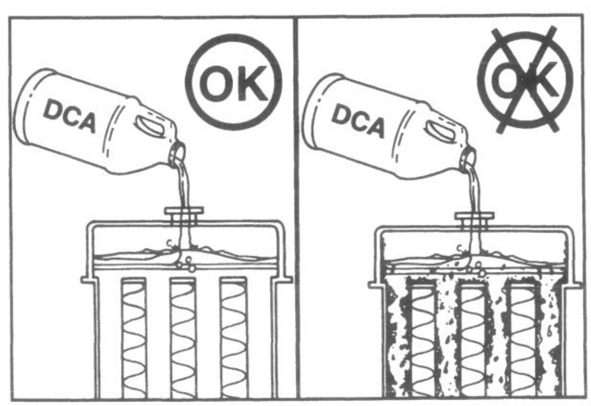
Caution: Do not add cold coolant to a hot engine. Engine castings may be damaged. Allow the engine to cool below 70° C [160° F] before adding coolant.

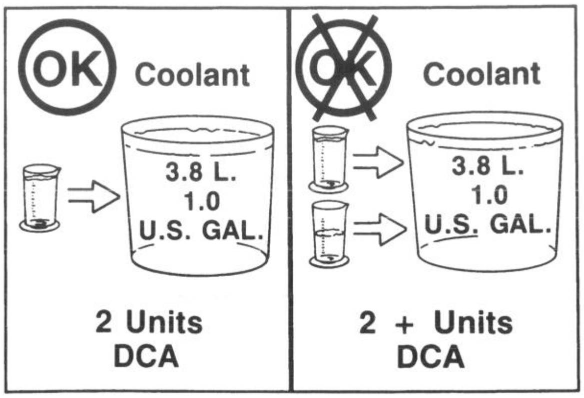


Coolant Additives (1-07)

Add DCA (Diesel Coolant Additive) to the cooling system to prevent the build up of corrosion and scale deposits.

Caution: The cooling system must be clean before adding DCA. Refer to Section 1-08 to clean the cooling system.

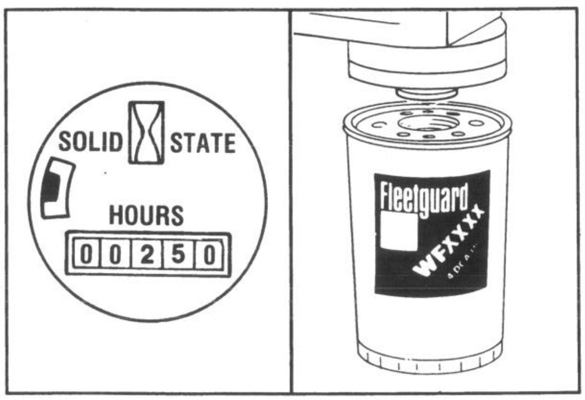




Use a minimum concentration of one DCA unit for each 3.8 litre [one U.S. gallon] of cooling system capacity.

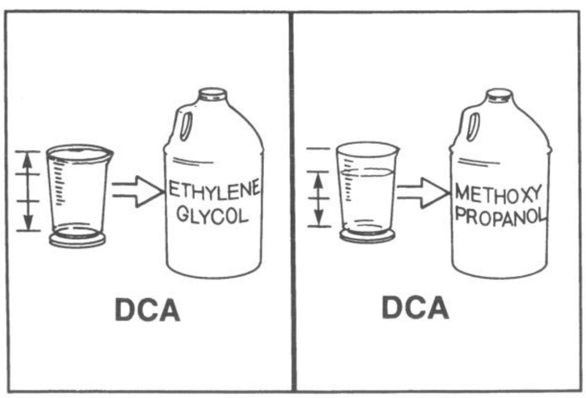
NOTE: One DCA unit equals 42 grams [1.5 dry ounces] or 118 milliliters [4.0 fluid ounces].

Caution: Do not use more than two DCA units per 3.8 litre [one U.S. gallon]. Overconcentration will cause sludge to form in the cooling system.

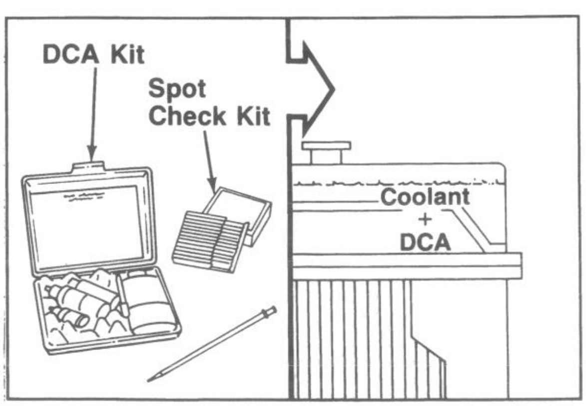


Use the proper Fleetguard® coolant filter to maintain the correct DCA concentration in the system.

Replace coolant filters at 250 hours or 6 months intervals.



NOTE: DCA is compatible with all permanent-type antifreeze except Methoxy Propanol. If using Methoxy Propanol antifreeze reduce the amount of DCA by 1/3 to prevent inhibitor loss due to precipitation caused by chemical incompatibility.



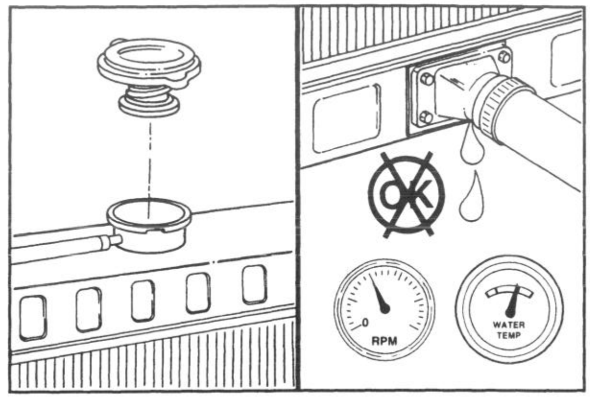
DCA Test Kit

Check DCA concentration with the Fleetguard® DCA Coolant Checking Kit, Part No. 3300846S, of the Cummins Part No. 3375208 available from Cummins Distributors or Dealers.

Use the Fleetguard® Spot Check Test Kit, Part No. CC-2530 and a Reusable Plunger Type Sampler, Part No. CC-2535 for nitrite based coolants.

Install the radiator or coolant system cap.

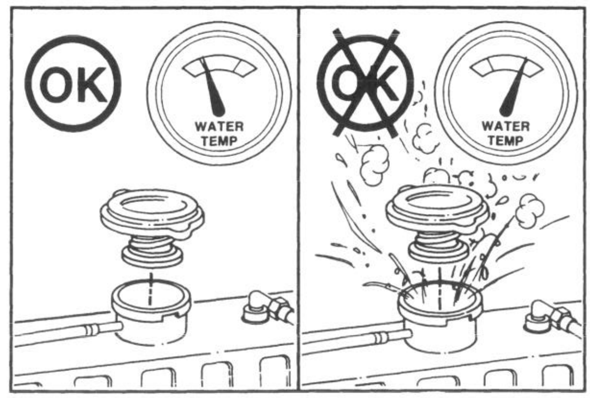
Operate the engine to 90° C [194° F] temperature and check for leaks.



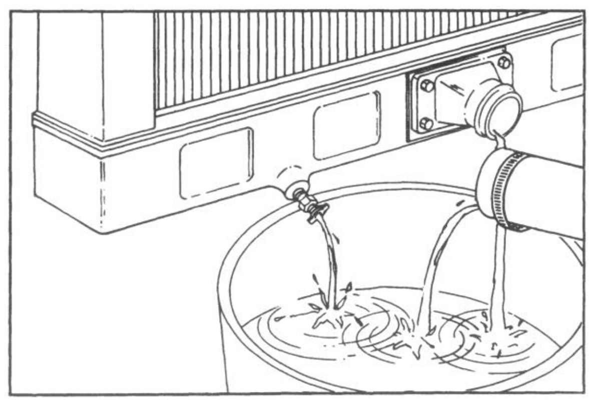
Clean The Cooling System (1-08)

System Flushing

Warning: Do not remove the radiator cap from a hot engine. Hot steam can cause serious personal injury. Wait until the coolant temperature is below 70° C [160° F] before removing the radiator cap.



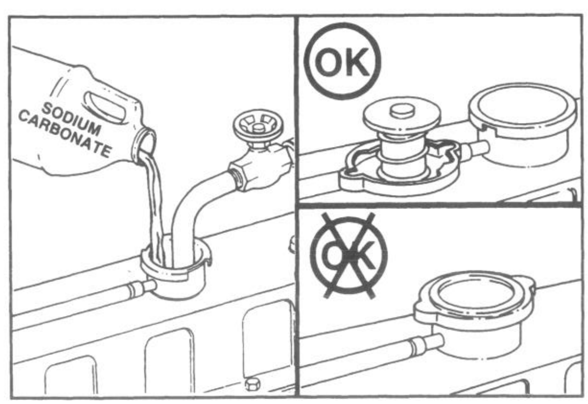
Drain the cooling system. Refer to Section 1-04.

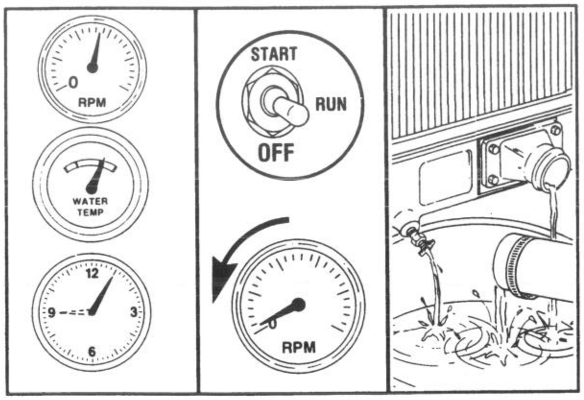


Fill the system with a mixture of sodium carbonate and water (or a commercially available equivalent).

NOTE: Use 0.5 kilogram [1.0 pound] of sodium carbonate for every 23 litres [6.0 U.S. gallons] of water.

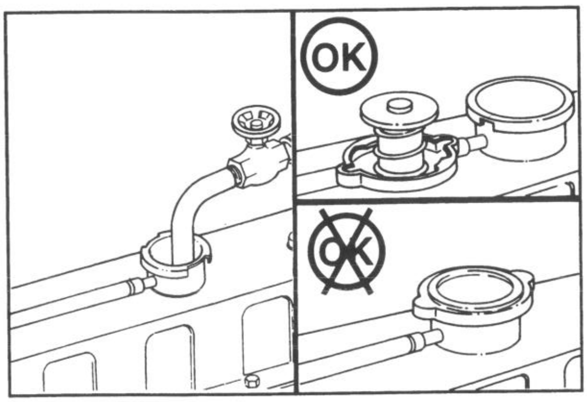
Do not install the radiator cap.





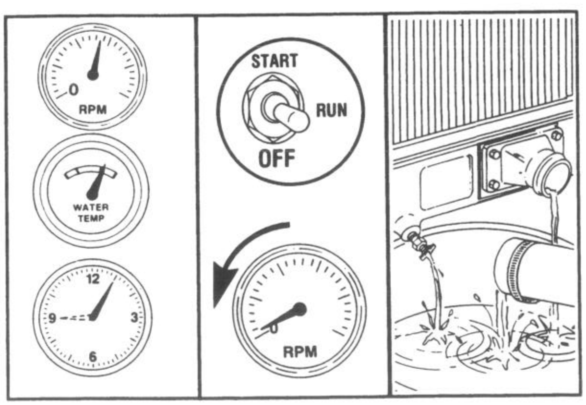
Operate the engine for 5 minutes with the coolant temperature above 90° C [194° F].

Shut the engine off and drain the system.



Fill the cooling system with clean water.

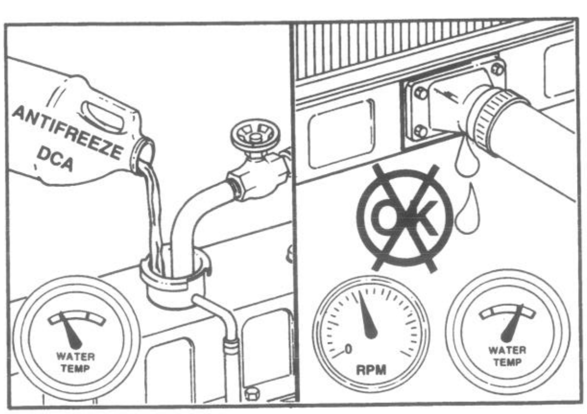
Do not install the radiator cap.



Operate the engine for 5 minutes with the coolant temperature above 90° C [194° F].

Shut off the engine and drain the system.

NOTE: If the water being drained is still dirty, the system must be flushed again until the water is clean.



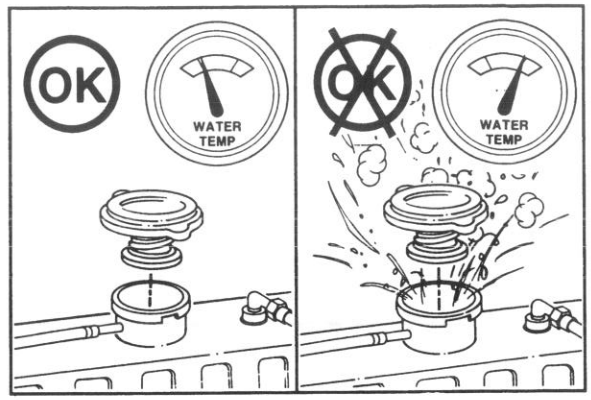
Fill the cooling system with coolant and DCA. Refer to Section 1-07. Install the radiator cap.

Operate the engine to 90° C [194° F] temperature and check for leaks.

Test For Air In The Cooling System (1-09)

Allow the engine to cool and remove the radiator cap.

Warning: Do not remove the radiator cap from a hot engine. Hot steam will cause serious personal injury. Wait until the coolant temperature is below 70° C [160° F] before removing the radiator cap.

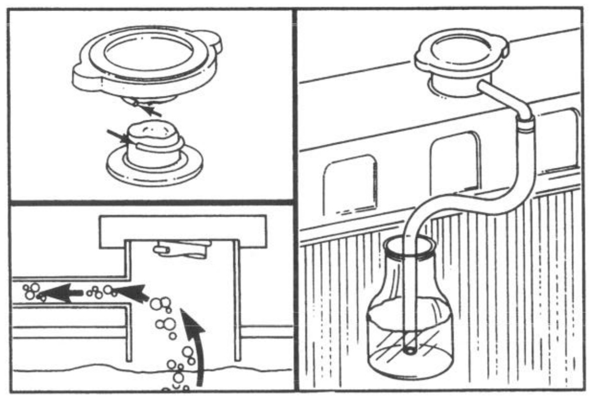


Install a radiator pressure cap which has had the spring and pressure relief valve removed.

Caution: The pressure cap must make a tight seal.

Attach a rubber hose to the radiator overflow connection.

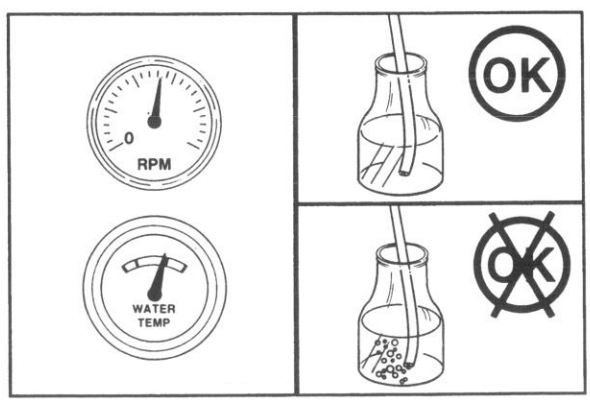
Install the free end of the hose in a container of water.



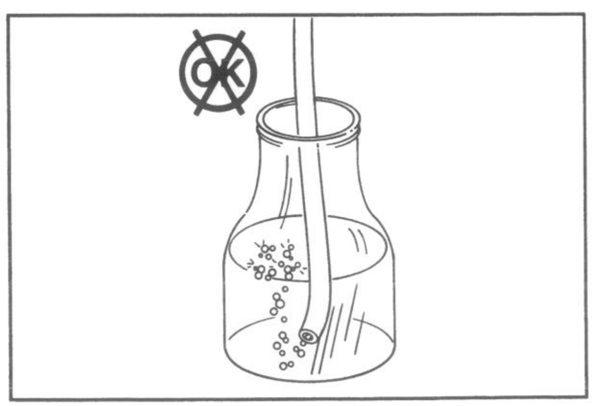
Operate the engine at rated RPM to 90° C [194° F] temperature with the thermostat open.

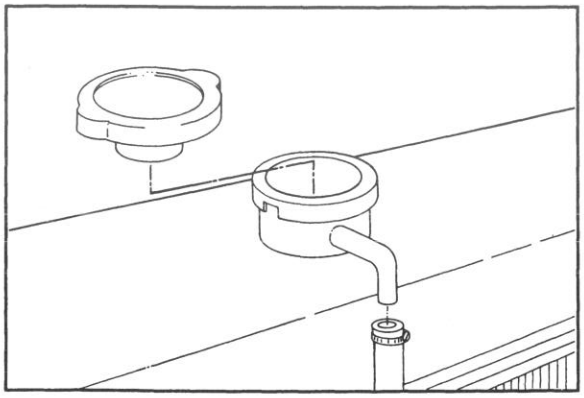
Check for a continuous flow of air bubbles from the hose in the water container.

Note: Thermostats do not open till 82° C (180° F).



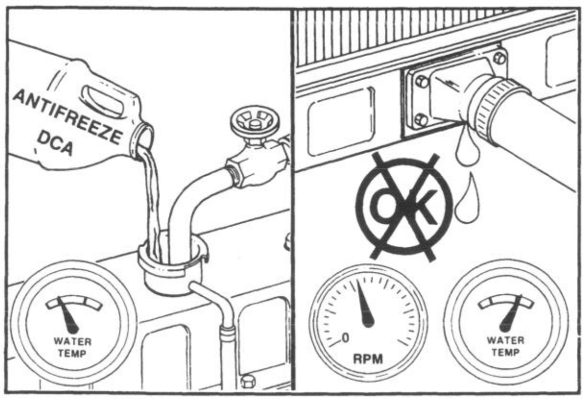
If a continuous flow of air bubbles are present, refer to the specific engine troubleshooting and repair manual.



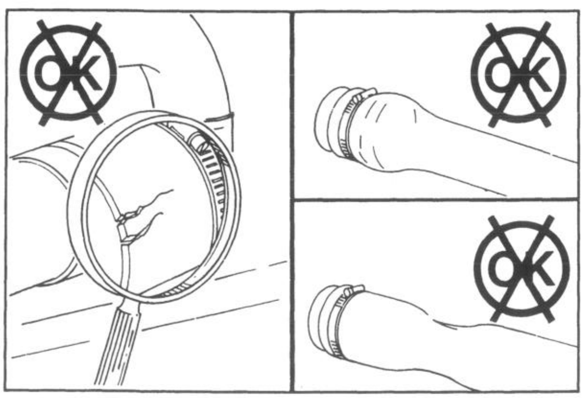


If no air is found in the system:

1. Remove the test equipment.



2. Fill the cooling system. Refer to Section 1-05.
3. Operate the engine to 90° C [194° F] temperature and check for coolant leaks.



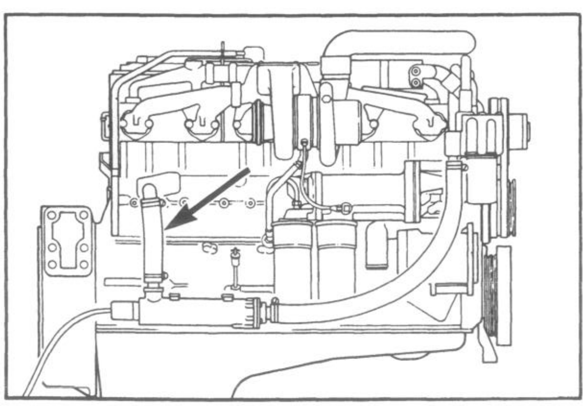
Hoses - Check (1-10)

Inspect all hoses for cracks or cuts.

Inspect all hoses for signs of ballooning or collapsing.

Water line hoses can balloon on generator sets when a remote, high mounted radiator is in use. The maximum permitted radiator height is 18.3 m [60 ft.] above the crankshaft centerline.

Water line hoses do not normally collapse on generator sets, but this can occur if the radiator tubes become clogged with scale or debris.



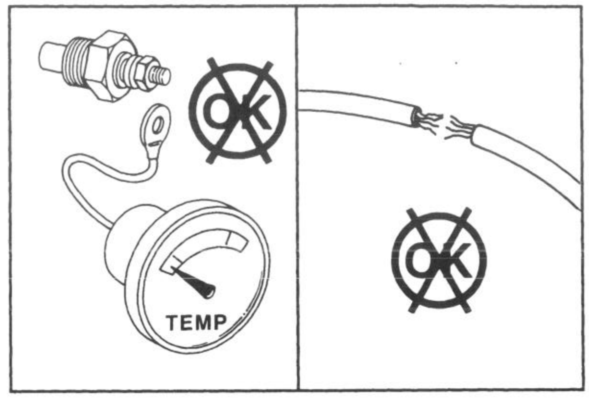
Check the lines which take coolant from the coolant heater to the engine block to determine that they are flexible. These lines normally consist of steel tubing connected with teflon hose.

Do **not** replace the teflon hose with normal radiator hose. It becomes brittle and breaks in approximately 1 year.

Coolant Temperature Gauge And Sender - Check (1-11)

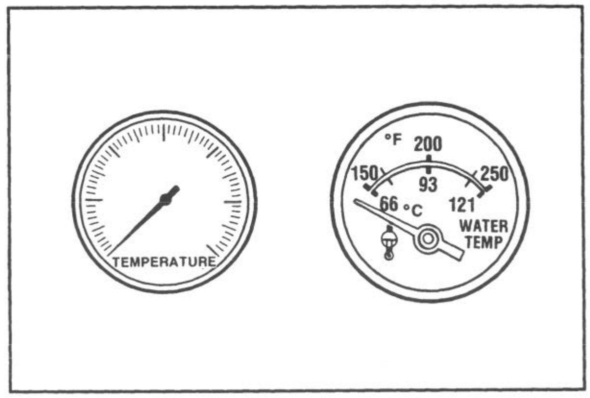
Check the electrical wiring at the sender and gauge to make sure it is not broken, loose or shorted.

NOTE: The coolant temperature sender is located in the coolant (water) manifold on all generator set engines. The Part No. 3015238, Temperature Sender, is used for both the oil and the coolant temperature gauges.

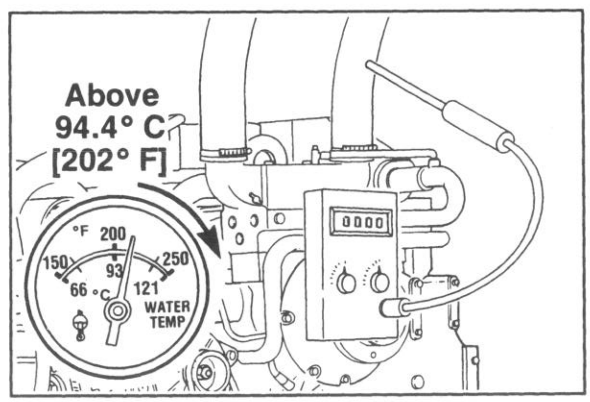


Use a master gauge of known accuracy to check the coolant temperature in the coolant manifold or thermostat housing. Check the calibration of the suspect gauge and sender against the master gauge.

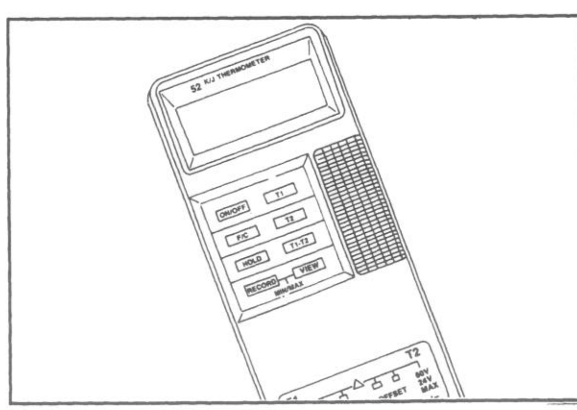
Replace the sending unit and coolant temperature gauge if there is an excessive difference from the master temperature gauge reading.

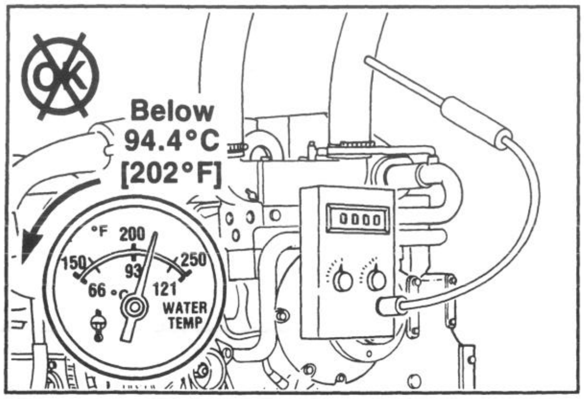


NOTE: A thermocouple in the coolant on the engine side of the thermostat and a pyrometer are the ideal means of checking the calibration of the coolant temperature gauge and sender. When the thermostat(s) are full open, above 94.4° C [202° F] all of the coolant flows through the coolant outlet tube(s) to the radiator. When the coolant is 94.4° C [202° F] or hotter, use a service tool to measure the surface temperature on the metal portion of the coolant outlet tube that is close to the engine.

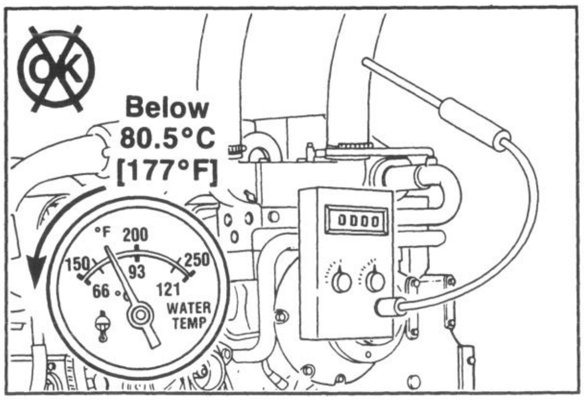


A Fluke Model 51 or 52 can be used to measure the temperature.

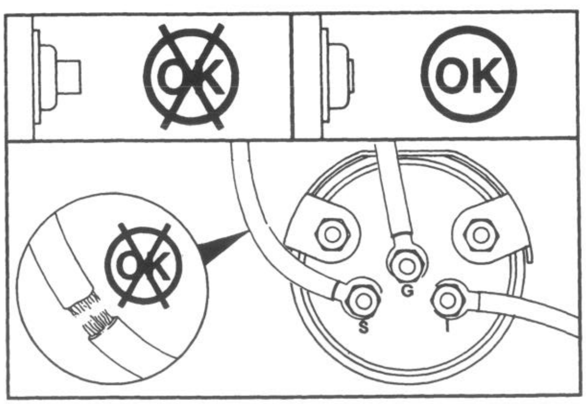




When the temperature is below 94.4° C [202° F], the thermostat(s) will not be completely open. The coolant flow from the engine will be reduced and the tube temperature will not be accurate.



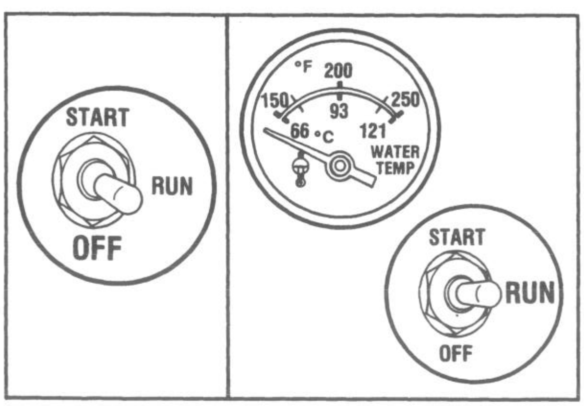
When the temperature is below 80.5° C [177° F], the thermostat(S) will be completely closed. The coolant will not flow from the engine. The coolant tube temperature will be much cooler than the engine coolant temperature.



Coolant Temperature Gauge - Verification (1-12)

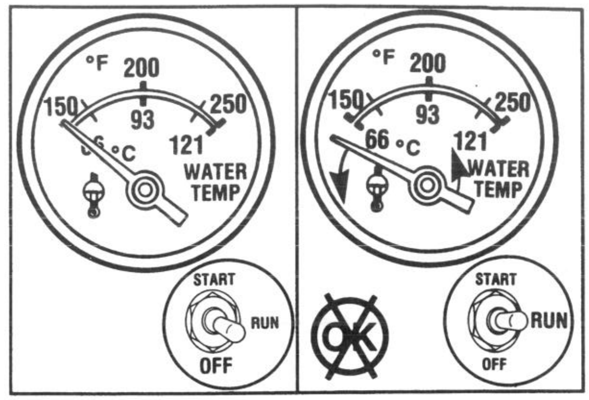
Make sure Engine Control Panel DC Circuit Breaker is closed.

Check the wiring to the temperature gauge for broken, loose or shorted wires.

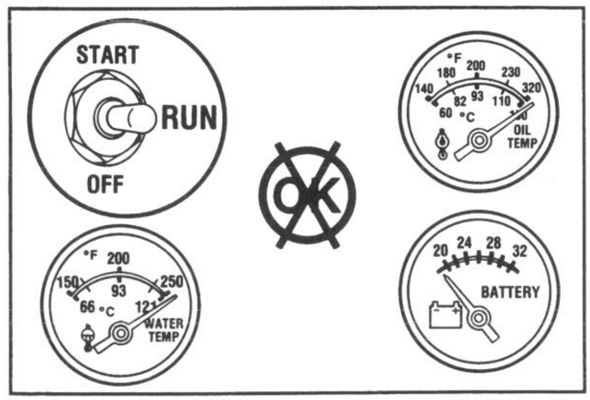


Stop the engine. Move the Off-Run-Start Switch to the "Run" position. The gauge will show the engine coolant temperature if the coolant temperature is above 66° C [150° F]. Refer to Section 1-11. If the engine has not been run for 16 hours, the coolant temperature is probably below 66° C [150° F] and the pointer should be slightly below the 66° C [150° F] mark.

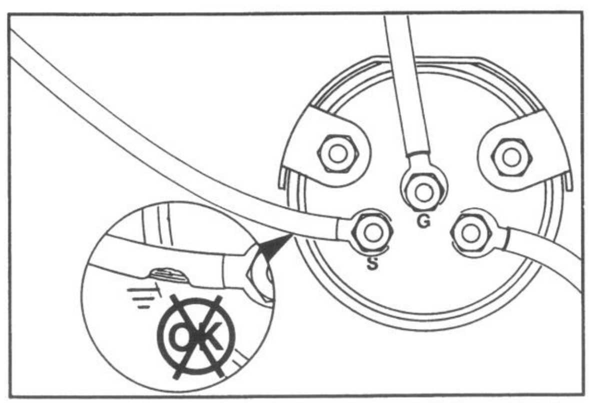
1. Note the pointer position when the Off-Run-Start Switch is in the "Off" position. Move the Off-Run-Start Switch to the "Run" position. If the pointer moves CCW, check for a missing ground strap from the negative starter terminal to the block. Check for a broken or disconnected wire (No. 76) at the gauge, sender or in plugs B, D, F, H or K.



2. If the pointer moves off of the scale to the right, when the switch is moved to the "Run" position, check for a broken or disconnected ground wire (No. 12). The battery voltmeter will show low and oil temperature will show high if wire No. 12 is faulty.

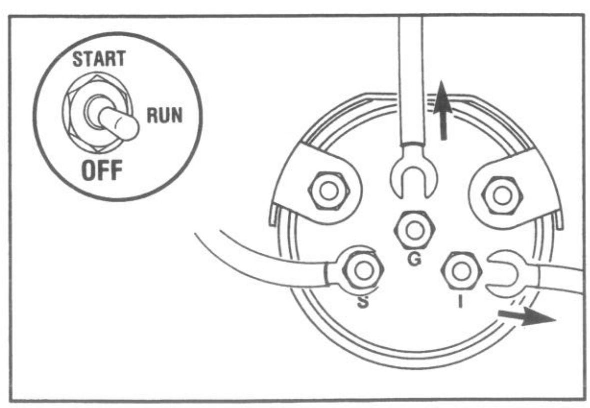


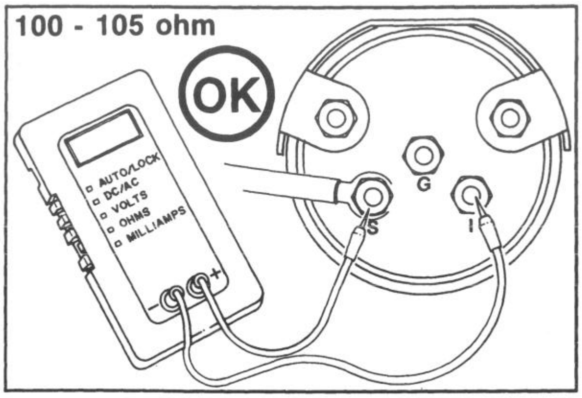
3. If the ground connection is good, check for a shorted sender (Section 1-13) or a short between the sender wire (No. 76) and ground.



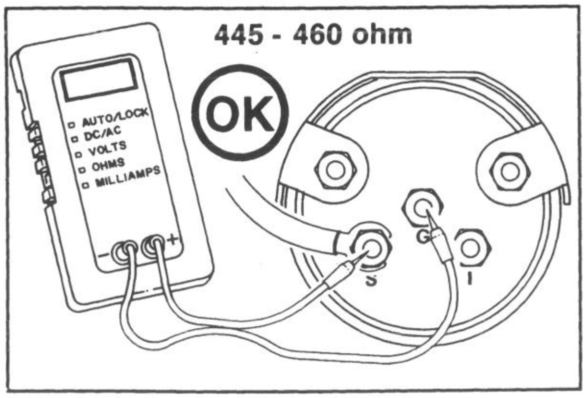
Move the Off-Run-Start Switch to the "Off" position.

Remove the wires from the gauge terminals "I" (Wire No.5) and "G" (Wire No. 12).

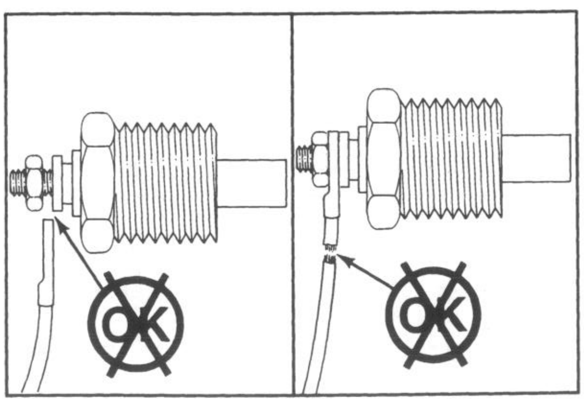




Use the Part No. 3376898, Multitester, to measure the resistance between the gauge terminals I and S. The acceptable resistance is 100 to 105 ohms. Replace the gauge if it is outside of these limits.



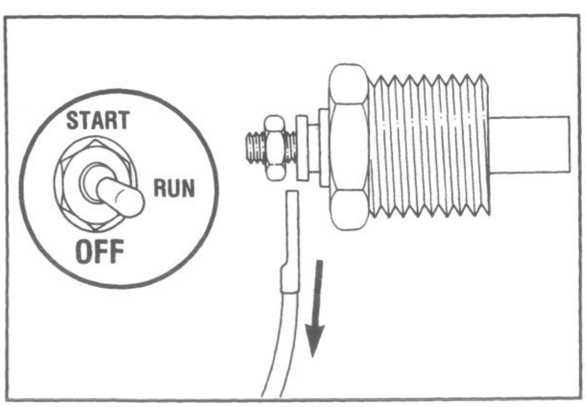
Measure the resistance between gauge terminals G and S. The acceptable resistance is 445 to 460 ohms. Replace the gauge if it is outside of these limits.



Coolant Temperature Sender - Verification (1-13)

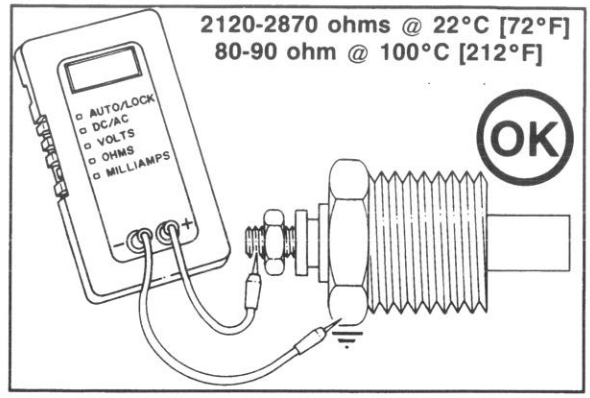
Check the coolant temperature sender for a broken or disconnected wire.

Repair, splice or replace the wire as required.



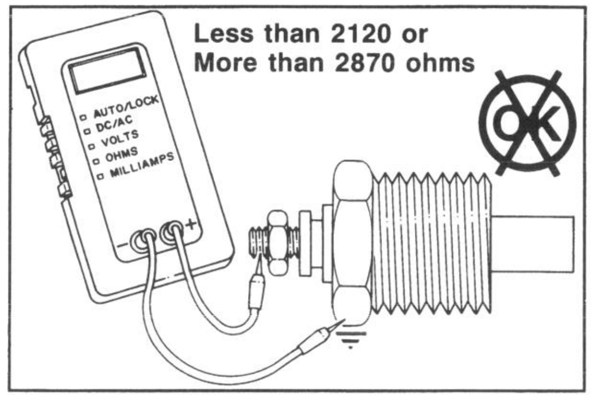
Stop the engine and remove the wire (No. 76) from the sender.

Use the Part No. 3376898, Multitester, to check for continuity between the sender terminals and ground. This resistance to ground increases as the temperature goes down. At 22° C [72° F] the resistance to ground will be 2120 to 2870 ohms. At 100° C [212° F], the resistance to ground should be 80 to 90 ohms.



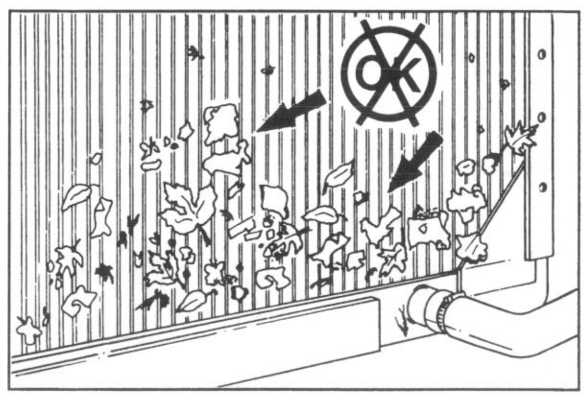
Replace the Part No. 3015238, Sender, if it is open or shorted to ground.

NOTE: The Part No. 3015238, Sender, is also used for oil temperature.

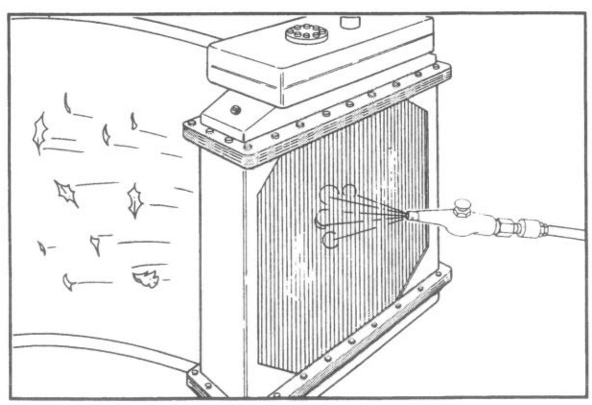


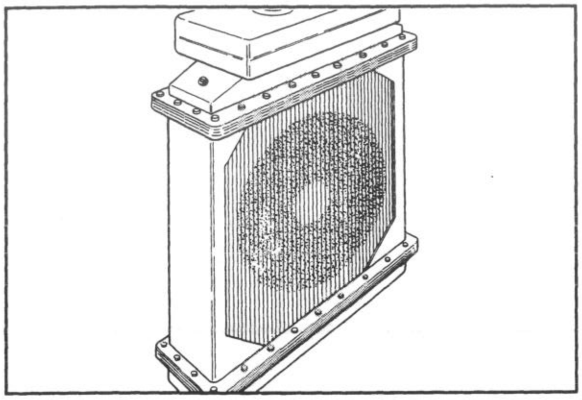
Radiator - Inspect (1-14)

Visually inspect for debris (paper, leaves, lint, etc.) which can obstruct the fins and reduce the flow of air through the radiator.

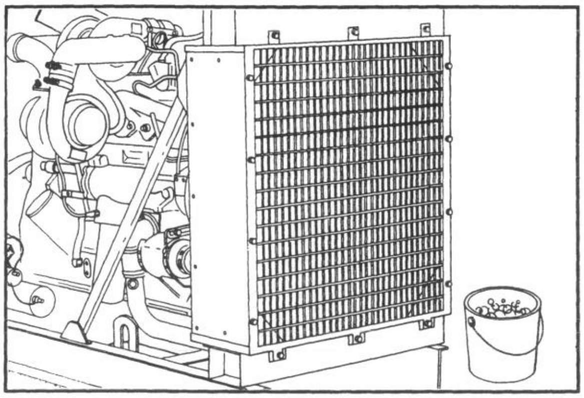


Use 550 kPa [80 psi] air pressure to blow the dirt and debris from the radiator.

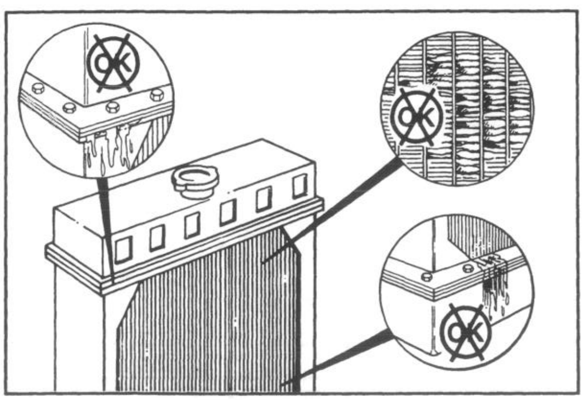




Visually inspect the radiator for oil and dirt build-up in the fins. This is usually in a pattern where the maximum air velocity is located.



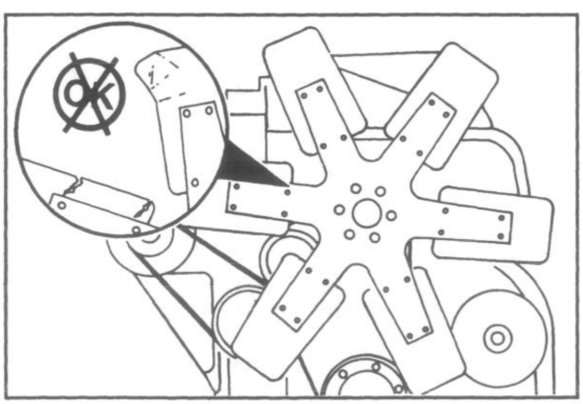
Use a soap and water solution or Safety Solvent 140 and 550 kPa [80 psi] air pressure to remove oil and dirt build-up from between the fins. On generator sets, work at the front of the radiator.



Visually inspect for bent or broken fins.

Visually inspect for radiator core and gasket leaks.

Repair or replace the radiator, as required.

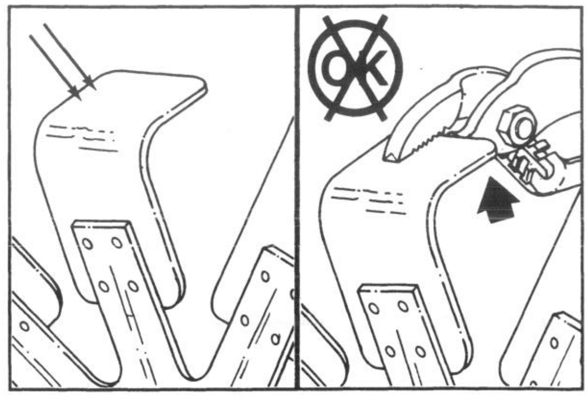


Fan, Shroud, Spacer and Pulley Inspection (1-15)

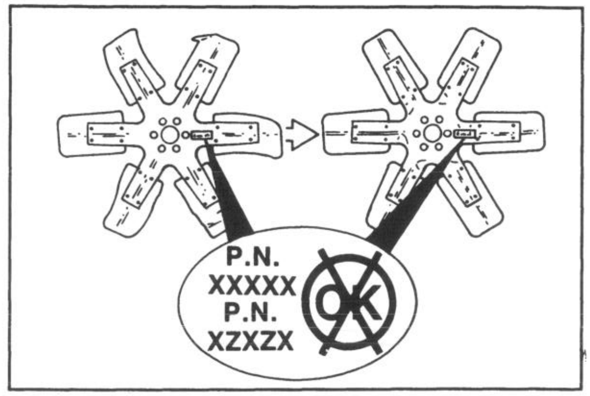
Fan - Inspect

Visually inspect the fan for cracked, bent or broken blades.

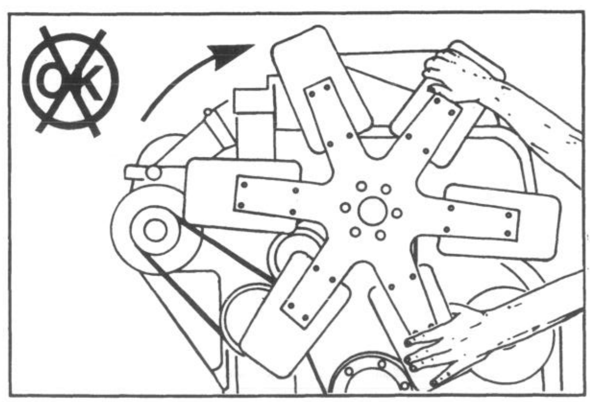
Warning: Do not straighten a bent fan blade or continue to use a damaged fan. A bent or damaged fan blade can fail during operation and cause serious personal injury or property damage.



Caution: Replace the original Cummins fan with a fan of the identical Cummins part number.



Warning: Do not rotate the engine by pulling or prying on the fan. The fan blade(s) may be damaged and cause the fan to fail and cause serious personal injury or property damage. Use the engine barring device to rotate the engine.

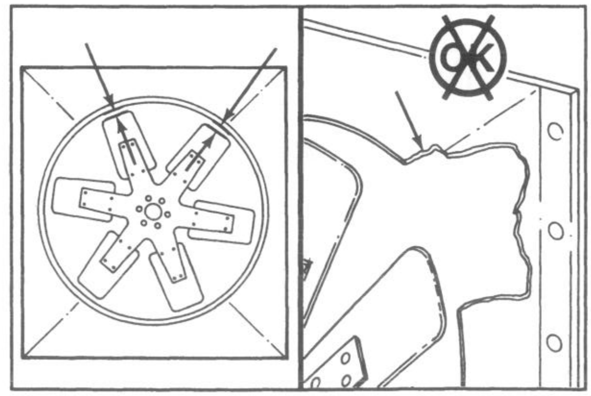


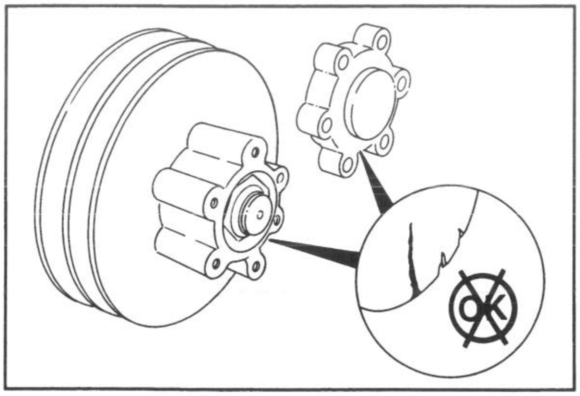
Fan Shroud - Inspect

Caution: The fan shroud must be installed correctly, and be in good condition. The shroud to fan clearance must be as noted below to provide the correct engine cooling.

855 Series: 1.6 to 3 mm (1/8 to 1/4 in.)
KT-19 Series: 5 to 8 mm (3/16 to 5/16 in.)
KT-38 Series: 5 to 8 mm (3/16 to 5/16 in.)
KT-50 Series: 5 to 8 mm (3/16 to 5/16 in.)
VT-28 Series: 5 to 8 mm (3/16 to 5/16 in.)

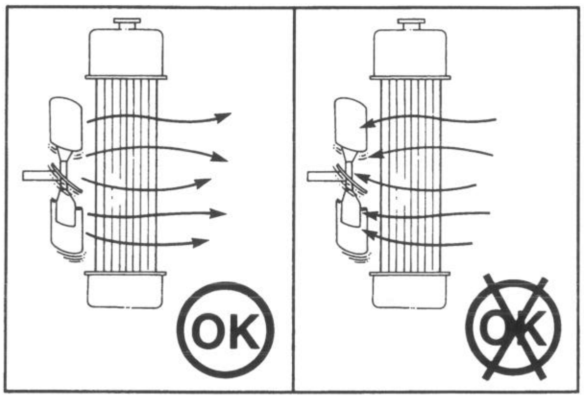
Visually inspect the fan shroud for proper fan clearance, cracks, air leaks or damage. Replace if necessary.





Fan Spacer And Pulley - Inspect

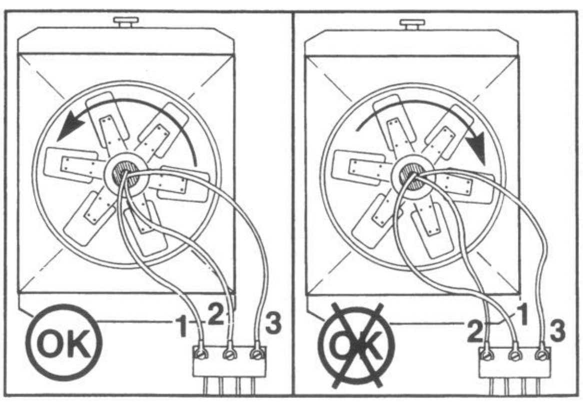
Visually inspect the fan hub and spacer (if used) for cracks, or damage. Replace if necessary.



Fan Operation Remote Radiator (1-16)

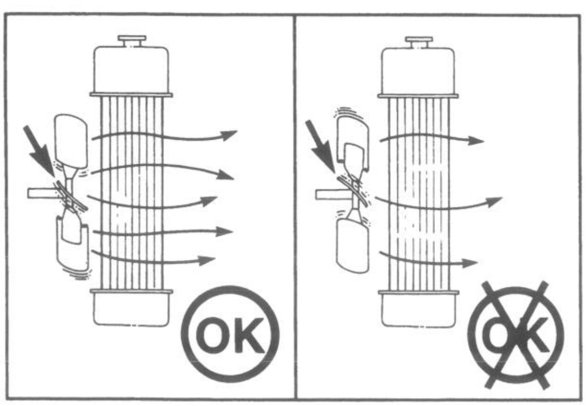
Make sure the fan rotation is correct.

The remote radiator fans almost always are blower fans that push relatively cool air through the radiator. This keeps the fan motor in a cooler ambient temperature.



Most radiator fans rotate counter-clockwise when viewed from the fan into the radiator. The rotation of any three phase motor, which normally drives a remote radiator fan, can be reversed by interchanging any two of the three phase leads going to the motor.

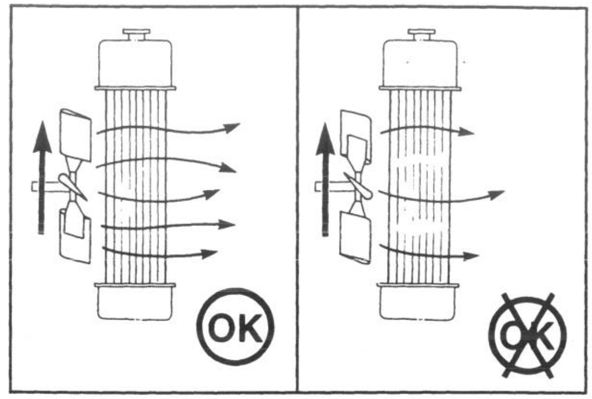
Caution: Do not interchange the ground or neutral lead.



To reverse the direction of air flow from a fan, reverse the fan rotation and reverse fan mounting face. For stamped steel cupped fan blades, the air flow must be in the direction of the blade cup.

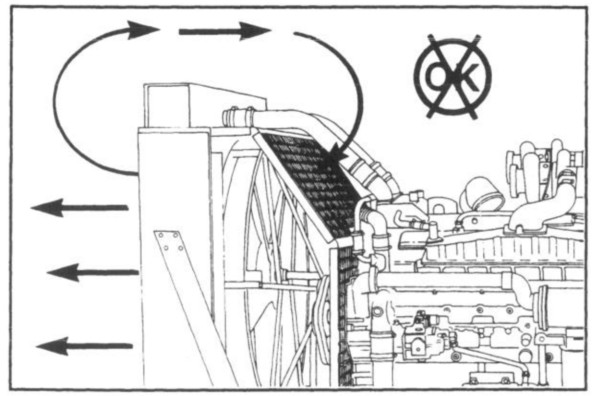
The air flow does **not** reverse direction when the front of the fan is turned to the back unless rotation is also reversed. Fan blades deliver more air when oriented correctly with respect to air flow.

Air foil cross section fan blades must have the thick section of the blade as the leading edge.

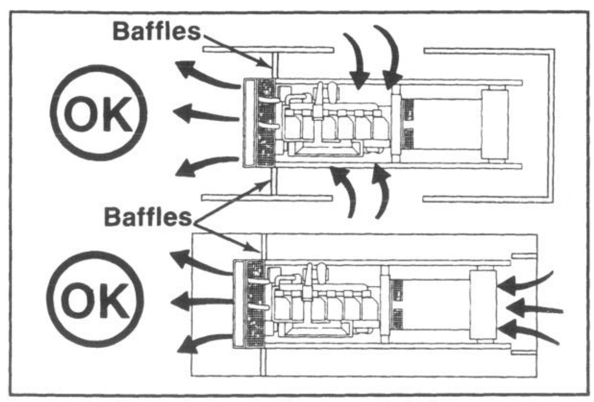


Recirculation - Air (1-17)

A generator set, installed on a flat-bed or enclosed trailer, can overheat at rated load in a 38° C [100° F] ambient temperature because of recirculation of air around the radiator. A string, held at the top and sides of the radiator will indicate air recirculation in most installations.



Install baffles to reduce or eliminate recirculation of air around and backwards over the radiator.

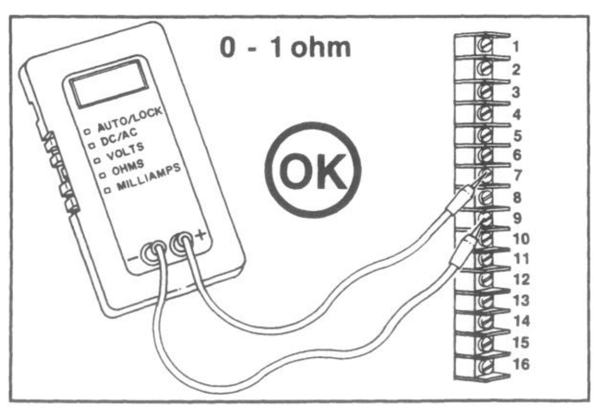


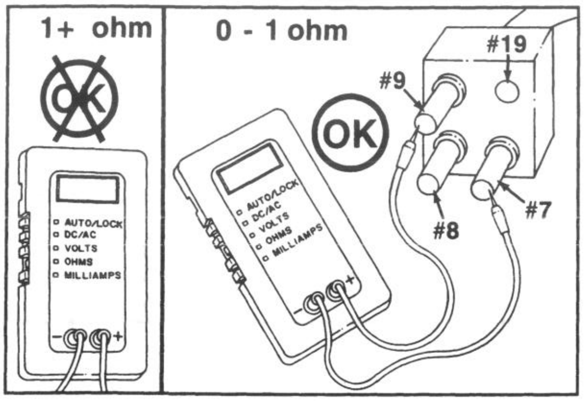
High Coolant Temperature Shutoff Switch - Wire Check (1-18)

Symptom: Engine Will Not Keep Running.

Turn permissive start switch to the " Off" position.

Use Part No. 3376898, Multitester, to measure the resistance between terminals No. 7 and No. 9 on the engine terminal board terminal strip in the engine control panel. Resistance must be 1 ohm or less. If the resistance is 1 ohm or less, the high coolant temperature shutoff switch and switch wiring are not the problem.

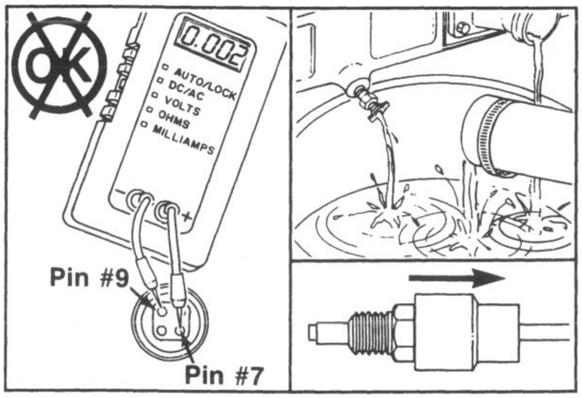




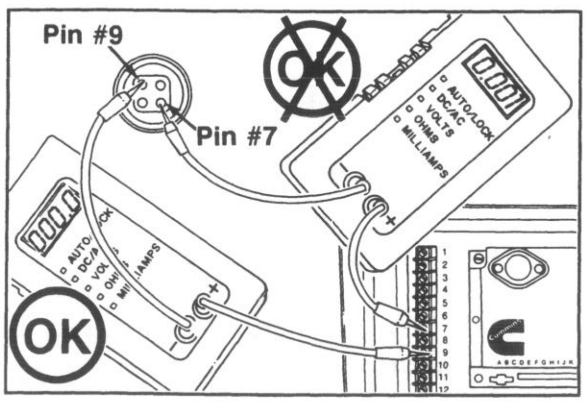
If the resistance is more than 1 ohm, disconnect the wiring harness from the high coolant temperature switch, Plug H.

Measure the resistance between pins No. 7 and No. 9 on the temperature switch plug.

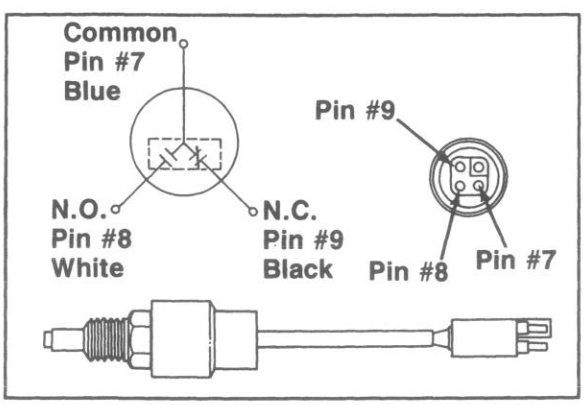
Resistance must be 1 ohm or less. If resistance between pins #7 and #9 on the switch is 1 ohm or less, the problem is in the wiring between high coolant temperature shut off switch and engine terminal board.



If the resistance between terminals No. 7 and 9 of the switch plug is more than 1 ohm, the switch is defective. Drain the coolant until the coolant level is below the switch. Replace the switch.



If the resistance between pins No. 7 and 9 of the switch plug is 1 ohm or less, the switch contacts are OK. Check for a broken wire No. 7 or 9 or a faulty connection between plug H and the engine terminal board termianls No. 7 and 9. Plugs A and C are likely possibilities for a faulty connection. Repair or replace the faulty plug or harness as required.

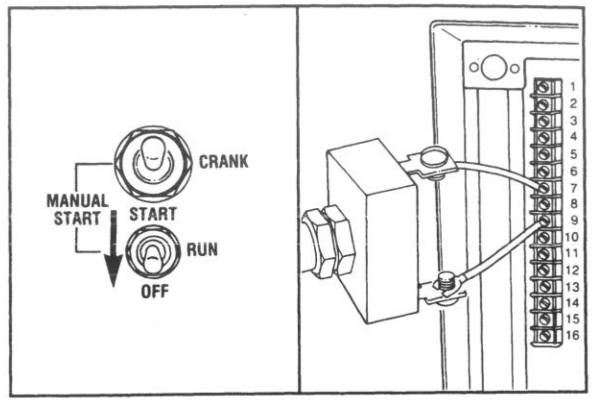


High Coolant Temperature Shutoff Switch - Calibration Check (1-19)

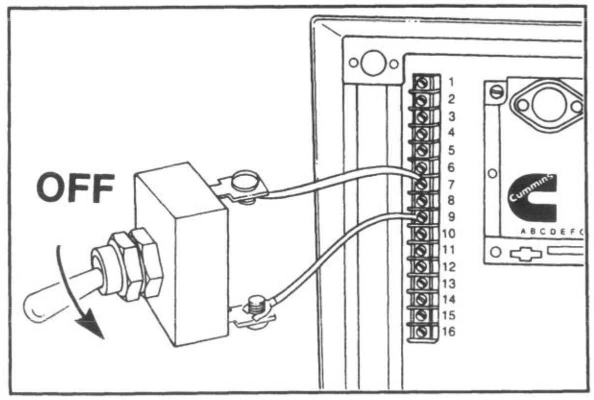
The high coolant temperature shutoff switch (3048725) is a double pole, single throw temperature switch, calibrated to operate at 104.4° to 107.8° C (220° to 226° F) on increasing temperature with the switch mounted on the engine. Checking the operation temperature by imersing the sensing portion of the switch in hot oil does not give repeatable or accurate results.

Before a calibration run, make the following modifications:

1. Move the Off-Run-Start switch to the "Off" position.
2. Install the leads from a single pole, single throw switch to Engine Terminal Board Terminals 7 and 9. This switch will be used as a "Bypass" switch to keep the engine running after the high coolant temperature shutdown switch operates.

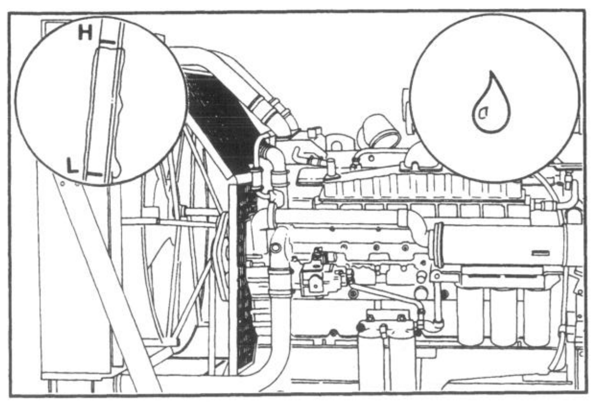


3. Place the "Bypass" switch in the "Off" position.
4. Locate the "Bypass" switch so that it may be operated conveniently while observing the coolant temperature gauge.



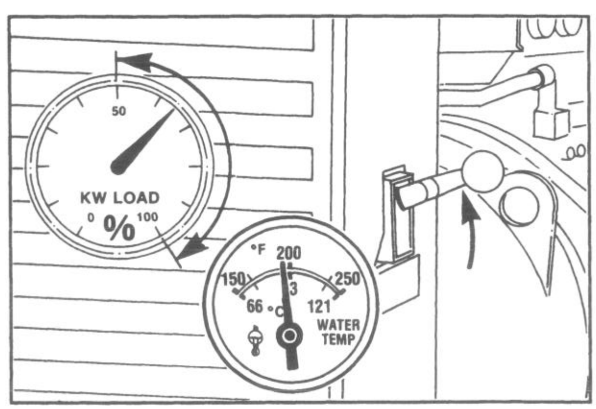
Block the radiator air flow or block the raw water flow from the heat exchanger.

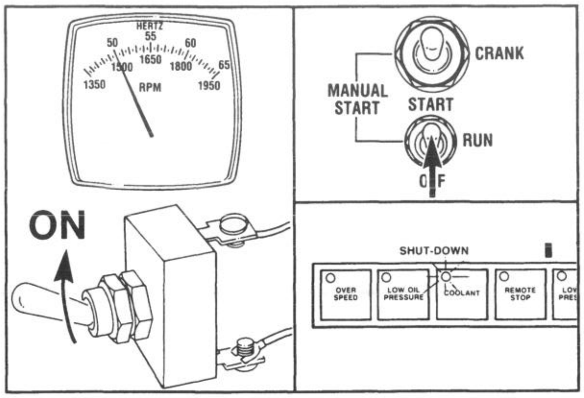
Make the normal oil, coolant and fuel pre-start checks.



Start the engine and increase the RPM to rated speed. Close the circuit breaker and apply 50 to 100 percent of the rated KW load.

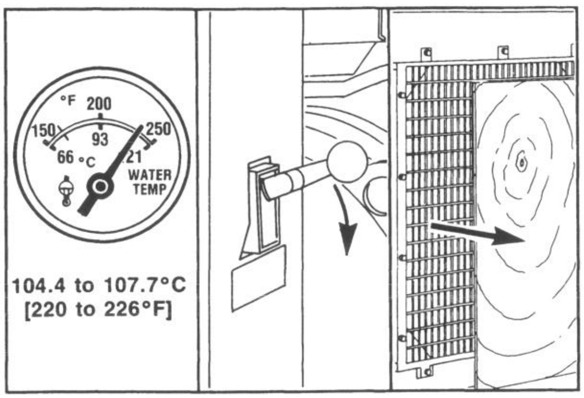
Watch the coolant temperature gauge. The rate of coolant temperature rise will depend on the ambient temperature, how well the radiator air (or heat exchanger raw water outlet) flow is blocked, and the amount of load on the generator set.





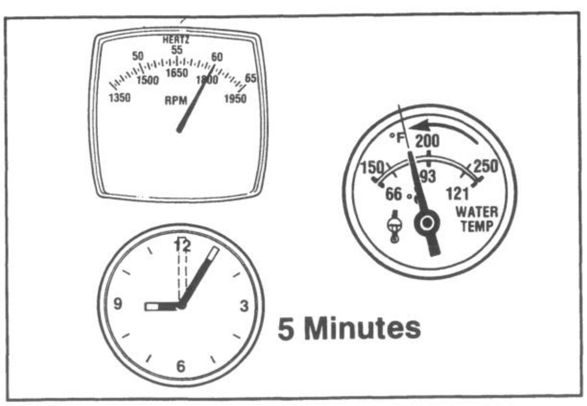
When the engine shuts off, IMMEDIATELY (Preferably before the engine speed drops 300 RPM) switch the installed "Bypass" switch to the "On" position. (If this does not keep the engine running, hold the Off-Run-Start switch in the "Start" position.) The red Coolant Shutdown light should come on when the engine starts to shut off.

Caution: Remove the generator load and the coolant system blockage if the water temperature exceeds 110° C (230° F). [The mark on the Water Temperature gauge between 93° and 121° C (200° and 250° F) indicates 107° C (225° F).]

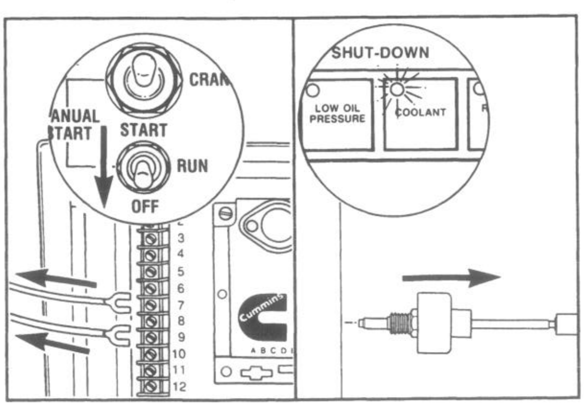


After the engine is running again,

1. Note the reading of the water temperature gauge. The temperature should be 104.4° to 107.7° C (220° to 226° F).
2. Turn off the generator load. (Load bank fans may be left running.)
3. Remove the blockage from the radiator (or heat exchanger raw water) outlet.



Continue to run the engine at rated speed, no load, for at least 5 minutes and until the coolant temperature gauge drops below 93° C [200° F].



Move the Off-Run-Start Switch to the "Off" position to stop the engine.

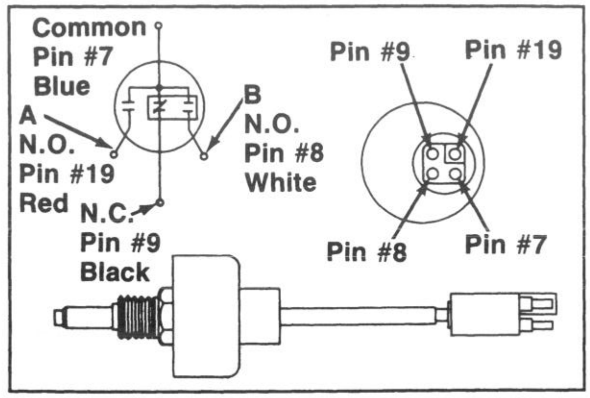
Remove the "Bypass" switch and leads from Engine Terminal Board terminals No. 7 and 9.

Replace the high coolant temperature switch if it did not shut the engine off within the temperature range.

Check the coolant shutdown lamp and circuits if it did not light when the high coolant temperature switch operated.

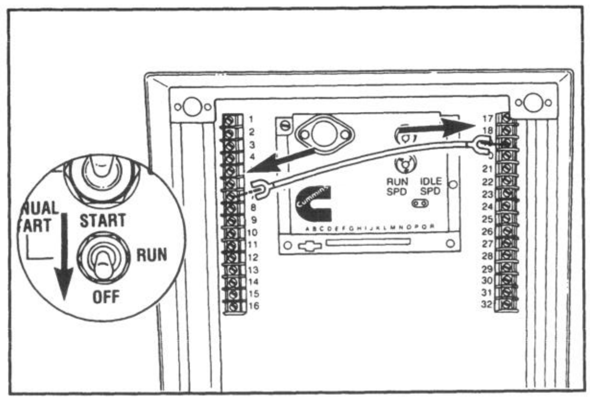
High Coolant Temperature Shutoff/ Alarm Switch – Calibration Check (1-20)

The high coolant temperature shutoff/alarm switch (3048727) is similar to the shutoff switch except that an additional alarm switch is added in the enclosure. This normally open alarm switch is calibrated to close at 100° to 103.3° C (212° to 218° F) on increasing temperature with the switch mounted in the engine. Checking the operation temperature by imersing the sensing portion of the switch in hot oil does not give repeatable or accurate results.

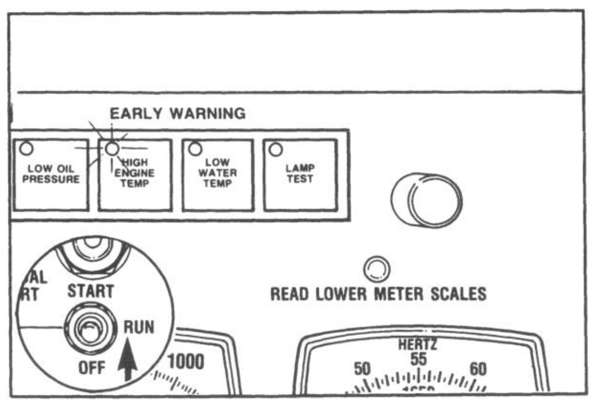


Before a calibration run, make the following check and modification:

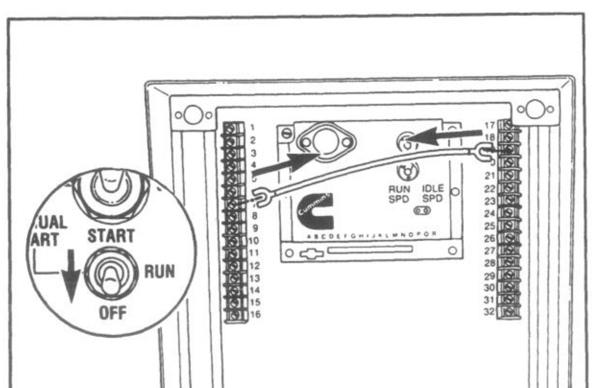
1. Alarm Light Check
   a. Move the Off-Run-Start switch to the "Off" position.
   b. Install a temporary jumper wire between Engine Terminals Board terminals No. 7 and No. 19.

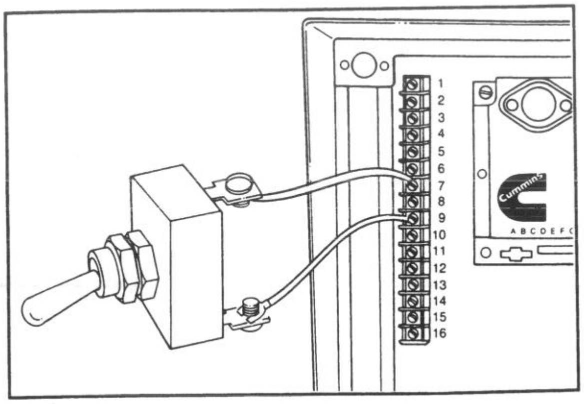


   c. Move the Off-Run-Start switch to the "Run" Position.
   d. The Amber Early Warning High Water Temperature light on the Generator Control Panel should come on.
   e. If the light does not come on, check for defective lamp or defective wiring within the control panels.
   f. Replace or repair as required.

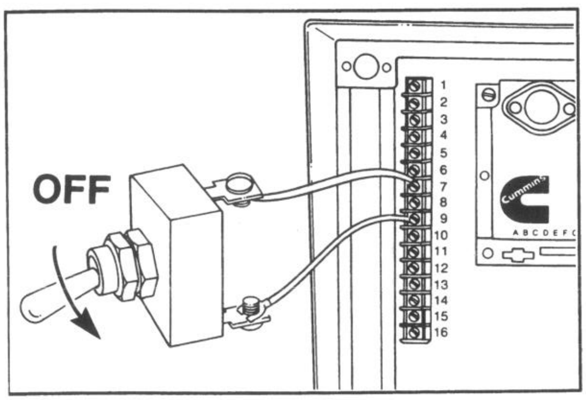


2. After the Early Warning High Water Temperature light has come on
   a. Move the Off-Run-Start switch to the "Off" position.
   b. Remove the temporary jumper wire that was installed between Engine Terminal Board Terminals No. 7 and No. 19.
   c. Tighten the screw on Terminal No. 19.



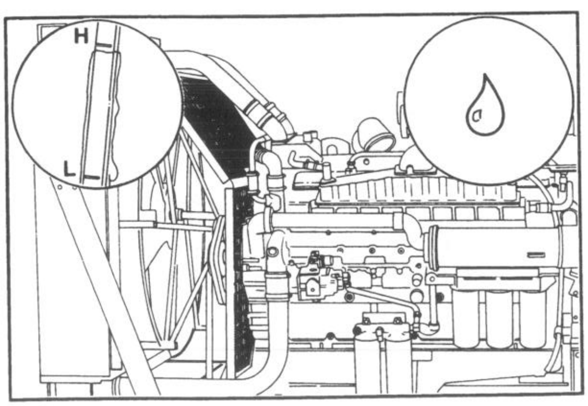


d. Install the leads from a single pole, single throw switch to Engine Terminal Board Terminals No. 7 and No. 9. This switch will be used as a "Bypass" switch to keep the engine running after the high coolant temperature shutdown switch operates.



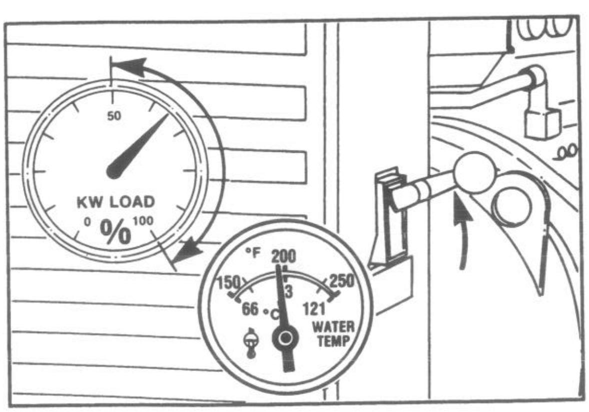
e. Place the "Bypass" switch in the "Off" position.

f. Locate the "Bypass" switch so that it may be operated conveniently while observing the coolant temperature gauge.



Block the radiator air flow or block the raw water flow from the heat exchanger.

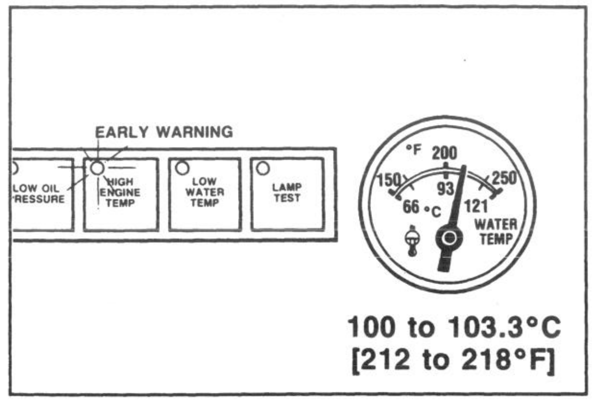
Make the normal oil, coolant and fuel pre-start checks.



Start the engine and increase the RPM to rated speed. Close the circuit breaker and apply 50 to 100 percent of the rated KW load.

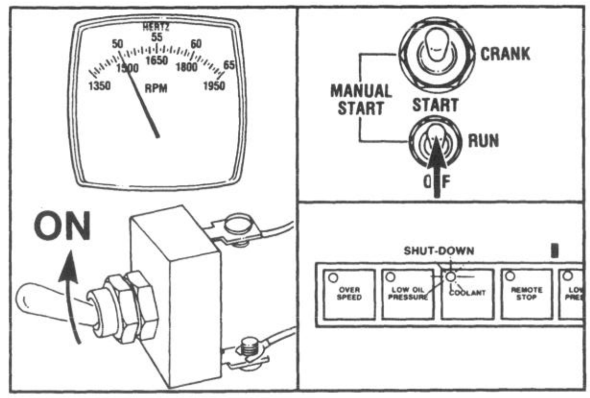
Watch the coolant temperature gauge. The rate of coolant temperature rise will depend on the ambient temperature, how well the radiator air (or heat exchanger raw water outlet) flow is blocked, and the amount of load on the generator set.

Note and record the reading of the Water Temperature gauge when the amber Early Warning High Water Temperature light comes on. This temperature should be 100.0 to 103.3 C (212 to 218 F).



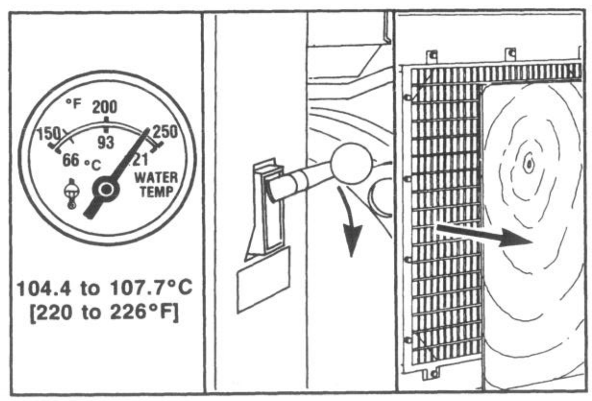
When the engine shuts off, IMMEDIATELY (Preferably before the engine speed drops 300 RPM) switch the installed "Bypass" switch to the "On" position. (If this does not keep the engine running, hold the Off-Run-Start switch in the "Start" position.) The red Coolant Shutdown light should come on when the engine starts to shut off.

Caution: Remove the generator load and the coolant system blockage if the water temperature exceeds 110° C (230° F). [The mark on the Water Temperature gauge between 93° and 121° C (200° and 250° F) indicates 107° C (225° F).]

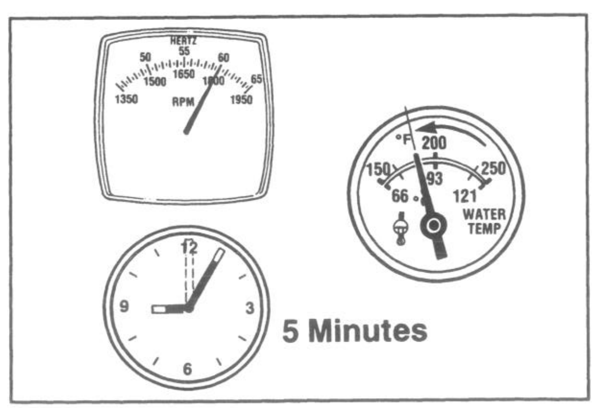


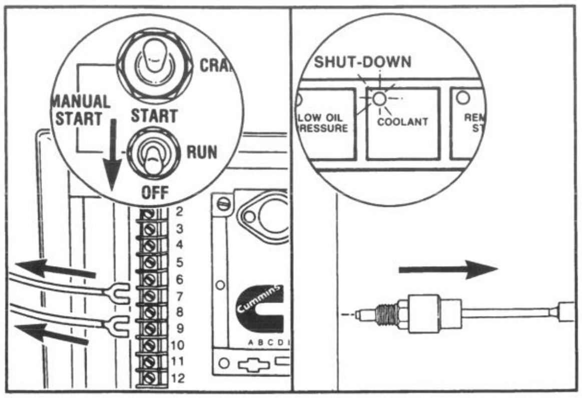
After the engine is running again,

1. Note the reading of the water temperature gauge. The temperature should be 104.4° to 107.7° C (220° to 226° F).
2. Turn off the generator load. (Load bank fans may be left running.)
3. Remove the blockage from the radiator (or heat exchanger raw water) outlet.



Continue to run the engine at rated speed, no load, for at least 5 mintues and until the coolant temperature gauge drops below 93° C [200° F].



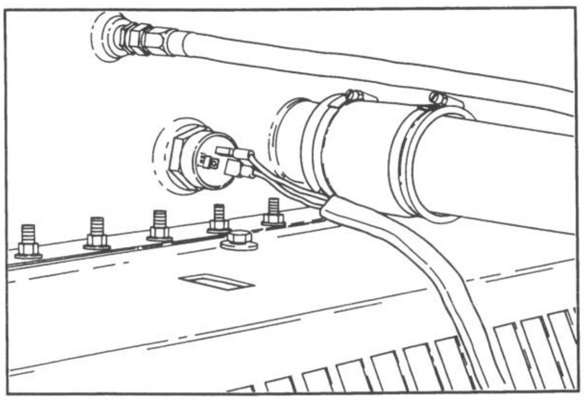


Move the Off-Run-Start switch to the "Off" position to stop the engine.

Remove the "Bypass" switch and leads from Engine Terminal Strip terminals No. 7 and No. 9.

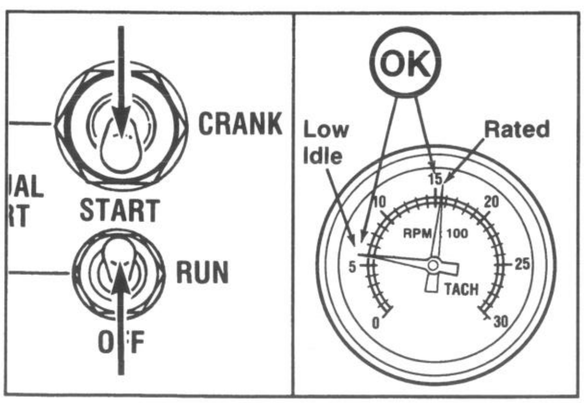
Replace the high coolant temperature alarm/shutdown switch if the Early Warning High Water Temperature light did not come on within the specified temperature range or the engine did not shut off within the specified temperature range.

Check the Coolant Shutdown Lamp and circuits if it did not light when the high coolant temperature shutdown switch operated.



Low Coolant Level Sensor (1-21)

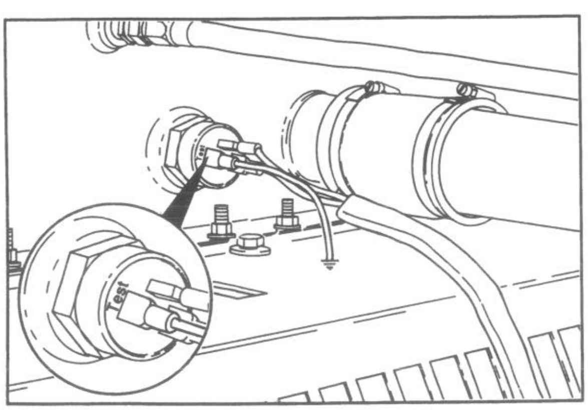
The housing of the three terminal sensor, Part No. 3046031, must be grounded. The Part No. 3046031 is normally used on units with a set mounted radiator. If the Part No. 3046031 sensor is used on a remote radiator, a No. 14 AWG minimum size ground wire must be installed between the generator set frame ground (B-, terminal No. 12) and the radiator frame.



Low Coolant Level Sensor Check

Fill the engine coolant system (See Procedure 1-05).

Start the unit, either manually or with the Test-Off-Auto switch in the Test position. The engine can be at low idle (approx. 600 RPM) or rated speed (1500 or 1800 RPM). See procedures 5-08 or 5-09.

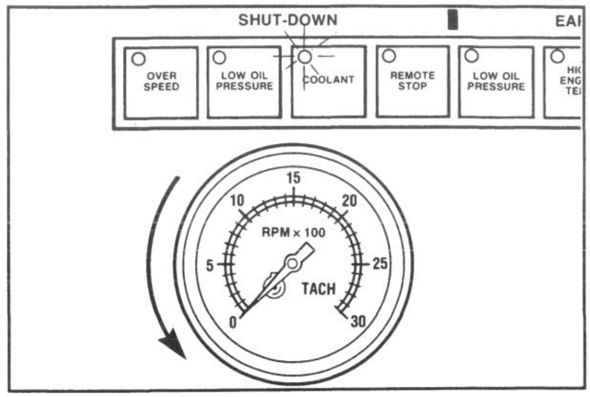


Connect the "Test" terminal of the sensor to a ground.

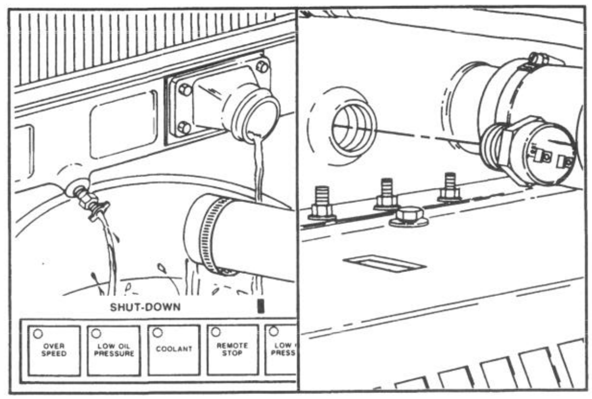
The coolant lamp must come on.

If the jumper J1 has been cut, the unit will stop.

If the coolant lamp is on, the sensor is working correctly. Make sure there is power to terminal No. 4 before replacing the sensor.



If the coolant lamp does not come on, stop the unit. Drain the coolant to below the level of the sensor and replace sensor. Fill the coolant system.



Belt Tension - Check (1-22)

Use the appropriate belt tension gauge to measure the belt tension.

Tighten the belts to the tension in the chart.

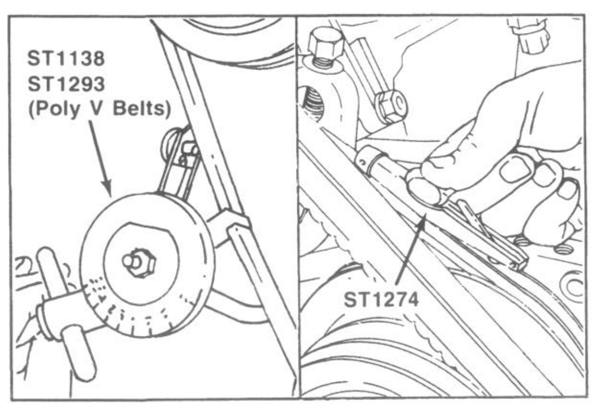
Belt Tension Chart (Pounds)

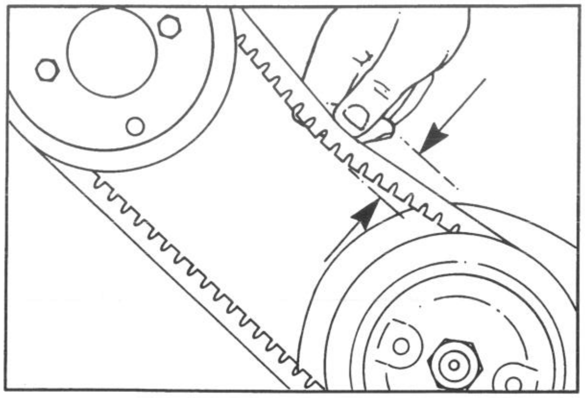
Belt Width Inches	Belt Gauge	New Belt Tension Min-Max	*Used Belt Installation Tension Min-Max
1/2	ST-1274	130-150	80-120
11/16	ST-1138	130-150	80-120
3/4	ST-1138	130-150	80-120
7/8	ST-1138	130-150	80-120
5 or 6 Rib	ST-1293	140-160	90-120
8 or 9 Rib	ST-1293	190-210	155-165

*Adjust used belts to the values in this column. If below minimum re-tension to maximum.

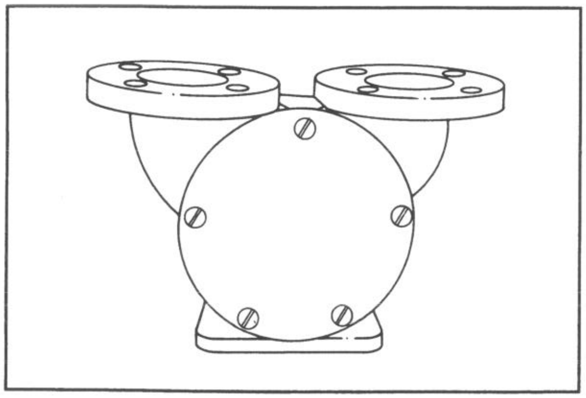
NOTE: A belt is considered used if it has been in operation for at least 10 minutes.

The illustrations show the gauges referenced in the belt tension chart.



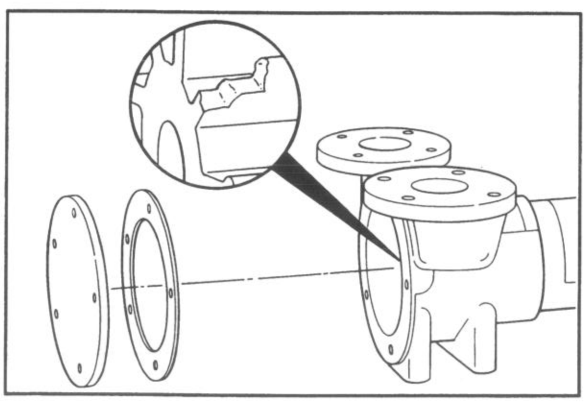


If there is not enough space to use a gauge, adjust "V" belts that have a deflection of more than one (1) belt thickness per foot of pulley center distance. Check belt deflection by applying a 110 N [25 lbs.] force midway between the pulleys on "V" belts.



Raw Water Pump - Check (1-23)

Raw water flow can be reduced by damaged impellers or air leaks in either the Jabsco or Gilkes raw water pumps. Jabsco raw water pumps are available on NT-855 and VT-28 series engines. Gilkes (Gilmec) raw water pumps are available on NT-855, KT-19, KT-38, and KTA-50 series engines.



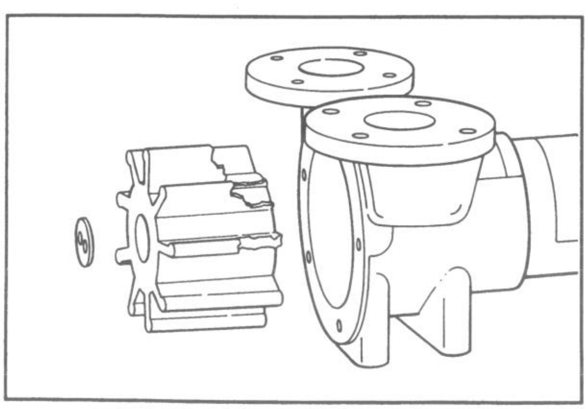
Jabsco Raw Water Pump - Check

Shut off the raw water inlet and outlet valves if the raw water pump is close to or below the raw water level.

Remove the fillister head screws from the end cover.

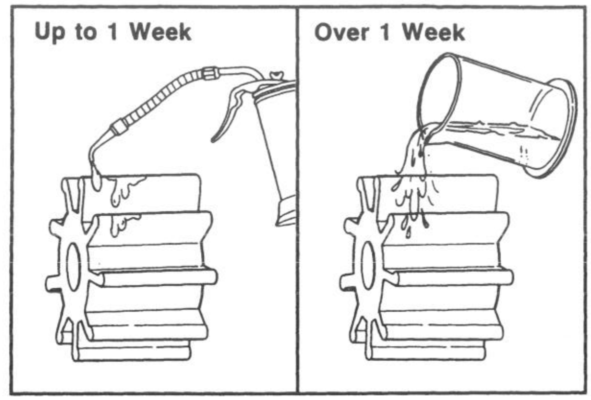
Remove the end cover. The rubber gasket may be reused if it is not damaged.

Check the impellers for damaged or missing blades. Jabsco pumps will normally operate satisfactorily if not more than two blades are missing.



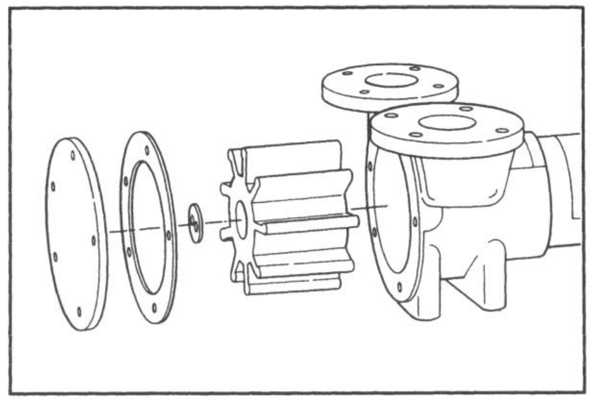
If more than two blades are missing, remove the spline seal(s) and impeller(s). Use water pump pliers or channel locks to hold the impeller hub when removing the impeller from the pump body.

The impeller(s) must be lubricated before installing in the pump body. If the pump will be used within a week, the impeller(s) can be lubricated with vaseline or engine lubricating oil. If the engine is to be stored for over a week, the impeller(s) must be lubricated with glycerine or water. The impeller is made of neoprene which deteriorates from prolonged exposure to petroleum based lubricants.

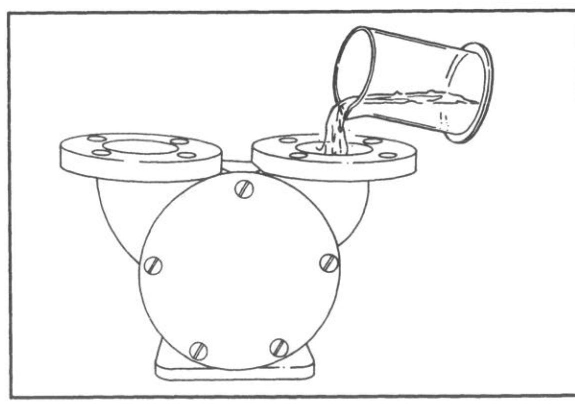


Install the impeller(s) on the shaft in the pump body.

If the cover plate gasket is damaged, use a new cover plate gasket. The gasket should be 0.38mm [0.015 inch] thick to maintain proper impeller-to-cover clearance. Install the cover plate.

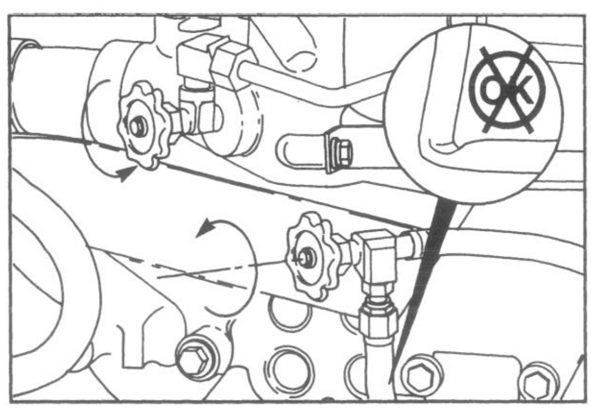


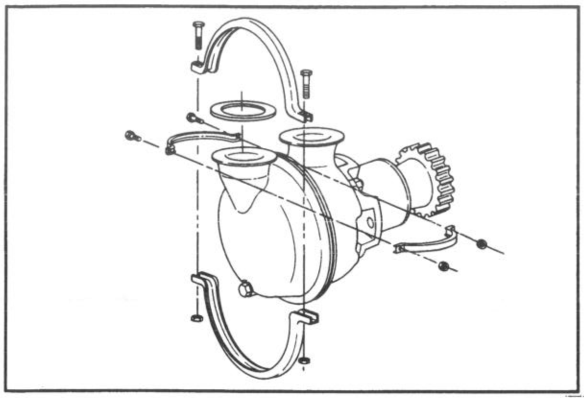
Fill the pump cavity with water to make sure the pump will have adequate lift if the engine is run at low idle.



Open the raw water inlet and outlet valves, if the unit is so equipped.

Check the raw water lines for restriction and air leaks.



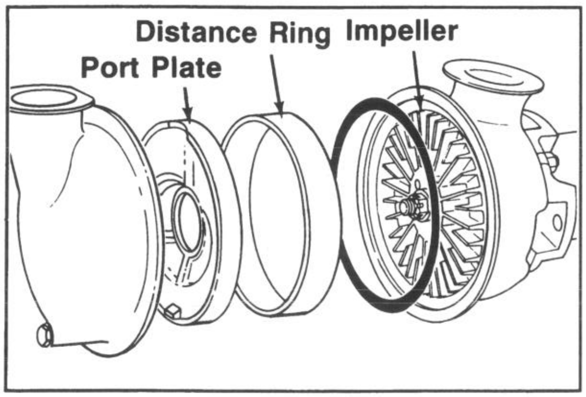


Gilkes (Gilmec) Raw Water Pump - Check

Shut off the raw water inlet and outlet valves if the raw water pump is close to or below the raw water level.

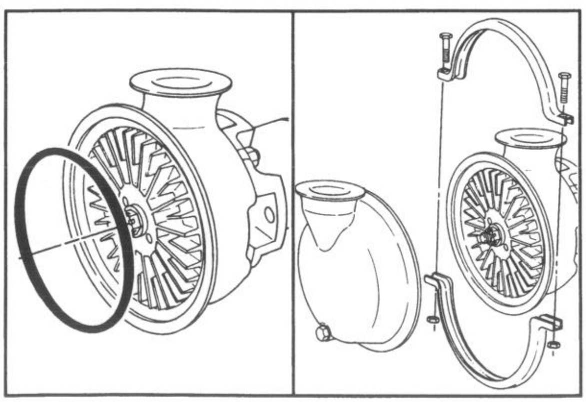
Remove the V-Band clamp end raw water pump gasket from the outboard port of the Gilkes pump.

Remove the V-Band clamp holding the two half bodies of the pump.



Remove the outboard half body.

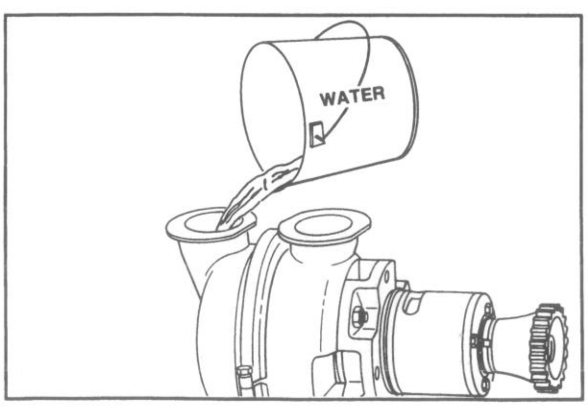
Examine the impeller, port plate and distance ring. Replace if damaged.



Assemble the O-ring on the pump.

Note: The O-ring normally can be used again.

Tighten the body V-band clamp nuts to 8 N•m [72 in-lb.].

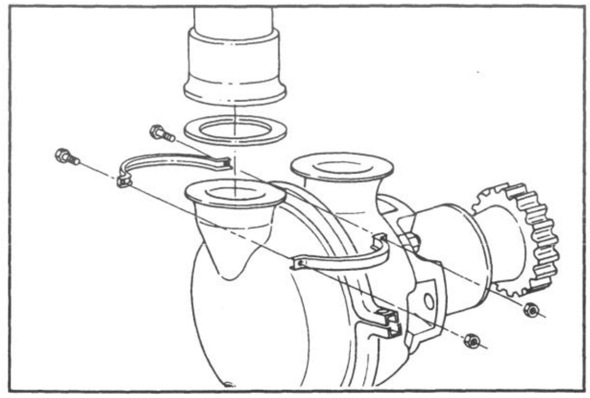


Fill the pump body with water.

NOTE: Although the Gilkes pump is self-priming, there must be water in the pump body for the pump to operate.

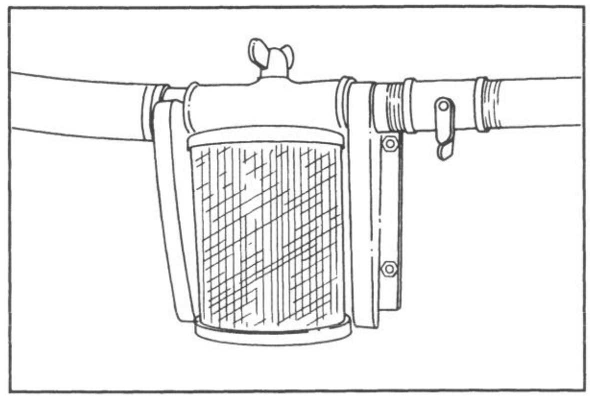
Assemble the raw water connection to the raw water line.

Tighten the raw water connection V-band clamp nuts to 8 N•m [72 in-lb.].



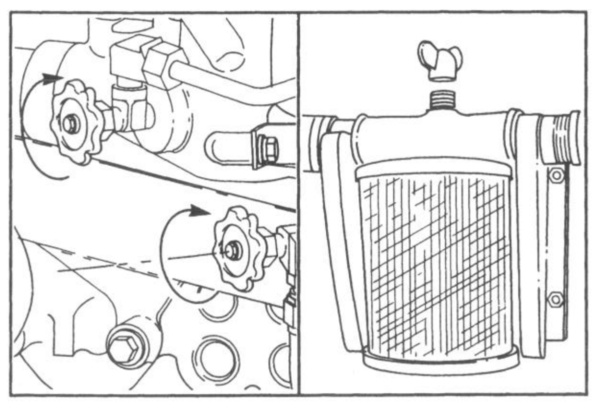
Raw Water Strainer - Check (1-24)

NOTE: Most raw water systems for heat exchanger cooled engines on boats and some land based heat exchanger cooled engines use a raw water strainer. The strainer removes debris from the raw water before it enters the raw water pump.

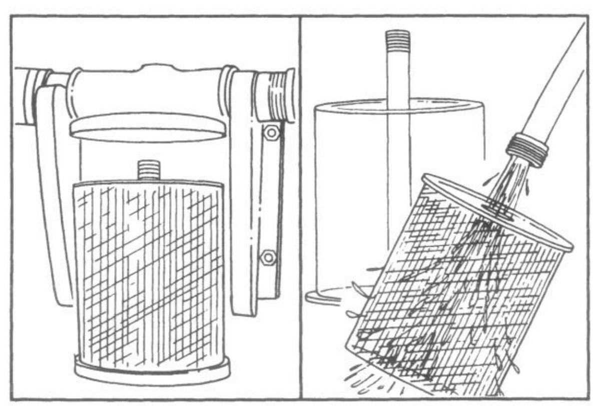


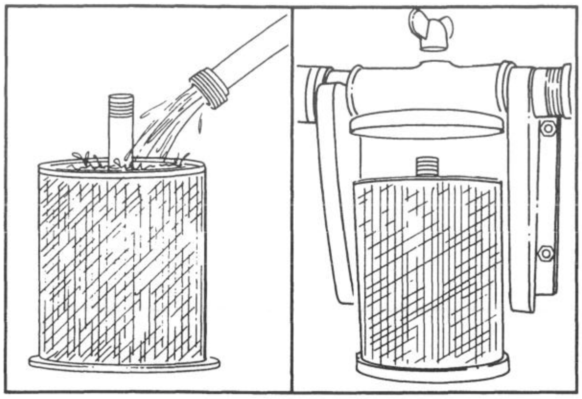
If the raw water strainer is below the raw water level (as on some marine applications), close the raw water inlet and outlet valves.

Loosen and or remove the raw water strainer wing nuts as required.



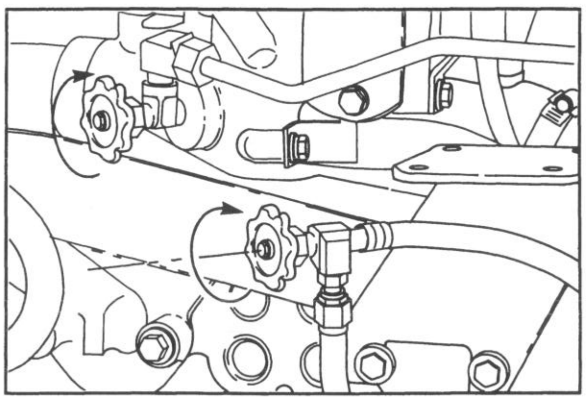
Remove the raw water (sea) strainer basket, empty the debris and wash the strainer basket.



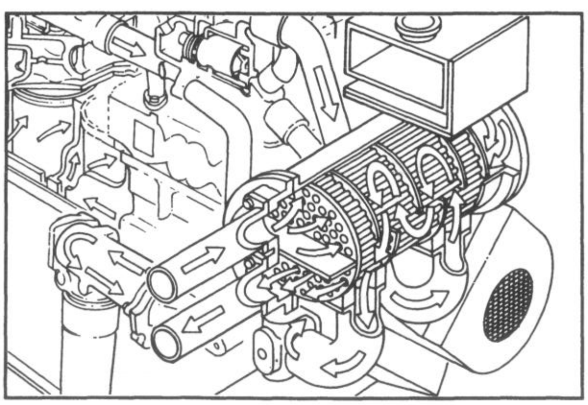


Prime the raw water strainer.

Install the raw water strainer. Install and tighten the wing nuts.



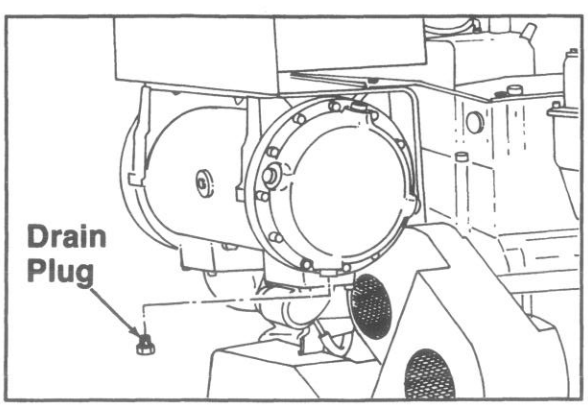
Open the raw water inlet and outlet valves, if these are a part of the system.



Heat Exchanger Element - Cleaning (1-25)

NOTE: The sea or raw water flows through the tubes in a heat exchanger and the engine water circulates around the tubes.

The heat exchanger tube bundle is removable on the NT-855, KT-19, KT-38, and KTA-50 series engines. It is **not** removable on the VT-28 series engine heat exchanger.



Drain the engine coolant. See Section 1-04.

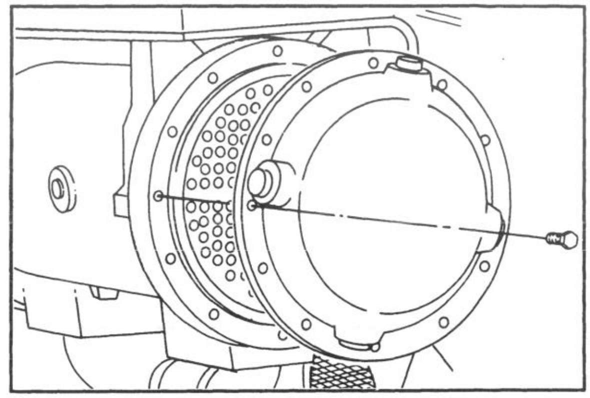
Close the raw water inlet valve if available.

Remove the drain plug from the heat exchanger and drain the raw water.

Remove the engine coolant line connections from the heat exchanger.

Remove the raw or sea water lines from the heat exchanger.

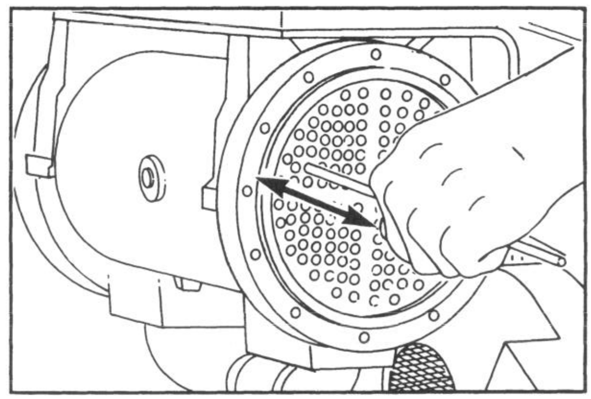
On NT-855, KT-19, KT-38, and KTA-50 series engines, the 12 capscrews can be removed from each end cover, and the end covers removed to permit access to the tube bundle.



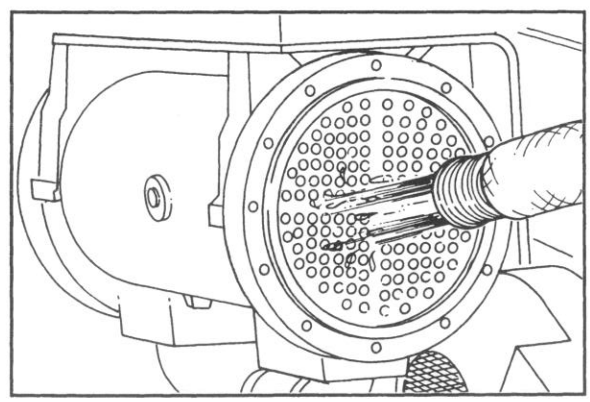
It is **preferable** to have the tube bundle or complete heat exchanger cleaned at a commercial radiator shop by boiling in caustic soda.

In an EMERGENCY the tubes may also be cleaned (rodded) by driving a steel rod through the tube, drilling with a dull drill bit, or driving a wood dowel rod through the tubes.

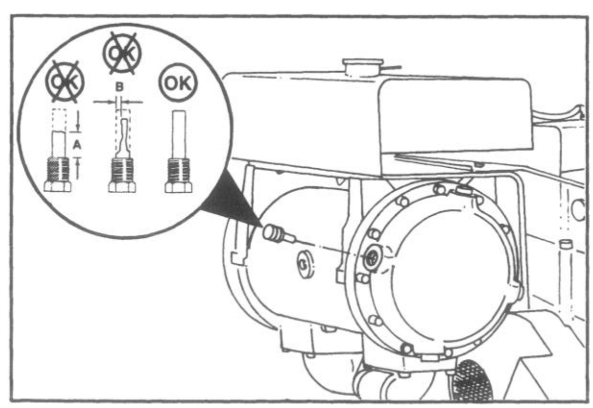
Caution: Wood dowel rods can break and mushroom outward. Broken dowel rods are difficult to remove.

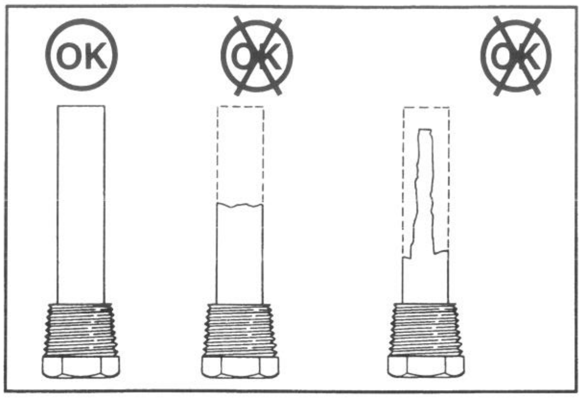


Flush the heat exchanger tubes with clean water. Make sure the end cavities are cleaned of all debris. Assemble the heat exchanger.



Erosion of the tube bundle end plates is a sign of galvanic action. This erosion is inhibited by the action of the zinc anode. Remove the zinc anode.



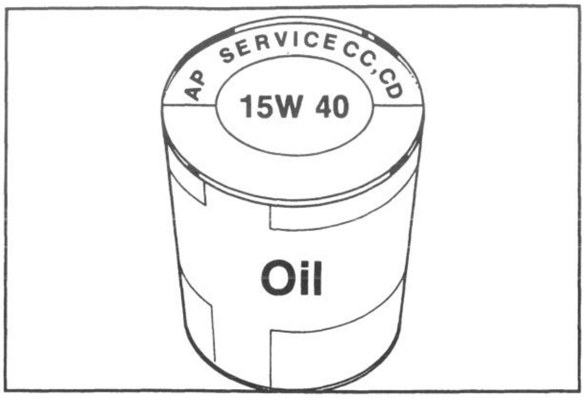


Inspect the zinc anode. If it has eroded over 50 percent, replace the plug.

Section 2 - Lubricating Oil System

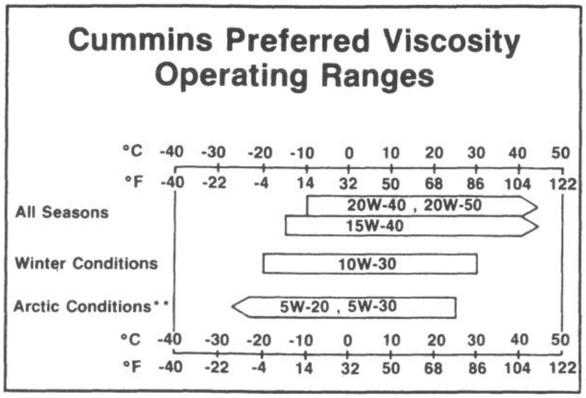
Table of Contents

System Troubleshooting and Repair List



General Information (2-01)

Cummins Engine Company, Inc. recommends the use of multiviscosity lubricating oil, preferably 15W-40, if ambient conditions permit. The oil must meet API Classification CC/CD for turbocharged engines.



Caution: Limited use of oils, such as 10W or 10W-30, may aid in starting the engine and providing sufficient oil flow at ambient temperatures below -5° C [23° F]. However, the continuous use of low viscosity oils may decrease engine life. Refer to the accompanying chart.

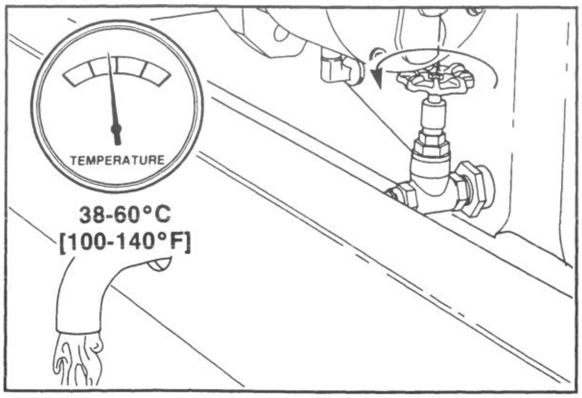
Lubricating Oil System Specifications (2-02)

	NT-855 Series	KT-19 Series	VT-28 Series	KT-38 Series	KTA-50 Series
Oil Pressure					
Idle (Min.) kPa (psi)	103 (15)	140 (20)	140 (20)	140 (20)	140 (20)
1500/1800 RPM (Min.) kPa (psi)	345 (50)	345 (50)	345 (50)	310 (45)	310 (45)
Oil Pan Capacity					
High, Litres (U.S. gal.)	34.0 (9)	38 (10)	68 (18)	114 (30)	125 (33)
Low, Litres (U.S. gal.)	26.5 (7)	32 (8.5)	60.5 (16)	87 (23)	95 (25)
Oil Filter Capacity					
Full Flow, Litres (U.S. gal.)	2.6 (0.7)	5.3 (1.4)	13.2 (3.5)	7.9 (2.1)	10.6 (2.8)
Bypass, Litres (U.S. gal.)	2.8 (0.73)	2.8 (0.73)	5.5 (1.46)	5.5 (1.46)	5.5 (1.46)
Total Oil System Capacity (Including Bypass Filter)					
Litres (U.S. gal.)	39.8 (10.5)	46 (12.1)	84.4 (22.3)	132 (35)	146 (38.5)

Required Service Tools - (2-03)

Lubricating Oil System

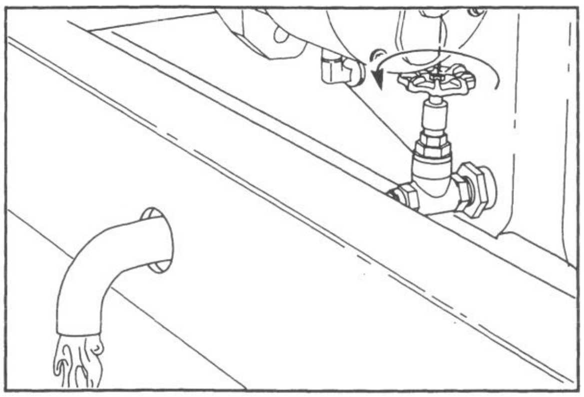
Part No.	Description
3376898	Multimeter - Use to measure Volts, K Ohms, and Milliamperes. (B and K Precision 2845, Auto-ranging Digital Multimeter).
N.A.	Digital Thermometer - Fluke Model Number 51 or 52.



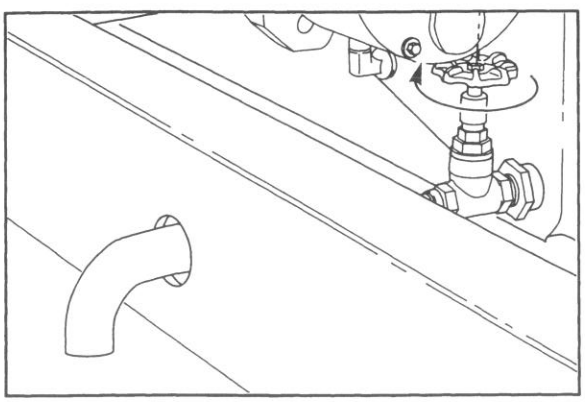
Drain the Oil (2-04)

Warning: Hot oil can cause serious personal injury.

Note: It is best to drain the oil when the oil temperature is 38 to 60° C [100 to 140° F] to permit good drainage.

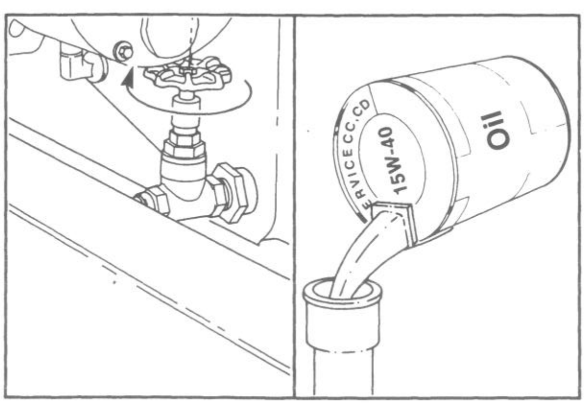


Drain the oil by opening the oil drain gate valve. This valve is located inside the base rail, opposite the fuel pump side on all generator set series except the VT-28 series. The VT-28 series generator set oil drain valve is inside the fuel pump side base rail.



Close the oil drain gate valve.

Note: The oil filter(s) must also be changed during the oil change. For additional maintenance information, refer to Bulletin #3379052-10 or the specific engine O&M manual.



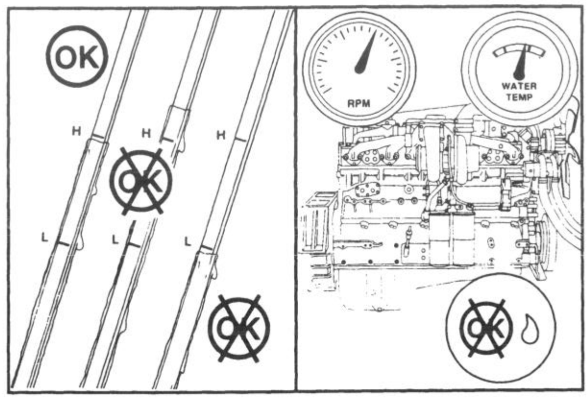
Fill the Oil Pan (2-05)

Close the oil drain gate valve.

Add the specified amount of clean 15W-40 oil to fill the oil pan. Refer to section 2-02 for engine oil capacity.

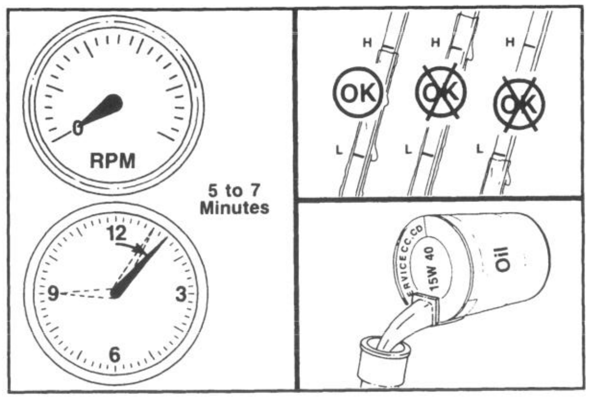
Check the oil level on the dipstick. It must be filled to the "H" (high) mark.

Operate the engine to normal operating temperature and check for oil leaks.



Shut the engine off and wait 5 to 7 minutes for the oil to drain back to the oil pan.

Check the oil level. Add oil as necessary to bring the level up to the "H" (high) mark on the dipstick.

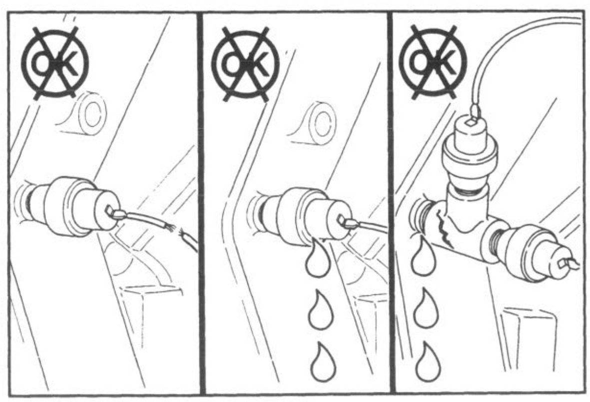


Oil Pressure Gauge and Sender - Check (2-06)

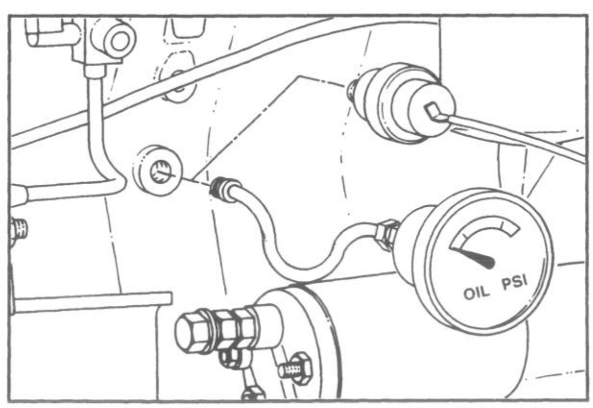
Test

Check for the following defects:

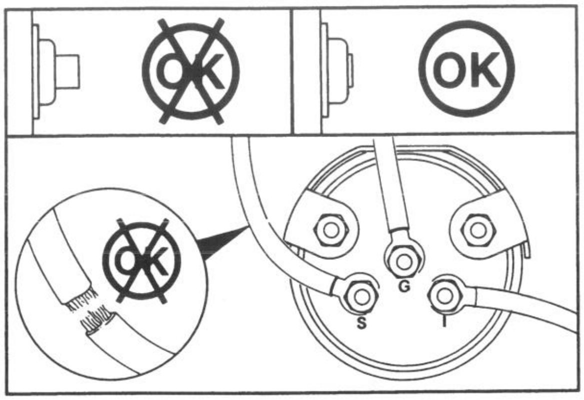
1. Electrical wiring at sender and gauge broken, loose or shorted.
2. Plumbing broken or loose.



Use a master gauge of known accuracy to verify the reading of the suspect gauge. Connect the line from the master gauge to the main oil rifle on the same side as the sending unit. Replace the sending unit and oil pressure gauge if there is a significant difference from the master gauge reading.

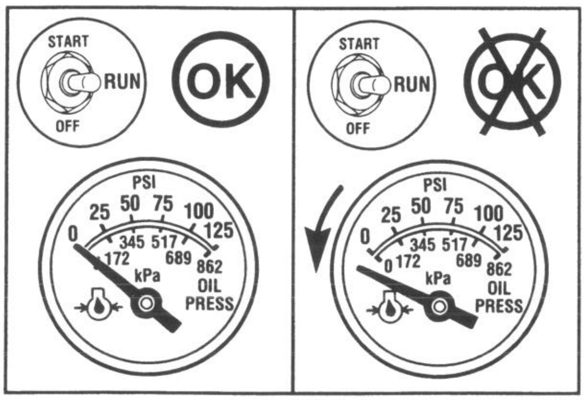


Oil Pressure Gauge - Verification (2-07)



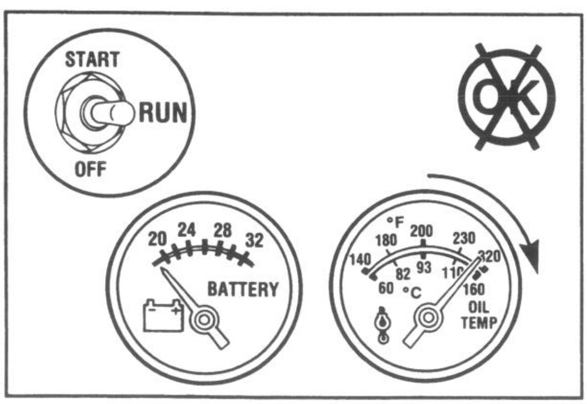
Make sure the engine control panel DC circuit breaker is closed.

Check the wiring to the pressure gauge for broken, loose or shorted wires.

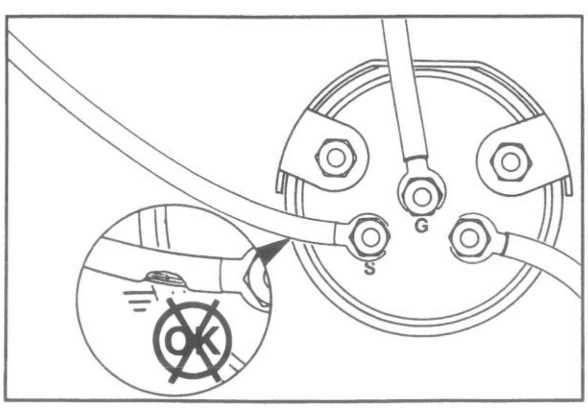


Stop the engine, move the Off-Run-Start Switch to the "Run" position.

1. The gauge must show "O" or below pressure.
2. If the gauge pointer moves to the left when the switch is moved to the "Run" position, check for broken or disconnected sender wire (No. 74) at gauge, sender or plugs B, D, F, H, or K.



3. If the pointer moves off of the scale to the right when the switch is moved to the "Run" position, check for a broken or disconnected ground wire (No. 12) The battery voltmeter will show low if wire No. 12 is faulty.

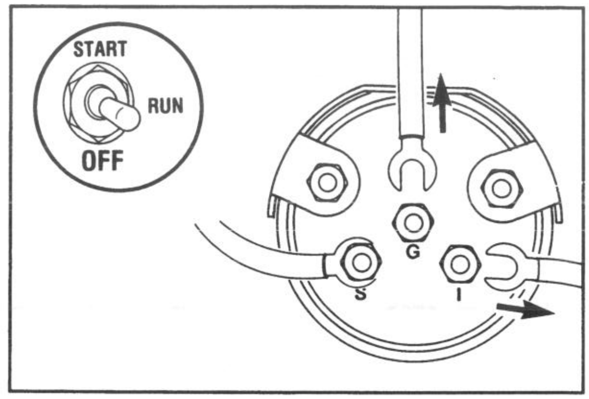


4. If the ground connection is good, check for a shorted sender or a short between the sender wire (No. 74) and ground, per the last step in this section.

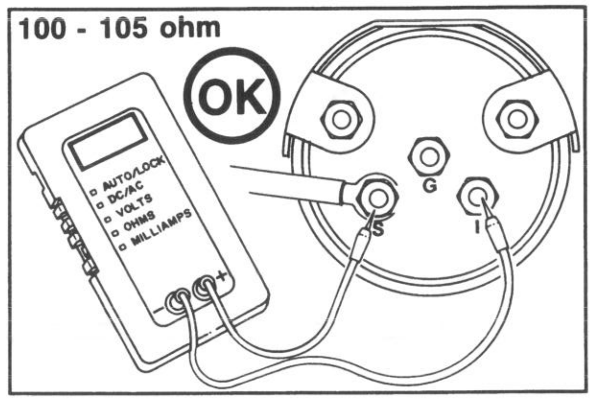
Note: The last step in this section does not check for a short of wire No. 74.

Move the Off-Run-Start Switch to the "Off" position.

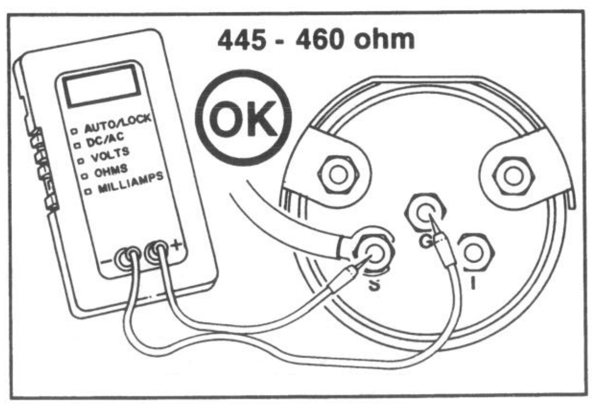
Remove the wires from the gauge terminals "I" (Wire No. 5) and G (Wire No. 12)



Use the Part No. 3376898, Multitester, to measure the resistance between gauge terminals I and S. The acceptable resistance is 100 to 105 ohms. Replace the gauge if it is outside of these limits.

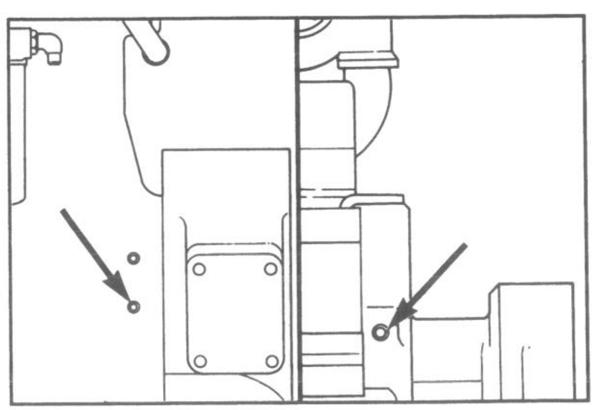


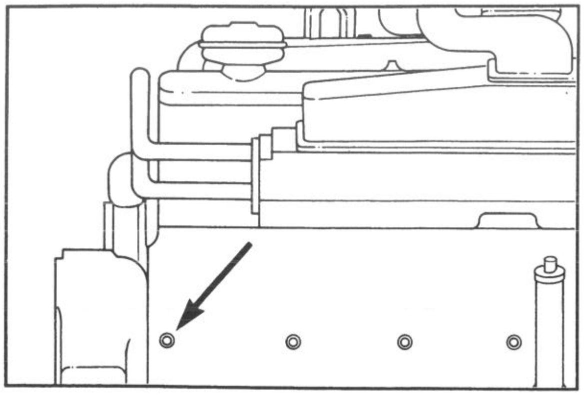
Measure the resistance between gauge terminals G and S. The acceptable resistance is 445 to 460 ohms. Replace the gauge if it is outside of these limits.



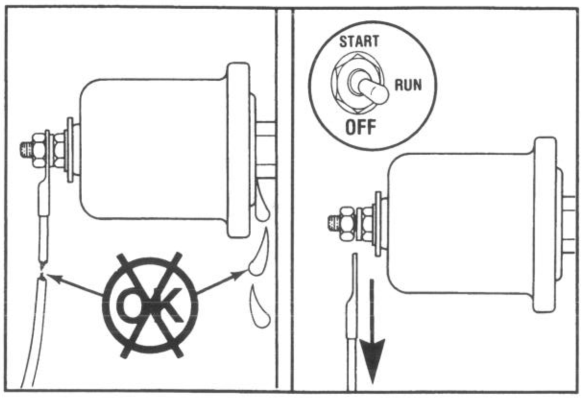
Oil Pressure Sender - Verification (2-08)

The oil pressure sender is located in the oil passage on the fuel pump side of the NT-855, KT-19, KT-38 and KT-50 series generator sets.





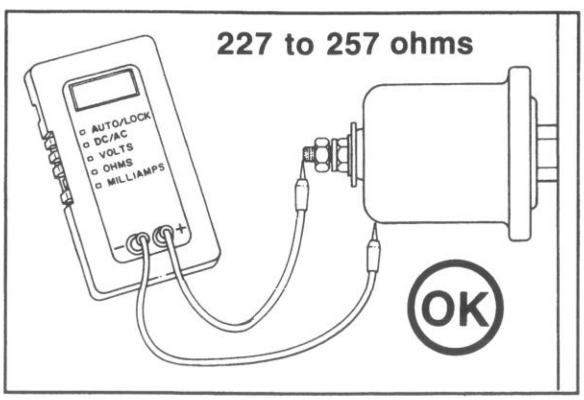
On the VT-28 series generator sets, it is located in the oil passage, opposite the fuel pump side, toward the rear of the block.



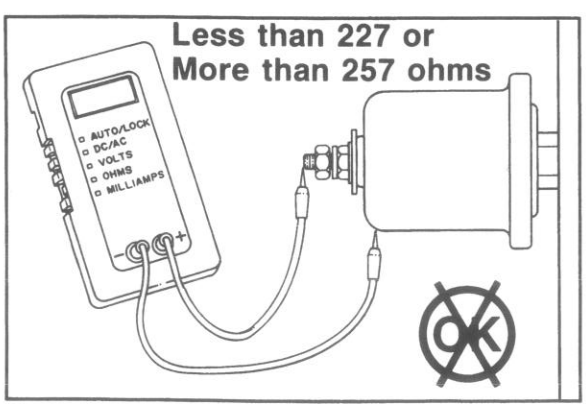
Check the oil pressure sender for a broken or disconnected wire and leaks.

Repair, splice or replace the wire or part as required.

Stop the engine, remove the wire from the sender.



Use the 3376898 Multitester to measure the resistance between the sender terminal post and ground. At "0" pressure, the resistance must be 227 to 257 ohms.



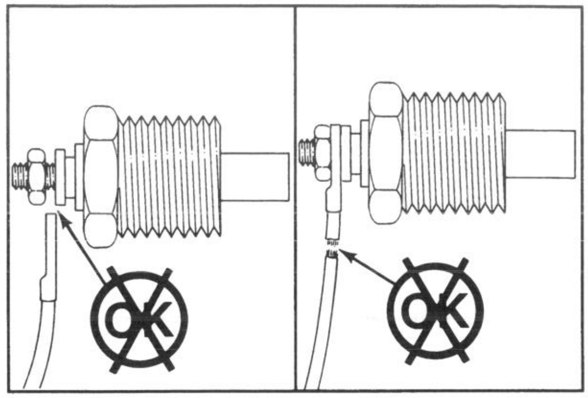
Replace the Part No. 3015237, Pressure Sender, if the resistance is not within these values.

Note: This sender has higher resistance at low pressure, it can not be replaced by the Part No. 208603 Sender.

Oil Temperature Gauge and Sender - Check (2-09)

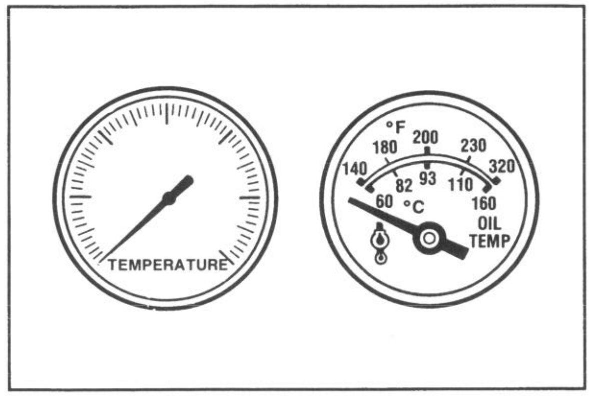
Check the electrical wire at the sender and gauge. Make sure it is not broken, loose or shorted.

Note: The oil temperature sender is located on the fuel pump side on all generator set engines. It is located in the oil pan on the NT-855, KT-19, KT-38 and KT-50 series engines. On the VT-28 series engines, the sender is located in the oil transfer tube below the fuel pump.



Use a master gauge of known accuracy or a surface temperature probe to check the calibration of the suspect gauge and sender. If a master gauge is used, install the sensor in the oil pan.

Replace the sending unit and oil temperature gauge if there is a significant difference from the master temperature gauge reading.

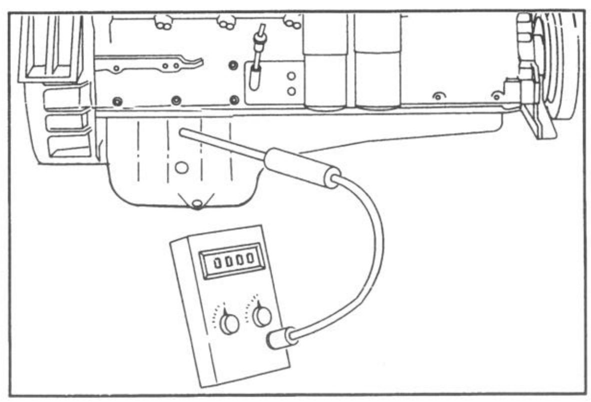


Note: A thermocouple in the oil and a pyrometer are the ideal means of checking the calibration of the oil temperature gauge and sender. However since there is very little blast air cooling of the oil pan, the surface temperature of the pan is close to the actual oil temperature.

A Fluke Model No. 51 or 52 may be used to measure surface temperatures.

Digital Thermometer, Part No. (N.A.) can be used to measure the oil pan surface temperature.

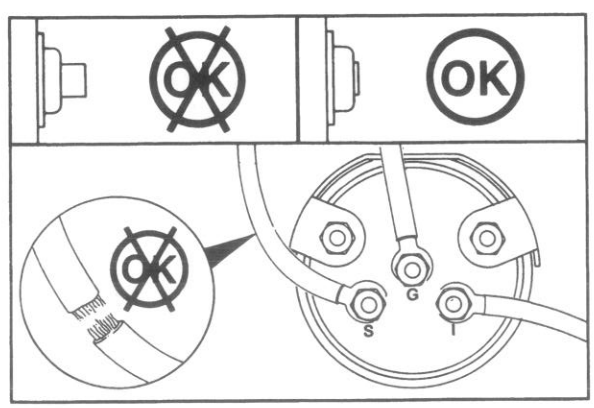
Note: Section 2-10 and 2-11 provide a means of troubleshooting the oil temperature gauge and sender as individual parts. They do not provide a method of checking the calibration of the oil temperature measurement system.

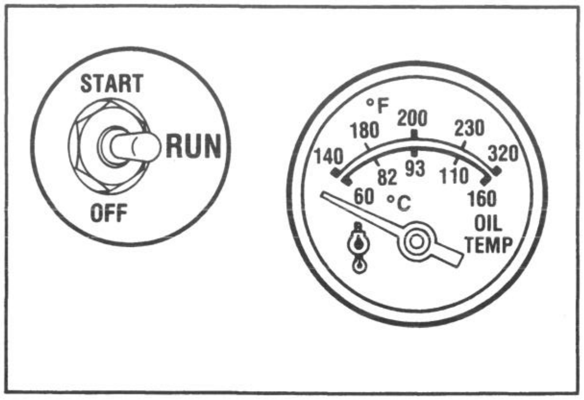


Oil Temperature Gauge - Verification (2-10)

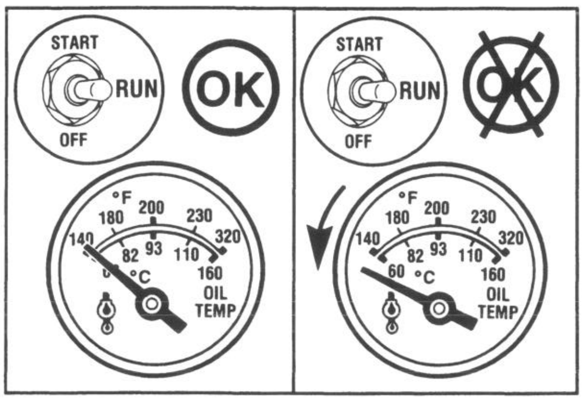
Make sure the engine control panel DC circuit breaker is closed.

Check the wiring to the temperature gauge for broken, loose or shorted wires.

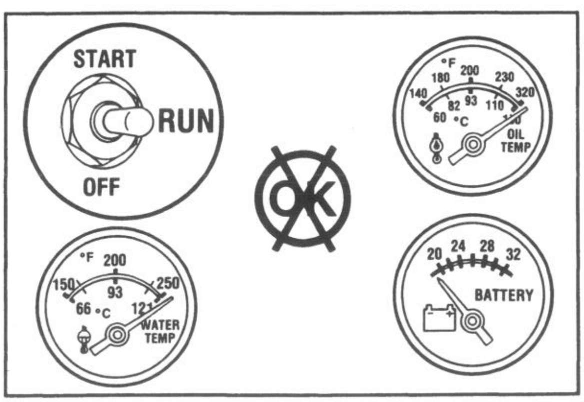




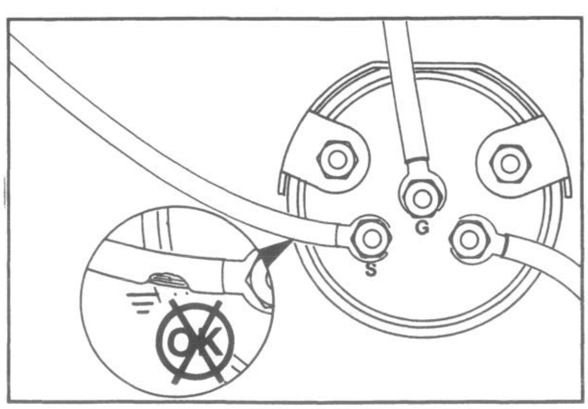
Stop the engine, move the Off-Run-Start Switch to the "Run" position. The gauge will show the engine oil temperature if the oil temperature is above 60° C (140° F). Refer to Section 2-09. If the engine has not been operated for 16 hours, the oil temperature is probably below 60° C [140° F] and the pointer will be slightly below the 60° C [140° F] mark.



1. If the pointer moves to the left, below the pointer position when the Off-Run-Start Switch was in the "Off" position, check for a broken or disconnected wire (No. 75) at the gauge, sender or plugs B, D, F, H or K.



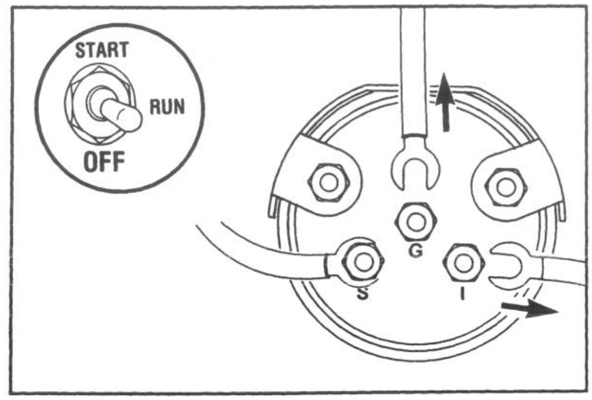
2. If the pointer moves off of the scale to the right when the switch is moved to the "Run" position, check for a broken or disconnected ground wire (No. 12). The battery voltmeter will also show low and the water temperature will show high if wire No. 12 is faulty.



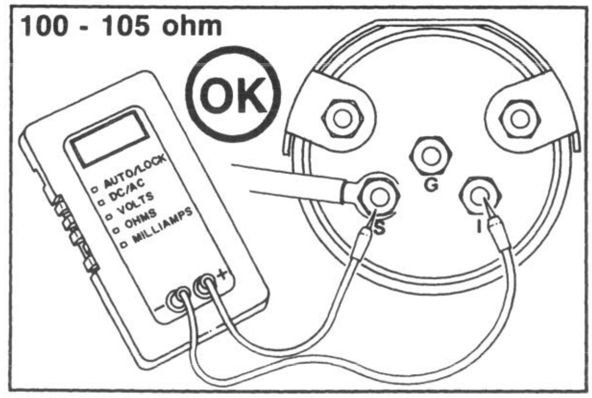
3. If the ground connection is good, check for a shorted sender or a short between the sender wire (No. 75) and ground.

Move the Off-Run-Start Switch to the "Off" position.

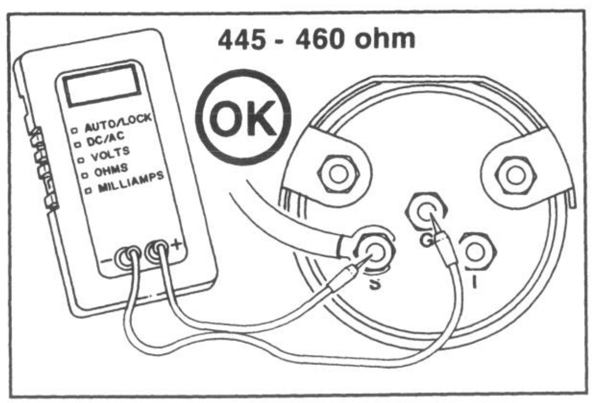
Remove the wires from the gauge terminals "I" (Wire No. 5) and G (Wire No. 12)



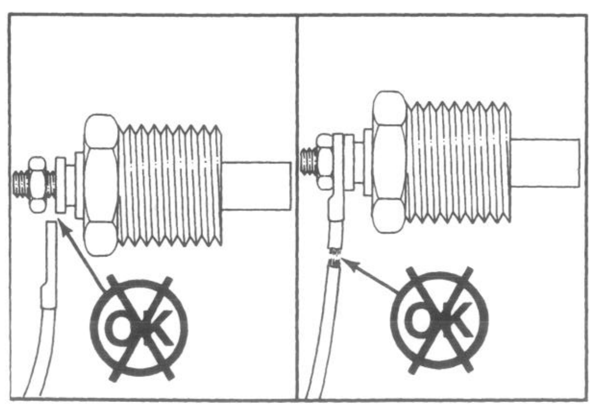
Use the Part No. 3376898, Multitester, to measure the resistance between gauge terminals I and S. The acceptable resistance is 100 to 105 ohms. Replace the gauge if it is outside of these limits.



Measure the resistance between gauge terminals G and S. The acceptable resistance is 445 to 460 ohms. Replace the gauge if it is outside of these limits.



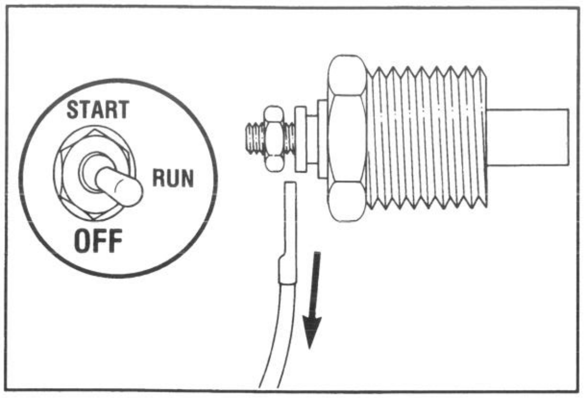
Oil Temperature Sender - Verification (2-11)



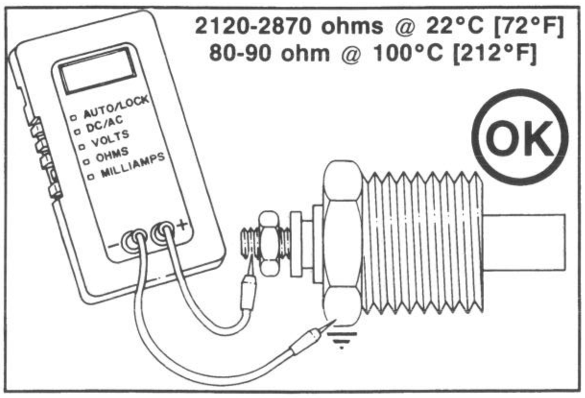
The oil temperature sender is located in the oil pan on the fuel pump side on the NT-855, KT-19, KT-38 and KT-50 series generator sets. It is located in the oil transfer tube below the fuel pump on the VT-28 series generator sets. See section 2-08.

Check the oil temperature sender for a broken or disconnected wire.

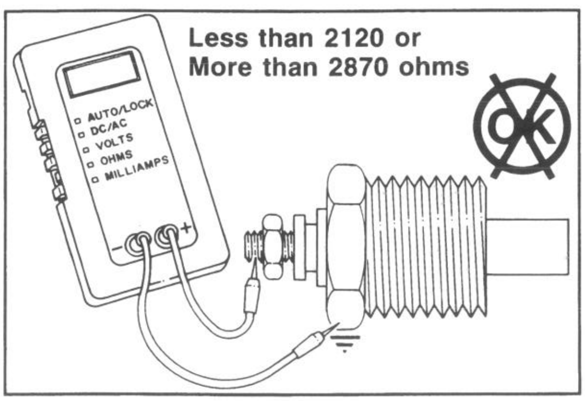
Repair, splice or replace the wire or part as required.



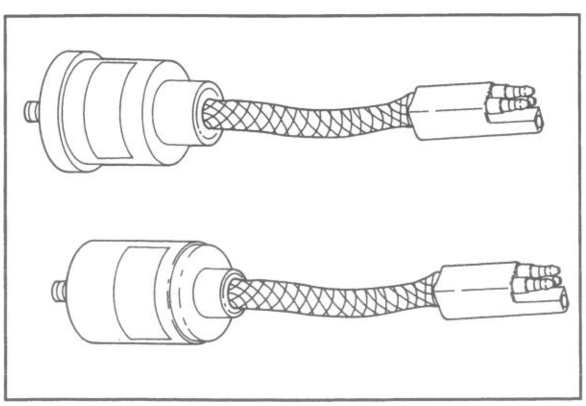
Stop the engine, remove the wire (No. 75) from the sender.



Use the Part No. 3376898, Multitester, to check for continuity between the sender terminal and ground. The resistance to ground increases as the temperature goes down. At 22° C, [71.6° F] the resistance to ground will be 2120 to 2870 ohms. At 60° C, [140° F] the resistance to ground will be approximately 270 ohms. At 93° C, [200° F] the resistance to ground will be approximately 106 ohms.



Replace the Sender if it is open or shorted to ground.



Low Oil Pressure Switch(es) - Check (2-12)

Operation

There are two different low oil pressure switches. Cummins Part No. 3034864 pressure switch is a single pole, double throw switch which operates at 97 to 69 kPa [14 to 10 psi] on decreasing pressure.

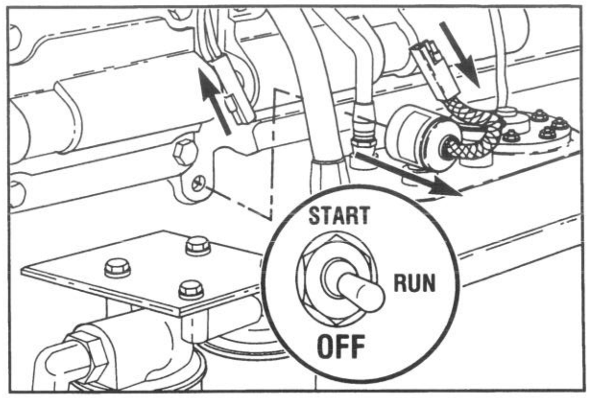
Cummins Part No. 3034863 contains two pressure switches in one enclosure. The alarm switch operates at 130 to 110 kPa [20 to 16 psi] on decreasing pressure. The shutoff switch operates at 97 to 69 kPa [14 to 10 psi] on decreasing pressure.

Test

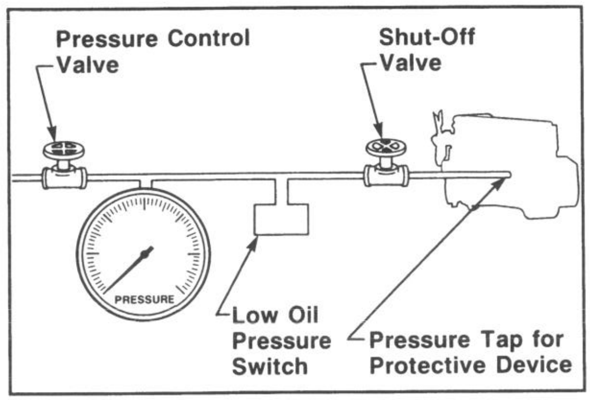
Stop the engine.

Unplug the switch from the harness.

Remove the pressure switch from the engine block.

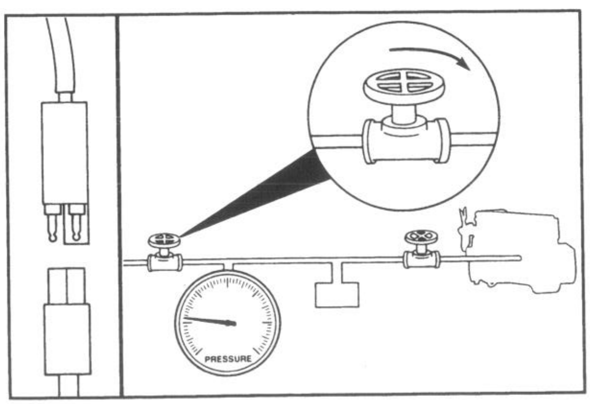


Connect the pressure switch as shown with the pressure switch and gauge in approximately the same horizontal plane as the engine block pressure tap.



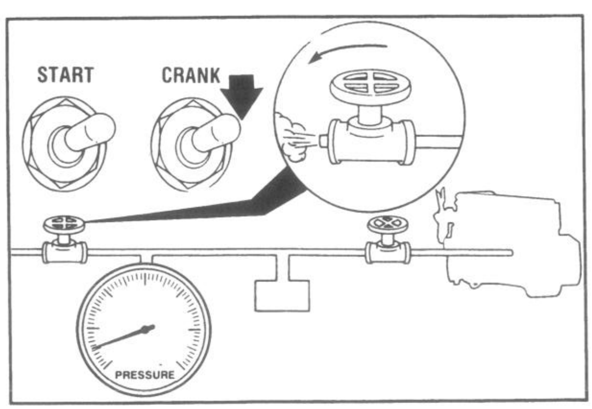
Connect the switch plug to the wiring harness.

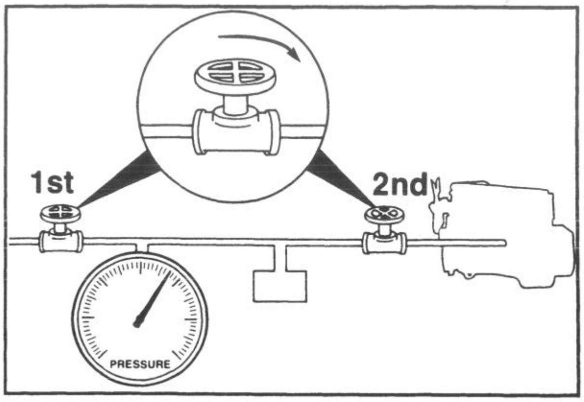
Close the pressure control valve.



Manually start the engine. Operate the engine at no load. The engine is to be operated at rated speed per MIL-STD-705B, Method 515.1a. The engine can be operated at low idle if it is more convenient.

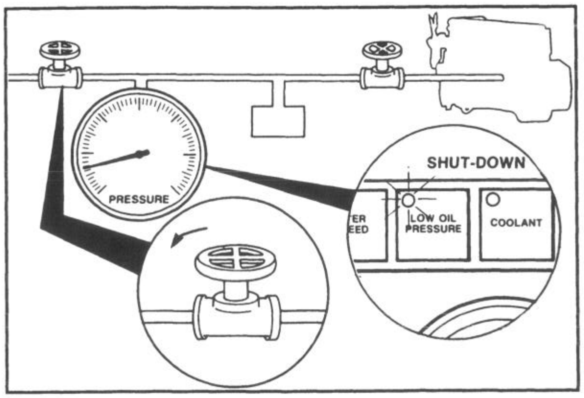
Open the pressure control valve slightly to remove the air from the system.





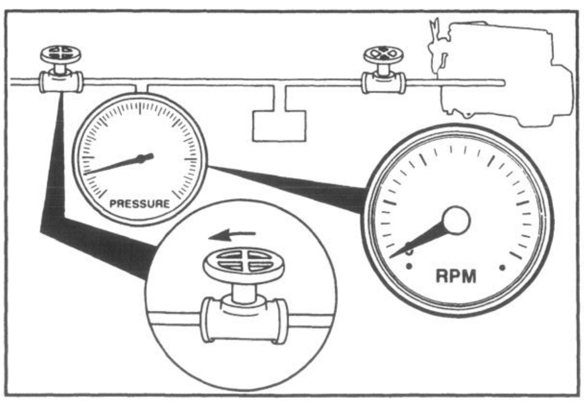
Close the pressure control valve when the air is out of the lines.

Close the system shut-off valve to hold the pressure in the lines.



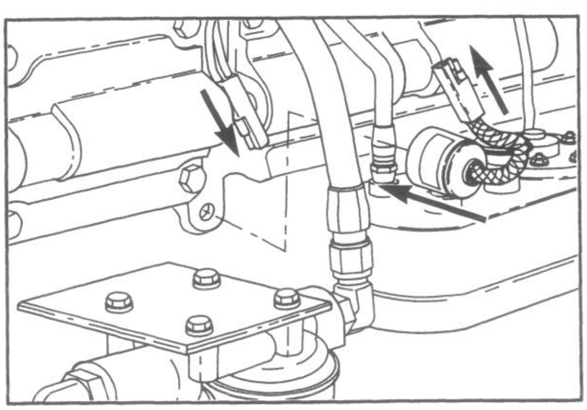
Slowly open the pressure control valve to lower the pressure.

If testing Part No. 3034863, Switch, notice the gauge pressure at the point when the pre-shutoff alarm light comes on. This will be 138 to 110 kPa [20 to 16 psi].



When testing Part No. 3034863 or 3034864, Switch, notice the gauge pressure at the point when the engine stops. This will be 97 to 69 kPa [14 to 10 psi].

If the switch operation pressures are outside of these values, replace the switch.

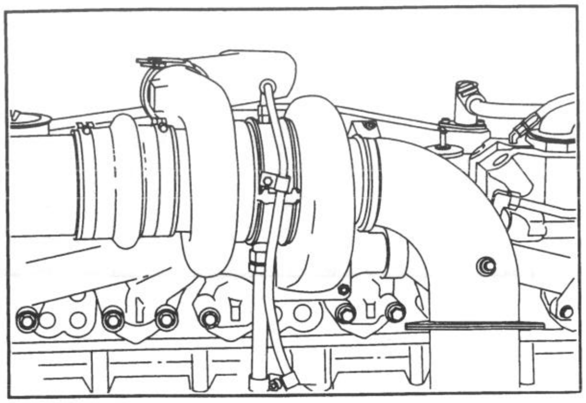


Disconnect the oil pressure switch from the harness, remove the switch from the valve arrangement and install it in the engine block. Reconnect the engine harness.

Section 3 - Combustion Air System

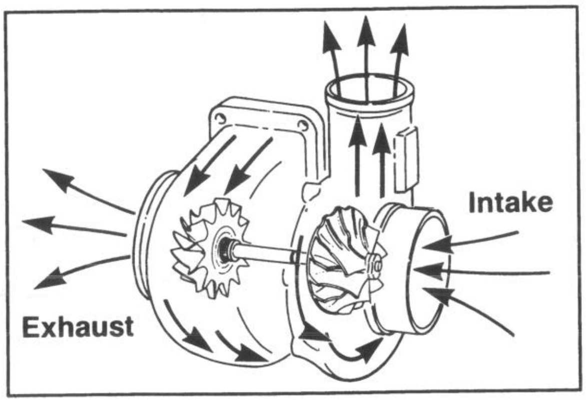
Table of Contents

System Troubleshooting and Repair List



General Information (3-01)

The " Combustion Air system" consist of intake air piping, turbocharger, and exhaust air piping.



The turbocharger uses exhaust gas flow to provide pressurized intake air to the engine.

Combustion Air System Specifications (3-02)

Air Induction System

Maximum Engine Inlet Air Temperature Before Derating Engine Horsepower..............................38° C [100° F]

Deration Factor..2% per 11° C above 38° C [1% per 10° F above 100° F]

Maximum Intake Restriction (Clean Air Filter Element)

Light Duty Type Air Cleaner..250 mm H_2O [10.0 in. H_2O]

Heavy Duty Dry Type Air Cleaner ....380 mm H_2O [15.0 in. H_2O]

Maximum Intake Restriction (Dirty Air Filter Element)..635 mm H_2O [25.0 in. H_2O]

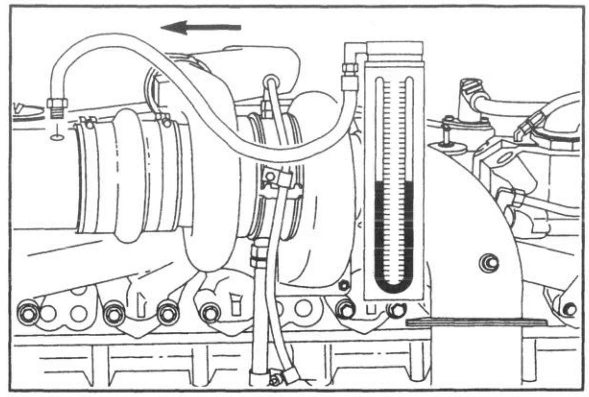
Exhaust System

Maximum Back Pressure From Piping and Silencer (Combined)............................75 mm Hg or 1016 mm H_2O [3.0 in. Hg. or 40.0 in. H_2O]

Intake Air Restriction - Check (3-03)

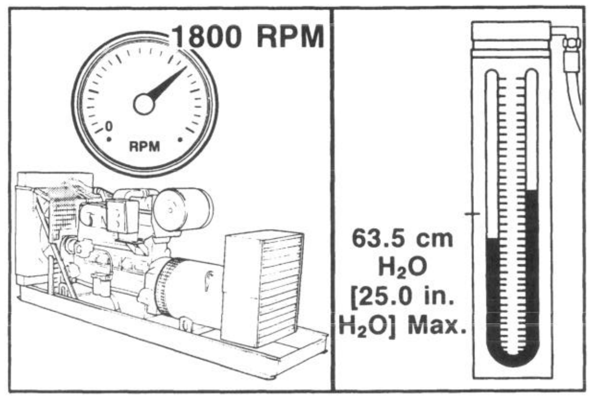
Install a vacuum gauge or water manometer in the intake air piping.

Caution: The gauge adapter must be installed at a 90 degree angle to the air flow in a straight section of pipe, one pipe diameter before the turbocharger.

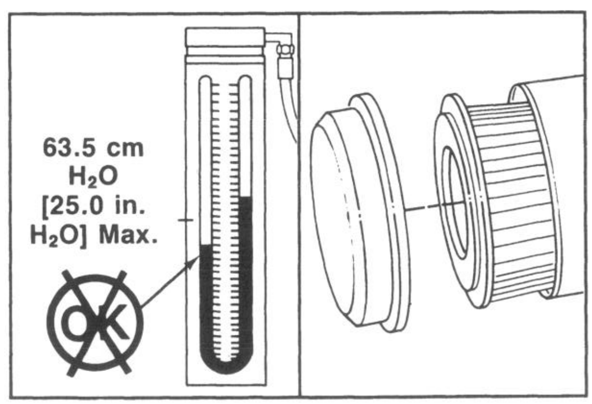


Operate the engine at rated load and speed. Record the reading on the gauge or manometer.

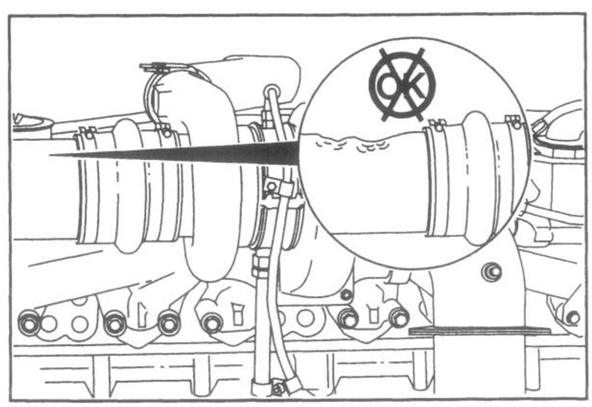
NOTE: Restriction **must** not exceed 635 mm H_2O [25.0 inches H_2O].

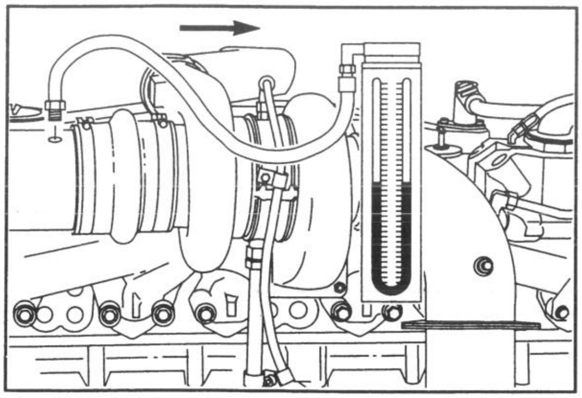


If the restriction exceeds the specifications, replace or clean the air filter element.

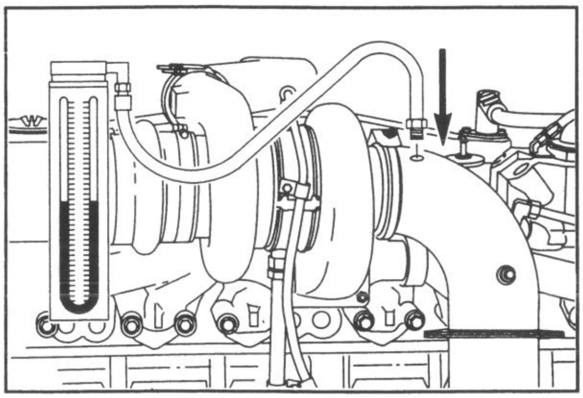


Visually inspect the intake air piping for damage.



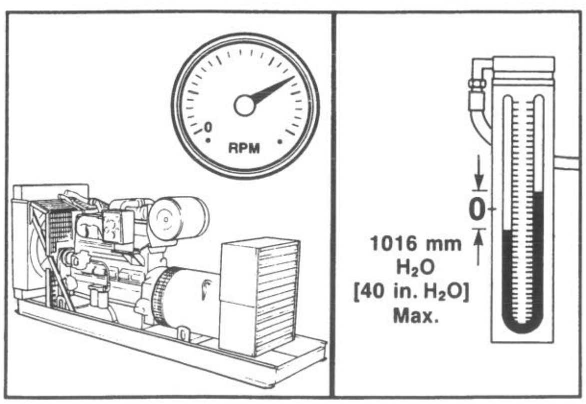


Remove the test equipment.



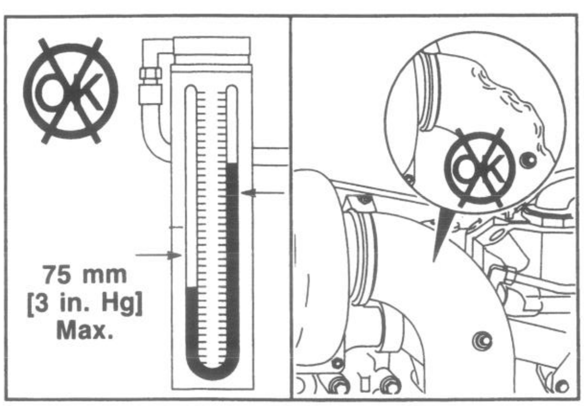
Exhaust Restriction - Check (3-04)

Connect a water manometer after the turbine housing as close as possible in a straight section of pipe.



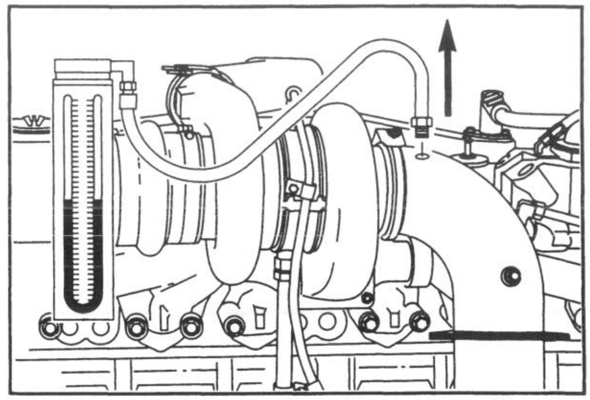
Operate the engine at rated load and speed. Record the manometer reading.

NOTE: Restriction must not exceed 1016 mm H_2O [40 inches H_2O].



If restriction exceeds the specifications, visually inspect the exhaust piping for damage.

Remove the test equipment.



Section 4 - Fuel System

Table of Contents

Service Troubleshooting and Repair List

Section 4 - Fuel System

Table of Contents

Service Troubleshooting and Repair List

Generator Set Fuel System - General Information (4-01)

Cummins Diesel Generator Sets using the 14 liter (NT-855) displacement and larger engines use the Cummins PT Fuel System with a precise generator set governor. The PT Fuel System consists of the PT fuel pump, supply lines, drain lines, fuel passages and injectors.

The precise generator set governor maintains a precise engine speed (plus or minus 1/4 percent, i.e. plus or minus 4.5 RPM at 1800 RPM and plus or minus 3.75 RPM at 1500 RPM) at any constant load.

Any one of three different precise generator set governors can be supplied on Cummins generator sets. These are designated as:

EFC (Electric Fuel Control)
United Technologies (Formerly American Bosch or Ambac)
Woodward (Models PSG and 2301)

Different variations of each of these governors are available. The "plug in" normally closed EFC governor is included in the generator set pricing configuration and is supplied unless some other option is specified. This manual covers the operation of the normally closed and normally open EFC governors. The operation of the United Technologies and Woodward governors are covered in the supplier catalogs on these governors. The supplier catalogs are included as a part of this fuel system chapter.

All electric governors today sense engine speed by means of a magnetic pickup mounted in the flywheel housing. The magnetic pickup senses the movement of flywheel ring gear teeth. A signal from the governor control is sent to the governor actuator which regulates the amount of fuel provided to the injectors. The EFC actuator is located inside the fuel pump in the EFC cavity. The United Technologies actuator is located external to the fuel pump and essentially regulates the fuel flow from the fuel pump to the injector supply line. All Woodward governors and actuators move the fuel pump automotive throttle to regulate fuel to the injectors.

The Woodward PSG hydraulic governor senses speed by means of flyweights. The Woodward model EGB-2P actuator normally receives its signal from the Woodward 2301 controller. However, if the electric signal fails, the EGB-2P actuator contains a PSG hydraulic flyweight governor which will govern the engine at a slightly (normally 105 percent of rated) higher speed.

If either the normally closed EFC or United Technologies actuators lose the electrical signal, the actuator will completely stop all fuel flow to the injectors.

Cummins Engine Company does not concur with the use of governor components from different manufacturers to assemble an engine governing system. While there are some actuators that will work quite well with another manufacturers governor control, no manufacturer will assume responsibility for satisfactory operation of a hybrid governor system. Very expensive difficulties have been encountered in attempting to make hybrid governor systems function on paralleled generator sets.

Fuel System Specifications (4-02)

Generator Set Requirements

Engine Idle Speed....600 to 700 RPM

Fuel Inlet Maximum Restriction
- Clean Fuel Filter....102 mm Hg. (4.0 inch Hg.)
- Dirty Fuel Filter....203 mm Hg. (8.0 inch Hg.)

Fuel Drain Line Maximum Restriction
- Without Check Valves....102 mm Hg. (4.0 inch Hg.)
- With Check Valves....165 mm Hg. (6.5 inch Hg.)

Fuel Check Valve between Fuel Pump and Cylinder Head
- Opening Pressure....21 to 55 kPa (3 to 8 psi)

Fuel Check Valve in Fuel Drain Line
- Opening Pressure....13 to 25 mm Hg. (1/4 to 1/2 psi)

Derate Engine Fuel Rate for
- High Altitude....4% per 300 M (1000 ft) above 1525 m (5,000 ft.)

Derate Engine Fuel Rate for
- Hot Weather....2% per 11° C Above 38° C (1% per 10° above 100° F)

Shutoff Valve Solenoid Coil Resistance in Ohms - 24VDC....28 - 32

Fuel Oil Recommendations

Cummins diesel engines have been developed to take advantage of the high energy content and generally lower cost of No. 2 diesel fuels. A Cummins diesel engine will also operate satisfactorily on No. 1 fuels or other fuels within the following specifications.

Fuel Oil Recommended Properties:

Viscosity (ASTM D-445)	1.3 to 5.8 CentiStoke (1.3 to 5.8 mm^2 per second) at 40° C [104° F].
Cetane Number (ASTM D-613)	40 minimum except in cold weather or in service with prolonged low loads, a higher cetane number is desirable.
Sulfur content (ASTM D-129 or 1552)	Not to exceed 1% by weight.
Water and Sediment (ASTM D-1796)	Not to exceed 0.1% by weight.
Carbon Residue (Ransbottom ASTM D-524 or D-189)	Not to exceed 0.25% by weight on 10% residue.
Flash Point (ASTM D-93)	52° C [125° F] minimum. Certain marine registries require higher flash points.
Density (ASTM D-287)	-1 to 6° C [30 to 42° F] A.P.I. at 16° C [60° F] (0.816 to 0.876 Sp. Gr.)
Cloud Point (ASTM D-97)	5.6° C [10° F] below lowest temperature expected to operate.
Active Sulfur-Copper Strip-Corrosion (ASTM D-130)	Not to exceed No. 2 rating after 3 hours at 50° C [122° F].
Ash (ASTM D-482)	Not to exceed 0.02% by weight.
Distillation (ASTM D-86)	The distillation curve should be smooth and continuous. At least 90% of the fuel should evaporate at less than 360° C [680° F]. All of the fuel should evaporate at less than 385° C [725° F].

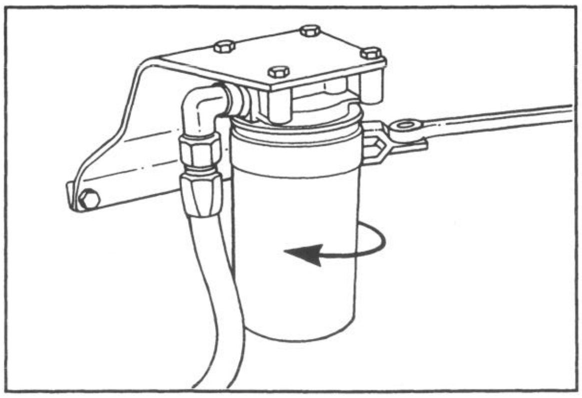
Required Service Tools (4-03)

Fuel System

Part No.	Description
ST-434	Vacuum Gauge Kit - Includes
ST-434-12	Vacuum Gauge, 0-760 mm Mercury, [0-30 inch Mercury (Hg)]
3375845	Hose Adapter, No. 12 Hose
ST-434-2	Hose Adapter, No. 10 Hose
ST-998	Fuel Sight Glass, No. 10 Hose, SAE 45° Fittings, For NT-855 and KT-19 Engines
ST-1273	Pressure Gauge, 0-1900 mm Mercury, [0-75 inch Mercury (Hg)]
ST-1375	Dial Gauge Attachment
3375049	Filter Wrench
3375362	Fuel Sight Glass, No. 12 Hose, SAE 45° Fittings, For VT-28 Engines
3375599	AFC Barrell Puller
3375808	Fuel Sight Glass, No. 16 Hose, JIC 37° Fittings, For KTTA-38 and KTA-50 Engines
3375855	Level and Angle Indicator
3376050	Dial Indicator and Sleeve Assembly
3376547	Governor Plug Tool
3376613	Trim Potentiometer Screwdriver
3376718	Hose - No. 12, JIC 37° Fittings, For KT-38 Engines
3376719	Hose Adapter - No. 12, JIC 37° Fittings, For KT-38 Engines
3376897	Cycle (Frequency) Meter
3376898	Multitester, Use to Measure Volts, K Ohms, and Milliamperes; (B and K Precision 2845 Auto-ranging Digital Multimeter)
3376922	Hose Adapter, No. 16, JIC 37° Fittings, For KTTA-38 and KTA-50 Engines
3377462	Digital Optical Tachometer

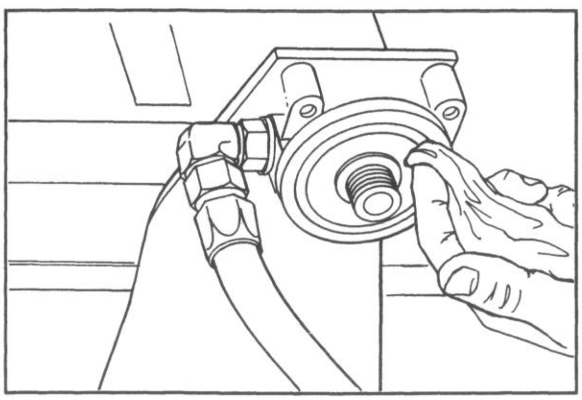
Warning - Hazardous Locations (4-04)

Operating a diesel engine in a combustable atmosphere can result in a fire, an explosion, and an engine run-away. Cummins Generator sets are not " Explosion Proof" . The engine could possible run at uncontrolled speeds on air containing various hydrocarbons such as gasoline vapor, propane, methane, acetylene, ether, etc. in excessive amounts.

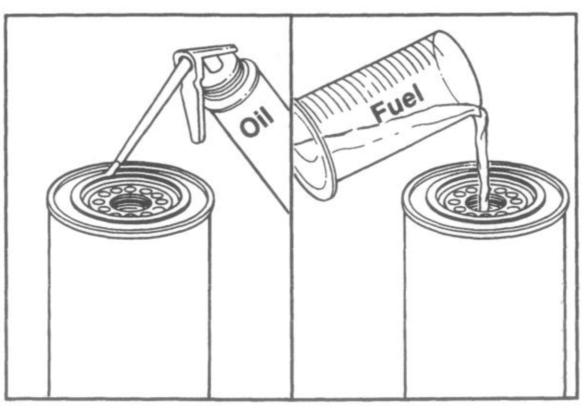


Fuel Filter - Replace (4-05)

Remove the fuel filter with Part No. 3375049, Filter Wrench.



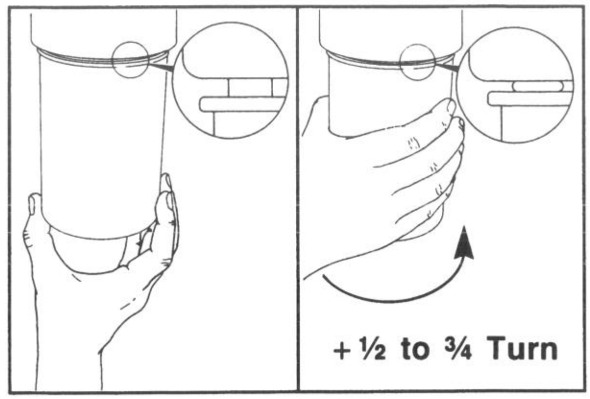
Use a clean, lint-free towel to clean the filter head gasket surface.



Apply a light coating of clean engine oil to the filter gasket surface.

Fill the filter with clean fuel.

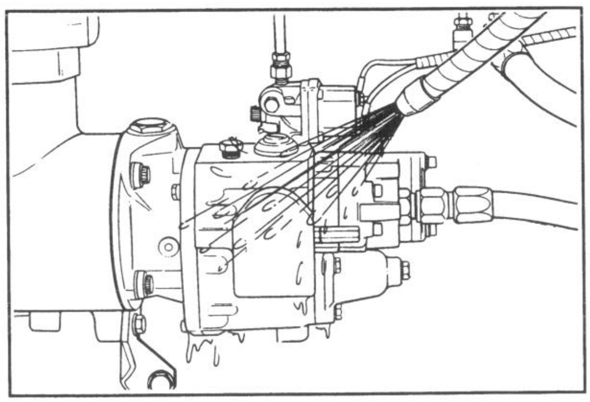
Install the filter on the filter head. Tighten the filter per the manufacturer's recommendations found on the filter.



Fuel Pump - Prime (4-06)

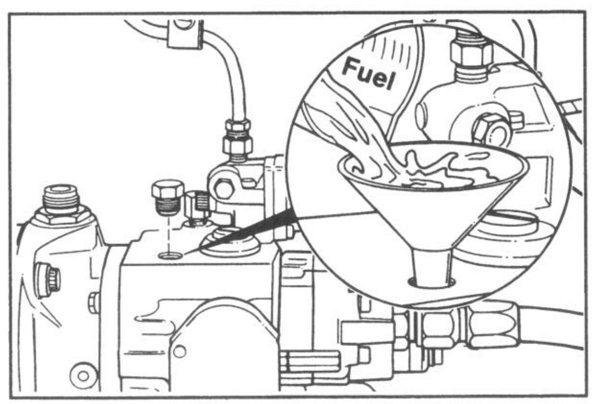
To reduce engine cranking time, prime the fuel pump.

Note: If the fuel pump is dirty, clean the outside of the pump.

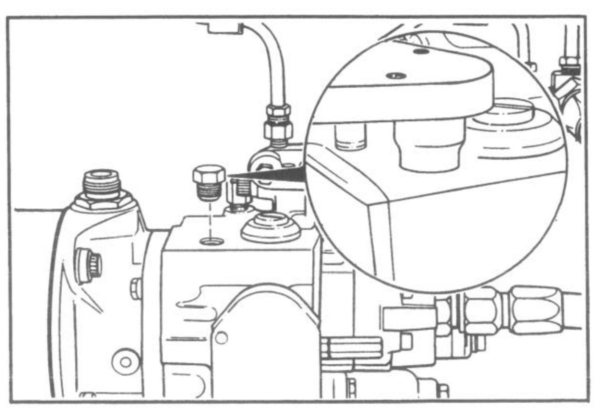


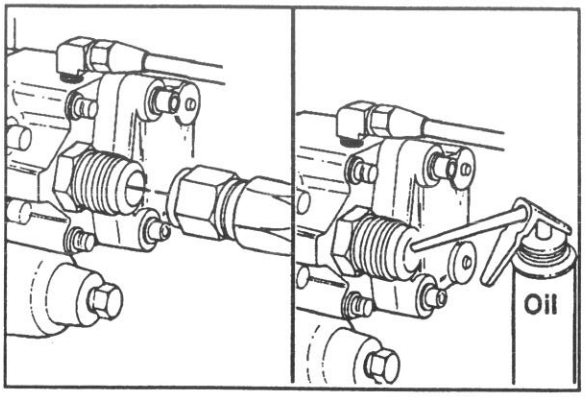
Remove the plug from the top of the housing.

Fill the housing with clean fuel.



Tighten the plug to 30 N•m [20 ft. lb.] torque.

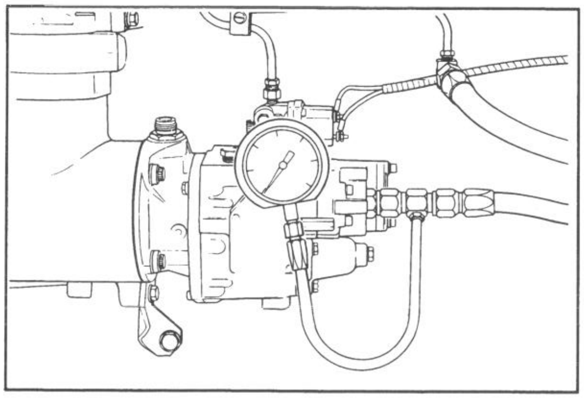




If the priming plug is hard to remove or the fuel pump is a VS type, remove the fuel supply hose to the gear pump.

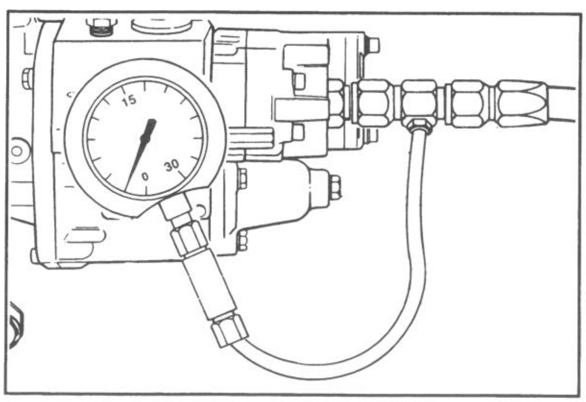
Fill the gear pump with clean engine lubricating oil.

Install the supply hose to the gear pump.

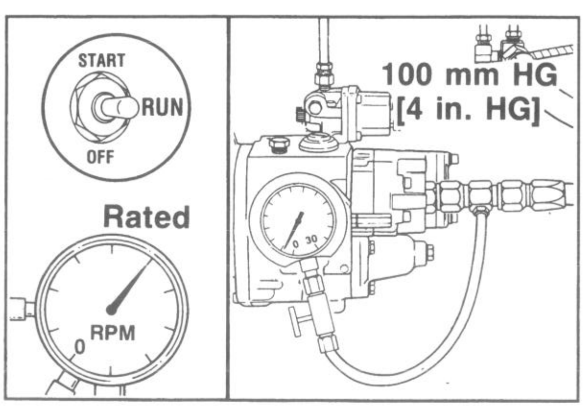


Fuel Supply Line Restriction - Check (4-07)

Remove the fuel supply hose to the gear pump and install the vacuum gauge, Part No. ST-434-12. Use the appropriate hose adapter for the specific engine as described in the Service Tools list.



Hold the gauge at the same level as the gear pump.



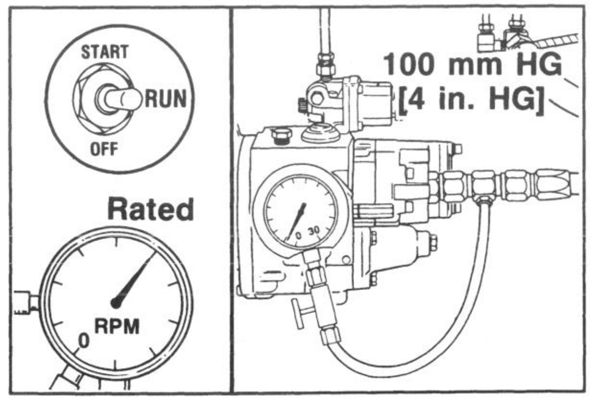
Operate the engine at rated speed and rated load, if available. If the rated load can not be applied, operate at the maximum load available up to the rated load.

Observe the reading on the gauge.

Note: The maximum fuel inlet restriction is as follows:

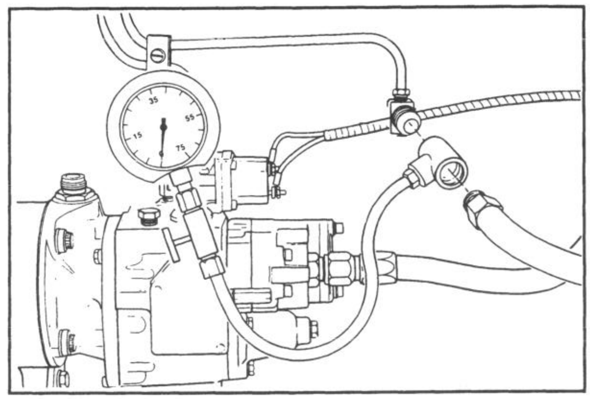
1. Clean fuel filter is 100 mm, Hg. [4 in. Hg.].
2. Dirty fuel filter is 200 mm, Hg. [8 in. Hg.].

Correct the restriction or replace the fuel filter. Refer to section 4-05.

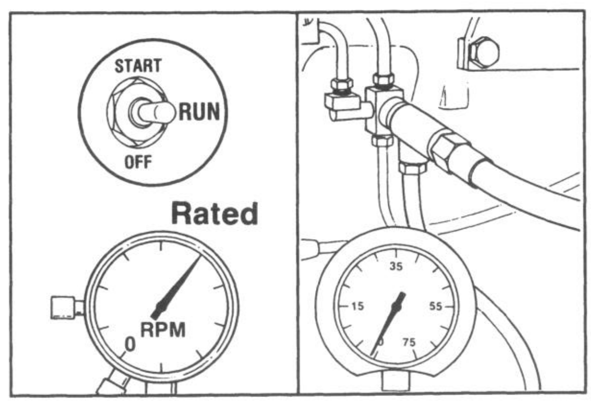


Fuel Drain Line Restriction - Check (4-08)

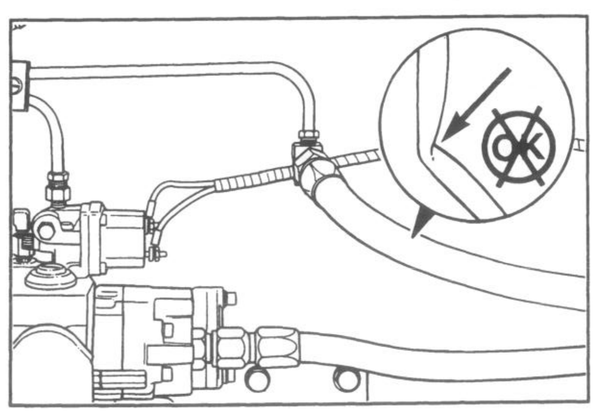
Remove the fuel drain line and install the pressure gauge, Part No. ST-1273.

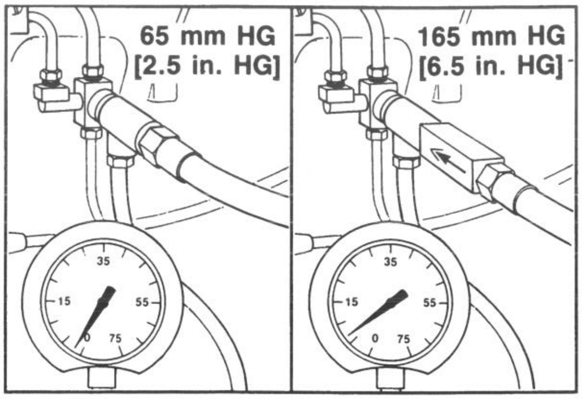


Operate the engine at rated speed and rated load, if available. If rated load can not be applied, operate at the maximum load available, up to the rated load.



Note: Make sure the drain line does not have any loops or is not crimped.

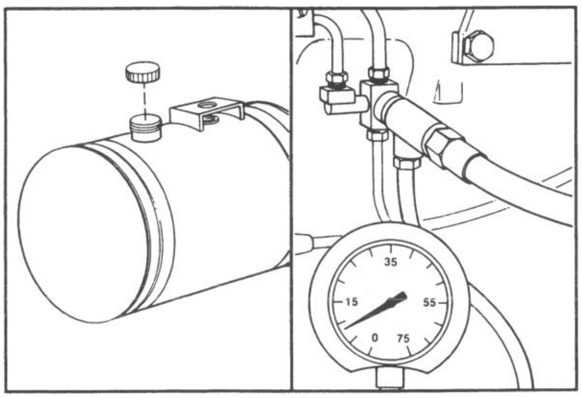




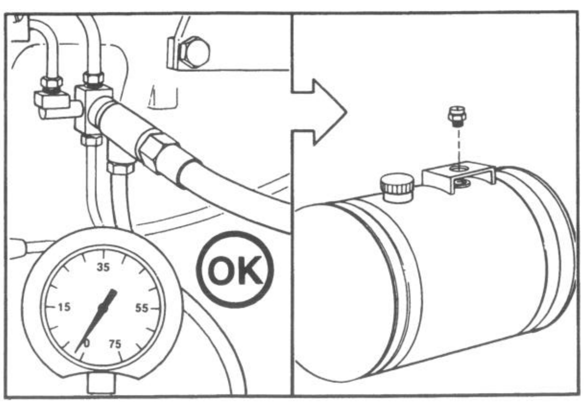
Observe the reading on the gauge. Hold the gauge at the same level as the connection.

Note: The maximum drain line restriction is as follows:

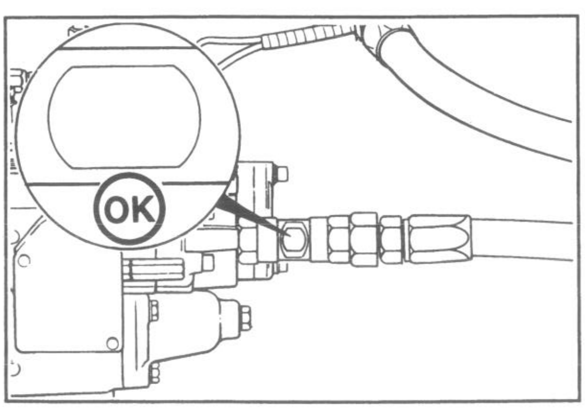
Without Check Valves	With Check Valves
102 mm Hg. [4.0 in. Hg.]	165 mm Hg. [6.5 in. Hg.]



If the restriction is above the specifications, remove the fuel tank fill cap and check again.



If the restriction is below the specifications when the cap is removed, replace the tank vents.



Air Leak in Fuel Suction Line - Check (4-09)

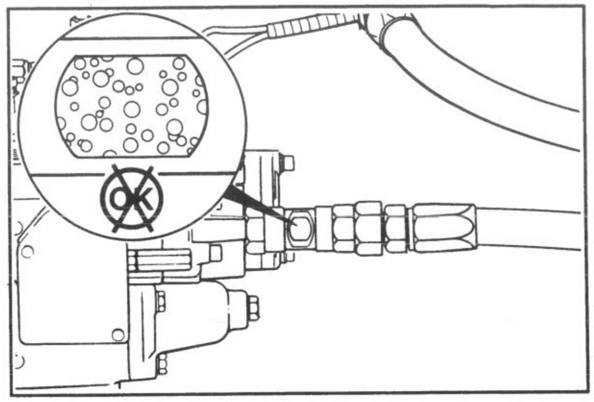
Remove the fuel suction line from the fuel pump. Install a sight glass in the line at the fuel pump.

Engine Series	Sight Glass Part No.	Hose Size	Filling Type
NT-855	ST998	#10	SAE
KT-19	ST998	#10	SAE
VT-28	3375362	#12	SAE
KT-38	3376718	#12	JIC
KTTA-38	3375808	#16	JIC
KTA-50	3375808	#16	JIC

Operate the engine at rated speed at rated load. If the rated load can not be applied, operate the engine at the maximum load available up to the rated load.

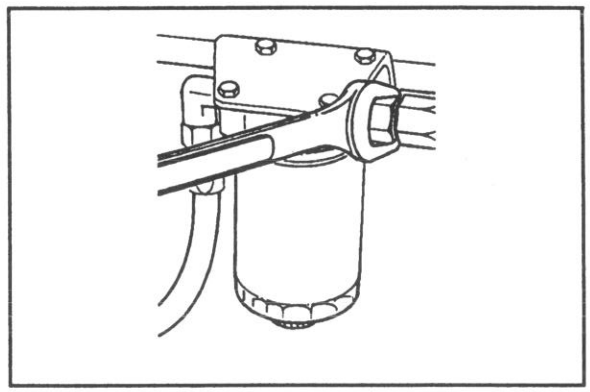
Note: A small air leak will have a "milky" appearance.

Note: A large air leak will look like bubbles in the fuel.

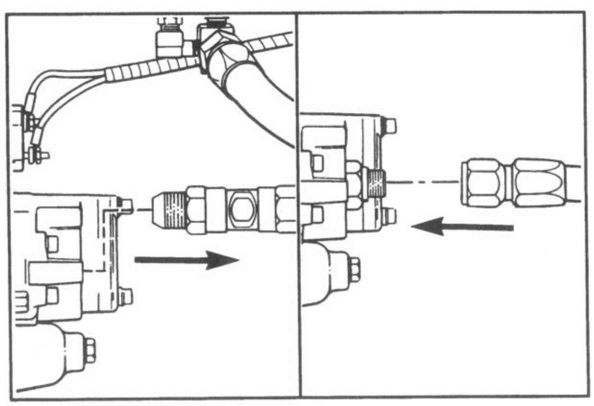


If an air leak is found, visually inspect the fuel lines and fittings for damage. Check for loose connections. Check fuel filter.

Replace the damaged lines or tighten the loose connections.

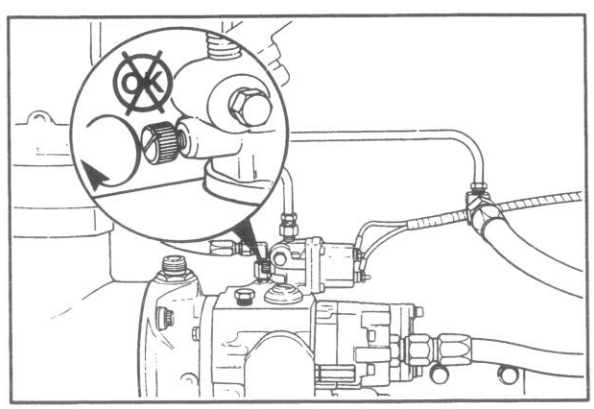


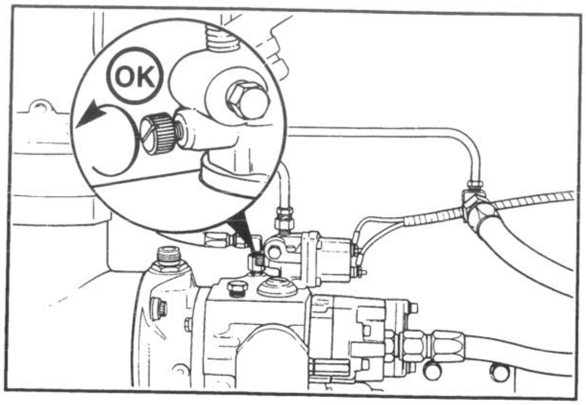
Remove the sight glass and install the suction hose.



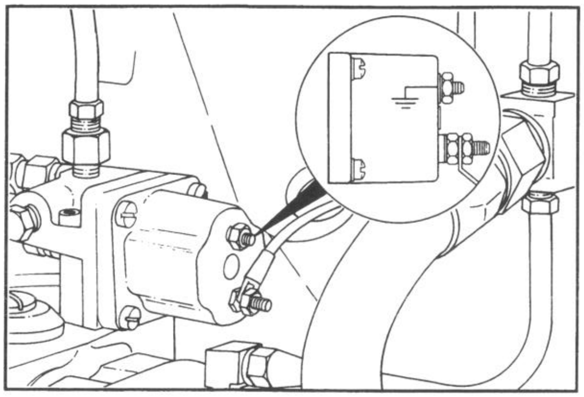
Fuel Solenoid Shutoff Valve (4-10)

The fuel solenoid shutoff valve is located on top of the fuel pump. It is an electrically operated, normally closed, fuel shutoff valve. If the knob on the front of the valve is turned clockwise (when viewed from the front of the engine) the fuel solenoid shutoff valve is mechanically blocked open, and the safety controls will not stop the engine. If a Woodward governor is used, the off-run-start switch will not stop the engine.

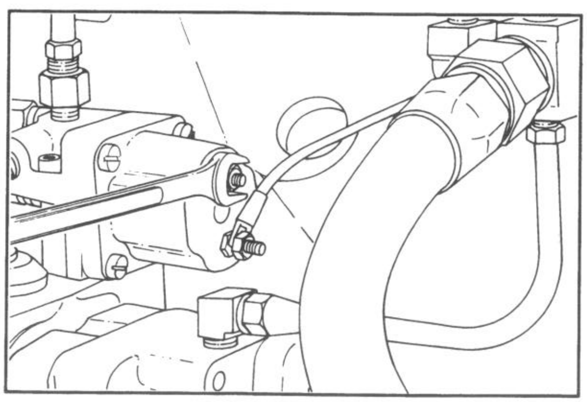




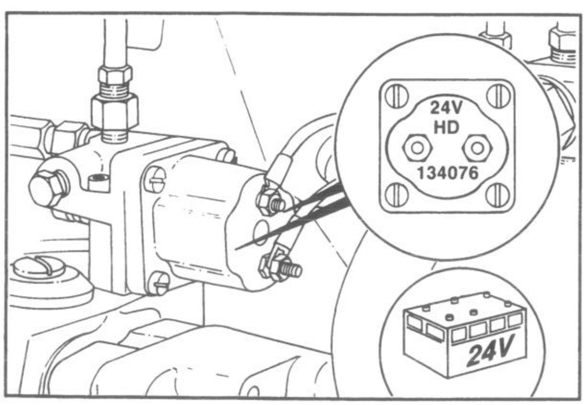
Except for specific test conditions, the fuel solenoid shutoff valve must always be in the mechanically closed or full counter-clockwise position.



Most of the shutoff valves are internally grounded. If the valve has a long post and a short post, the short post is internally grounded.



Make sure all of the wire connection nuts are tight, whether a wire is attached or not.



Make sure the shutoff valve coil is the correct voltage.

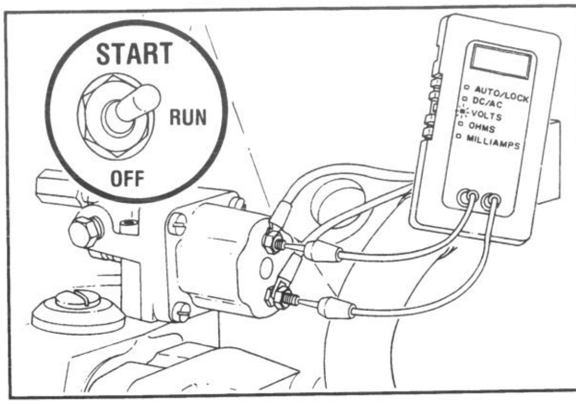
The coil voltage and part number are cast into the terminal connection end of the coil.

Generator sets will normally have a 24 volt coil.

Stop the engine.

Move the off-run-start switch to the " Start" position.

Check the voltage to the coil with a Service Tool 3376898, Multitester or a convenient DC voltmeter. The voltage will be 24 to 28 volts.



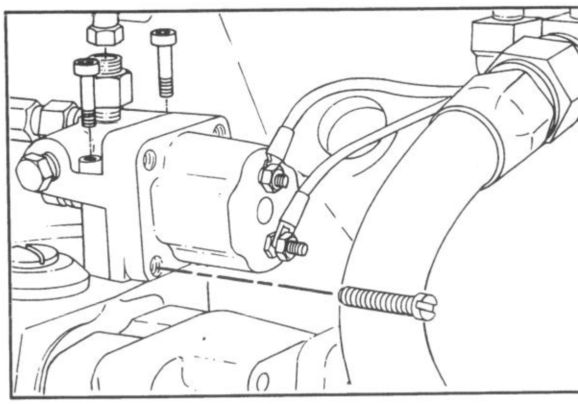
High Pressure/Rapid Restart Fuel Solenoid Valve - Disassembly (4-11)

Remove the fuel supply line from the fuel solenoid valve. Remove the two socket head capscrews holding the fuel solenoid valve to the fuel pump body.

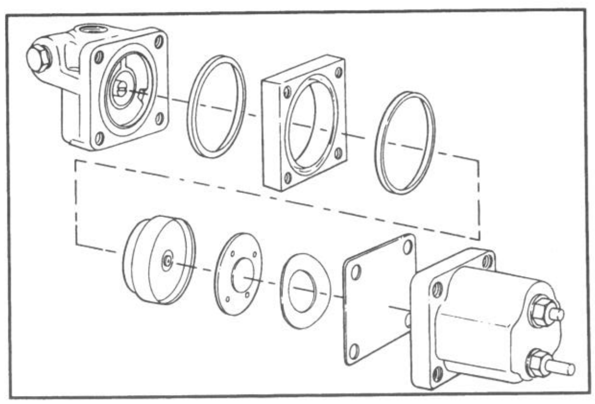
Remove the No. 10 - 24 fillister head cap screws that hold the assembly together.

Note: On the NT-855, KT-19 and VT-28 series engines, there are four No.10 - 24 fillister head capscrews 25.4 mm (1 in. long).

On the KT-38 and KT-50 series engines, there are three No. 10 - 24 fillister head capscrews 25.4 mm (1 in.) long and one No. 10 - 24 pan head capscrew 19 mm (3/4 in.) long.



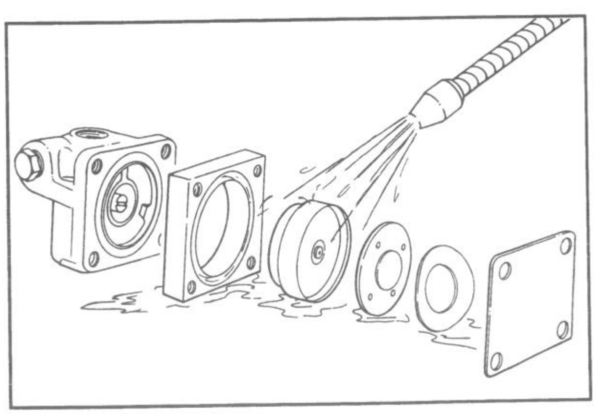
Remove the coil housing, fuel shield, spring washer, valve disc, actuator housing and actuator disc. Discard the two rectangular ring seals. One rectangular ring seal is in the actuator housing and the other is in the body of the shutoff valve.

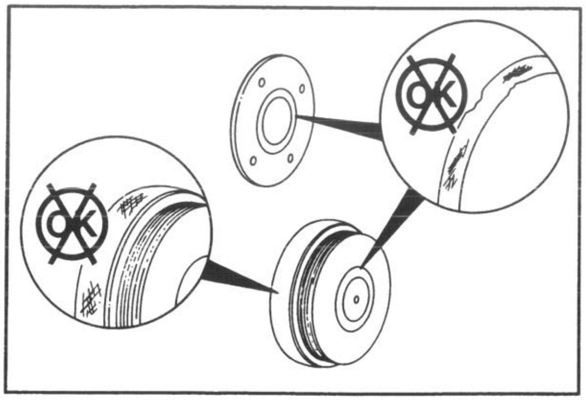


Unless there is a leak from around the override shaft, it is not necessary to unscrew the override shaft from the manual override knob.

Clean all parts except the coil housing in clean solvent No. 40.

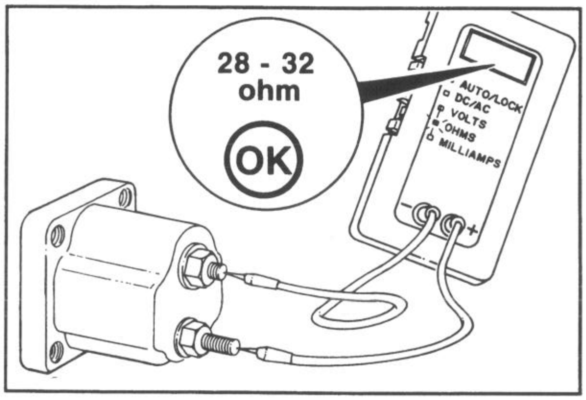
Note: Do not wet the coil assembly or new rectangular ring seals with solvent. Wipe the coil assembly clean with a lint free cloth.



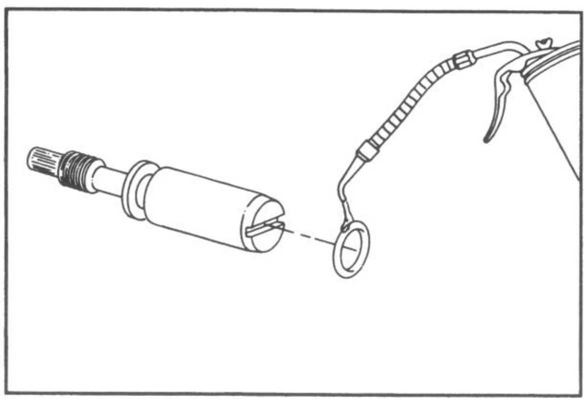


Examine the rubber surfaces on the valve and the actuator discs for holes, scratches, or torn places. Replace as required.

Examine the outside spherical radius on the actuator disc for burrs or scratches. Replace as required.

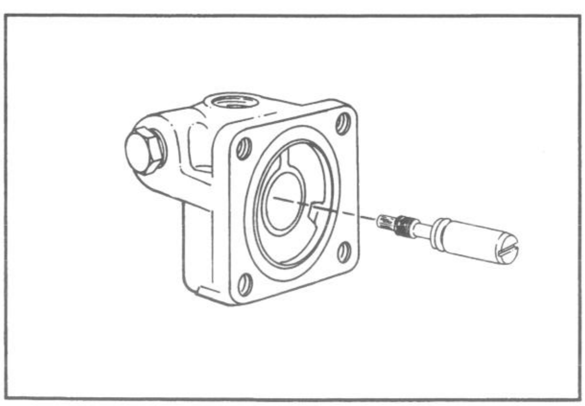


Check the resistance of the coil with a Part No. 3376829, Multitester. The resistance of the 24 volt coil will be 28 to 32 ohms. Discard the coil assembly if shorted or open.



High Pressure/Rapid Restart Fuel Solenoid Valve - Assembly (4-12)

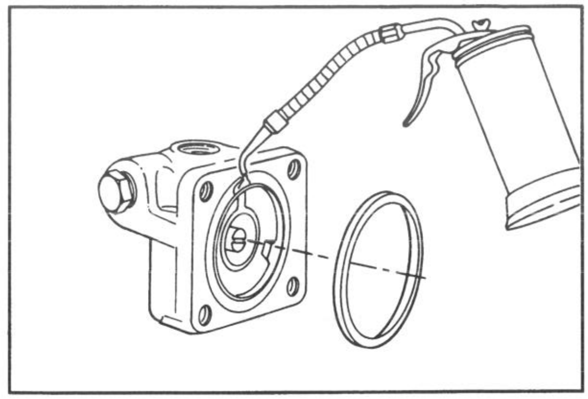
If the override shaft has been removed, install a new "O" ring on the new override shaft and apply a coating of lubricant.



Screw the shaft into the housing until it reaches the bottom of its bore. Use a depth micrometer set at 3 mm [0.118 inch] and check the distance from the face of the valve housing to tip of shaft. If necessary, screw the shaft out until it is 3.0 mm [0.118 inch] below the housing face. Do not move the shaft and press on the knob until it contacts valve housing which will act as a stop.

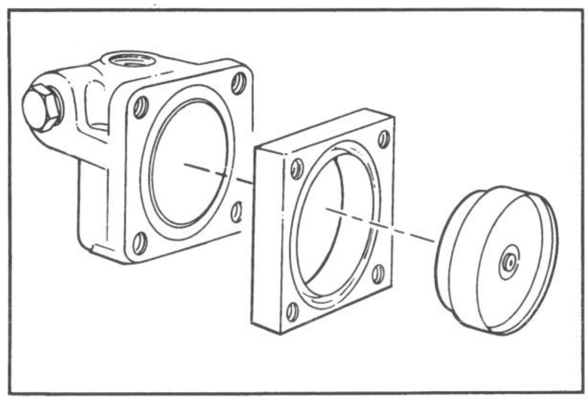
Apply clean engine oil to the ring groove of the shutoff valve body.

Install a rectangular ring seal in the ring groove of the shutoff valve body.



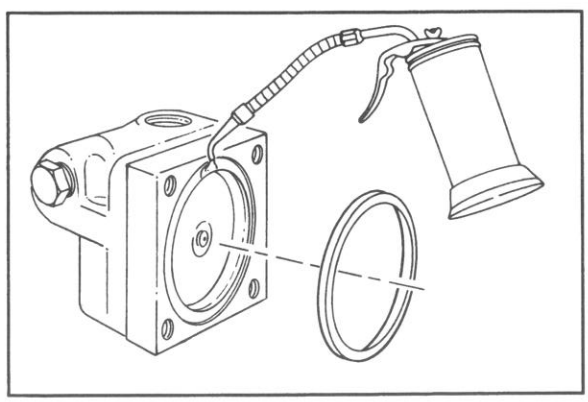
Place the actuator housing on the shutoff valve body.

Install the actuator disc in the actuator housing with the rubber ring toward the shutoff valve body.

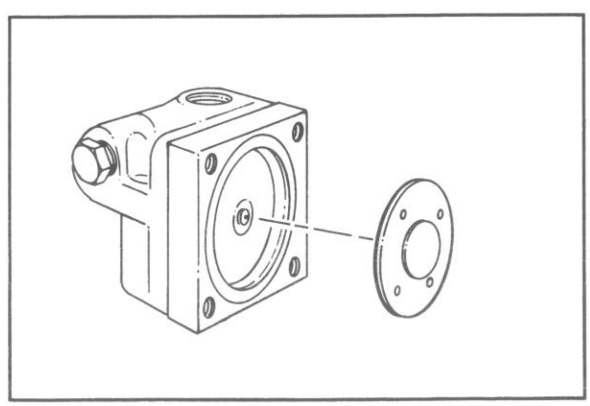


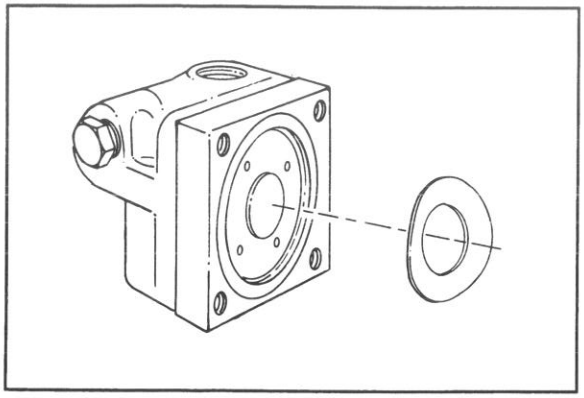
Apply lubricant to the ring groove of the actuator housing.

Install the second rectangular ring seal in the ring groove of the actuator housing.

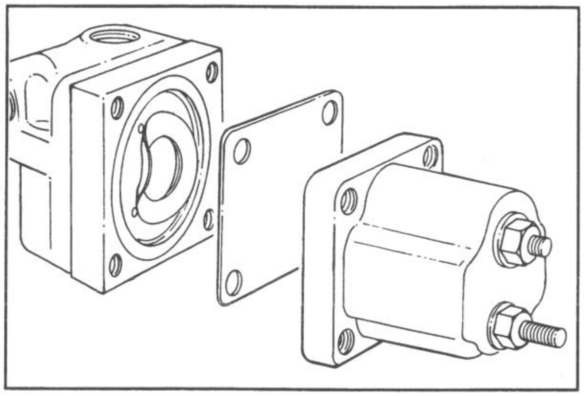


Install the valve disc in the actuator disc. Make sure the rubber side of the valve disc is toward the actuator disc.

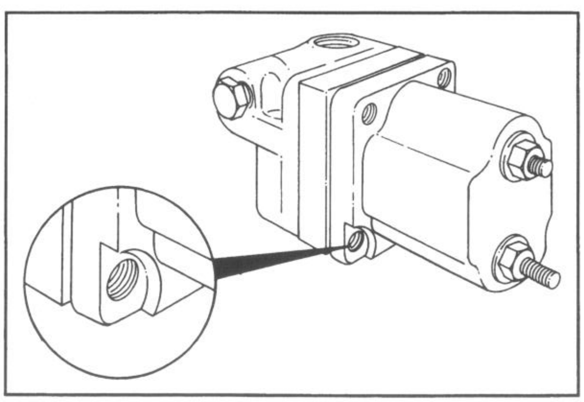




Install the spring washer on the valve disc. Make sure the concave side of the spring washer is up. The spring washer must be piloted around the locator portion of the valve disc.

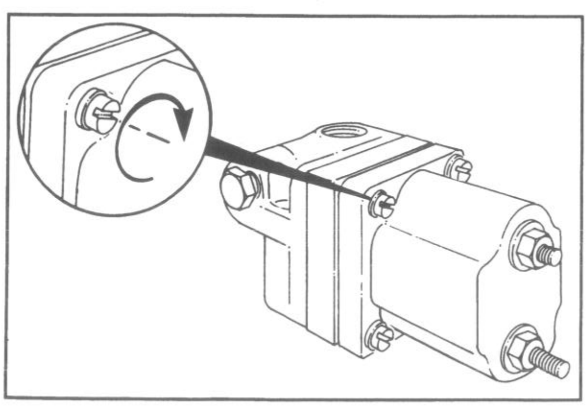


Install the fuel shield on the solenoid coil assembly. Install the shield and coil on the spring washer and valve assembly.



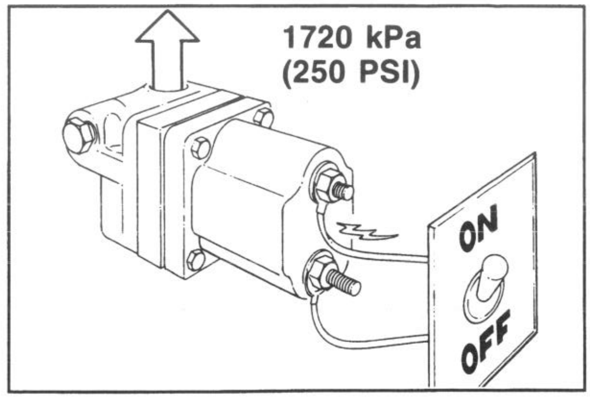
Note: On PT (type H) fuel pumps, one hole of the solenoid coil assembly is counterbored so that the capscrew head will not interfere with the gear pump body of the fuel pump.

The 19 mm (3/4 in.) long No. 10 - 24 pan head capscrew must be assembled in this hole.

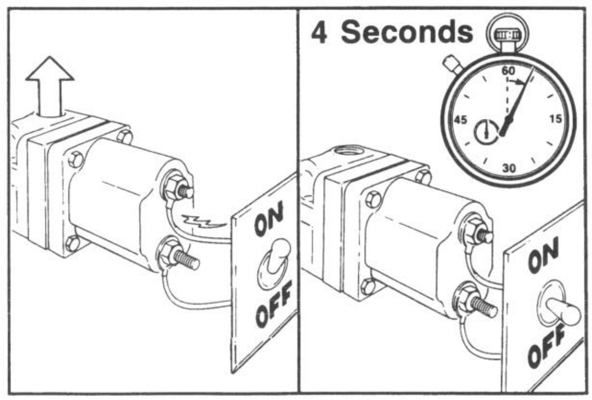


Tighten all four capscrews to 2.8 to 3.4 N•m (25 to 30 inch-pounds) torque.

At rated voltage, the shutoff valve must open against 1720 kPa (250 psi) gear pump pressure at zero flow when the valve is energized.

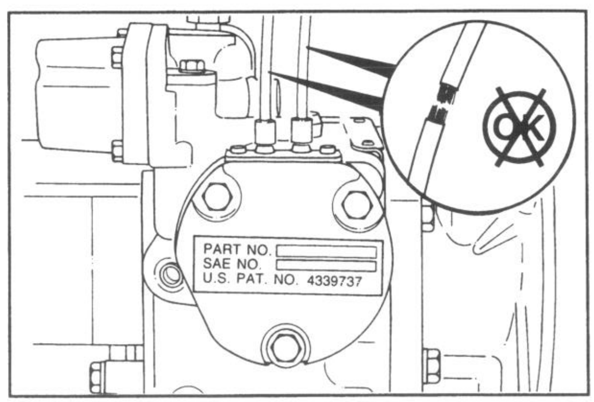


When the flow is 11.4 to 15.9 kg. per hour (25 to 35 pounds per hour) through the valve, the valve must close within 4 seconds after the coil is turned off.

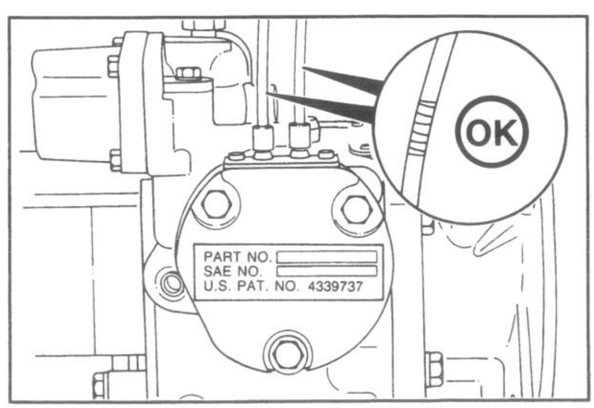


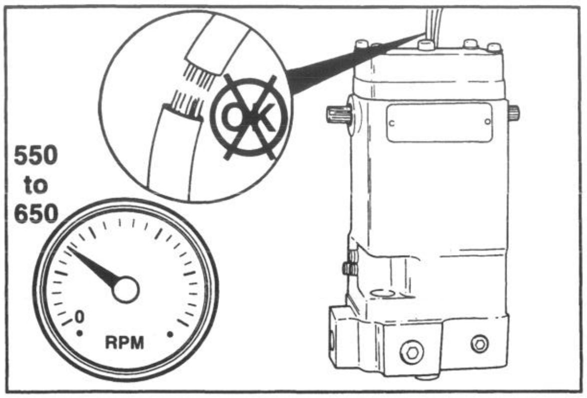
Actuator Leads Disconnected (4-13)

If either of the leads to the normally closed EFC or United Technologies governor actuators is broken or disconnected, the injectors will not receive any fuel and the engine will not start. There will be no smoke from the exhaust.



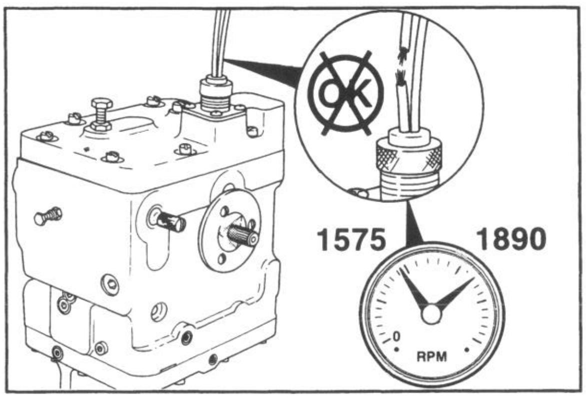
Connect, repair or replace the actuator leads, as required.





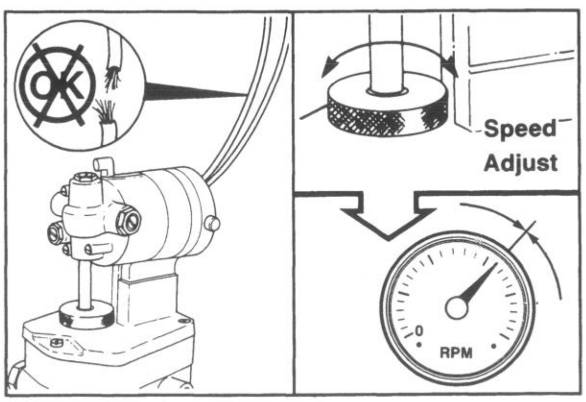
If either of the leads to the Woodward EG-1P actuator is broken or disconnected, the injectors will receive fuel and the engine will operate at low idle (550 - 650 RPM) speed. The throttle will remain at the minimum fuel position and the Woodward 2301 Control will have no effect on the engine speed.

Connect, repair or replace the actuator leads, as required.



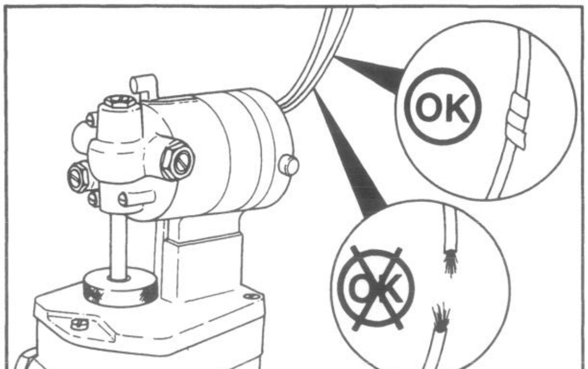
If either of the leads to the Woodward EGB-2P actuator (Hydraulic Backup) is broken or disconnected, the engine will run at approximately five percent above the rated speed (1575 or 1890 RPM). The Woodward 2301 governor control will have no effect on the engine speed.

Connect, repair or replace the actuator leads, as required.



If either of the leads to the Woodward motorized head PSG governor is broken or disconnected, the governed speed of the engine cannot be changed by means of the Raise-Lower Switch on the engine instrument panel.

The speed may be changed manually by turning the knurled knob on top of the governor housing.

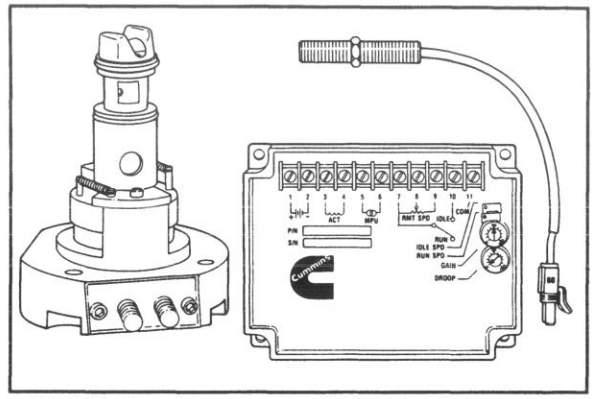


Connect, repair or replace the motor lead wire harness, as required.

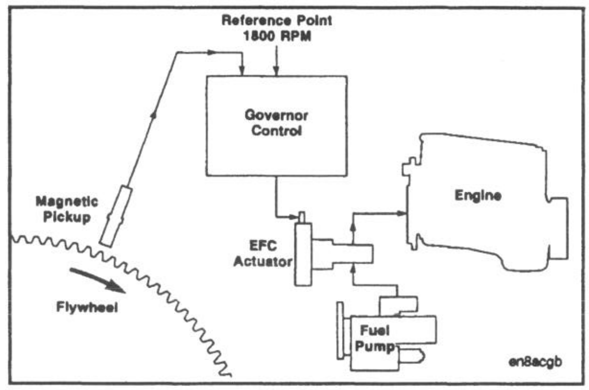
Electric Fuel Control EFC Governor (4-14)

Governor Description

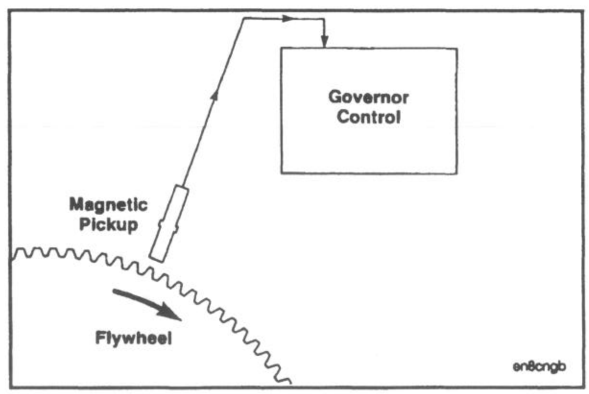
The governor contains a magnetic pickup, a governor control, an actuator and the mounting parts.



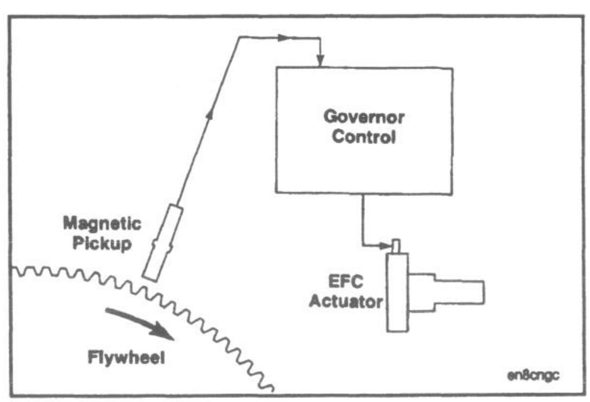
The governor is available with normally open or normally closed governor systems.

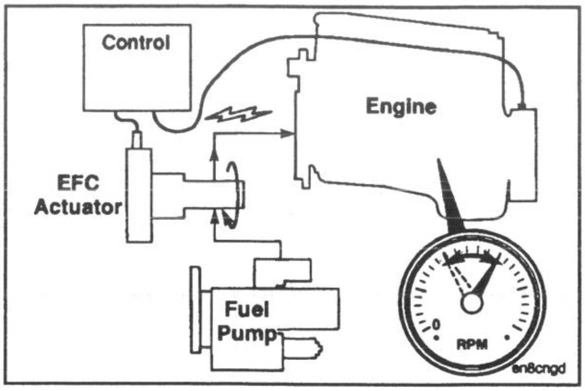


The magnetic pickup senses the engine speed at the flywheel ring gear and sends an alternating current (A.C.) electrical signal to the governor control.

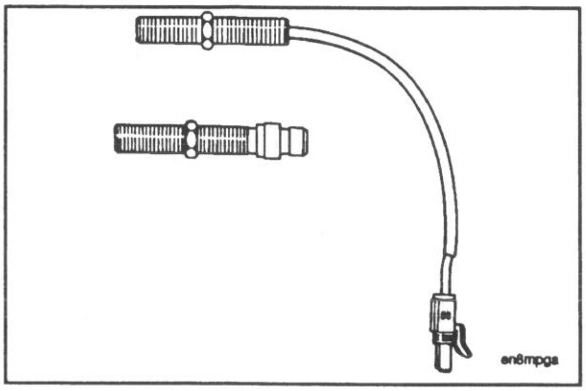


The governor control compares the electrical signal from the magnetic pickup with a preset reference point. If there is a difference in the two signals, the control will change the current to the actuator.



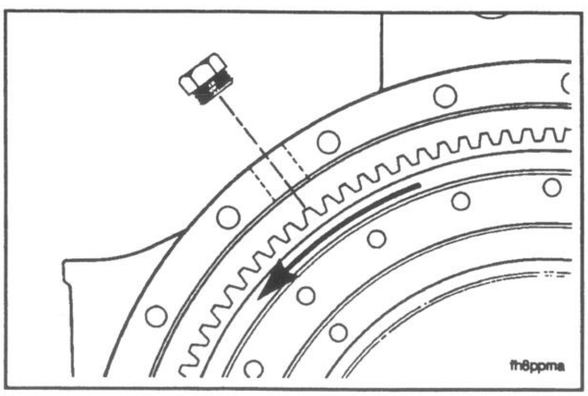


The change in current in the actuator coil will make the actuator shaft rotate. The fuel flow, and engine speed or power will change when the actuator shaft rotates.

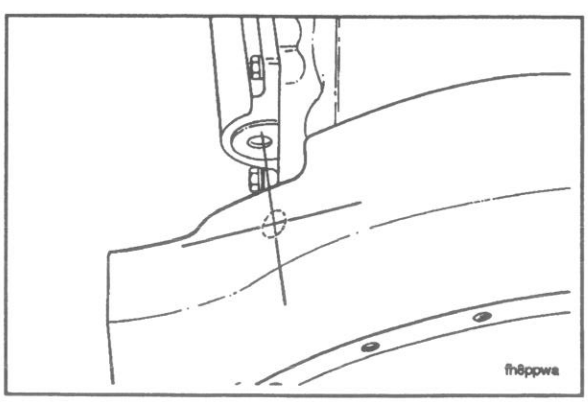


Magnetic Pickup Installation

The magnetic pickup is an electromagnetic device. The pickup is mounted in the flywheel housing. Two different types of magnetic pickups are used. A pickup with leads ending in a plug is used on generator sets when the engine wiring harness is supplied. A pickup with an internal 2 pin receptable is used when the engine wiring harness is not supplied.



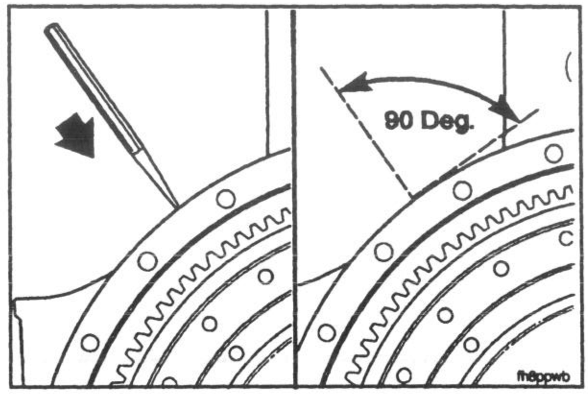
Remove the 5/8 straight plug from the flywheel housing that aligns with the flywheel gear teeth. Rotate the flywheel to center a gear tooth below the magnetic pickup hole, if necessary.



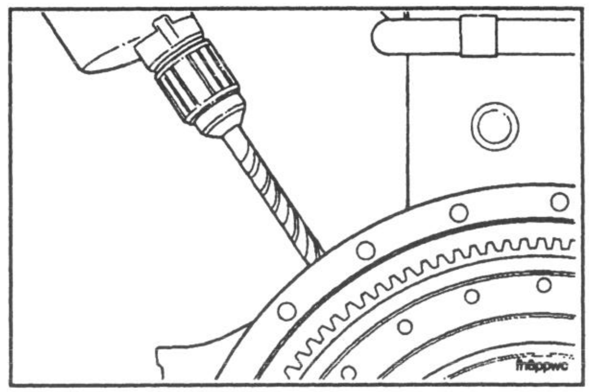
If the flywheel housing does not have a straight plug that aligns with the flywheel gear teeth, drill and tap a hole in the housing.

Note: The drill chips must be removed from the flywheel housing. The main generator must be removed to clean the chips out of the housing.

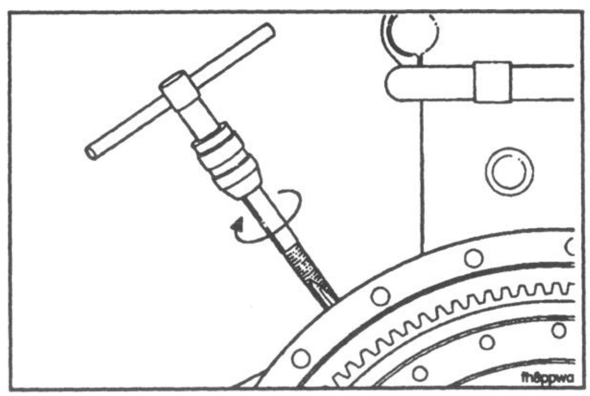
1. The hole must be perpendicular to the gear teeth. The hole can be over any part of the gear teeth.



2. Drill a 37/64 inch [14.7 mm] hole in the housing.



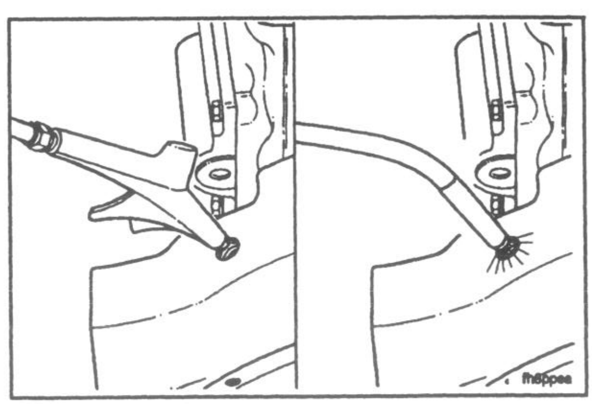
3. Tap the hole with a 5/8-18 UNF-2A size tap.

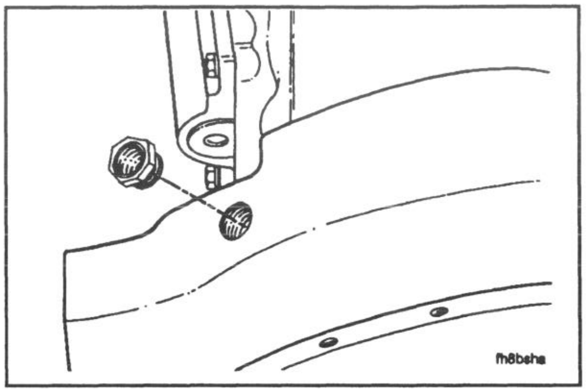


4. Remove the chips with compressed air if the housing is aluminum.

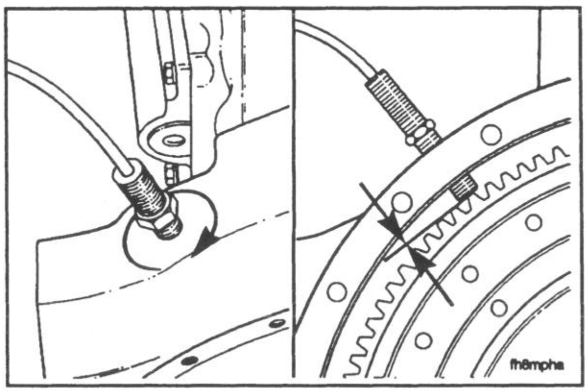
or

5. Remove the chips with a magnet if the housing is cast iron.



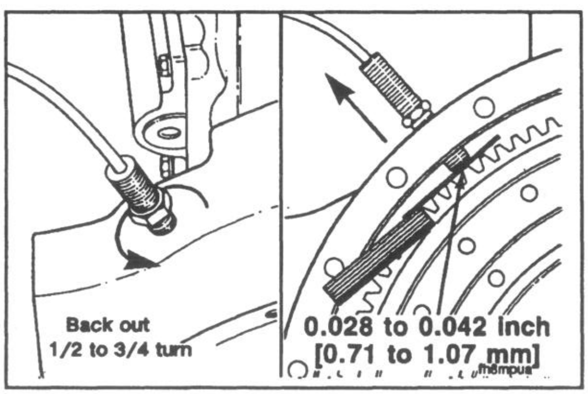


If the housing has a 3/4-16 UNF hole, install a bushing in the hole to reduce the threads to 5/8-18 UNF-2A.



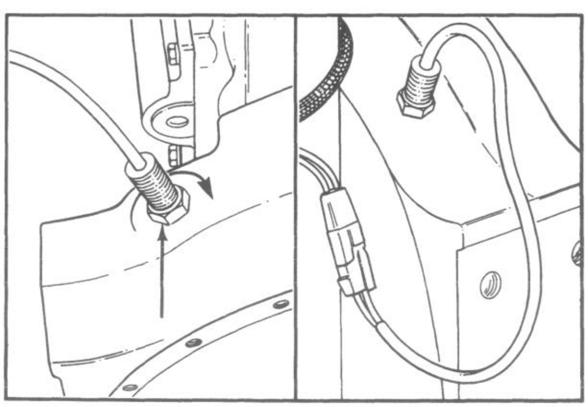
Screw the magnetic pickup all of the way down until it contacts a flywheel gear tooth. The pickup should screw in very easily, do not use excessive pressure to install the pickup.

Note: If the pickup does not screw in with finger pressure, check the hole and the pickup threads. Tap the hole again, if required.



Back the pickup out 1/2 to 3/4 of a turn.

If you can get a feeler gauge between the magnetic pickup and the flywheel gear tooth, back the pickup out 0.028 to 0.042 inch [0.71 to 1.07 mm] from the flywheel gear tooth.

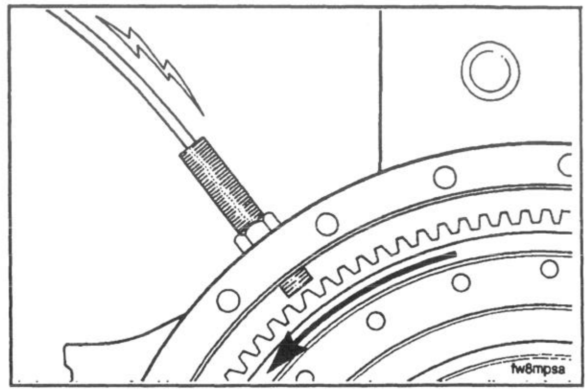


Tighten the locknut down on the flywheel housing.

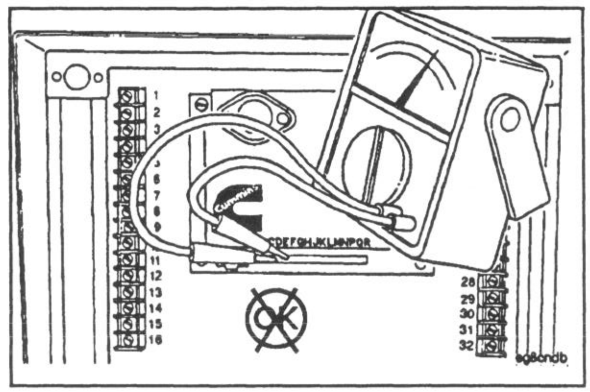
Plug the electrical connection into the pickup, when required.

Install the main generator, if it was removed.

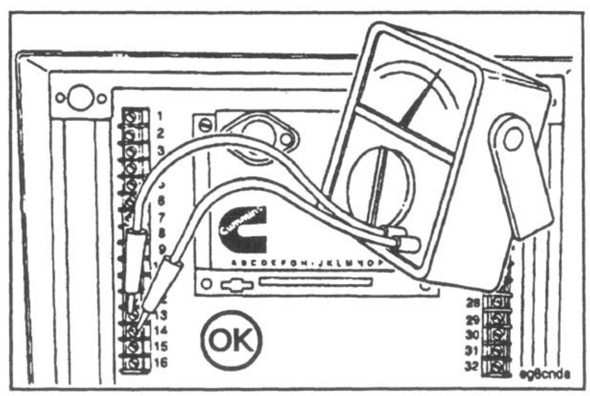
When the flywheel gear teeth pass the pickup, an A.C. voltage is induced. One cycle is induced for each gear tooth.



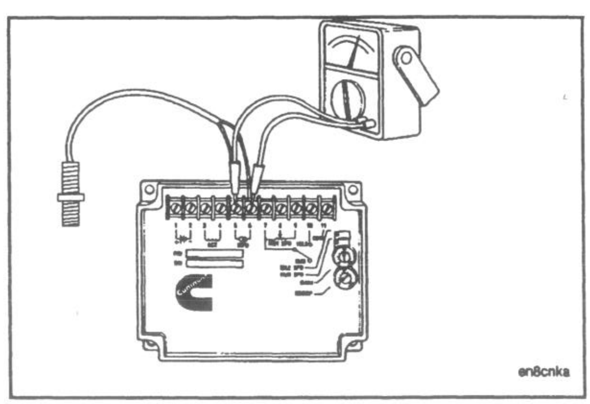
Caution: Measure the voltage of the panel mounted governor control on the engine control terminal strip. Do not measure the voltage on the control terminal strip. If two terminals on the panel mounted governor control terminal strip are shorted, it can damage the control unit.

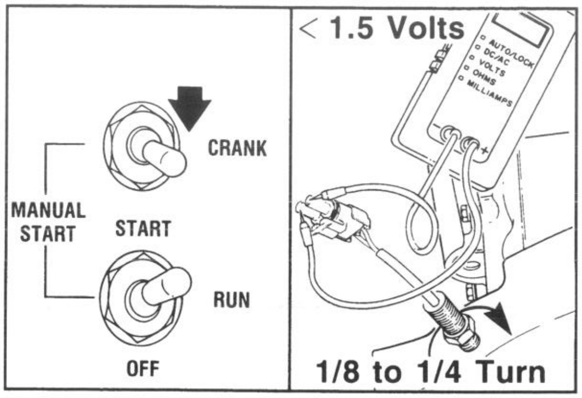


Check the magnetic pickup voltage on terminals 13 and 14 on the engine control terminal strip inside the engine mounted instrument panel.



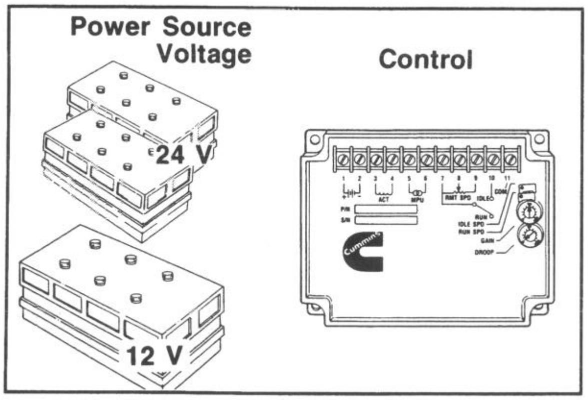
If a remote mounted governor control is used, check the magnetic pickup voltage on governor control terminals 5 and 6.





If the pickup signal is less than 1.5 volts AC when cranking the engine, screw the pickup in 1/8 to 1/4 turn.

If magnetic pick-up voltage can not be obtained, unplug the magnetic pick-up from the wiring harness and measure the output voltage directly at the magnetic pick-up.

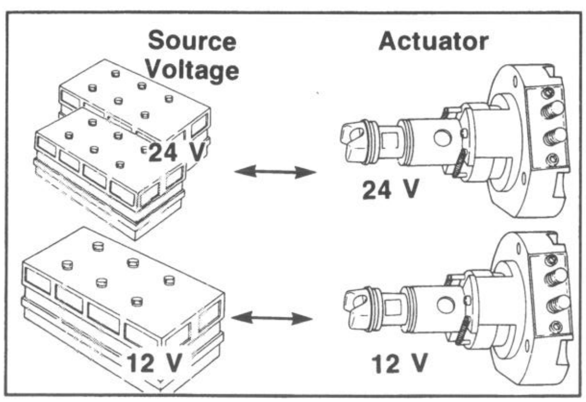


Power Source

The governor control can operate on either 12 or 24 volts D.C.

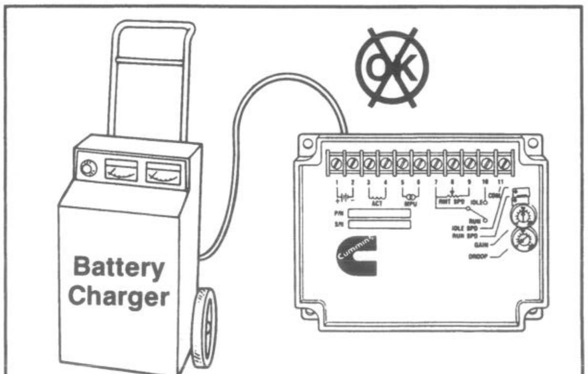
A normally closed control must be used with a normally closed actuator.

A normally open control must be used with a normally open actuator.



The actuators have a rating of either 12V. or 24V.D.C. The source (battery) voltage at the control must be the same as the voltage rating of the actuator.

Generator sets of 160 KW and up normally use a 24 volt DC system.

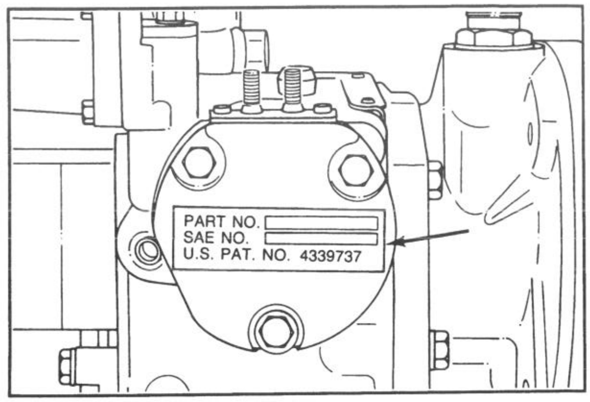


Caution: Do not connect the governor control to a battery charger. Due to the circuitry and method of operation of the chargers, the governor will not function properly. Connect the battery charger to the battery.

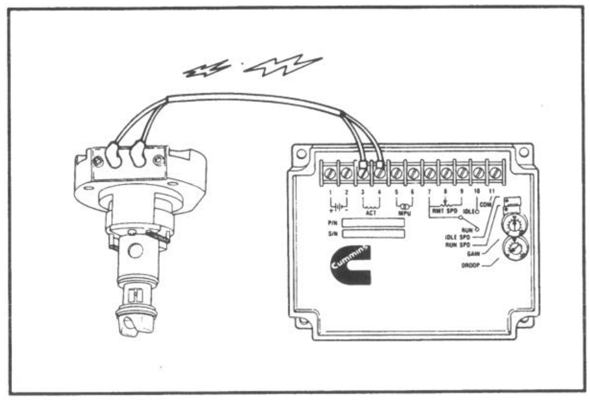
Note: See the panel mounted and remote governor control wiring diagrams for the specific wiring. See page 46 and 47.

Actuator Description

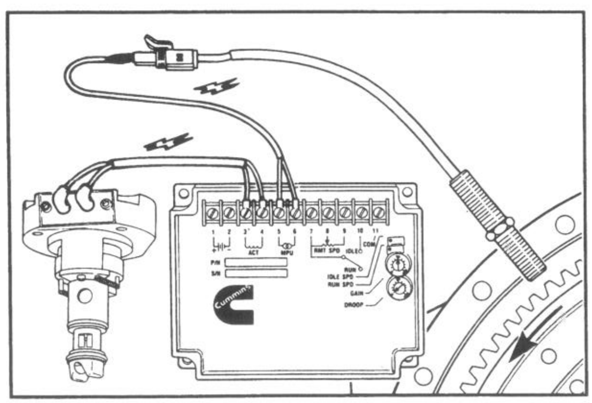
The actuator is an electromagnetic rotary solenoid valve. The actuator is installed in the EFC cavity of the PT fuel pump. The actuator controls the engine speed and horsepower by controlling the fuel flow to the injectors.



The actuator shaft will turn when the current from the governor control changes.

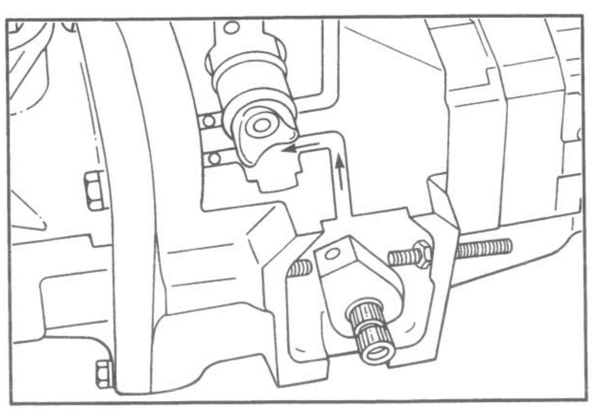


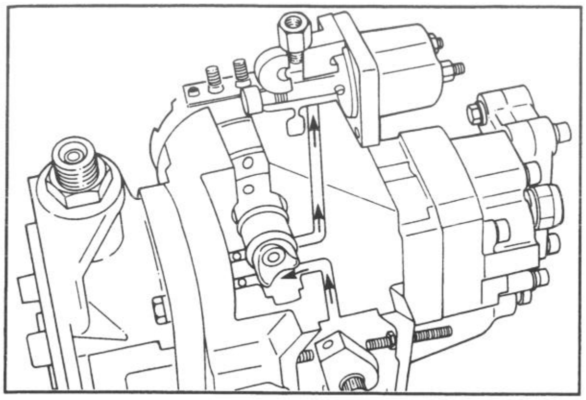
The current from the governor control will change when the magnetic pickup senses a change in the engine speed.



Fuel Flow Through the Fuel Pump

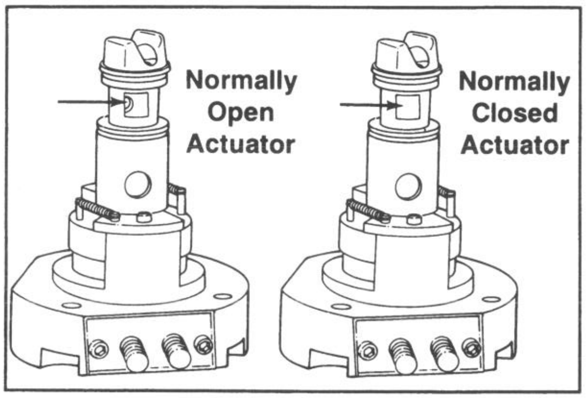
The throttle shaft is set in the full open position. The fuel flows through the fuel pump to the actuator (EFC) cavity.





The actuator controls the fuel flow to the injectors.

The fuel flows through the actuator to the shutoff valve.

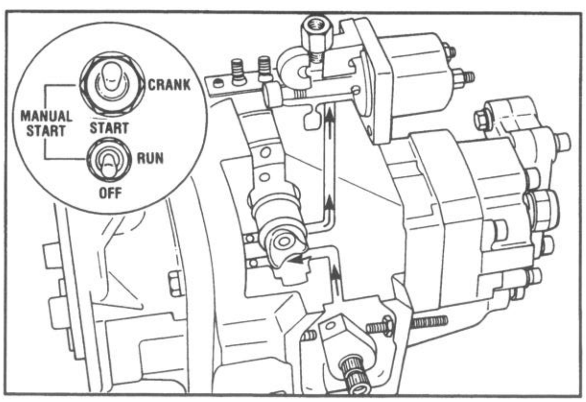


Actuator Identification

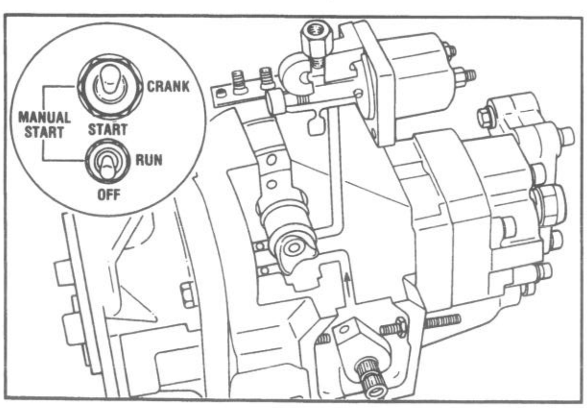
Two styles of the actuator are now available.

a. Normally open

b. Normally closed

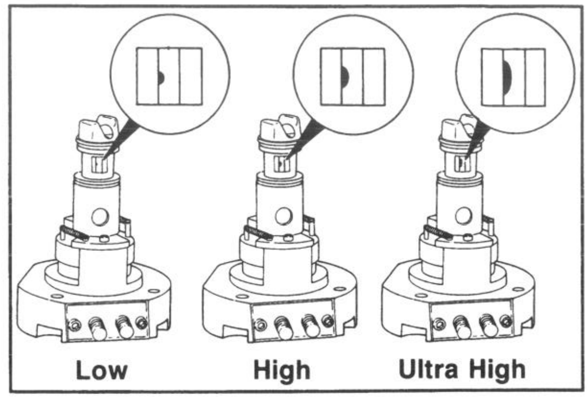


The normally open actuator is in the full fuel position when the electrical system is turned off.



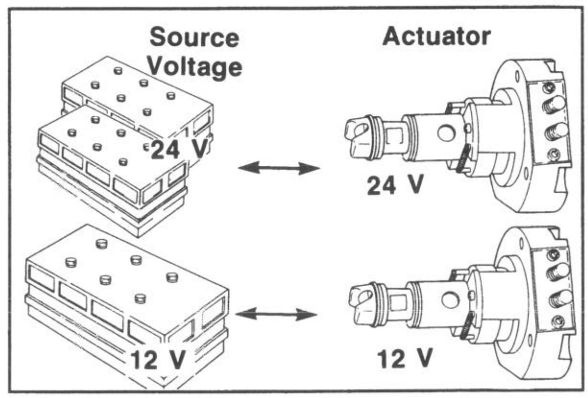
The normally closed actuator will stop the fuel flow when the electrical system is turned off.

The actuators are available in low, high, and ultra high flow.



The actuators are rated at 12 or 24 volts D.C.

Make sure the governor control voltage is the same as the actuator voltage rating.



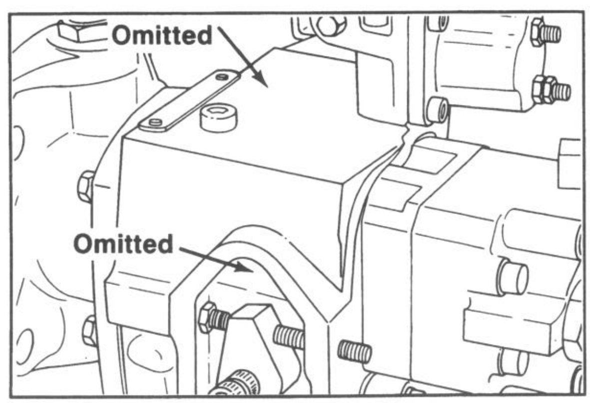
EFC Fuel Pump Housing

When a new EFC fuel pump is built at Cummins, the pump will have an EFC housing.

The EFC fuel pump housing can be identified in the following areas:

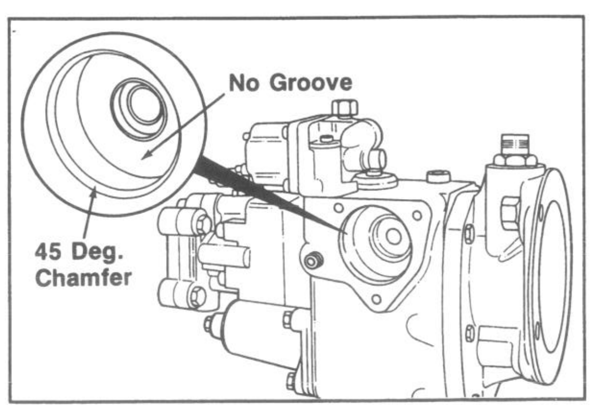
The AFC no-air adjusting screw hole has been omitted.

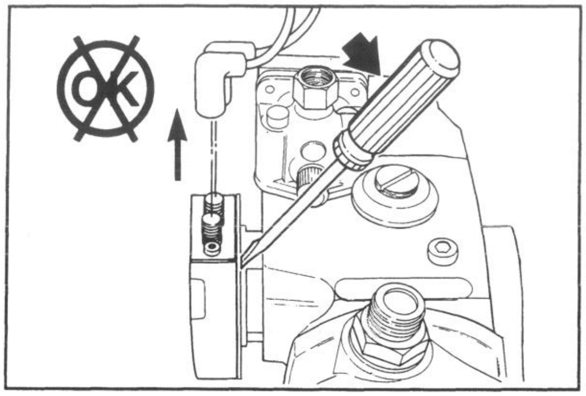
The ASA of AFC vent hole, in the top of the housing has been omitted.



The AFC spring seat groove is not machined.

A 45° chamfer is at the EFC actuator mounting surface.

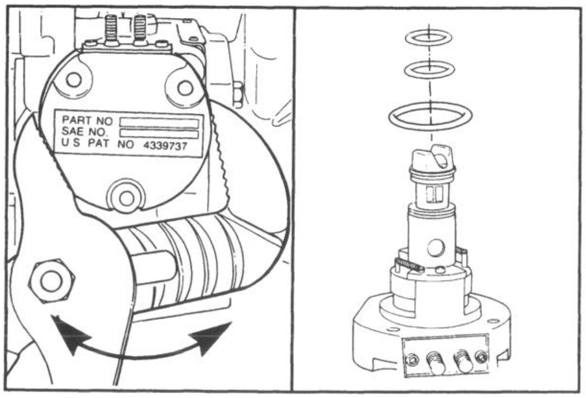




Actuator Removal From an EFC Fuel Pump Housing

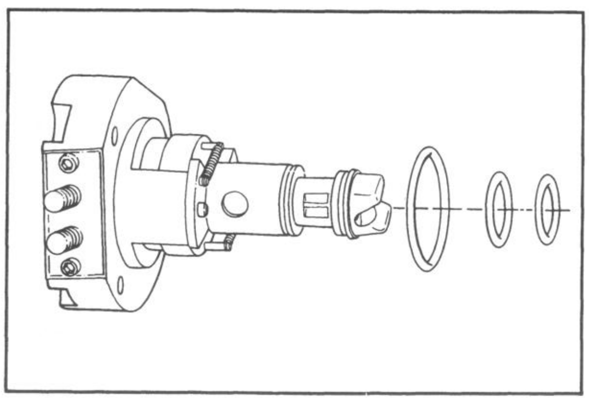
Remove the actuator wires and capscrews.

Caution: Do not pry the actuator from the housing. This can damage the actuator shaft and make it stick.



Twist the actuator and pull it from the housing.

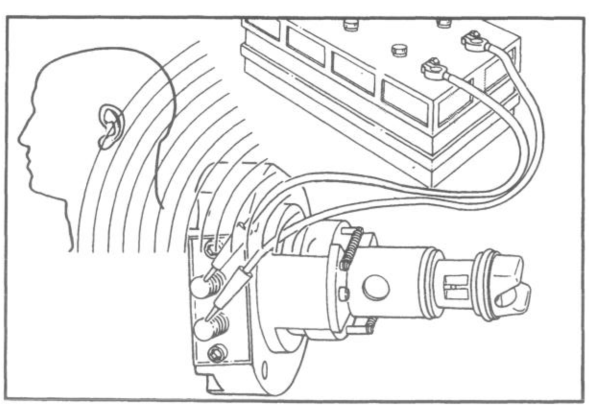
Remove the three O-rings from the actuator.



Actuator Installation in an EFC Fuel Pump Housing

Install a new O-ring on the 50 mm [2 in.] diameter of the actuator.

Install two new O-rings on the actuator barrel.

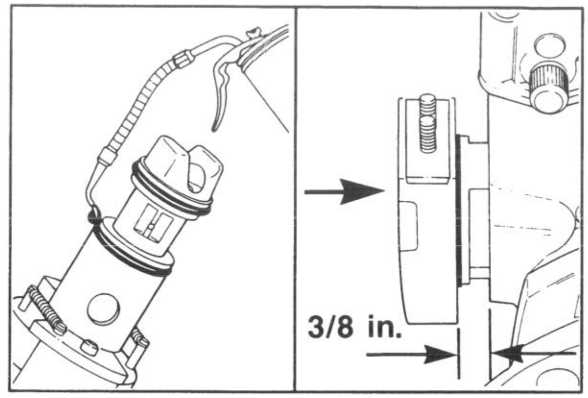


Apply the actuator rated battery voltage across the two terminals on the actuator to test the solenoid and to observe actuator operation. The actuator will make a loud click when the actuator shaft hits the internal stop. Removing the voltage from the actuator terminals will allow the force of the springs to return the actuator shaft to its original position. A click must be heard when the voltage is removed.

Note: The EFC housing does not require the EFC plug in the bottom of the EFC housing bore.

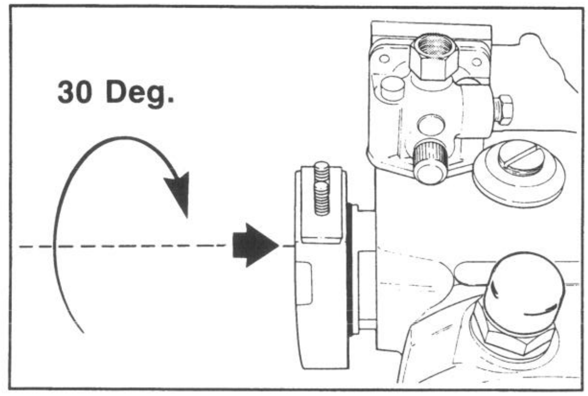
Lubricate the two barrel O-rings with clean engine oil.

Insert the actuator in the fuel pump housing. The actuator flange will be approximately 3/8 inch [9.5 mm] from the fuel pump housing.

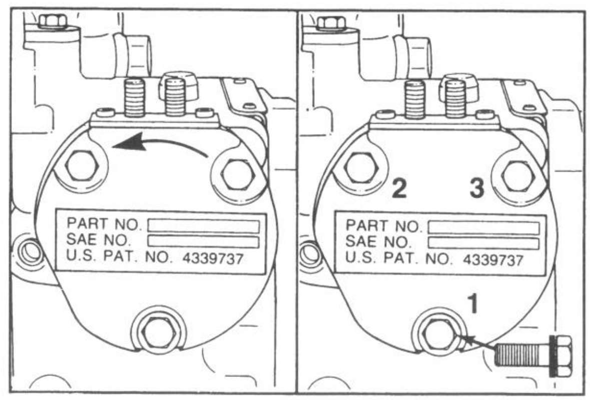


Use the palm of the hand. Firmly push and rotate the actuator approximately 30 degrees until the actuator flange contacts the fuel pump housing.

Rotate the actuator until the mounting holes are aligned.

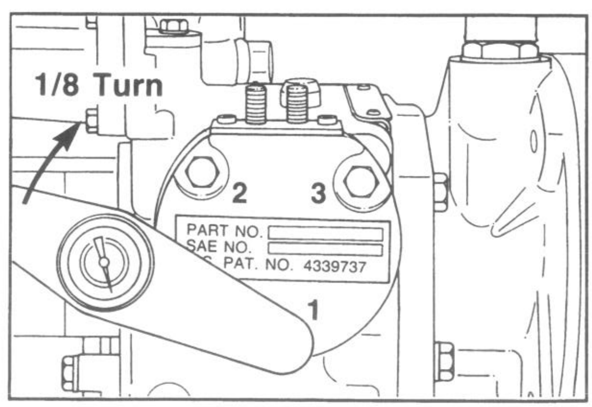


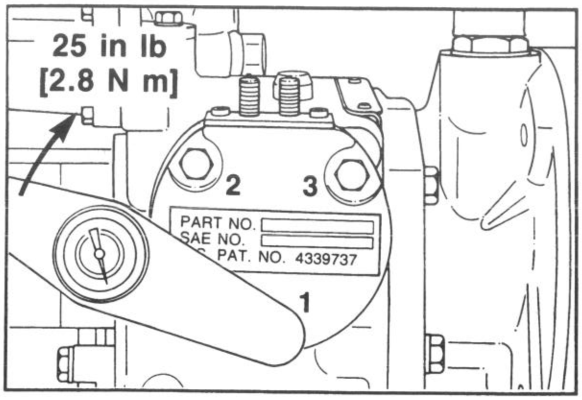
Install the three 1/4-20 x 1-1/4 inch hex head capscrews. These capscrews have captive spring washers and do not require lockwashers. Tighten the capscrews until they are finger tight.



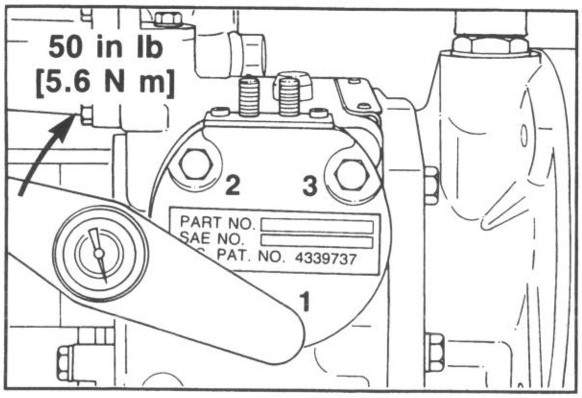
The actuator capscrews must be tightened in the following sequence.

1. Tighten the mounting capscrews 1/8 of a turn, in the sequence shown in the figure, until they are seated.

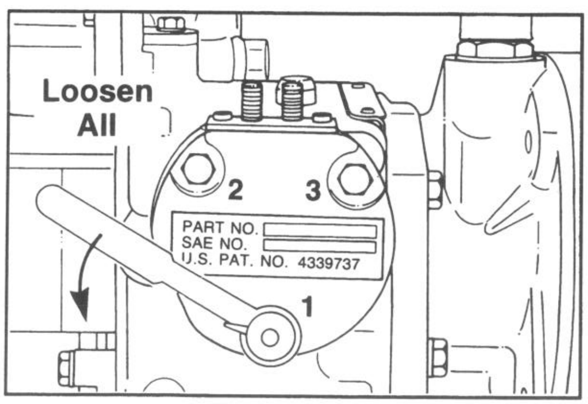




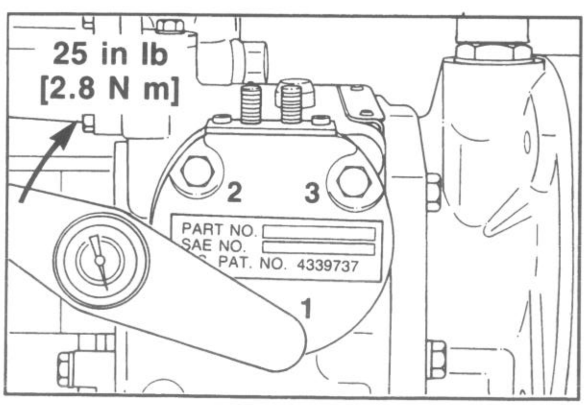
2. Tighten the capscrews in sequence to 25 in-lb [2.8 N•m] torque.



3. Tighten the capscrews in sequence to a torque of 50 in-lb. [5.6 N•m].

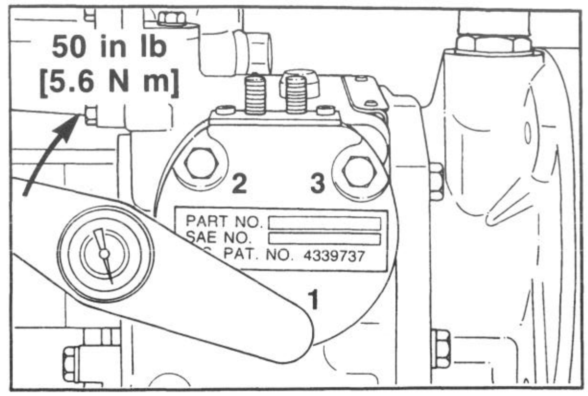


4. Loosen all three capscrews completely.



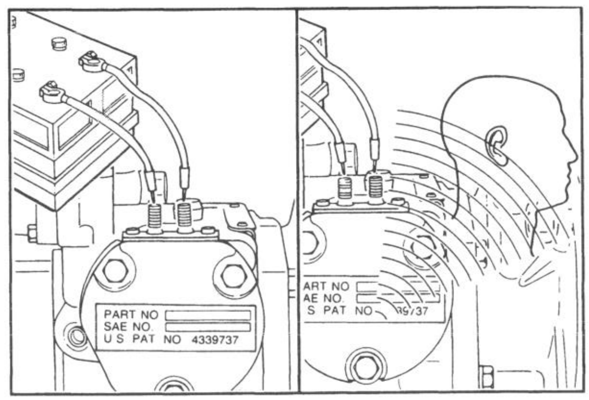
5. Tighten the capscrews again in sequence to 25 in-lb. [2.8 N•m] torque.

6. Tighten the capscrews again in sequence to 50 in-lb. [5.6 N•m] torque.
7. This procedure is to make sure that the actuator is properly installed and is not binding.



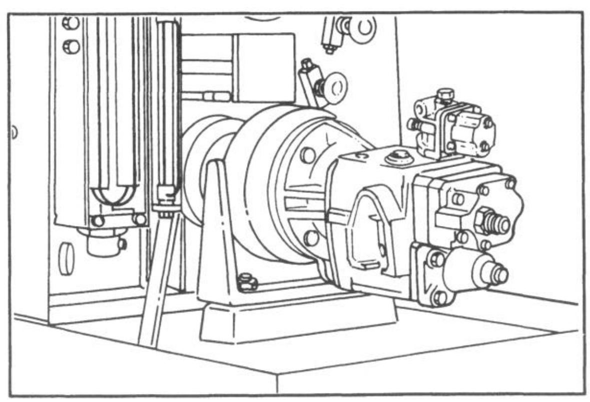
A final check is to apply and remove battery voltage across the two actuator terminals. The operation of the actuator must have a similar sound as it did before installing in the fuel pump housing. If the actuator does not click, as if it is not oeprating, or operating slower than before, loosen all of the capscrews and tighten them again as described in the previous procedure.

Caution: This test will only verify that the actuator will go from the full open to the full closed position. A slight binding of the actuator shaft can cause a governor stability complaint. This test may not detect a slight binding.

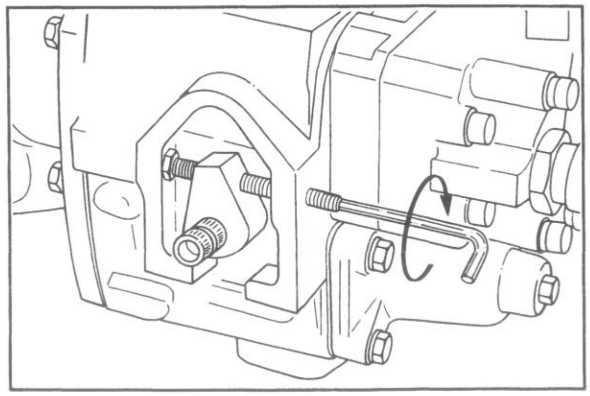


The fuel pump can now be calibrated (Refer to the Fuel Pump Calibration Manuals or the monthly Cumulative Supplement Update).

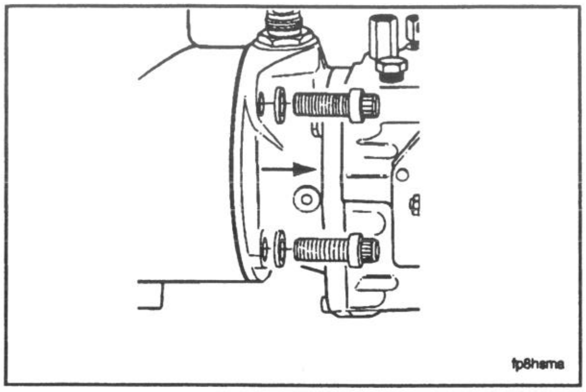
Note: Apply the actuator rated battery voltage to the normally closed actuator when the fuel pump is calibrated.



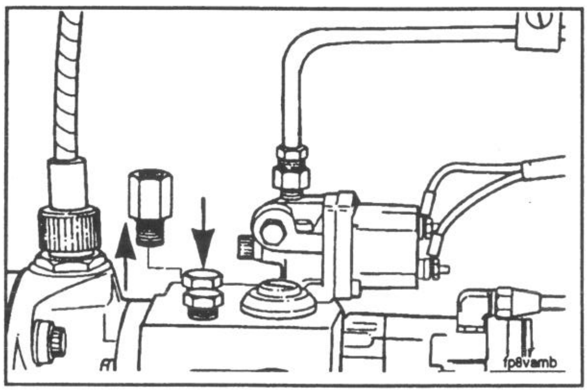
The throttle shaft must be locked in the full open position. After the calibration, the fuel pump can be mounted on the engine.



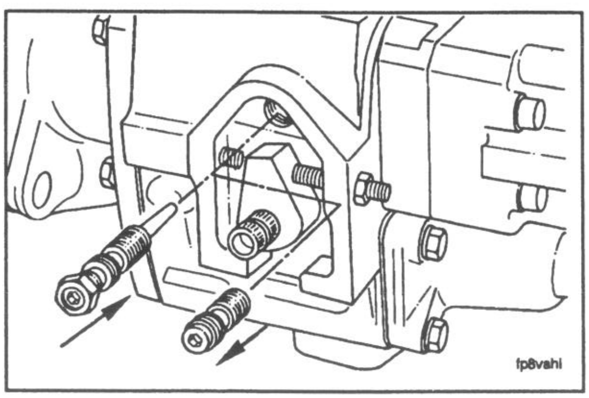
Actuator Installation in an AFC Fuel Pump Housing



Remove the fuel pump if it is on the engine.

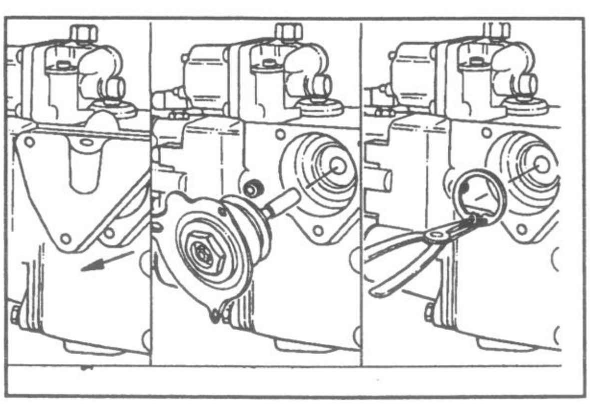


Remove the hydraulic ASA (Air Signal Attenuator), if required, and the AFC fuel drain tube. Install a plug in the housing. Install a plug in the fuel drain tube connection.



Remove the AFC no-air plug, if the fuel pump does not have an AFC, replace it with the no-air needle valve. The AFC no-air plug is located directly above the throttle shaft.

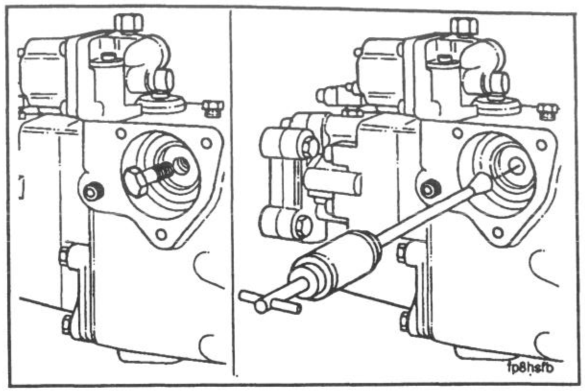
Tighten the AFC no-air needle valve in the housing to 25 in-lb. [2.8 N•m]. Tighten the jam nut.



Remove the AFC cover plate. Remove the AFC bellows/plunger assembly, if required. Use a pair of snap ring pliers to remove the barrel or barrel plug snap ring.

Thread one of the previously removed 1/4-20 capscrews into the AFC barrel plug. Pull out the barrel plug with a pair of pliers. Discard the three original cover plate capscrews.

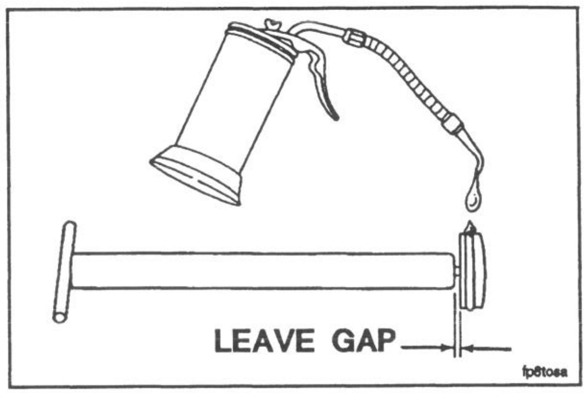
If the fuel pump has a functional AFC, use the AFC barrel puller, Service Tool 3375599 to remove the barrel. The AFC cannot be used with an EFC governor. The AFC cavity is now ready for the installation of the EFC governor actuator.



Install the O-ring plug on the Governor Plug Tool, Part No. 3376457, approximately three turns. Install the O-ring on the plug.

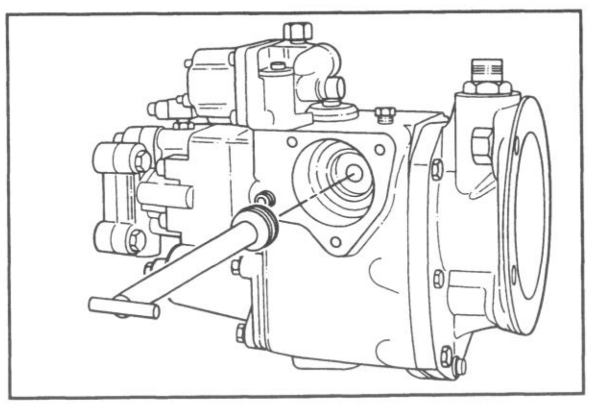
Caution: Do not tighten the O-ring plug to the plug tool or the tool can not be removed after the plug is inserted in the pump AFC cavity.

Lubricate the O-ring with clean engine oil.



Press firmly until the O-ring plug is seated in the pump housing.

Carefully unscrew the plug tool.

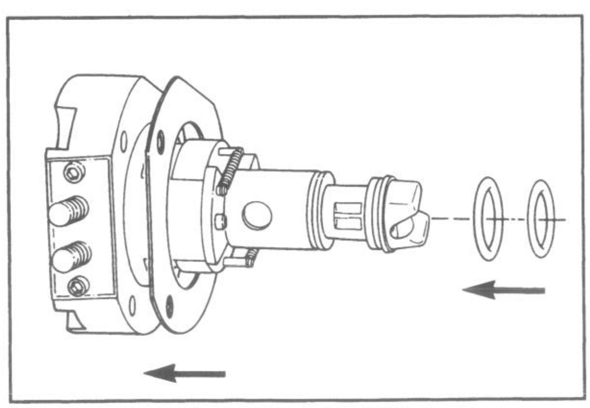


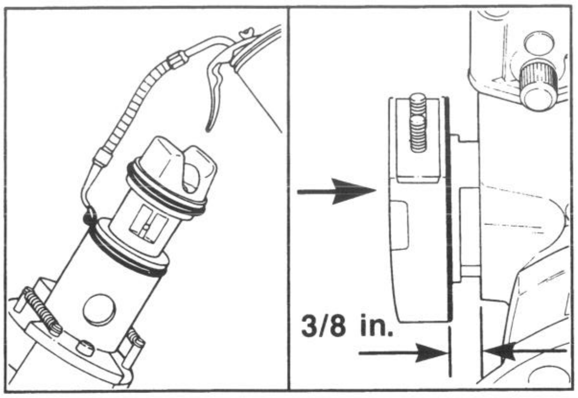
Install the EFC gasket on the actuator. The gasket will fit only one way. The fuel pump side goes against the fuel pump.

Caution: Do not use any gasket adhesive or sealant on this gasekt.

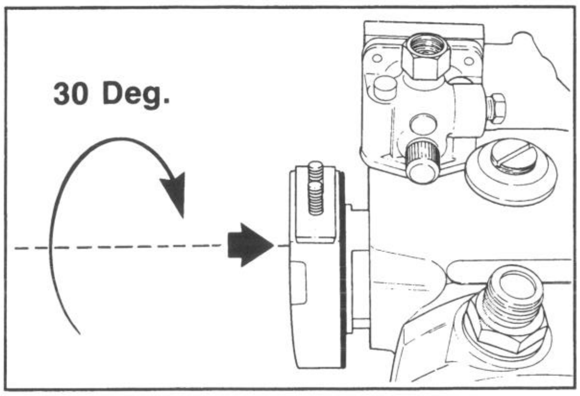
Check that all of the mounting holes can be aligned.

Install the O-rings on the shaft.

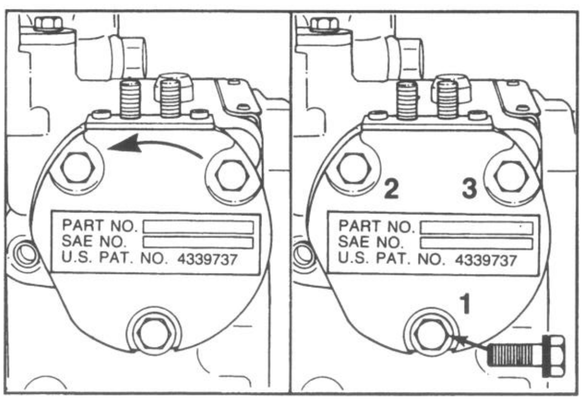




Lubricate the actuator O-rings with clean engine oil. Insert the actuator in the EFC cavity of the fuel pump housing. The actuator flange will be approximately 3/8 inch [9.5 mm] from the fuel pump housing.

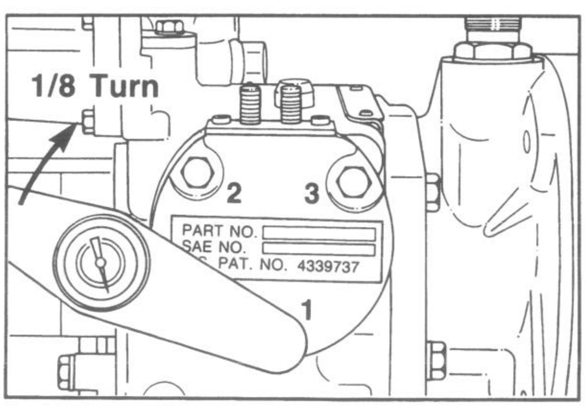


Use the palm of the hand. Firmly push and rotate the actuator approximately 30 degrees until the actuator flange contacts the fuel pump housing.



Rotate the actuator until the mounting holes are aligned.

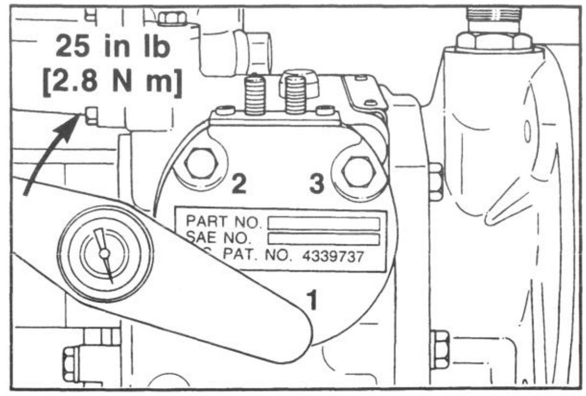
Install the three 1/4-20 X 1 1/4 inch hex head capscrews. These capscrews have captive spring washers and do not require lockwashers. Tighten the capscrews until they are finger tight.



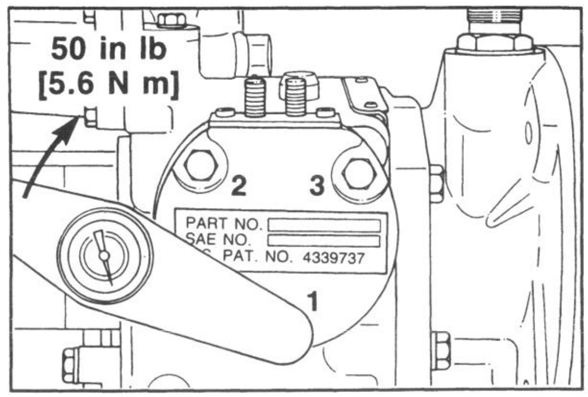
The actuator capscrews must be tightened in the following procedure:

1. Tighten the mounting capscrews 1/8 of a turn, in the sequence shown in the figure until they are seated.

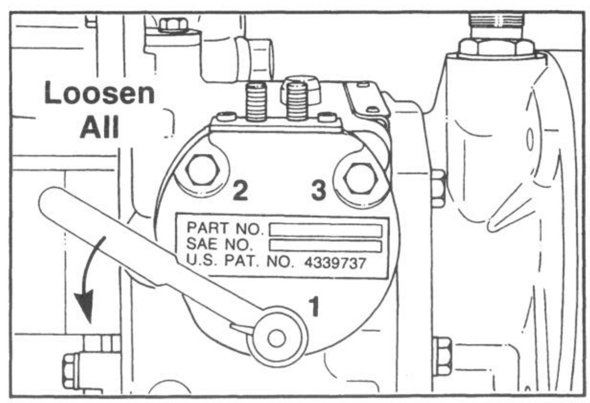
2. Tighten the cpascrews in sequence to 25 in-lb [2.8 N•m] torque.



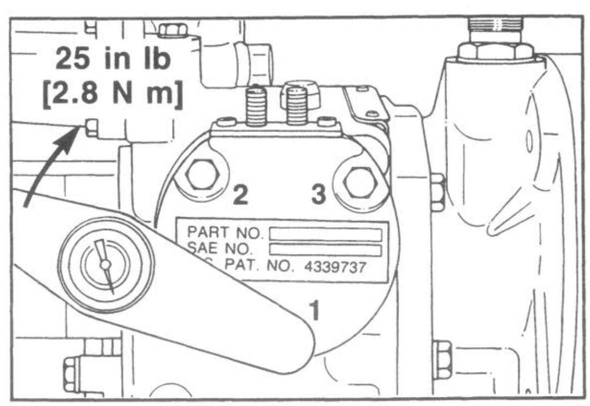
3. Tighten the capscrews in sequence to a torque of 50 in-lb [5.6 N•m].

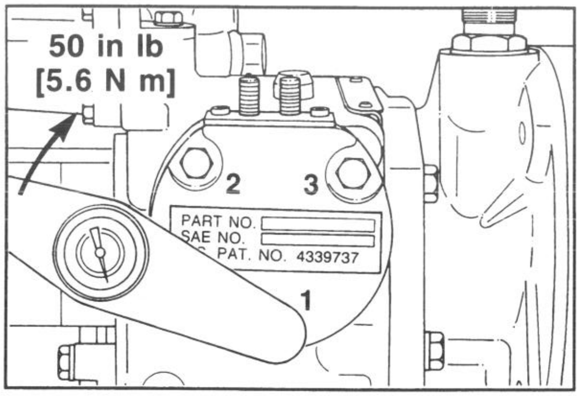


4. Loosen all three capscrews completely.

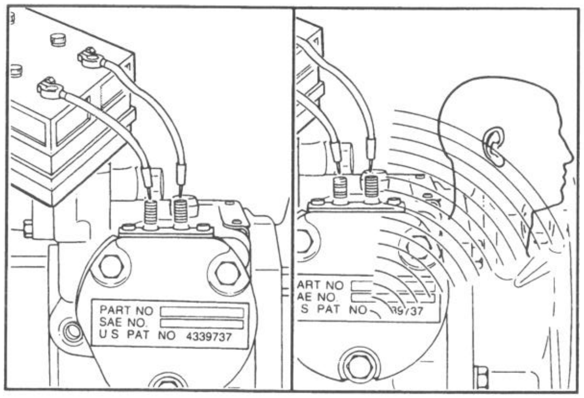


5. Tighten the capscrews again in sequence to 25 in-lb [2.8 N•m] torque.



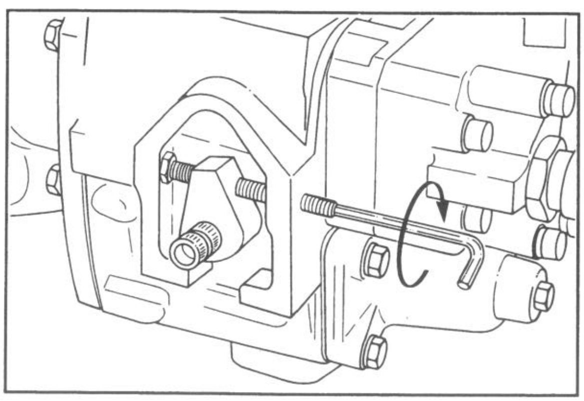


6. Tighten the capscrews again in sequence to 50 in-lb [5.6 N•m] torque.
7. This procedure is to make sure that the actuator is properly installed and is not binding.



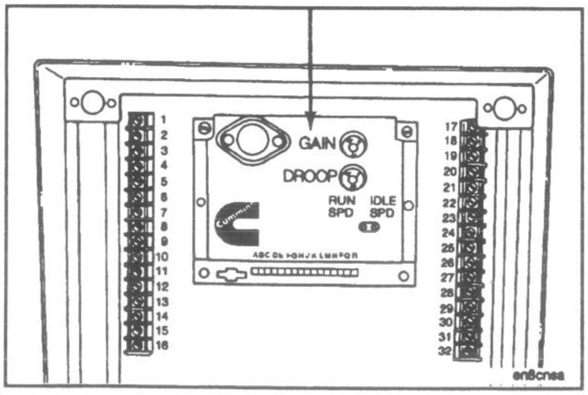
A final check is to apply and remove battery voltage across the two actuator terminals. If the actuator does not click, as if it is not operating, or operating slowly, loosen all of the capscrews and tighten them again as described in the previous procedure.

Caution: This test will only verify that the actuator will go from the full open to the full closed position. A slight binding of the actuator shaft can cause a governor stability complaint. This test will not detect a slight binding.



The fuel pump can now be calibrated (Refer to the Fuel Pump Calibration Manuals or the monthly Cumulative Supplement Update). The throttle shaft must be locked in the full open position. After the calibration, the fuel pump can be mounted on the engine.

Note: Apply the actuator rated battery voltage to the normally closed actuator when the fuel pump is calibrated.

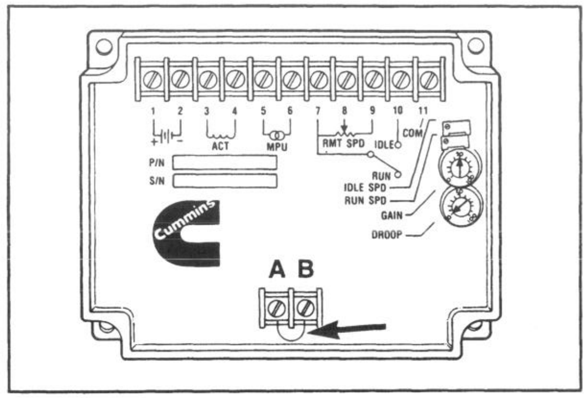


System Adjustments - Single Unit Governor

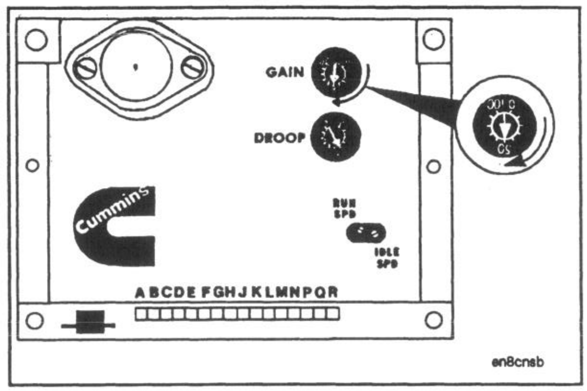
Panel Mounted Governor Control Adjustments

The panel mounted governor control has four potentiometers for making system adjustments. These components are mounted on the control which is located inside the engine instrument panel or generator control panel.

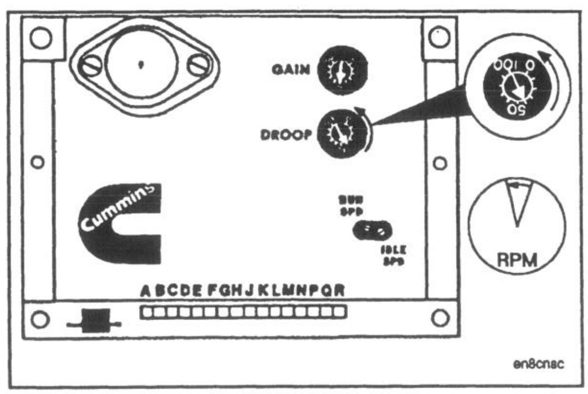
Note: When a two bearing generator or a single bearing generator with a flexible drive between the flex discs and shaft (eg. Kohler 4T10 generators, Models 230ROZ, 250 ROZ and 275 ROZ) is installed, use a remote mounted control. If the engine is not stable after the gain adjustment is made, install a jumper wire between terminals A and B.



The **gain** control is a one-trun potentiometer. It is used to adjust the sensitivity of the governor. A clockwise rotation of the potentiometer knob will shorten the response time of the governor to load changes. Refer to the glossary for the gain description.



The **droop** control is a one-turn potentiometer. It is adjustable for zero percent (isochronous) to five percent speed droop. Counterclockwise rotation will decrease the speed droop.

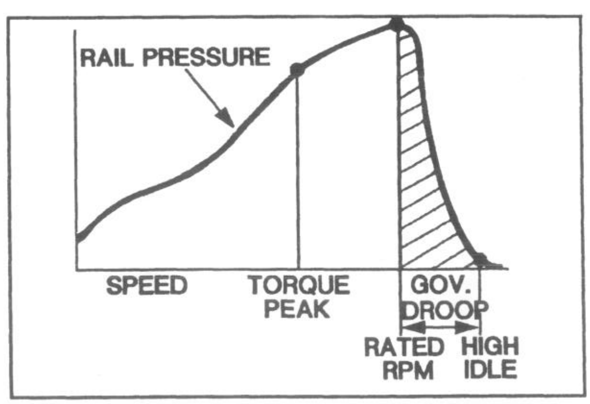


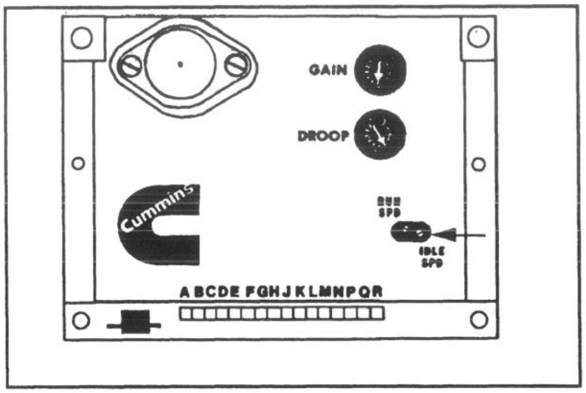
Refer to the glossary for the droop description.

$$\frac{\text{No Load Speed - Rated Speed}}{\text{Rated Speed}} \times 100\% = \text{Governor Droop}$$

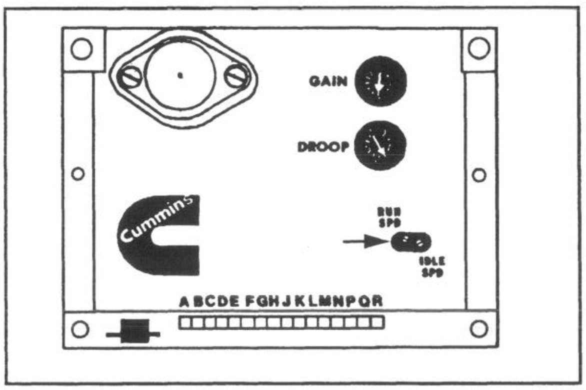
$$\frac{1890 - 1800}{1800} \times 100 = 5\%$$

$$\frac{1800 - 1800}{1800} \times 100 = 0\% \text{ (Isochronous)}$$

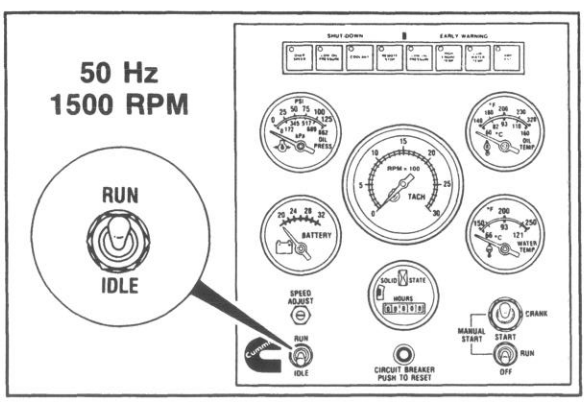




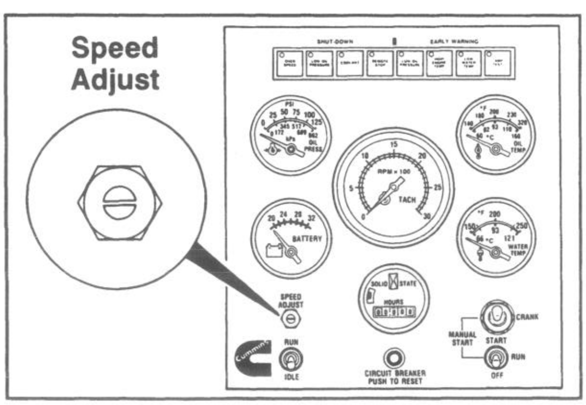
The **idle speed** control is a 20-turn potentiometer for adjusting the idle speed. A clockwise rotation will increase the idle speed.



The **run speed** control is a 20 turn potentiometer for setting the desired no-load governed speed. A clockwise rotation will increase the run speed.

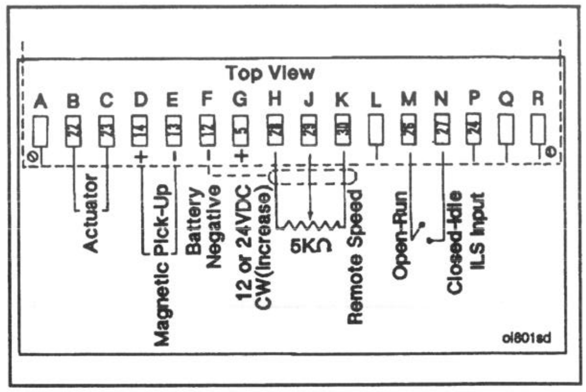


An **idle-run** switch, located on the engine instrument panel, allows the selection of the idle or run mode.

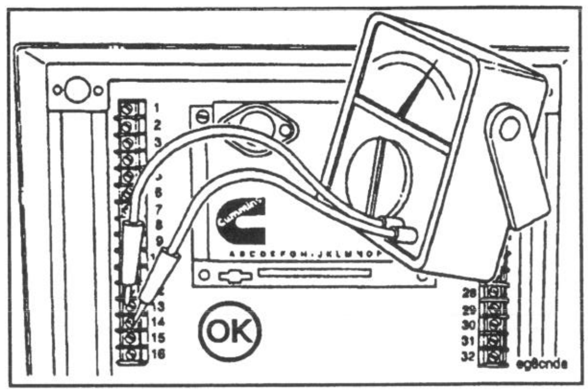


Also located on the engine instrument panel is the **Speed Adjust** potentiometer which is used for fine speed adjustment after **Run Speed, Droop,** and **Gain** have been set.

The panel mounted governor control wiring.



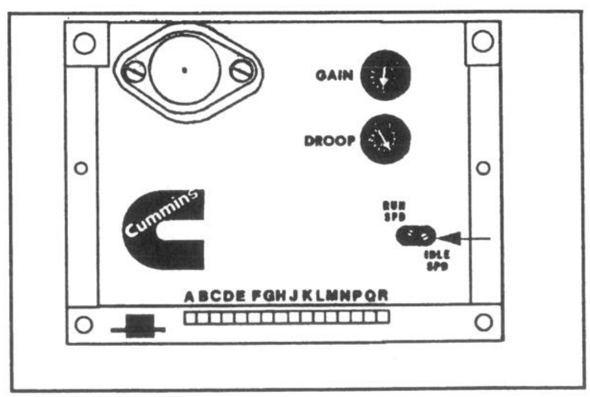
Caution: Measure the voltage on the engine control circuit board terminal strip and not on the control terminal strip. If the two terminals on the control terminal strip are shorted out, it can damage the control unit.



Preliminary Adjustments

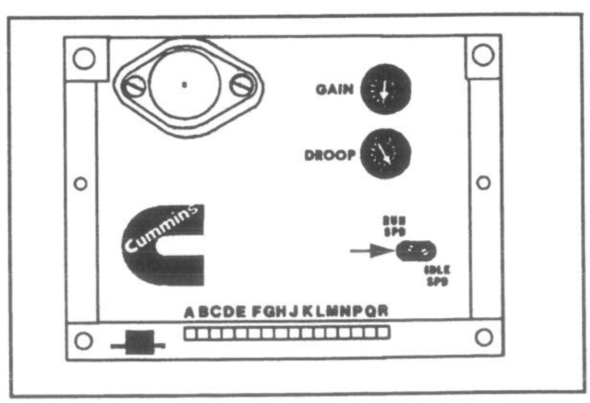
The idle speed potentiometer adjustment.

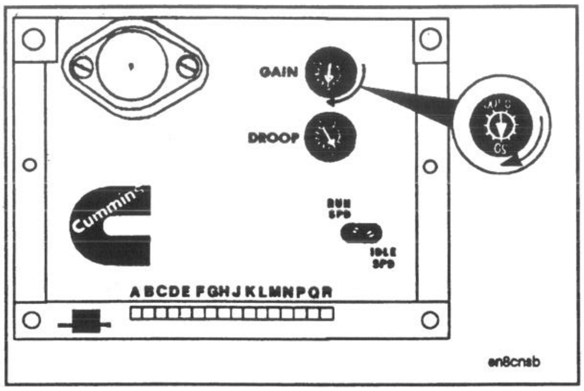
1. Turn the screw counterclockwise 20 turns.
2. Turn the screw clockwise 10 turns.
3. This will set the idle speed potentiometer to its mid position.
4. The potentiometer has a ratchet at both ends of the travel. Turning the potentiometer beyond the normal range does not damage the potentiometer.



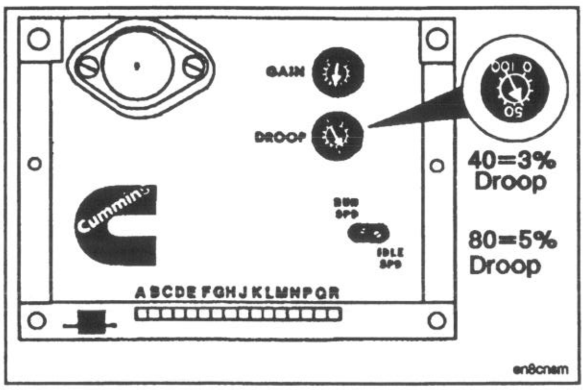
The run speed potentiometer adjustment.

1. Turn the screw counterclockwise 20 turns.
2. Turn the screw clockwise 10 turns.
3. This will set the run speed potentiometer to its mid position.
4. The potentiometer has a ratchet at both ends of the travel. Turning the potentiometer beyond the normal range does not damage the potentiometer.





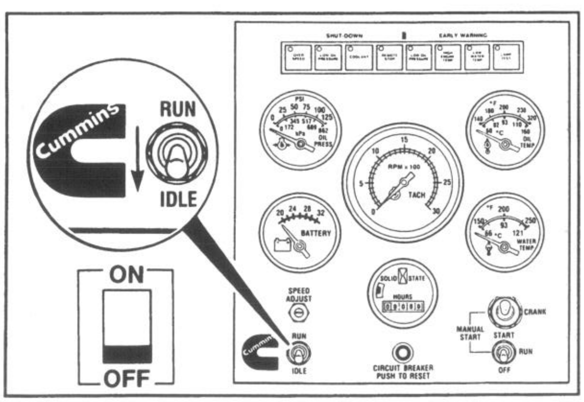
Turn the gain potentiometer adjustment to midposition or 50.



The droop potentiometer adjustment.

1. Turn the screw fully counterclockwise for isochronous operation.
2. Turn the screw to approximately 40 for 3 percent droop.
3. Turn the screw to approximately 80 for 5 percent droop.

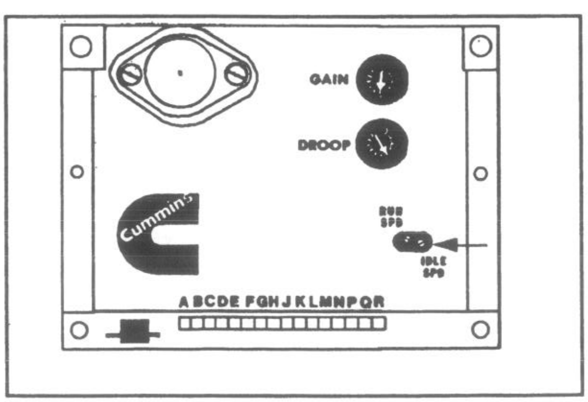
Adjust any remote speed potentiometers to the center of their adjustment range.



Governed Speed Adjustment

Place the idle-run switch on the engine instrument panel in the idle position.

Note: Open the main line circuit breaker while the engine is at idle.



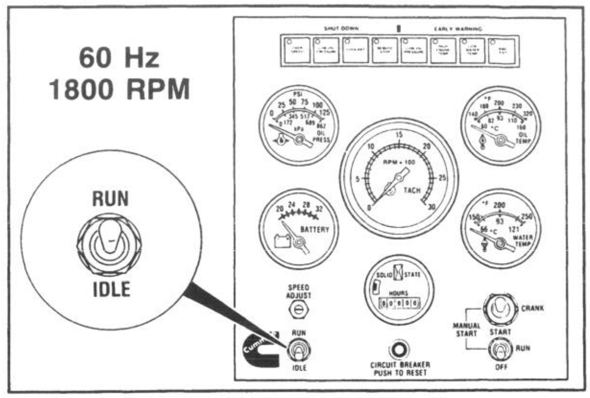
Start the engine. Adjust the idle speed potentiometer on the governor control until the engine is running at 600 to 650 RPM.

Generators which are to operate at 60 Hz full load, must have the engine no load governed speed adjusted to:

60.0 Hz (1800 RPM) for isochronous operation

61.8 Hz (1854 RPM) for 3% speed droop

63.0 Hz (1890 RPM) for 5% speed droop



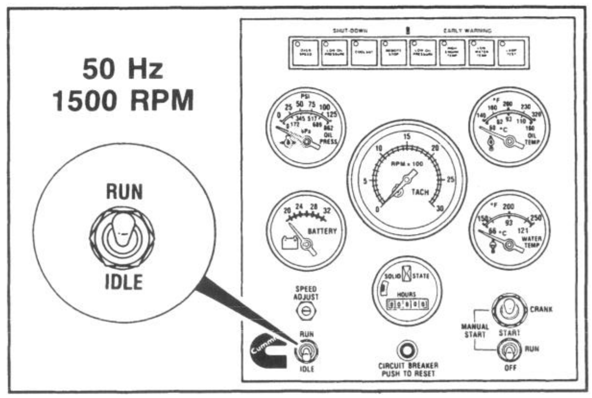
For generators which are to operate at 50 Hz full load, the engine no-load governed speed must be adjusted to:

50.0 Hz (1500 RPM) for isochronous operation

51.5 Hz (1545 RPM) for 3% speed droop

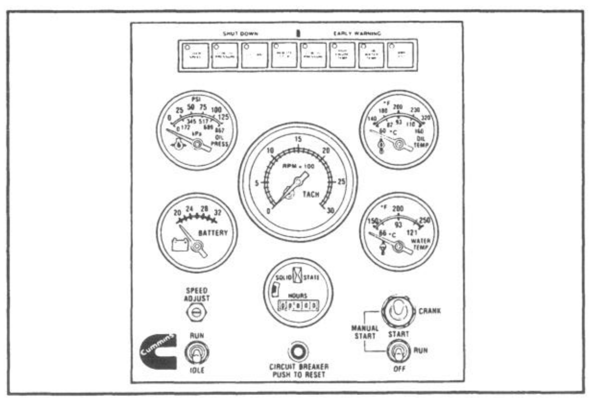
52.5 Hz (1575 RPM) for 5% speed droop

Move the idle run switch to the "Run" position.



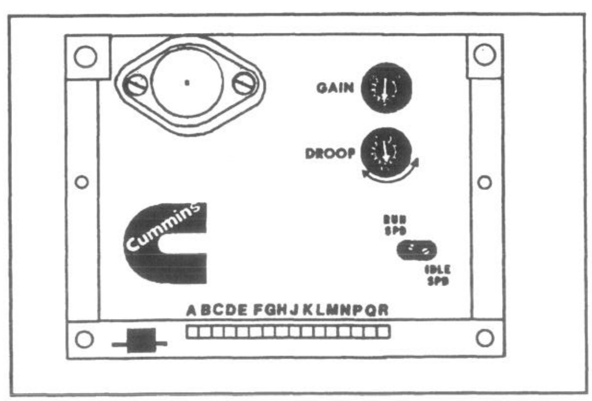
Adjust the run speed potentiometer on the governor control until the no load speed is correct.

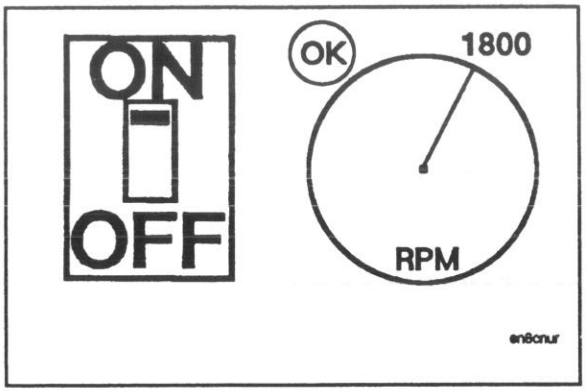
Note: You can now close the main line circuit breaker.



Droop Adjustment - Isochronous Operation

For isochronous operation, the droop potentiometer must be turned fully counterclockwise and will not require any further adjustment.

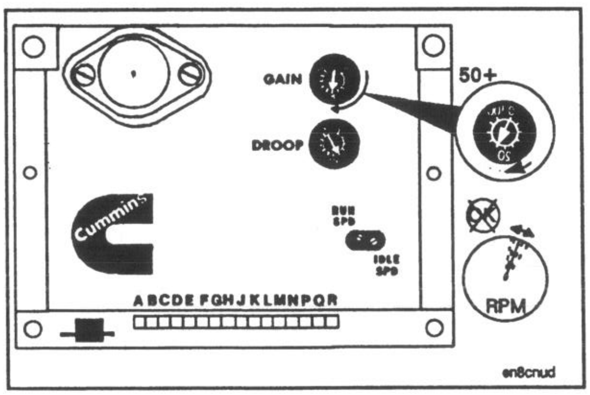




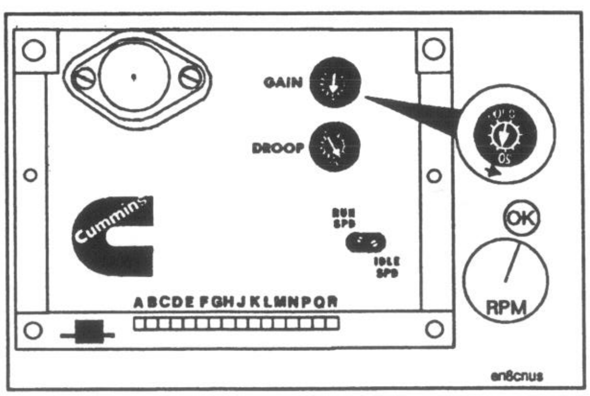
Gain Adjustment

Close the main line circuit breaker and apply approximately 1/4 of the rated load.

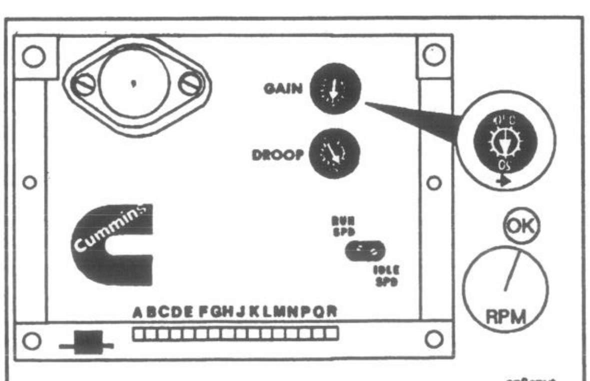
Make sure the engine speed is constant.



If the engine speed is constant, turn the GAIN potentiometer clockwise slowly until the engine speed is not constant.



1. Slowly turn the potentiometer counterclockwise until a constant speed is achieved.

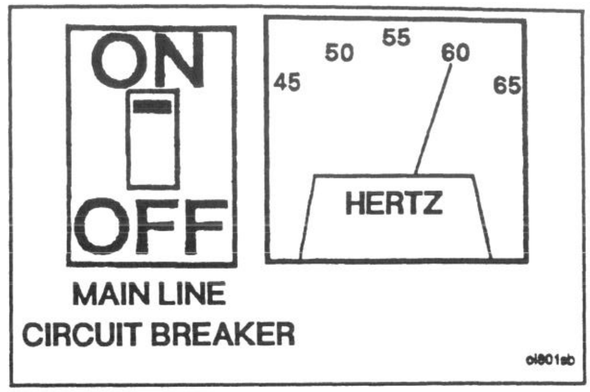


2. Turn the potentiometer counterclockwise an additional 1/2 division.

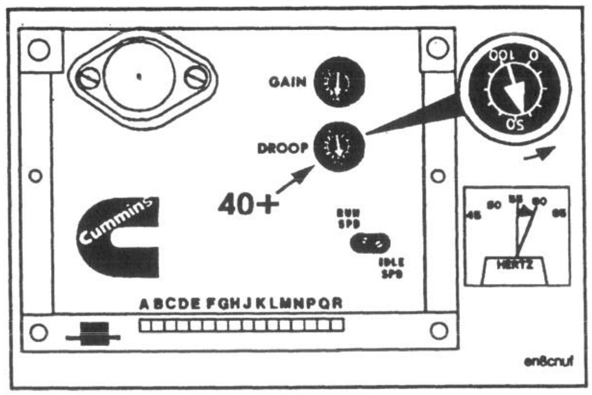
Droop Operation

Close the main line circuit breaker and apply the rated KW load.

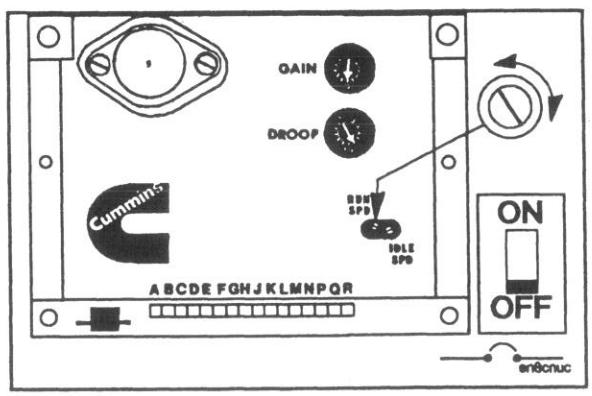
Check the frequency meter to make sure the full load governed speed is correctly set at 60 Hz or 50 Hz..



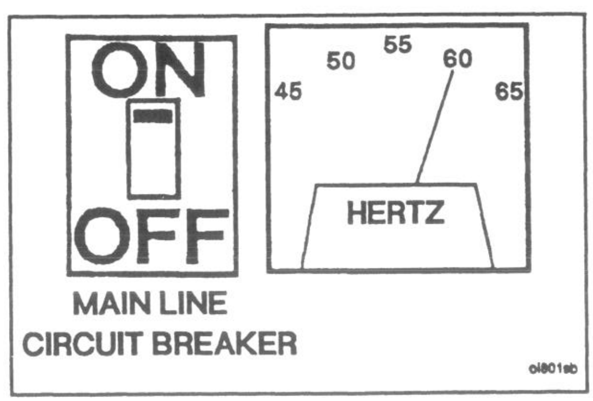
1. If the frequency meter is less than 60 Hz or 50 Hz, more droop is present than desired.
2. Turn the droop potentiometer counterclockwise slowly until it is 60 Hz or 50 Hz.
3. The droop potentiometer will be at approximately 40 for 3 percent frequency droop.



4. Open the main line circuit breaker and adjust the no load governed speed again to the correct setting.



5. Close the main line circuit breaker and apply full load. The frequency meter must read 60 Hz or 50 Hz.
6. If the frequency meter is not 60 Hz or 50 Hz, repeat the procedure. It will usually take two or three successive adjustments to obtain the correct frequency.



7. To calculate the operating (governed) speed under the available load for droop operation, when the full KW load is not available, use the following formula:

Note: The engine speed in RPM is equal to 30 times the frequency (Hz.). At 60.0 Hz., Engine Speed = 30 X 60 = 1800 RPM.

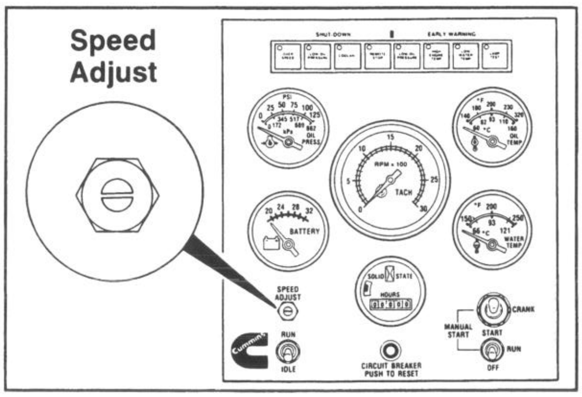
$$S_{al} = S_{nl} - \left[\left(\frac{\text{Available KW Load}}{\text{Rated KW}}\right) \times \left(S_{nl} - S_{fl}\right)\right]$$

Where
S_{al} = Speed at Available KW Load
S_{fl} = Speed at Full KW Load
S_{nl} = Speed at No Load

Example
Available KW Load = 400
Rated KW = 500
Speed at Full KW Load = 1800
Speed at No Load = 1854

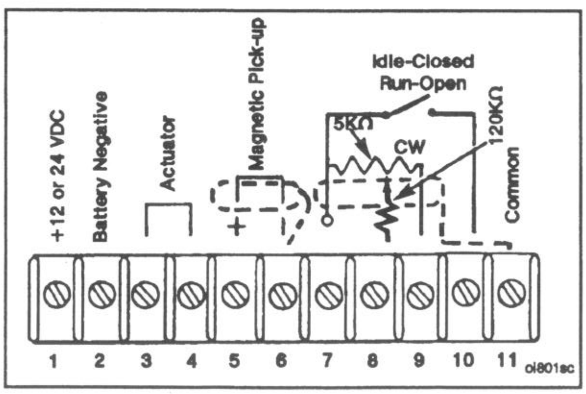
$$S_{al} = 1854 - \left[\left(\frac{400}{500}\right) \times (1854 - 1800)\right]$$

S_{al} = 1811 RPM



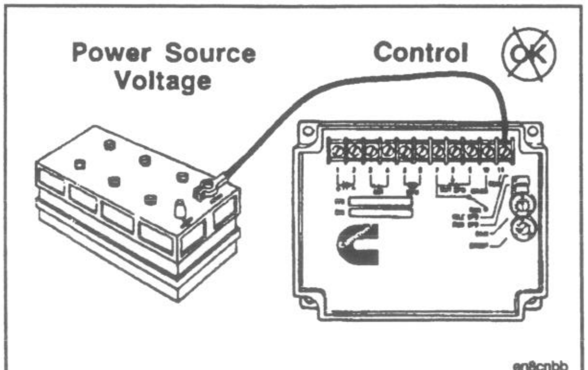
Fine Speed Adjustment

After the gain adjustment is made, the full load governed engine speed may require a minor adjustment to equal the desired speed (i.e. 60 Hz, 1800 RPM or 50 Hz, 1500 RPM). Use the SPEED ADJUST potentiometer on the engine instrument panel for fine speed adjustments of less than ± 100 RPM.



System Adjustment Remote Mounted Governor Control

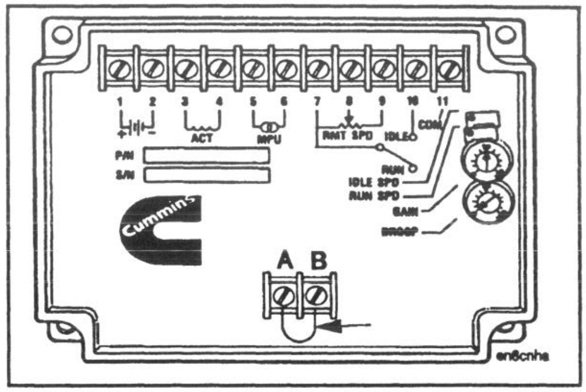
Follow the panel mounted governor control instructions for setting the governed speed, idle, droop and gain on the remote mounted control. The wiring for the remote mounted control is shown.



Caution: Do not attach the battery negative to Terminal Number 11. The control circuitry will be damaged.

Remote Mount Governor Control

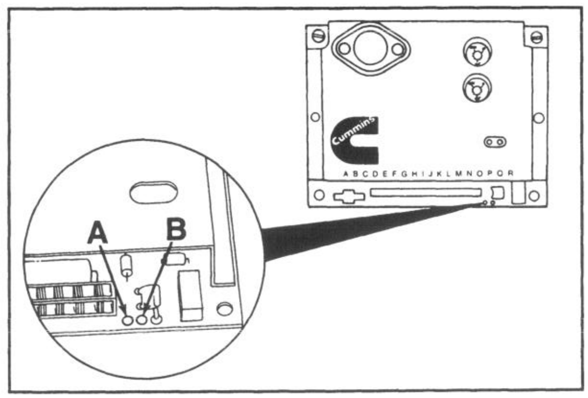
Note: When a two bearing generator or a single bearing generator with a flexible drive between the flex discs and shaft (e.g. Kohler 4T10 generators, Models 230 ROZ, 250 ROZ and 275 ROZ) is used, install a jumper between terminals A and B. This jumper provides additional stability in the governor control. The oscillation frequency of the coupling between the engine and the generator can cause the governor control to react to this oscillation in addition to a change in engine speed.

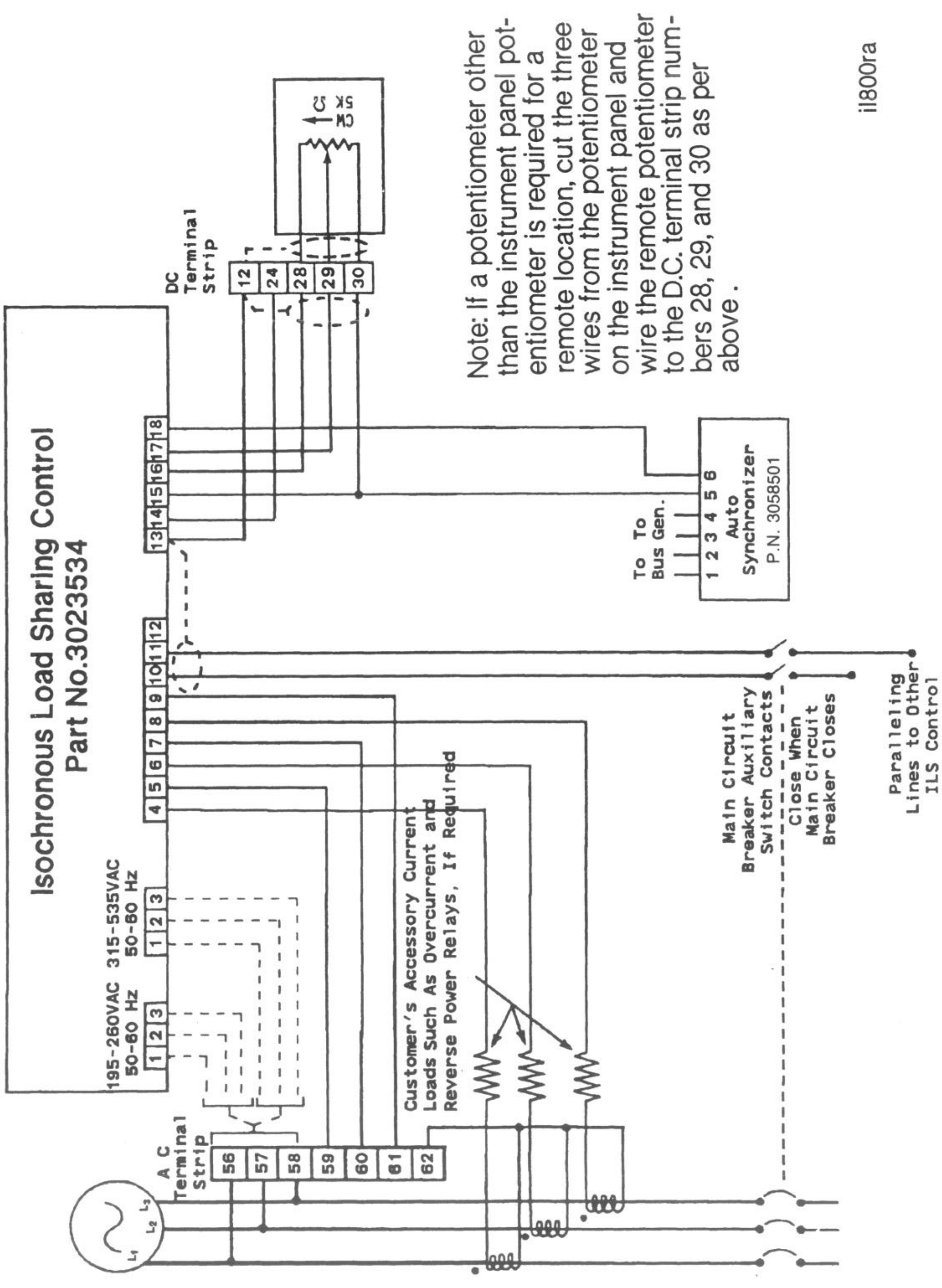


Plug-In Governor Control

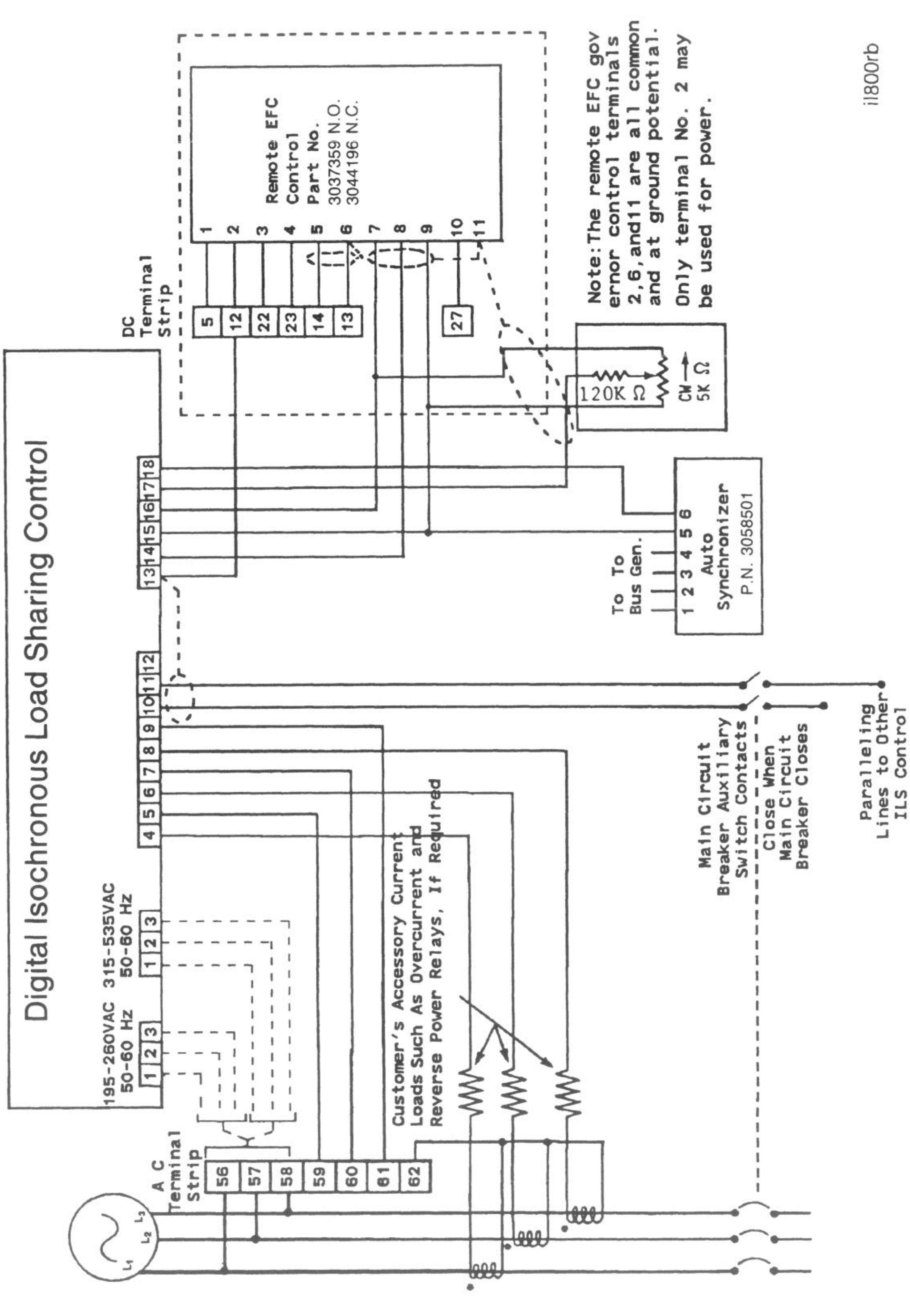
The same function of the A and B jumper can also be done on the Normally closed EFC plug-in control.

Note: It is highly recommended that the remote control be used when the A and B jumper is required, because of the ease of installation and the possible circuit board damage when soldering the jumper in place on the plug-in controller. The conformal coating must be removed at points A and B, and a AWG #20 to 22 wire be soldered in place on the circuit board. All solder flux must then be cleaned off to prevent corrosion from occurring on the circuit board foil. The board should then be resealed where the coating was removed.





The load sharing control with a panel mounted plug in control and a remote speed adjusting potentiometer for use with an auto synchronizer and an isochronous load sharing control.



The load sharing control with a remote control and a remote speed adjusting potentiometer for use with an auto synchronizer and an isochronous load sharing control.

Wiring Of Generator Sets (Refer To The Diagram On The Next Page)

Caution: Measure the voltage of the panel mounted governor control on the printed circuit board terminal strip. Do not measure the voltage on the control terminal strip.

Notes For Auto-Synchronizer

1. The "Gain Range" is changed by adding a jumper between Terminals 6 and 14.

   No jumper 6 to 14: Auto-Synchronizer is set for fast responding engines.

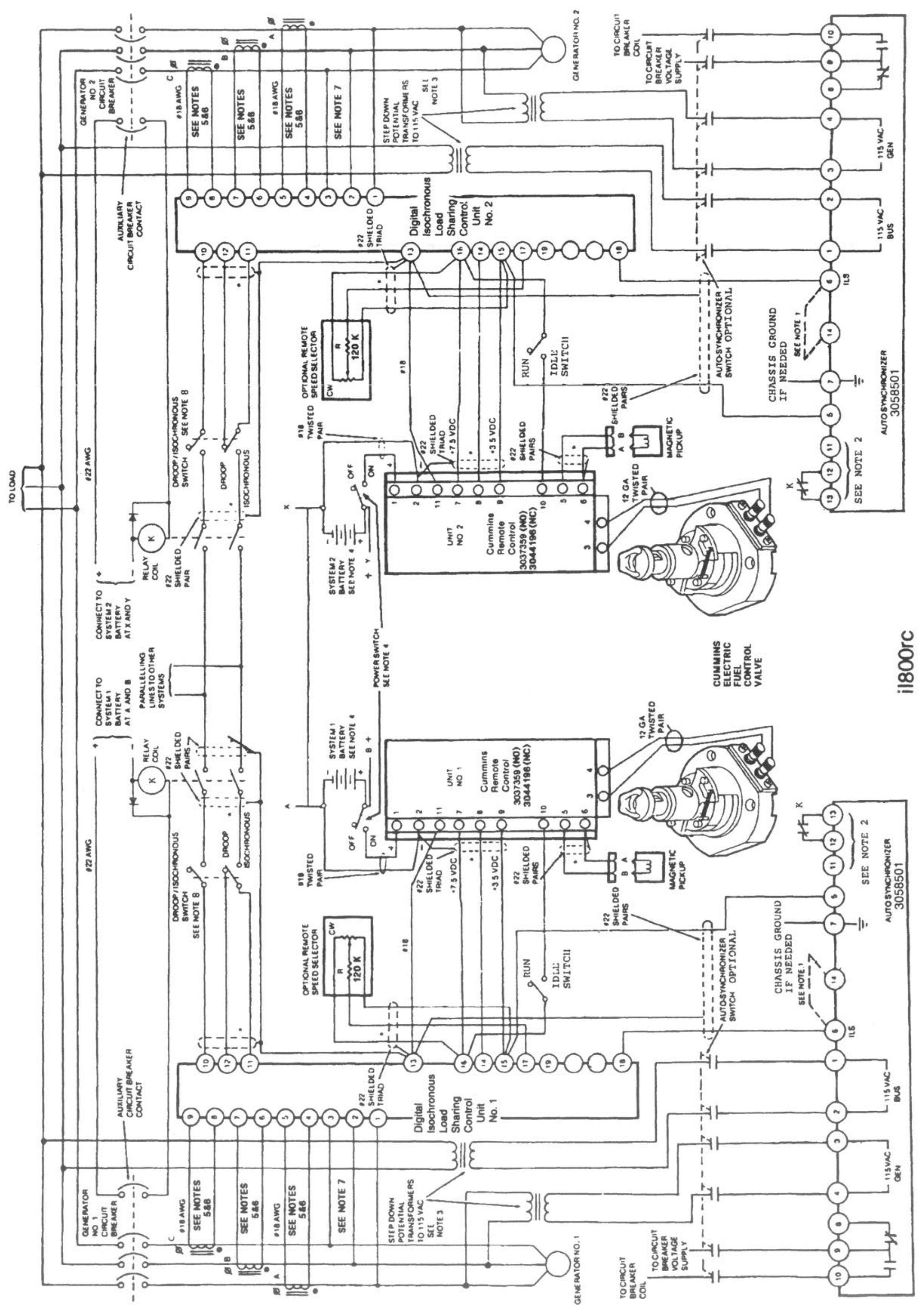
   With jumper 6 to 14: Auto-Synchronizer is set for slow responding engines.

2.
   a. Closing a contact or jumpering 11 to 12 allows the Auto-Synchronizer to perform as a sync check relay only, with circuit breaker contact output but no control on the incoming generator.
   b. Closing a contact between 12 to 13 allows the Auto-Synchronizer to perform as a speed matching unit. The speed and phase of the incoming generator are controlled and contact is closed to drive circuit breaker. Once the circuit breaker is closed, the contact between 12 and 13 should be opened. (See the diagram for an example of how one would most likely wire Terminals 11, 12 and 13.)
   c. Open contacts or no jumper 11 to 12 or 12 to 13 allows the Auto-Synchronizer to still sense any error but it does not provide any control or contact closures.

3. Phasing of voltage potential to the Auto-Syncrhonizer is necessary to keep each signal in its correct phase relationship. If the generator voltage is not the same as the voltage rating of the Auto-Synchronier, step-down transformers are required. Correct phasing of the transformer leads is necessary. Step-down transformers require a nominal 10 VA/PHASE for the GEN. input to the Auto-Synchronizer and 7 VA/PHASE for the BUS input to the Auto-Synchronizer.

Notes For Digital Isochronous Load Sharing

4. Systems battery supply. If more than one engine is started using the same battery supply, use separate battery supply for the DYNA System. Twist power leads as shown. Use shielded leads as shown. Use a single pole, single throw 4 ampere switch.
5. Select current transformers to provide as close as possible 5.0 amps at full-rated load. Current transformers require 12.5 VA/PHASE at 5.0 amps.
6. Observe current transformer polarity markings when connecting.
7. Phasing of voltage potential to the Isochronous Load Sharing Control is necessary to keep each signal in its correct phase relationship. Cummins supplied ILS panels are capable of input voltage ranges from 195 to 260 VAC or 315-535 VAC. If the generator voltage is not the same as the voltage rating of Isochronous Load Sharing Control, step-down transformers are required. Correct phasing of the transformer leads is necessary. Step-down transformers require a nominal 6 VA/PHASE for the Isochronous Load Sharing Control.
8. Droop/Isochronous switch is not required if units are always operated in the Isochronous mode.



A typical wiring diagram for two generator sets with a load sharing control, governor control, EFC fuel control and auto-synchronizer.

Component Specifications

Actuator and Governor Control

Operation

Governing Mode	: Isochronous to 5% droop
Steady State Stability	: ±1/4%
Operating Input Frequency Range	: 1K to 5K Hz
Idle Frequency Range	: 200 to 2200 Hz
Response Time of Actuator	: 15 milliseconds

Power

Operating Voltage	: 12 Volts D.C. ±3 Volts or 24 Volts D.C. ±6 Volts Continuous
Ground Polarity	: Negative ground (case isolated)
Power Consumption (Maximum)	: 94 Watts (12 or 24 Volts D.C.)
Nominal Operating Current	: 1.3 amps at 24 volts
Nominal Operating Current	: 2.6 amps at 12 volts
Maximum Operating Current	: 3.9 amps at 24 volts
Maximum Operating Current	: 7.8 amps at 12 volts

Environmental

Ambient Operating Temp.	: -40° to 185° F [-40° to 85° C]
Maximum Temp. Drift	: ±1% @ - 40° to 185° F [- 40° to 85° C]
Relative Humidity	: 0 to 100% non Condensing

Physical-Remote Control

Dimensions	: 5.75 in. x 4.44 in. x 2.15 in. (146mm x 113mm x 55mm)
Weight	: 2 lbs. [.9 kg]
Mounting	: Any position, typically in enclosure
Case Material	: Die cast aluminum

Panel Mounted Control

Dimensions	: 5.5 in. x 4.1 in. x 1.3 in. (140mm x 104mm x 33mm)
Weight	: 1 lb. [.45 kg]
Mounting	: 16 pin plug-in receptacle

Protection Features

High voltage protection (15 VDC for 12 volts or 32 VDC for 24 volts continuous)
Reverse of supply polarity
Surge protection (80 VDC, 10 msec transient)

Vibration Protection: (Remote Control) Entire printed circuit board sealed with Silicone filled Epoxy.

(Panel Mounted Control) Circuit board sealed with Silicone Epoxy.

Magnetic Pickup Specifications

Thread Size	: 5/8 - 18 UNF-2A
Tap Drill Size	: 37/64 inch
Proximity to Gear Teeth	: .028 in. min. - .042 in. max. (Approximately 1/2 to 3/4 turn)
Temperature Range	: - 67° to 220° F [- 55° to 105° C]
Output at Cranking Speed	: 1.5 volts AC minimum
Maximum Output	: 30 volts AC
Coil Resistance	: 300 ohms maximum

Remote Potentiometer Specifications

Resistance	: 5K Ohms ±5%
Linearity	: .25%
Travel	: 360° x 10
Power Rating	: 2 Watts @ 160° F [70° C]
Insulation Rating	: 1000 M Ohms @ 500 VDC
Dielectric Strength	: 100 V RMS
Operating Temperature Range	: +220° F to - 67° F [+105° C to - 55° C]

Wiper Resistor — For the Remote Mounted Control Fine Speed Adjustment Potentiometer

120K Ohms, 1/4 Watt

100 PPM Temperature Coefficient or Less Metal Film

Resistance Test of Actuator Coil

When the actuator leads are disconnected, the coil resistance must be 6.8 to 7.6 ohms* for the 24 volt model or 2.0 to 2.3 ohms for the 12 volt model.

Table 1: Normally Open Electric Fuel Control Governor Parts

Part No.	Description
3052504	Actuator Low Flow-24V-For use on NT-855 and KTA-19 engines
3052505	Actuator High Flow-24V-For use on VTA-28, KTA-38 and KTA-50 engines
3052506	Actuator Ultra High Flow-24V-For use on KTTA-38 and KTTA-50 engines
3052507	Actuator Low Flow-12V-For use on NT-855 and KTA-19 engines
3052508	Actuator High Flow-12V-For use on VTA-28, KTA-38 and KTA-50
3052509	Actuator Ultra High Flow-12V-For use on KTTA-38 and KTTA-50 engines
3037359	Control-12 or 24V (For Remote Mounting, Enclosed)
3032733	Control-12 or 24V (Plug-In type, for mounting in Cummins Engine Instrument Panel or Generator Control Panel Enclosure)

Table 2: Normally Closed Electric Fuel Control Governor Parts

Part No.	Description
3044189	Actuator, 24V, Normally Closed, Low Flow, for use on NT-855 and KTA-19 engines
3044190	Actuator, 24V, Normally Closed, High Flow, for use on VTA-28, KT(A)38, and KTA-50
3044191	Actuator, 24V, Normally Closed, Ultra-Hi Flow, for use on KTTA-38 and KTTA-50
3044192	Actuator, 12V, Normally Closed, Low Flow, for use on NT-855 and KTA-19 engines
3044193	Actuator, 12V, Normally Closed, High Flow, for use on VTA-28, KT(A)-38, and KTA-50
3044194	Actuator, 12V, Normally Closed, Ultra-Hi Flow, for use on KTTA-38 and KTTA-50
3044195	Control-12 or 24V, Plug-In-Type, for mounting in Cummins Engine Panel or Generator Control Panel Enclosure
3044196	Control-12 or 24V, Remote Mounting, Enclosed

Table 3: Parts Common for Both Systems

Part No.	Description
3034572	Magnetic Pickup (For SAE #1 or #0 Flywheel Hsg. with engine wiring)
3034573	Magnetic Pickup (For SAE #00 Flywheel Hsg. with engine wiring)
3015105	Remote Speed Potentiometer (See Remote Control)
104215	Idle-Run Toggle Switch
213272	Magnetic Pickup (For SAE #1 or #0 Flywheel Hsg. without engine wiring)
3003916	Magnetic Pickup (For SAE #00 Flywheel Hsg. without engine wiring)
213273	Wiring Harness for 213272 and 3003916 magnetic pickups
3052510	Wiring Harness for EFC Psuedo Rolled Connectors (New)
3035133	Wiring Harness for EFC Spade Type Connectors (Old)

*Electric fuel control actuator coil resistance — normally-closed coils manufactured between 10-1-86 and 11-1-86 may have 8.6 ohms.

Table 4: Actuator Mounting Parts for an AFC Housing

Part No.	Description
193734	O-ring, Plug
145504	O-ring, Actuator
145505	O-ring, Actuator
3029854	Gasket
3029853	Spring, Return (Qty. 2)
3029300	Plug, O-ring
3017051	Capscrews, 1 1/4 inch (Qty. 3)

Table 5: Actuator Mounting Parts for an EFC Housing

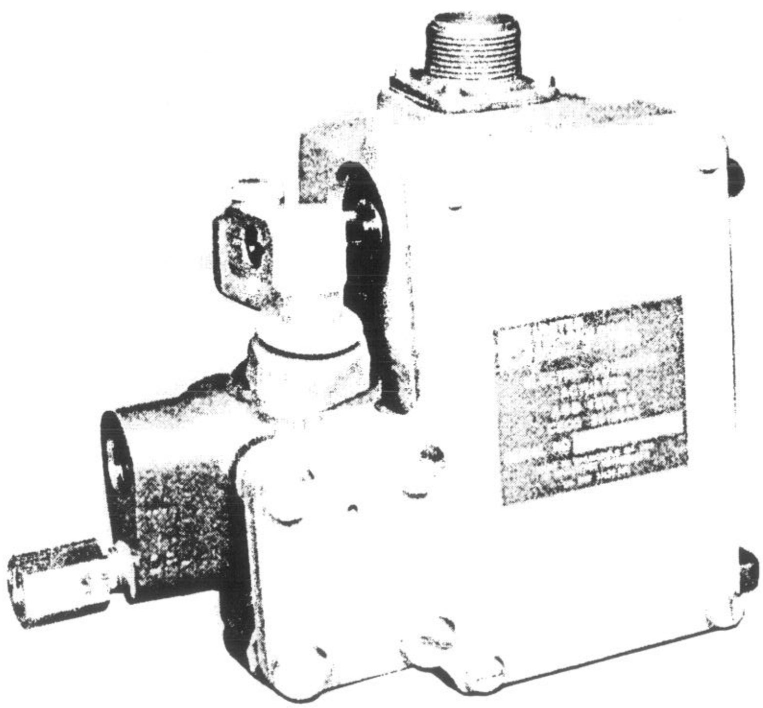
Part No.	Description
145504	O-ring, Actuator
145505	O-ring, Actuator
3029853	Spring, Return (Qty. 2)
3048182	O-ring, Flange
3017051	Capscrews, 1 1/4 inch (Qty. 3)

Page No.

United Technologies Governing Systems

The following sections (4-15 through 4-19) are reprints of the United Technologies Governing Systems manuals with the permission of United Technologies Company. Therefore Cummins Engine Company assumes no responsibility of their Content or Accuracy therein.

ACTUATOR
AGD 130



EG-29

ENGINE GOVERNING SYSTEMS

INTRODUCTION

The AGD 130 actuator can be used with 12VDC, 24VDC, or 32VDC power supplies. See Pages 4 & 5 for proper wiring diagrams.

The actuator is a linear electro-magnetic fuel metering device. It meters fuel quantities up to 1700 lbs. per hr. according to the amount of current flowing from the speed control unit through the actuator.

SPECIFICATIONS

AGD-130 ACTUATOR PERFORMANCE

- Maximum Flow Rate (Diesel #2) .... 771 kg/hr (14.4 litre/min)
  1700 lbs/hr (3.80 gpm)

POWER INPUT

- Operating Voltage .... 12, 24, or 32 VDC
- Normal Operating Current .... 2A at 12 VDC
  1.5A at 24 or 32 VDC
- Maximum Current (Instantaneous) .... 6A at 12 VDC
  3A at 24 or 32 VDC

ENVIRONMENTAL

- Temperature Range .... −54° to + 93°C (−65° to + 200°F)
- Relative Humidity .... up to 100%
- Case .... Fungus proof and corrosion resistant

PHYSICAL

- Dimensions .... See Figure 1
- Weight .... 1.75 kgs (3.85 lbs)
- Mounting .... Any position (See Installation Page 2)

RELIABILITY

- Tested 100%

MATING CONNECTOR

- Use .... EC1249-2 (6 pins)/MS3106R14S-6S
- For CU671C series speed control units use .... EC1248-6 (17 pins)
- Wiring harness (includes both connectors prewired) CB679

VARIATIONS

- AGD 130 E4 .... With temperature probe and standard fuel metering valve
- AGD 130 E5 .... High temperature coil and standard fuel metering valve −54° to +107°C (−65° to +225°F)
- AGD 130 F1 .... Standard electro-mechanical section with fuel metering valve drain port plugged
- AGD 130 F2 .... High temperature electro-mechanical section with fuel metering valve drain port plugged
- AGD 130 G4 .... Reverse acting with fuel metering valve

KITS

- KT 6723 .... For all AGD 130 Series Actuators
  - contains .... Fuel Metering Valve, Actuator Lever Assembly, Dust Boot
- KT 6724 .... For VA 671A and VA 673A valves
  - contains .... Valve Plunger Assembly, Actuator Lever Assembly, Dust Boot "O" Ring Gasket,(2) Aluminum Gaskets
- KT 6726 .... For AGD 100A1 and AGD 130D1 actuator
  - contains .... Fuel Metering Valve, Actuator Lever Assembly, Dust Boot Spacer Plate, (4) Screws, Gasket
- KT 6732 .... For AGD 130 E4/F1 (High Temperature Coils)
  - contains .... Housing Assembly, Plate - Ident, Gasket

ENGINE GOVERNING SYSTEMS

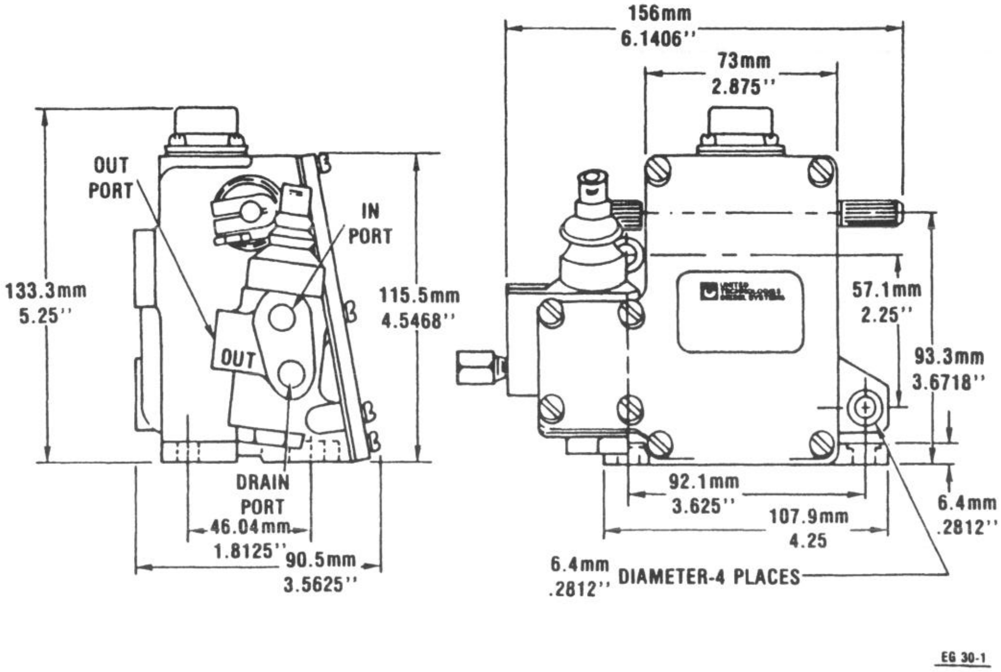


Figure 1. AGD 130 actuator dimensions

DESCRIPTION

An AC frequency signal (proportional to speed), generated by a magnetic speed sensor is constantly fed into the speed control unit and compared with a preset frequency. If the frequencies do not remain identical, a change in current from the speed control unit changes the magnetic force in the actuator which causes angular rotation of the actuator shaft and, in turn, linear movement of the metering valve. Fuel metering is proportional to the amount of current flowing through the actuator and in counterbalanced by an internal spring. The valve is used to meter fuel quantities up to (1700 lbs. per hour) 771 kg per hour, which is ample for all Cummins engines. The actuator housing is sealed against engine environment with gaskets at all openings so steam or other water based cleaning will not affect the system's operation. **No maintenance is necessary.**

INSTALLATION

The actuator should be mounted as closely as possible to the outlet of the fuel injection pump. The actuator may be mounted in any position. However, the preferred mounting position is with the electrical connector at the top. The actuator should be located in an air stream if possible. No adjustment of the valve linkage is necessary.

Actuator bracket, BK 6726 may be used to facilitate preferred mounting on all Cummins engines. The fuel valve is connected into the fuel line to the injectors. The valve inlet (marked "in") on the actuator is connected to the outlet of the PT fuel pump. The valve outlet (marked "out") is connected to the rail leading to the injectors. Steel tubing or single wire braided rubber hose may be used for all fuel lines. Use 5/16" I.D. tubing for all engines except the 12 and 16 cylinder units which required 3/8" I.D. lines. The valve ports are 1/4" NPTF.

The drain port (marked drain) is 1/8" NPTF. It should be connected to the injector fuel return line. A normal back pressure on the drain of 2-4 PSI is acceptable. Higher back

ENGINE GOVERNING SYSTEMS

pressures may cause external fuel leakage. Additionally, all fuel valve fittings should be hand tightened and then wrench tightened 1 to 1-1/2 turns. If sealant is used it should be liquid type and not tape.

Right angle bends in fuel lines and fittings should be avoided near the fuel pump and actuator; use 30° or 45° fittings, or tubing with gradual sloping bends.

On original installations made at the factory, the fuel pumps have been calibrated to compensate for a small pressure drop across the actuator valve. On installations made in the field, it will be necessary to re-adjust the throttle stop as required to obtain rated h.p. However, on engines where the h.p. is marginal for the load at the outset, it will be necessary to compensate for the pressure drop by adding shims to the PTR pumps. On AFC pumps, it will be necessary to replace the throttle shaft, and turn in the adjusting screw until the required rail pressure is obtained. The pressure drop should be measured only at rated speed. This adjustment is necessary only for engines that have no reserve power.

AFC fuel pumps with turbo-charger fuel limiting will limit the transient response of the engine.

The leads used for actuator connections should be at least #18 wire for 24 volt and 32 volt operation and #16 wire for 12 volt operation.

12 VOLT OPERATION

Connect the following actuator terminals together with jumpers at the mating half of the connector (see Figure 2).
1. A to C
2. B to D
3. A,D,E & F to the respective terminals of the speed control unit. (SEE TABLE A)

24 VOLT OPERATION

Connect the following actuator terminals together with jumpers at the mating half of the connector (see Figure 3).
1. B to C
2. A,D,E, & F to the respective terminals to the control unit. (SEE TABLE A)

32 VOLT OPERATION

To use with 32 volt supply, wire the connector as for 24 volt operation but add a 2 ohm, 20 watt resistor (minimum) in series with terminal A of the actuator (see Figure 4).

SPEED CONTROL UNIT	ACTUATOR TERMINALS	
LSP 672B	16	17
CU 671C SERIES*	B	D
CU 673C SERIES*	B	D
ECQ 1000 SERIES	1	2
ECD 67-2000 SERIES	1	2
ECD 67-5111 SERIES	A	B
ECD 67-7000 SERIES	B	C
ECD 67-5221	A	B

*
NOTE:
For droop operation see
Droop Control Literature EG 70-2.

NOTE: See speed control unit literature specifications for proper operating voltage

Table A
Wiring chart for AGD 130 actuators

ENGINE GOVERNING SYSTEMS

ADJUSTMENTS

> CAUTION:
> THE ENGINE SHOULD BE EQUIPPED WITH AN INDEPENDENT OVERSPEED SHUTDOWN MECHANISM TO PREVENT RUNAWAY WHICH CAN CAUSE EQUIPMENT DAMAGE OR PERSONNEL INJURY.

After the governor system has been installed and properly wired, apply battery power. Refer to the applicable speed control unit publication to momentarily apply full power to the actuator. The actuator valve should go into the full flow position (the valve actuator link moves down). If not, check for proper wiring of the 6 pin actuator connector. Remove the cable and check between pins A and B and between C and D on the actuator. Each coil should have about 4 ohms resistance. If not, replace the actuator.

The throttle lever on the PT pump should be held in the full fuel position. However, it may be used to manually control the engine during the first startup. DC power should be applied through the wiring harness to the engine governing system by closing a switch in the battery circuit. Starting the engine may now proceed normally. During cranking, but before the engine starts, the actuator will push its valve open. Once started, the engine will be controlled at low idle by the speed control unit. The throttle lever on the PT pump should be held wide open at this time if it hasn't been earlier. If the engine is under the control of the governor, engine speed and performance adjustments can be made in accordance to the speed control unit publication.

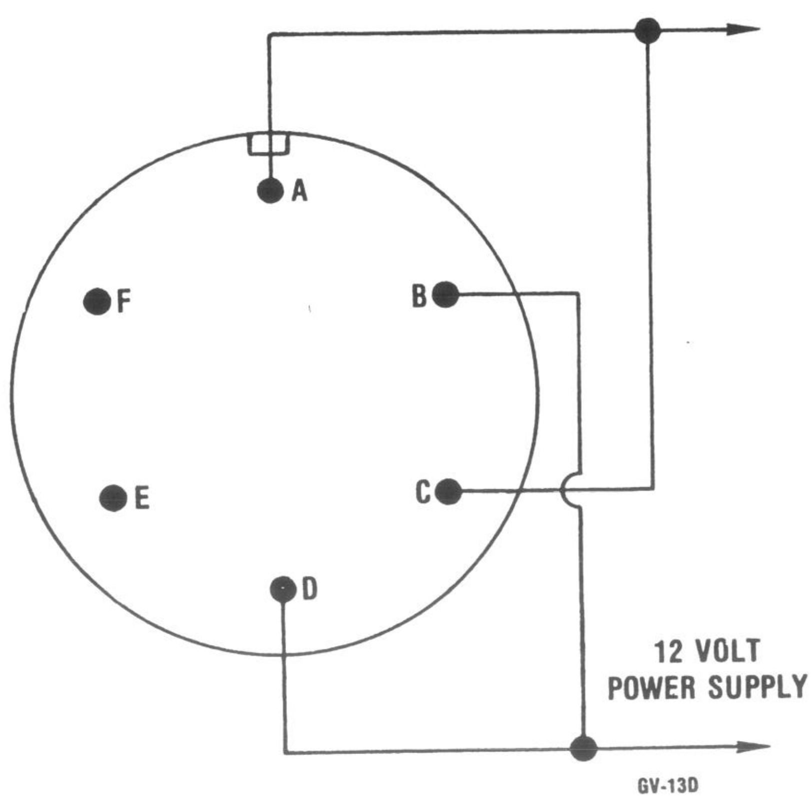


Figure 2. Wiring to AGD 130 actuator for 12 volt operation

ENGINE GOVERNING SYSTEMS

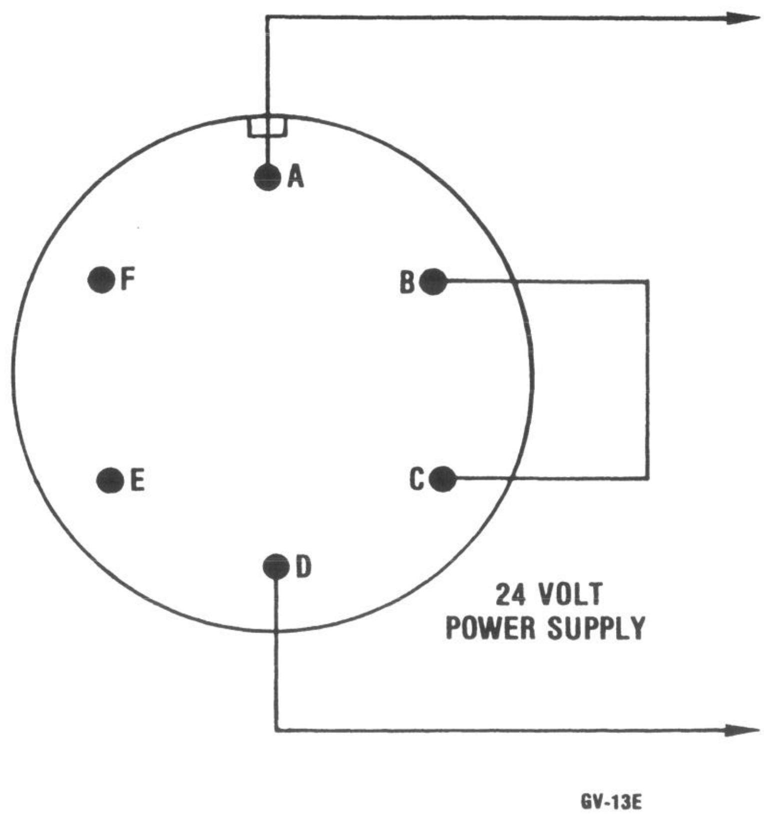


Figure 3. Wiring to AGD 130 actuator for 24 volt operation

ENGINE GOVERNING SYSTEMS

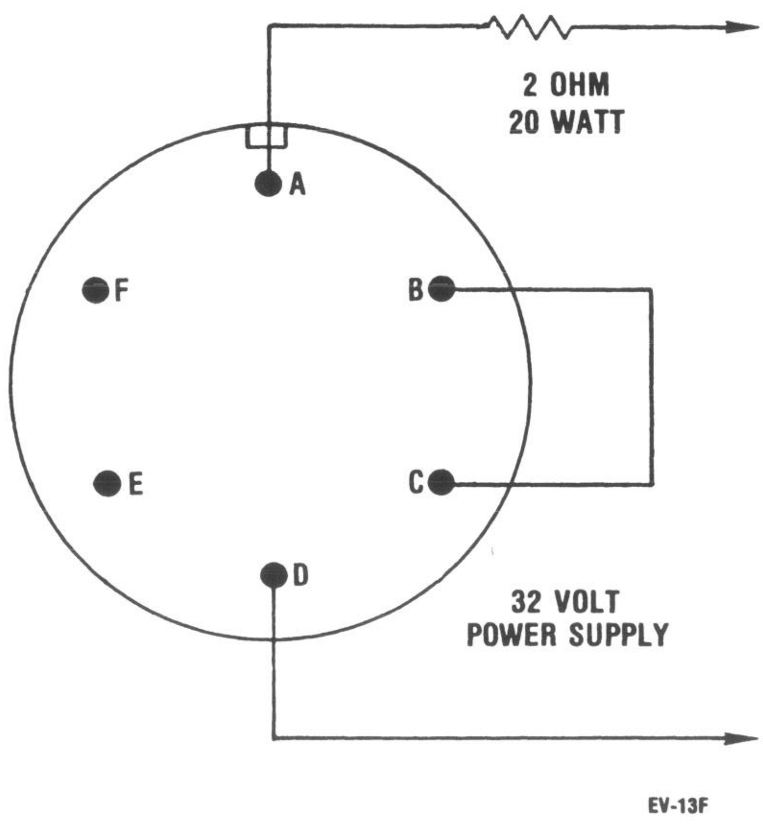
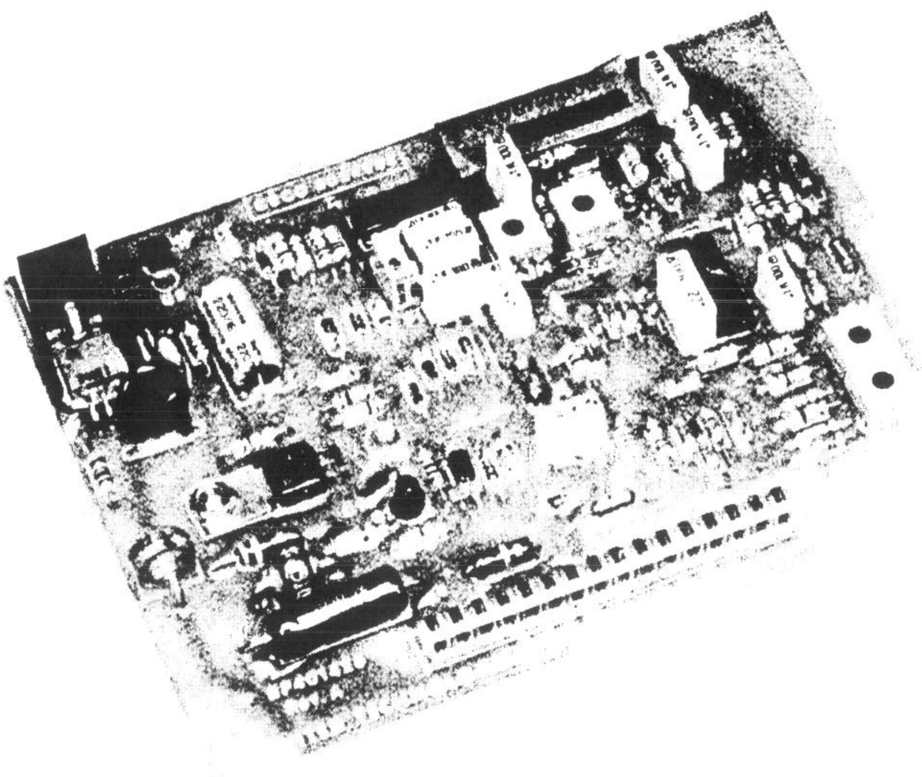


Figure 4. Wiring to AGD 130 actuator for 32 volt operation

SPEED CONTROL UNIT ECD 67-7000



ENGINE GOVERNING SYSTEMS

INTRODUCTION

The speed control unit contains all solid state electronic circuits which sense speed from a magnetic speed sensor or other suitable signal source. The pulse from the magnetic speed sensor, which is directly proportional to engine speed, is summed with the speed control unit speed set point. The appropriate current output is supplied to the actuator to control the engine fuel system.

The performance of the speed control unit is isochronous. Speed droop can be selected. A droop control is provided on the speed control unit. The speed range is 6:1 and is adjustable via a 22 - turn speed adjust control.

Only two governor system performance adjustments are needed to achieve optimum performance. A gain control to adjust the governor system's response and a stability control to match the time constant of governor system to the engine.

The speed control unit also includes the special feature of speed anticipation to minimize speed overshoot on engine start-up or from lug-down. Engine idle feature is selectable which may be utilized for engine warm-up or maintenance.

Wide tolerances of speed sensor input signals and DC supply voltages can be accepted by this speed control unit. In case of loss of speed sensor signal or DC supply voltage, failsafe features are built-in to provide engine shutdown. Reverse voltage polarity protection is provided at battery input.

The ECD 67-7000 speed control unit is specifically designed for Cummins engine generator sets requiring plug-in controls.

SPECIFICATIONS

ECD 67-7000 SPEED CONTROL UNIT PERFORMANCE CHARACTERISTICS

- Isochronous .... ±0.25% regulation or better
- Droop .... 0-5% regulation
- Steady-state Stability .... ± 0.25% or better
- Frequency Range .... 1K-6K Hz continuous
- Frequency Range (Idle) .... 1K-2.9K Hz maximum
- Speed Trim Range .... ±200 Hz.
- Speed Drift with Temperature .... ±1% maximum

POWER INPUT

- Magnetic Speed Sensor Signal .... 0.25-30 volts rms
- Supply .... 10 - 40 VDC (transient and reverse voltage protected)
- Polarity .... Negative Ground (Case isolated)
- Power Consumption .... 90mA (continuous) plus actuator current
- Maximum Controllable Actuator Current at 25 °C (77 °F) .... 7 Amps

ENVIRONMENTAL

- Temperature Range .... −40° to + 85 °C (−40° to + 185 °F)
- Relative Humidity .... up to 100%
- Case .... Fungus proof and corrosion resistant

PHYSICAL

- Dimensions .... See Figure 1
- Weight .... 0.14 kgs (0.3 lbs)
- Mounting .... Any position (See Installation Page 4)

RELIABILITY

- Tested 100%
- Vibration .... All printed circuit boards are conformally coated on both sides

MATING CONNECTOR

- Use .... AMP 1 - 87993-6

ENGINE GOVERNING SYSTEMS

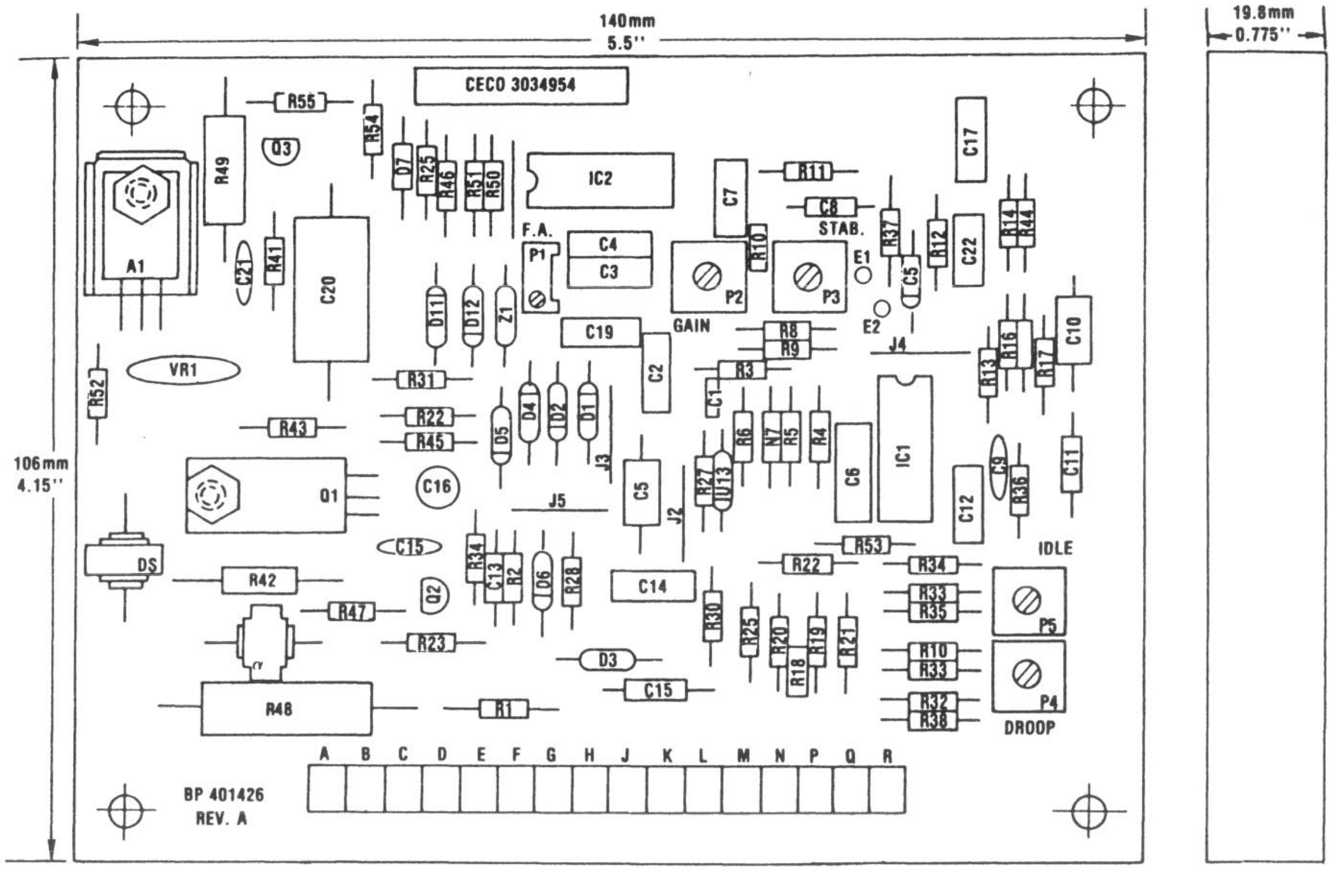


Figure 1. ECD 67-7000 speed control unit dimensions

DESCRIPTION

The speed control unit circuits are designed to operate directly from a 12, 24 or 32 VDC battery system. An internal 10 volt regulator supplies all DC power to the speed control circuits. The speed control unit has sufficient current capacity to handle all actuators.

The engine speed signal is usually obtained from a magnetic speed sensor mounted in close proximity to the teeth of a ferrous gear that is driven by the engine. The frequency of the speed sensor signal is proportional to the engine speed.

The flywheel ring gear is normally used because of the ease of speed sensor installation and because of the high frequency speed sensor signal. Other speed sensors may be used for a speed signal. The governor will accept any signal if the frequency is proportional to the engine speed, and in the frequency range of the governor (1K to 6K Hz).

The signal strength must also be within the range of the input amplifier (0.25 volts rms to 30 volts rms for approximately sinusoidal signals). When a magnetic speed sensor is used, it is connnected to terminals D and E. The speed control unit has an input impedance of 10,000 ohms between terminal D and terminal E. Terminal E is connected internally to the battery negative.

The speed sensor signal is amplified and shaped by the circuit to form constant area pulses. The averaging of these pulses from the speed sensor amplifier section of the speed control unit are then fed to a summing circuit (see Figure 2).

A speed sensor monitor circuit detects the pulses and, if the pulses disappear for longer than 0.1 second, the speed control unit will turn off the output circuit (current to actuator).

During cranking, the actuator will move to full load position and remain there during starting and acceleration of the engine. The summing point of the speed sensor and the speed adjust control is the input to the dynamic control section of the governor.

A gain control is provided to adjust the governor sensitivity. The gain is usually advanced (CW) as far as possible for

ENGINE GOVERNING SYSTEMS

best performance without instability. (See adjustment procedure).

The gain control has a non-linear range of 33:1. The dynamic control circuit has a control function that will provide isochronous and stable performance from almost all types of engine systems. The stability control will match the time constants of engines with a wide variety of characteristics.

The output actuator current switching circuit provides current to drive the actuator. The output transistor is alternately switched off and on at a frequency of 200 Hz. which is well beyond the natural frequency of the actuator, hence no visible motion from the switching results. The actuator responds to the average current to position the engine throttle. The output transistor is switched to reduce its internal power dissipation. The output of the circuit provides up to 12 amps instantaneously at voltages up to 40 VDC. The output is suitable to drive United Technologies actuators or a similar proportional electric actuator. Excellent start-up performance is assured via a speed anticipation circuit which minimizes the overshoot of speed on start-up.

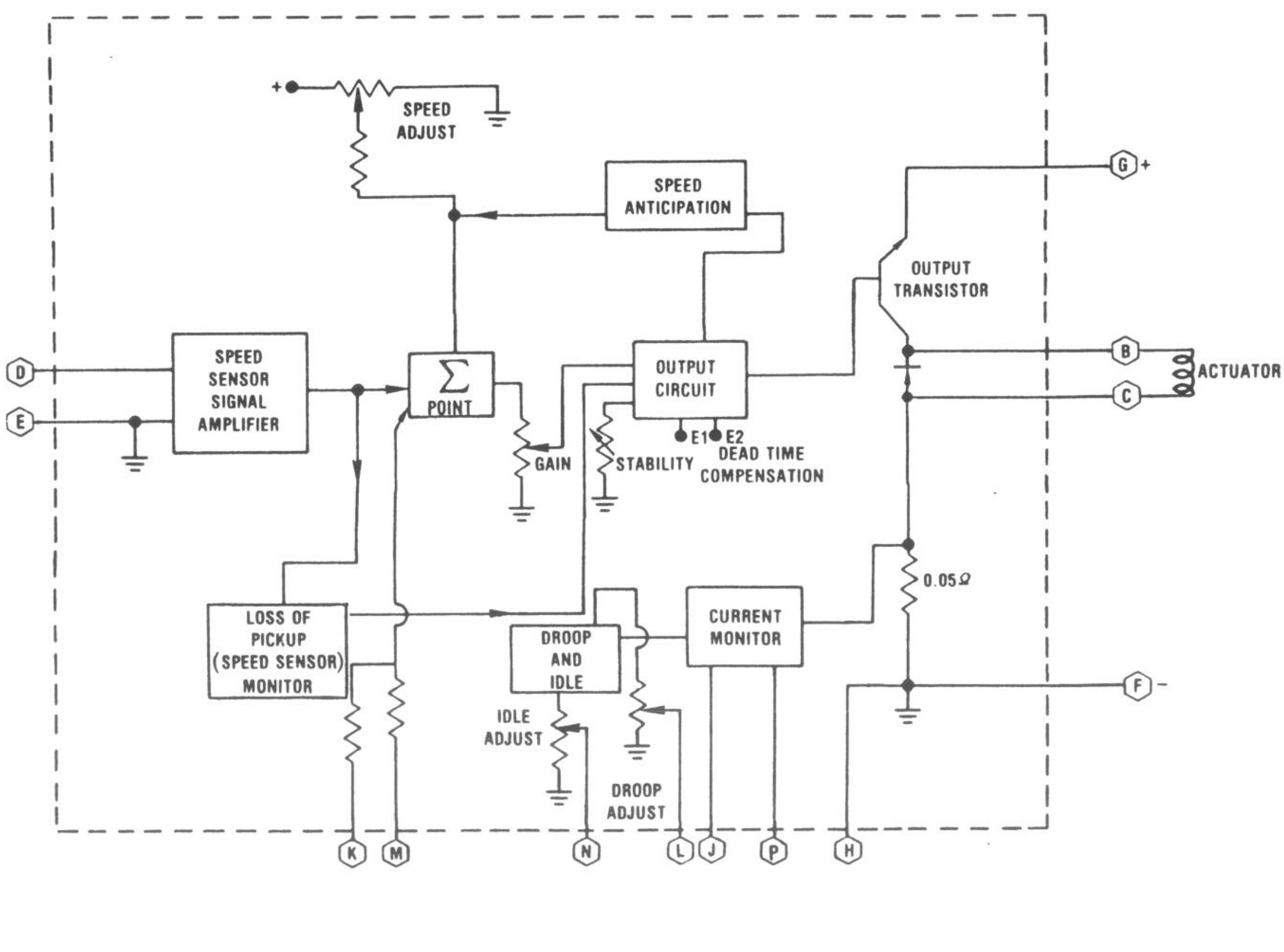


Figure 2. Functional schematic

ENGINE GOVERNING SYSTEMS

INSTALLATION

The speed control unit is connected by plugging it into its mating connector located in the control cabinet or engine mounted enclosure. Care should be taken to insure that the speed control unit is not subjected to extreme heat, as the life of electronic devices is always related to heat.

Wiring to the speed control should be as shown in Figure 3. Leads to the battery and the actuator from the speed control unit should be #16 or larger. These are the leads that are connected to terminals B, C, F and G of the speed control unit. An external fuse or circuit breaker is recommended in series with terminal G, the positive (+) battery input terminal. The magnetic speed sensor leads are twisted and/or shielded for their entire length.

Connect leads to terminals D and E. Connect the shield to terminal E only. Do not connect the shield at the speed sensor end. Actuator connections should be made according to the actuator publications. Since, ECD 67-7000 is similar to the ECD 67-5111, Table A shows the similarity with respect to wiring.

ADJUSTMENTS

> CAUTION:
> THE ENGINE SHOULD BE EQUIPPED WITH AN INDEPENDENT OVERSPEED SHUTDOWN MECHANISM TO PREVENT RUNAWAY WHICH CAN CAUSE EQUIPMENT DAMAGE OR PERSONNEL INJURY.

> CAUTION:
> **DO NOT**
> CONNECT THE SPEED CONTROL UNIT TO A BATTERY CHARGER.

STARTING THE ENGINE INITIALLY

The speed control unit has been adjusted at the factory for starting conditions and will control the engine at approximately idle speed (1000 Hz. speed sensor signal). The following adjustments or checks should be made prior to starting the engine.

A. Pre-set the gain, stability, and if used, the external speed trim control to their mid-points.

B. Apply DC power to the engine governing system thru the wiring system by closing the switch S1. The actuator may momentarily move but should remain in the no fuel position.

C. Momentarily connect terminal B to terminal G. This should cause the actuator to snap into the maximum fuel position. If not, check for wiring defects or consult the "Trouble-shooting" Section (Page 7).

Crank the engine. During cranking, the actuator will move the fuel control to the maximum fuel position. Once started, the engine will be controlled at a low idle by the engine governing system.

GOVERNOR SPEED

Place the external selector switch in the isochronous position. Increase the engine speed to the desired governed speed by turning the "speed adjust" control in a CW direction. If used, final precise speed adjustment may be made with the external Speed Trim control. If at any time the engine governing system becomes unstable, turn the gain and stability controls CCW until the engine is stable.

PERFORMANCE

Once the engine is at governed speed, the two performance adjustments, gain and stability can be made as follows:

A. At no load, turn the gain control CW until instability results. Then back-off slightly CCW (1/8 turn) beyond the point where stability returns.

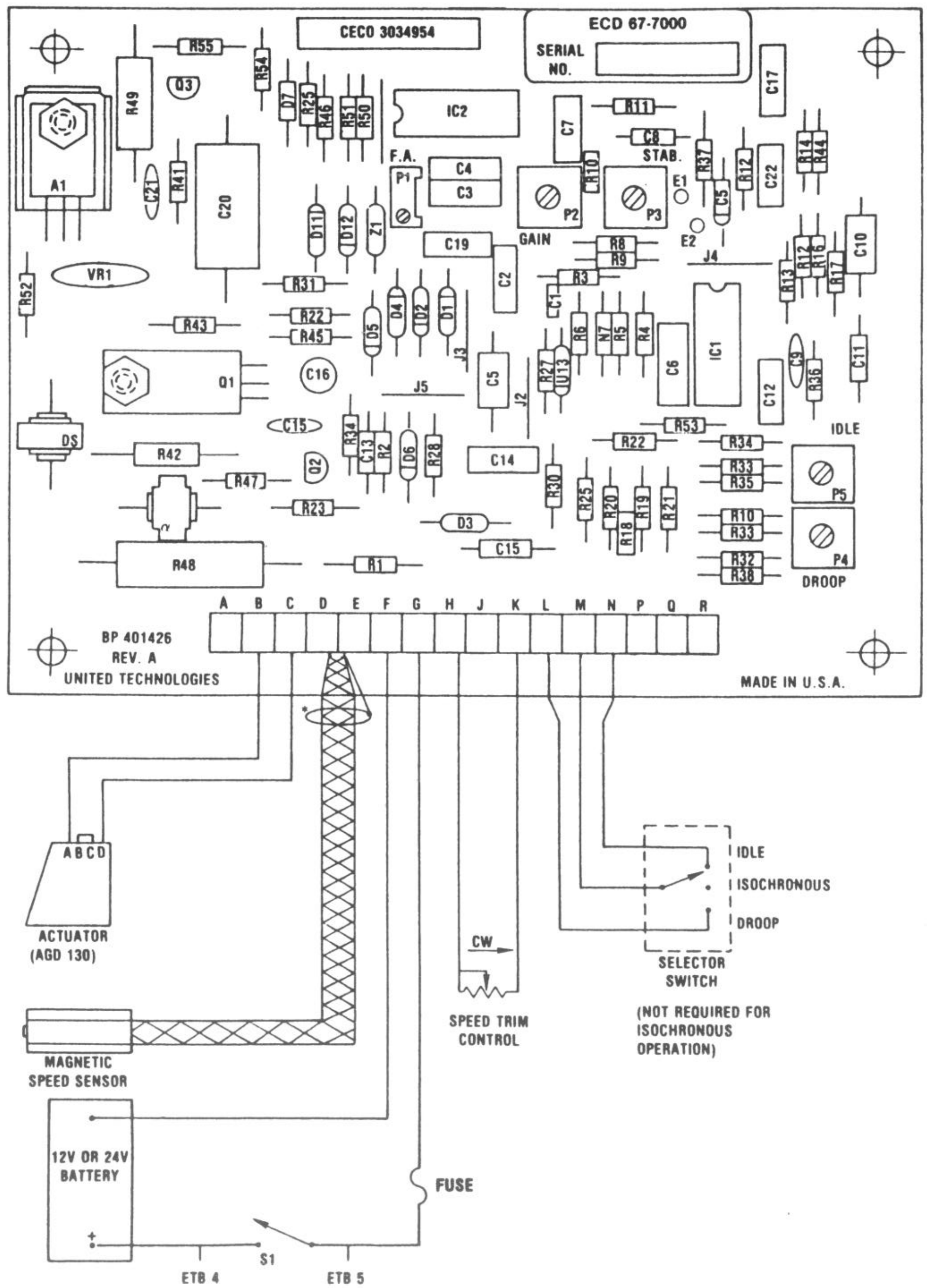
B. Turn the stability control CW until instability results. Then back-off slightly CCW (1/8 turn) beyond the point where stability returns. Excellent performance should result from these adjustments.

C. Load may now be applied to the engine. If necessary, repeat A and B above until optimum performance is obtained. Normally, the critical condition for gain and stability adjustment is at no load.

NOTE: Optimum adjustment of both controls is in the furthest CW position, without causing instability and will result in the best response and stability under all operating conditions. Backing off slightly from this position will allow for changing conditions that may affect the dynamic response of the engine. If a load bank and a recorder are available, use them to verify the performance using Figure 4 as a guide. If a stable system cannot be obtained, refer to the "Trouble-shooting Section, Page 7".

The previous procedures should result in a high performance isochronous governed speed control system.

ENGINE GOVERNING SYSTEMS



*NOTE: A SHIELDED CABLE SHOULD BE USED IF LEADS ARE LONGER THAN 3 METERS (10 FT.). GROUND SHIELD AT ONE END ONLY.

Figure 3. Wiring to ECD 67-7000 speed control unit

ENGINE GOVERNING SYSTEMS

ECD 67-5111	—	A	B	C	D	E	F	G	H	J	K	L	M	N	—	—
ECD 67-7000	A	B	C	D	E	F	G	H	J	K	L	M	N	P	Q	R

Table A
Cross reference chart

IDLE SPEED SETTING

Place the external selector switch in the idle position. Adjust the idle adjustment of the speed control unit for ideal engine idle speed. CW rotation increases the idle speed setting.

SPEED DROOP

Place the external selector switch in the droop position. An adjustment range of 0.2 to 5% can be obtained. CW rotation increases droop.

If engine speed with droop is lower than desired, turn the speed adjust control CW to increase the engine speed. If used, fine tuning of engine speed can then be obtained by turning the speed trim control.

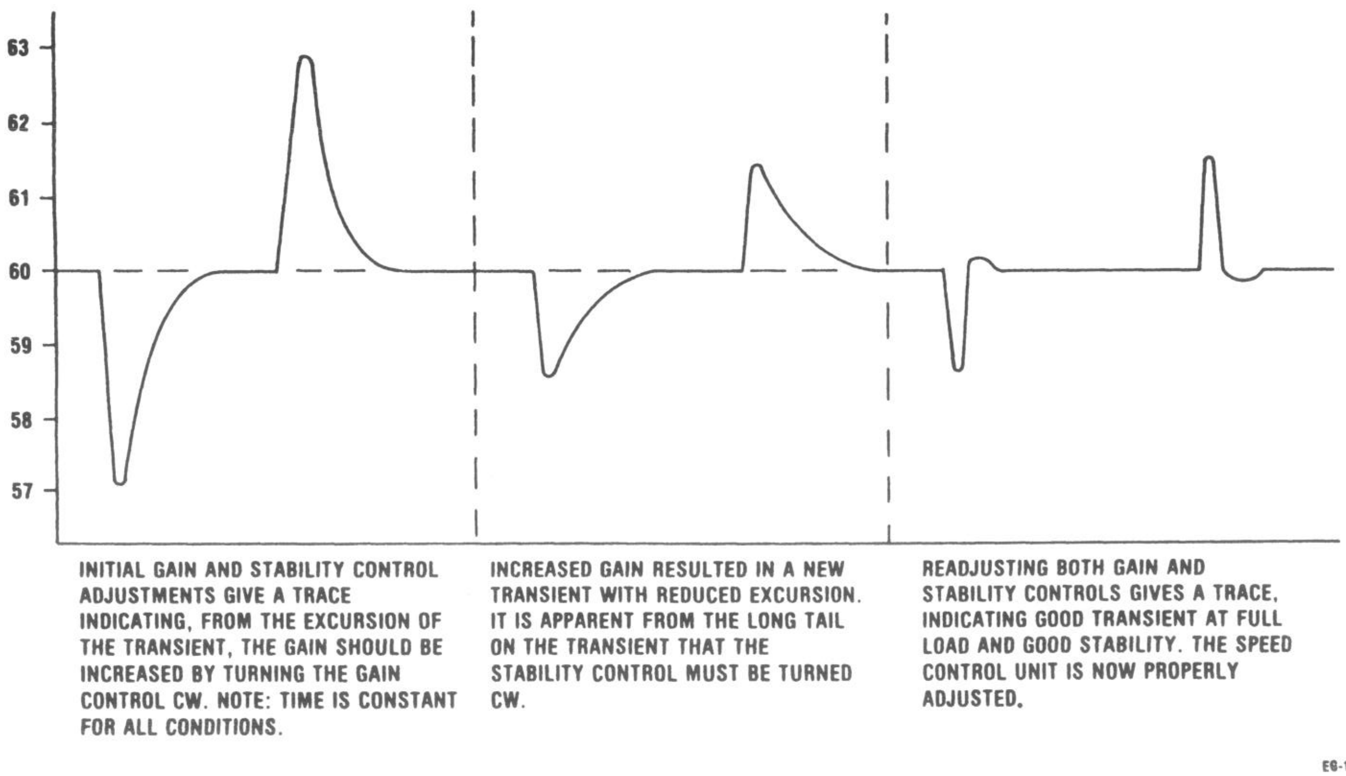


Figure 4. Typical performance chart

ENGINE GOVERNING SYSTEMS

TROUBLESHOOTING

SYSTEM INOPERATIVE

If the engine governing system does not operate, the fault may be found by performing the following tests. Should all three voltage tests indicate normal values, the defect must be in the actuator or the wiring to the actuator.

STEP	TERMINALS	NORMAL VALUE	PROBABLE CAUSE OF ABNORMAL READING
1	D & F	1.0 VAC RMS minimum while cranking	1. Defective magnetic speed sensor. 2. Gap between speed sensor and gear tooth too large. 3. Improper or defective wiring to the speed sensor.
2	G & F	24.0 VDC (Battery Voltage)	1. DC power not connected or low battery voltage. 2. Wiring error.
3	G & B	2.5 VDC maximum while cranking	1. "Speed adjust" set too low. Turn CW. 2. Error in wiring to actuator 3. Defective speed control unit. 4. Defective actuator.

UNSATISFACTORY SYSTEM OPERATION

SYMPTOM	TEST	PROBABLE TROUBLE
Engine overspeeds	Measure the voltage between terminals B and G on the speed control unit	1. If the voltage is 1.5 to 2.5 volts a) Frequency set too high, turn "speed adjust" CCW b) Defective speed control unit. 2. If the voltage is over 2.5 volts a) Fuel metering valve or linkage sticking. 3. If voltage is below 1.5 volts a) Shorted output transistor. Defective speed control unit.
Actuator does not fully open	1. Measure the voltage at the battery while cranking. It must not be less than 8 VDC. 2. Momentarily connect terminal B to G. The fuel metering valve should move to the full fuel position.	1. Replace the battery if it is defective. If it is undersized, replace the battery with one with a proper CCA rating. 2. a) Wiring to the actuator or the battery is incorrect. b) Fuel metering valve or actuator sticking. c) Defective actuator.
Engine stays at idle		Fuel pump throttle lever not at full fuel position when operating on lever other than throttle lever.

Insufficient Magnetic Speed Sensor Signal

Although the speed control unit will govern well on 0.5 volts RMS signal if it is a clean sine wave, a signal from the magnetic speed sensor of 3 volts RMS at governed speed will eliminate any possibility of missed or extra pulses.

This signal is measured at terminals D and E. Raise the magnetic speed sensor voltage by reducing the gap between the speed sensor and the ring gear to not closer than 0.75mm (0.030 in.). This is equivalent to backing the speed sensor out by ¾ turn after it touches the ring gear tooth.

ENGINE GOVERNING SYSTEMS

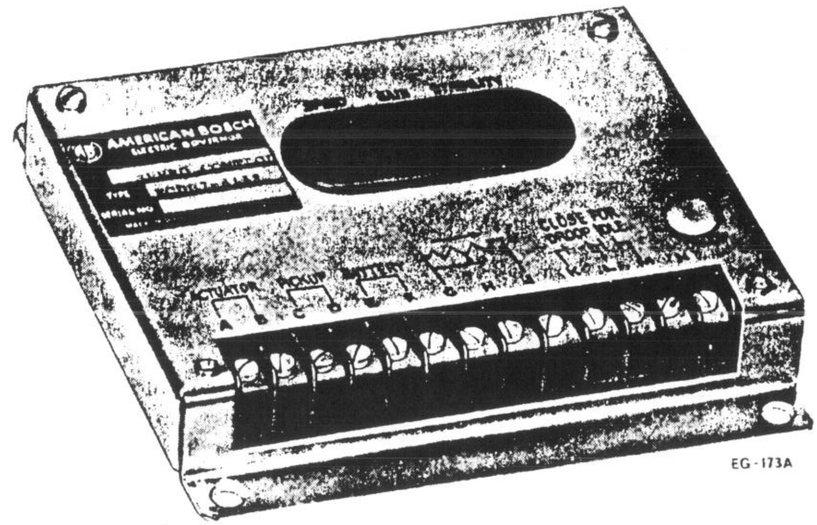
High Frequency Instability

When rapid instability or surge (about 8 Hz.) occurs, removing the jumper next to the stability control posts E1 and E2 (see Figure 3) should eliminate this problem.

Electrical Noise or Unwanted Droop

If noisy electrical devices are present, such as magnetos, solid state ignition systems, battery chargers or regulators which emit radio frequency interference (RFI), then unstable governing or droop may be noticed. The speed control unit has internal filters which provide some protection from radio frequency interference. Excessive levels of RFI must be treated separately. A metal shield placed around the emitting source and/or placing the governor harness and speed control unit as far away as possible from the RFI emitting source will help. Always twist the leads from the magnetic speed sensor all the way back to the speed control unit. When extreme RFI is encountered, it may be necessary to shield all the leads to the speed control units. These shields must be grounded at terminal E or F of the speed control units.

ELECTRIC GOVERNOR SPEED CONTROL UNIT
ECD 67-5111



EG-173A

INTRODUCTION

The speed control unit contains all solid state electric circuits which sense speed from a magnetic speed sensor or other suitable signal source. The pulse from the magnetic speed sensor, which is directly proportional to engine speed, is compared with the speed control unit speed set point. The appropriate current output is supplied to the actuator to control the engine fuel system.

The performance of the speed control unit is isochronous. Speed droop can be selected. A droop control is provided on the speed control unit. The speed range is 6:1 and is adjustable via a 22 - turn speed adjust control.

Only two governor system performance adjustments are needed to achieve optimum performance. A gain control to adjust the governor system's response and a stability control to match the time constant of governor system to the engine. All adjustments are accessible from the front cover.

The speed control unit also includes the special feature of speed anticipation to minimize speed overshoot on engine start-up or from lug-down. Engine idle feature is selectable which may be utilized for engine warm-up or maintenance.

Wide tolerances of speed sensor input signals and D. C. supply voltages can be accepted by this speed control unit. In case of loss of speed sensor signal or D. C. supply voltage, failsafe features are built to provide engine shutdown. Reverse voltage polarity protection is provided at battery input.

SPECIFICATIONS

OPERATION
Governing Mode: Isochronous or Droop (5%)
Steady State Stability: 1/4% or Better
Operating Frequency Range: 1K to 6K Hz.
Idle Frequency Range: 1K to 2.9K Hz.

POWER
Operating Voltage: 10 to 40 Volts D. C.
Ground Polarity: Negative or Positive (Case Isolated)
Current Consumption of Speed Control: 90 MA Plus Actuator Current
Maximum Controllable Actuator Current: 7 Amps.

ENVIRONMENTAL
Ambient Operating Temp. : -40° to 185° F (-40° to 85C)
Maximum Temp. Drift: $\pm$ 1%
Relative Humidity: 0 to 100%, Noncondensing

PHYSICAL
Dimensions: 5.75" x 5.5" x .875" 146mm x 140mm x 22.2mm)
Weight: 1.8 lbs. (.82 Kg)
Mounting: Any position, typically in an enclosure
Case Material: Steel, gold urethane paint (fungusproof)

RELIABILITY
Tested: Units 100% tested at 25°C and 70°C
Vibration: All printed circuit boards potted.

PROTECTION FEATURES
Loss of Pickup Signal
Loss of Supply Power
High Voltage Protection
Reverse of Supply Polarity

SYSTEM APPLICATIONS

Adaptable to a wide variety of Diesel, carbureted gas and gasoline engines requiring governed speed control.

PRINCIPLE of OPERATION (Ref. Figure 1)

The control circuits are designed to operate directly from a 12, 24 or 32 volt D.C. battery system. An internal 10 volt regulator supplies all D.C. power to the control circuits.

The engine speed signal is usually obtained from a magnetic pickup mounted in close proximity to the teeth of a ferrous gear that is driven by the engine. The frequency of the pickup signal is proportional to the engine speed.

The flywheel ring gear is normally used because of the ease of pickup installation and because of the high frequency pickup signal. Other speed sensors may be used for a speed signal. The governor will accept any signal if the frequency is proportional to the engine speed, and in the frequency range of the governor (1K to 6K Hz).

The signal strength must also be within the range of the input amplifier (.5 volts rms to 30 volts rms for approximately sinusoidal signals). When a magnetic pickup is used, it is connected to terminals C and D. The control unit has an input impedance of 10,000 ohms between terminal C and terminal D. Terminal D is connected internally to the battery negative.

The pickup signal is amplified and shaped by the circuit to form constant area pulses. The summing of these pulses form the speed sensor for the speed control unit.

A pickup monitor circuit detects the pulses and, if the pulses disappear for longer than .1 second, the control unit will turn off the output circuit (current to actuator).

During cranking, the actuator will move to full load position and remain there during starting and acceleration of the engine. The summing point of the speed sensor and the speed adjust control is the input to the dynamic control section of the governor.

A gain control is provided to adjust the governor sensitivity. The gain is usually advanced (CW) as far as possible for best performance without instability. (See adjustment procedure).

The gain control has a non-linear range of 33:1. The dynamic control circuit has a control function that will provide isochronous and stable performance from almost all types of engine systems. The stability control will match the constants of engines with a wide variety of characteristics.

The output actuator current switching circuit provides current to drive the actuator. The output transistor is alternately switched off and on at a frequency of 200 Hz. which is well beyond the natural frequency of the actuator, hence no visible motion from the switching results. The actuator responds to the average current to position the engine throttle. The output transistor is switched to reduce its internal power dissipation. The output of the circuit provides up to 12 amps at voltages up to 40 volts D.C. The output is suitable to drive United Technologies actuators or a similar proportional electric actuator. Excellent start-up performance is assured via a speed anticipation circuit which minimizes the overshoot of speed on start-up.

INSTALLATION

The control unit can be mounted in any position and can be located in an associated cabinet or in remote console up to 60 feet from the engine. Care should be taken so that ignition systems or other strong interfering sources are not directly adjacent to the unit or its cables.

As with all electronic circuits, areas having ambient temperatures above 185° F (85° C) are to be avoided.

WIRING

Leads to the battery and the actuator from the control unit should be #16 or larger. These are the leads that are connected to terminals A, B, E and F of the electronic control unit. An external fuse or circuit breaker is recommended in series with terminal F, the positive (+) battery input terminal. The magnetic pickup leads are twisted and/or shielded for their entire length.

Connect leads to terminals C and D. Connect the shield to terminal D only. Do not connect the shield at the pickup end. Actuator connections should be made according to the actuator publications. For 12 volt operation or on any actuator larger than an AGB130 when operating in droop control, jumper terminals H to N on control units with serial numbers above 2L23000.

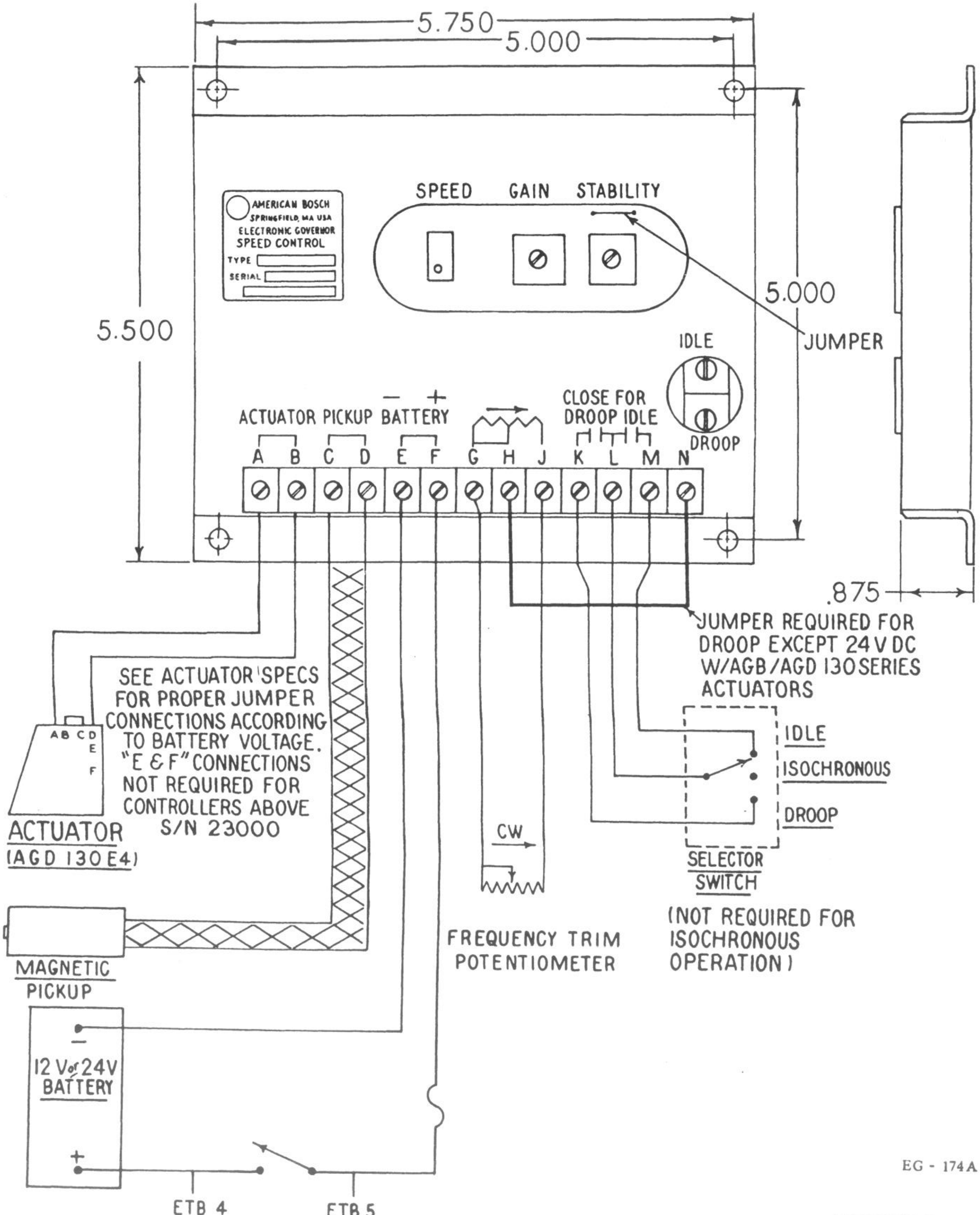

5.750
5.000
5.500
5.000
.875
AMERICAN BOSCH
SPRINGFIELD, MA USA
ELECTRONIC GOVERNOR
SPEED CONTROL
TYPE
SERIAL
SPEED
GAIN
STABILITY
JUMPER
IDLE
DROOP
ACTUATOR PICKUP BATTERY
− +
CLOSE FOR
DROOP IDLE
A B C D E F G H J K L M N
JUMPER REQUIRED FOR DROOP EXCEPT 24 V DC W/AGB/AGD 130 SERIES ACTUATORS
SEE ACTUATOR SPECS FOR PROPER JUMPER CONNECTIONS ACCORDING TO BATTERY VOLTAGE. "E & F" CONNECTIONS NOT REQUIRED FOR CONTROLLERS ABOVE S/N 23000
AB C D E F
ACTUATOR
(AGD 130 E4)
IDLE
ISOCHRONOUS
DROOP
SELECTOR SWITCH
(NOT REQUIRED FOR ISOCHRONOUS OPERATION)
CW
FREQUENCY TRIM POTENTIOMETER
MAGNETIC PICKUP
12 V or 24V BATTERY
ETB 4
ETB 5
EG - 174A

FIGURE 2

ADJUSTMENTS

STARTING THE ENGINE INITIALLY

The speed control has been adjusted at the factory for starting conditions and will control the engine at approximately engine idle speed. The following adjustments or checks should be made (see Figure 2 for location):

a) Set the stability and gain controls to their midpoint.

b) Set the frequency trim control (if used) to its midpoint.

c) Apply D.C. power to the electric governor through the wiring system by closing a switch in the battery circuit.

CAUTION: DO NOT connect the speed control to a battery charger.

Start the engine. During cranking, but before the engine starts, the actuator fuel valve will move to the open position. Once started, the engine will be controlled at low idle by the electric governor.

GOVERNOR SPEED ADJUSTMENT

Place the external selector switch in the isochronous position. Increase the engine speed to the desired governed speed by turning the "speed adjust" potentiometer in a CW direction. Final precise speed and frequency adjustment may be made with the frequency trim potentiometer, if used. If at any time the governor becomes unstable, turn the gain and stability potentiometers CCW until the engine becomes stable.

PERFORMANCE ADJUSTMENTS

Once the engine is at the governed speed, the two performance adjustments, gain and stability, can be made as follows (Figure 2):

a) At no load, turn the gain adjustment on the speed control unit CW until the system becomes unstable. Then back off slightly (about 30°) beyond the point where stability returns.

b) Turn the stability adjustment CW until instability results. Them back off slightly (about 30°) beyond the point that stability returns. Excellent performance will result from these adjustments.

c) Load may now be applied to the engine. If necessary, repeat (a) and (b) above until optimum performance is obtained. Normally, the critical condition for gain and stability adjustment is at no load.

The optimum adjustment of both controls is in the maximum clockwise position where the best response and stability are obtained under all operating conditions. Backing off slightly from this position will allow for changing conditions that may affect the dynamic response of the engine. If a load bank and recorder are available, use them to make and verify performance with Figure 3. If a stable system cannot be obtained, refer to "Troubleshooting, Poor System Operation".

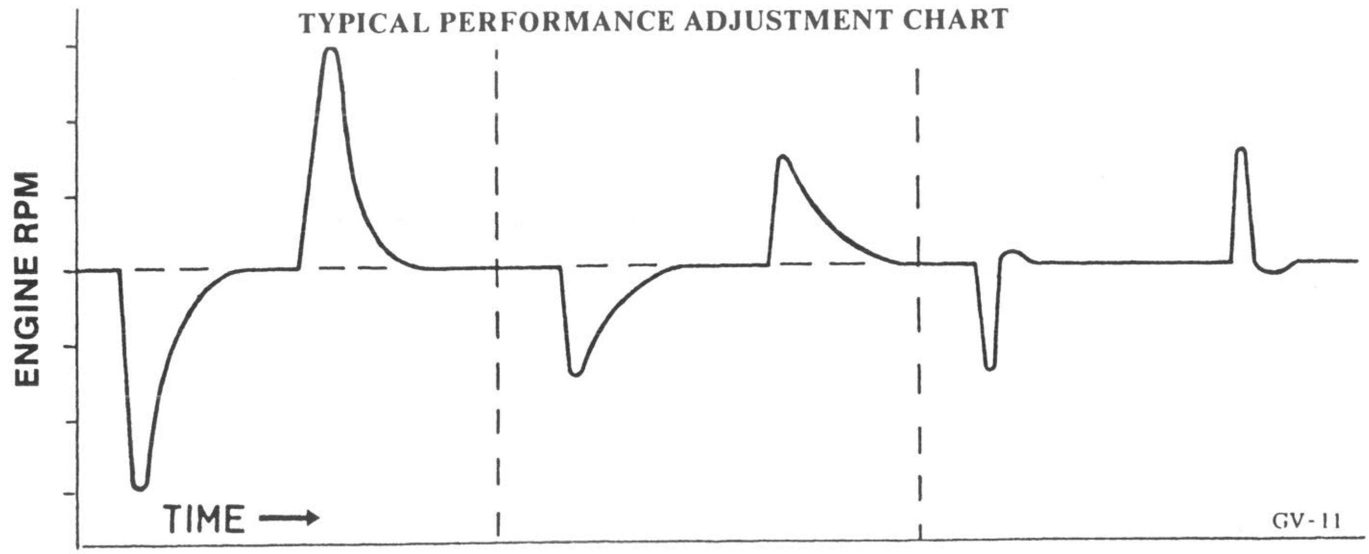
SELECTABLE FEATURES

IDLE SPEED SETTING ADJUSTMENT

Place the external selector switch in the idle position. Adjust the idle adjustment of the control unit for ideal engine idle speed. CCW rotation increases idle speed setting, CW on units above SN 2L23000.

SPEED DROOP ADJUSTMENT

Place the external selector switch in the droop position. An adjustment range of 0.2 to 5% can be obtained. CW rotation increases droop.



The initial gain and stability adjustments resulted in large frequency transients. The gain should be increased by turning the "gain" potentiometer CW.

Increased gain has resulted in a new transient with reduced amplitude. The sloping line indicates that the "stability" potentiometer must be turned CW to reduce the time constant.

Having readjusted both the "gain" and "stability" controls, good transients and stable operation result.

FIGURE 3

TROUBLESHOOTING

CONTROL UNITS WITH SERIAL NUMBERS BELOW SN 2L23000

SYSTEM INOPERATIVE

If the governor system does not operate, the fault may be found by performing the following tests. Should all three voltage tests indicate normal values, the defect must be in the actuator or the wiring to the actuator. See "Actuator Test" section.

STEP	TERMINALS	NORMAL VALUE	PROBABLE CAUSE OF ABNORMAL READING
1	C & E	1.0 Volt AC RMS minimum while cranking	1. Defective magnetic pickup. 2. Gap between pickup and gear tooth too large. 3. Improper or defective wiring to the pickup.
2	B & E	24.0 Volts DC (Battery Voltage)	1. DC power not connected or low battery voltage. 2. Wiring error. 3. Defective speed control.
3	A & E	2.5 Volts DC maximum while cranking	1. "Speed adjust" set too low. Turn CW. 2. Error in wiring to actuator. 3. Defective speed control. 4. Defective actuator

UNSATISFACTORY SYSTEM OPERATION

SYMPTOM	TEST	PROBABLE TROUBLE
Engine overspeeds	Measure the voltage between terminals A and E on the speed control	1. If the voltage is less than 2.5 volts a) Frequency set too high turn "speed adjust" CCW b) Wiring to actuator incorrect. c) Defective speed control. 2. If the voltage is over 2.5 volts a) Fuel metering valve or linkage sticking.
Actuator does not fully open	1) Measure the voltage at the battery while cranking. It must not be less than 8 volts DC. 2) Ground terminal A of the speed control. The fuel metering valve should move to the full fuel position.	1. Replace the battery if it is defective. If it is undersized, replace the battery with one with a proper CCA rating. 2. a) Wiring to the actuator or the battery is incorrect. b) Fuel metering valve or actuator sticking. c) Defective actuator
Engine stays at Idle		Fuel pump lever not at full fuel position.

TROUBLESHOOTING

CONTROL UNITS WITH SERIAL NUMBERS ABOVE SN 2L23000

SYSTEM INOPERATIVE

If the governor system does not operate, the fault may be found by performing the following tests. Should all three voltage tests indicate normal values, the defect must be in the actuator or the wiring to the actuator. See "Actuator Test" section.

STEP	TERMINALS	NORMAL VALUE	PROBABLE CAUSE OF ABNORMAL READING
1	C & E	1.0 Volt AC RMS minimum while cranking	1. Defective magnetic pickup. 2. Gap between pickup and gear tooth too large. 3. Improper or defective wiring to the pickup.
2	F & E	24.0 Volts DC (Battery Voltage)	1. DC power not connected or low battery voltage. 2. Wiring error.
3	F & A	2.5 Volts DC maximum while cranking	1. "Speed adjust" set too low. Turn CW. 2. Error in wiring to actuator. 3. Defective speed control. 4. Defective actuator

UNSATISFACTORY SYSTEM OPERATION

SYMPTOM	TEST	PROBABLE TROUBLE
Engine overspeeds	Measure the voltage between terminals A and F on the speed control.	1. If the voltage is less than 2.5 volts a) Frequency set too high turn "speed adjust" CCW b) Wiring to actuator incorrect. c) Defective speed control. 2. If the voltage is over 2.5 volts a) Fuel metering valve or linkage sticking.
Actuator does not fully open	1) Measure the voltage at the battery while cranking. It must not be less than 8 volts DC. 2) Momentarily connect terminal A to F. The fuel metering valve should move to the full fuel position.	1. Replace the battery if it is defective. If it is undersized, replace the battery with one with a proper CCA rating. 2. a) Wiring to the actuator or the battery is incorrect. b) Fuel metering valve or actuator sticking. c) Defective actuator
Engine stays at Idle		Fuel pump lever not at full fuel position.

Insufficient Magnetic Pickup Signal

Although the control unit will govern well on 0.5 volts RMS signal if it is a clean sine wave, a signal from the magnetic pickup of 3 volts RMS at governed speed will eliminate any possibility of missed or extra pulses.

This signal is measured at terminals C and D. Raise the magnetic pickup voltage by reducing the gap between the pickup and the ring gear to not closer than .030 in. (.75 mm). This is equivalent to backing the pickup out by one-half turn after it touches the ring gear tooth.

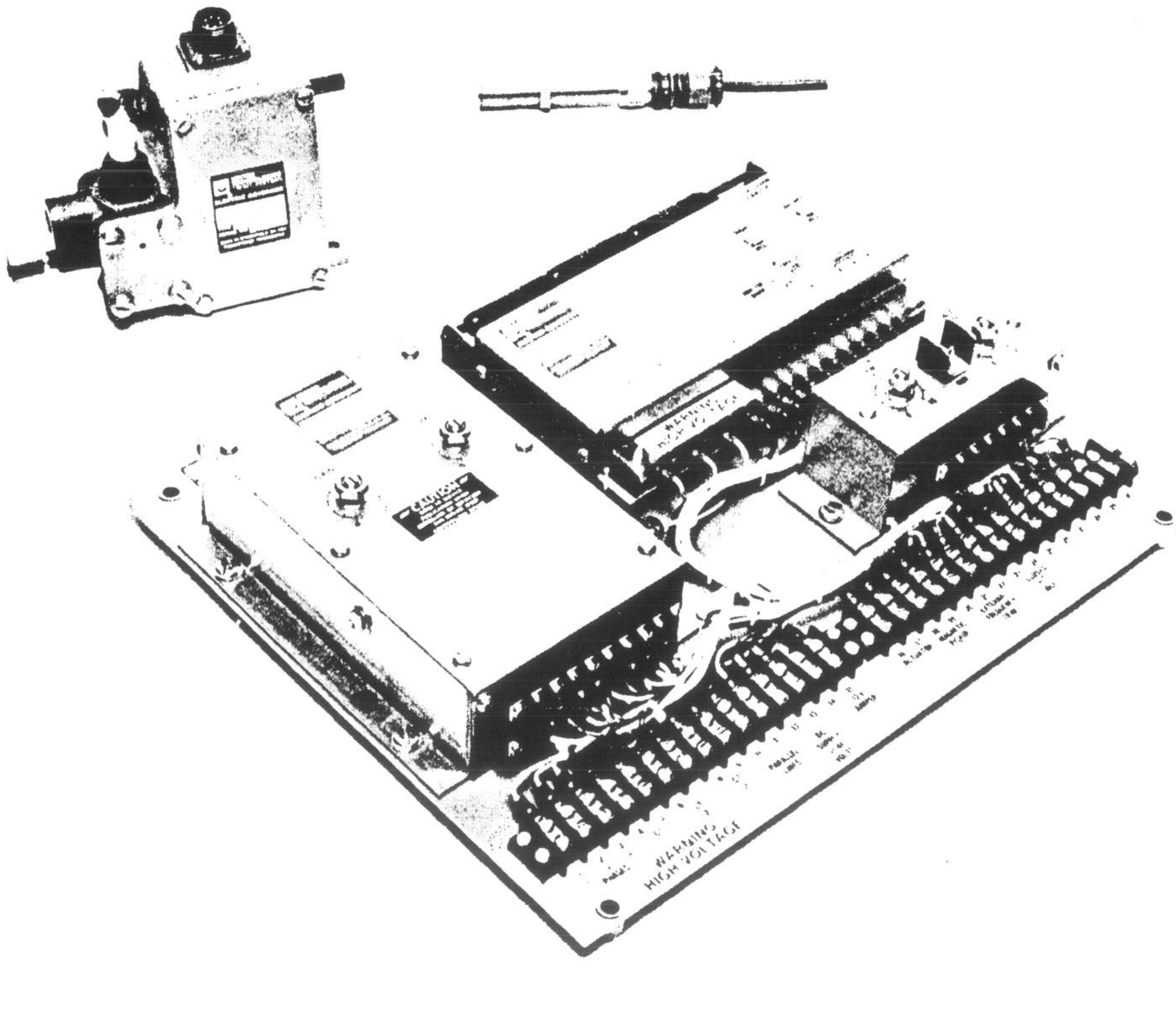
High Frequency Instability

When rapid instability or surge (about 8 Hz.) occurs, removing the jumper above the stability potentiometer (Figure 2) should eliminate this problem.

Electrical Noise or Unwanted Droop

If noisy electrical devices are present, such as magnetos, solid state ignition systems, battery chargers or regulators which emit radio frequency interference (RFI), then unstable governing or droop may be noticed. The speed control has internal filters which provide some protection from radio frequency interference. Excessive levels of RFI must be treated separately. A metal shield placed around the emitting source and/or placing the governor harness and speed control as far away as possible from the RFI emitting source will help. Always twist the leads from the magnetic pickup all the way back to the control unit. When extreme RFI is encountered, it may be necessary to shield all the leads to the speed control. These shields must be grounded at terminal D or E of the speed control.

LSP 672B PRECISE LOAD SHARING FOR CUMMINS ENGINES



ENGINE GOVERNING SYSTEMS

SYSTEM INTRODUCTION

The United Technologies engine governing system is an electrical sensing system that will maintain precise control of engine speed at any selected point and provides rapid transient response with changes in load. It is all electric and requires no engine drive nor hydraulic system and is ruggedly built to resist vibration and physical damage. The system is isochronous and will provide steady state speed stability of less than plus or minus ¼%. Droop can be obtained with a simple jumper connection at the control panel terminal block.

The basic systems employes three components. A Load Sharing Panel (LSP 672B), actuator (AGD 130) and a magnetic speed sensor.

The LSP 672B Load Sharing Panel consists of three components. A speed control unit (CU 673C-17), Load Sharing Unit (LS 671A), and an Idle/Run Kit (KT 6722A).

CU 673C-17 SPEED CONTROL UNIT

The speed control unit contains all solid state electronic circuits which sense speed from a magnetic speed sensor or other suitable signal source. A controlled output current is provided by the speed control unit to a proportional electric actuator for throttle control. The performance is isochronous.

Three integral adjustments are provided to achieve the desired performance. A "Frequency Adjust" which can adjust the speed control range by 30:1 and "Gain" control to increase or decrease governor response sensitivity and a "Stability" control to match the time constant of the governor to that of the engine. All adjustments are accessible from the top of the speed control unit.

In addition, a provision has been made to the electronics of the speed control unit to provide remote variable speed operation.

LS 671A LOAD SHARING UNIT

The Precise Load Sharing Module measures the true power output of an AC generator and converts this output to a proportional DC voltage. By proper connections of the outputs, a multiple arrangement of generator sets can be connected in parallel to share load equally. The module can also be used to control the power output of one or more generator sets delivering power to an infinite bus.

KT 6722A IDLE/RUN KIT

The Idle/Run Kit permits an engine to be run at either idle speed or operating speed by the use of an integral selector switch. Idle speed is adjustable by a control on the top cover. A frequency trim control is included on the top cover to trim engine speed.

AGD 130 ACTUATOR

The actuator is a linear electro-magnetic fuel metering device. It meters fuel quantities up to 1700 lbs. per hr. according to the amount of current flowing from the speed control unit through the actuator.

MAGNETIC SPEED SENSOR

The magnetic speed sensor responds to the number of ring gear teeth, or other types of ferrous projections, which pass the tip of the speed sensor, by inducing an electrical pulse within the coil. The pulses are then sent into the speed control unit. In effect, the magnetic speed sensor signals the number of teeth per second which pass the tip. This signal is directly proportional to engine speed.

ENGINE GOVERNING SYSTEMS

SPECIFICATIONS

LSP 672B LOAD SHARING PANEL PERFORMANCE CHARACTERISTICS

- Steady-state Stability .... ± 0.25% or better
- Frequency Range (Operating) .... 300-10K Hz continuous
- Frequency Range (Idle) .... 600 to 3500 Hz.
- Speed Drift With Temperature .... Less than ± 1%

LOAD SHARING

- Signal Inputs .... 190 to 480 volt (nominal)(2 ranges) AC line to line at 50/60 Hz. 5 amp current transformers, 12.5 VA.
- Load Sharing .... Adjustable to within ± 2% between sets
- Droop .... Adjustable up to 10%

POWER INPUT

- Magnetic Speed Sensor Signal .... 0.25-30 volts rms
- Supply .... 12, 24, or 32 VDC
- Polarity .... Negative Ground (Case isolated)
- Power Consumption (DC) .... 3 amp at 24 volts
- Power Consumption (AC) .... Voltage Input - Less than 5 watts; Current Input - 37.5 watts
- Line-to-Line Voltage ....

HZ	LOW RANGE		HIGH RANGE	
	Min	Max	Min	Max
•50	70	208	140	417
•60	85	260	170	500
50	140	208	280	417
60	170	260	340	500
400	170	260	340	500

•Low range input voltages can be accepted as long as CT secondary current is limited to 3 amps at maximum rated load. If higher voltages must be used, external PT's can be added. The transformer burden capability is insignificant.

ENVIRONMENTAL

- Temperature Range .... −55° to + 85°C (−65° to + 185°F)
- Relative Humidity .... up to 100%
- Case .... Fungus proof and corrosion resistant

PHYSICAL

- Dimensions .... See Figure 1
- Weight .... 5.0 kgs (11.0 lbs)
- Mounting .... Any position (See Installation Page 8)

RELIABILITY

- Tested 100%
- Vibration .... All printed circuit boards are conformally coated on both sides

ENGINE GOVERNING SYSTEMS

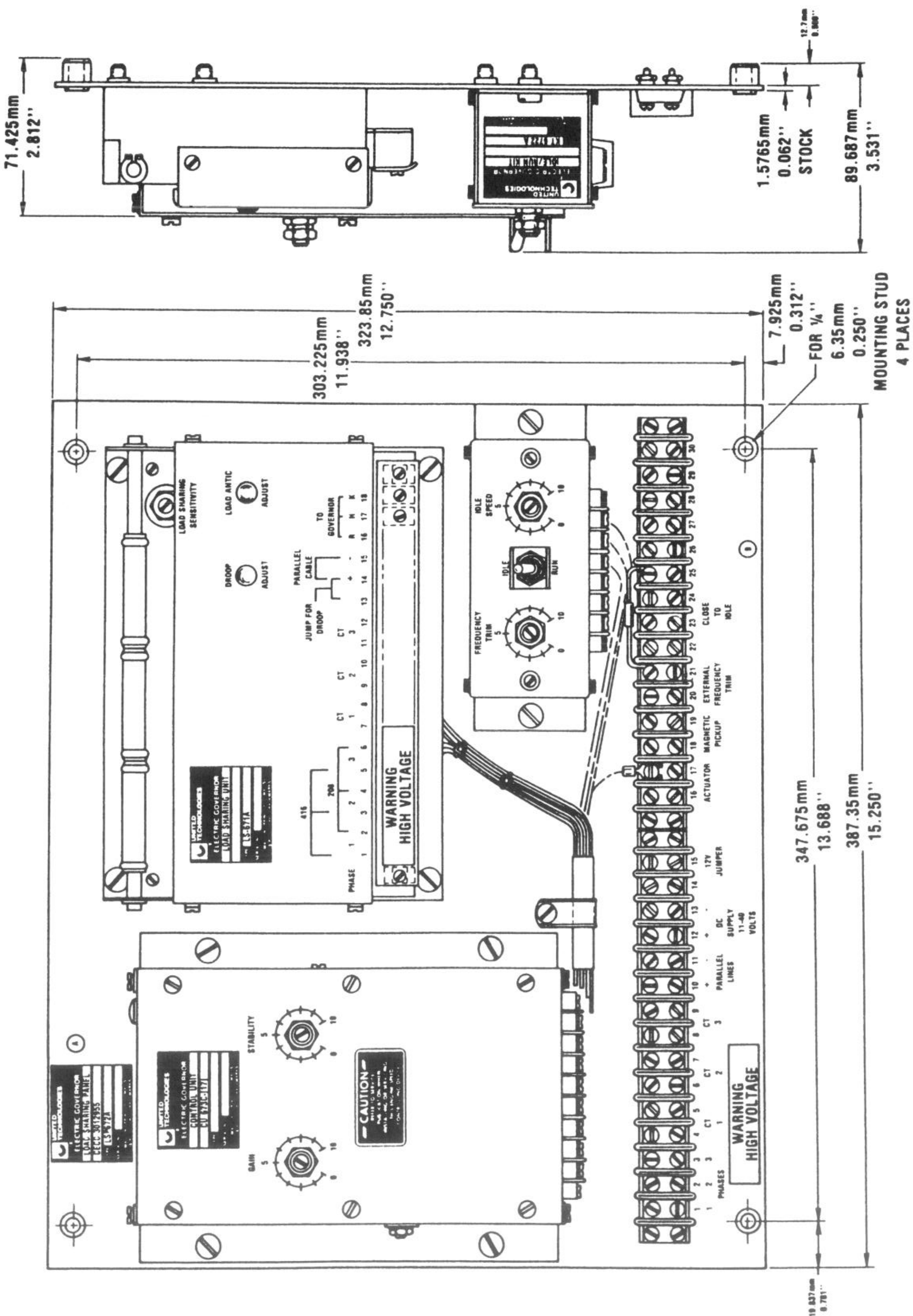


Figure 1. LSP 672B load sharing panel dimensions

ENGINE GOVERNING SYSTEMS

SPECIFICATIONS

AGD-130 ACTUATOR PERFORMANCE

- Maximum Flow Rate (Diesel #2)	771 kg/hr (14.4 litre/min) 1700 lbs/hr (~~3.80~~ 4.0 gpm)

POWER INPUT

- Operating Voltage	12, 24, or 32 VDC
- Normal Operating Current	2A at 12 VDC 1.5A at 24 or 32 VDC
- Maximum Current (Instantaneous)	6A at 12 VDC 3A at 24 or 32 VDC

ENVIRONMENTAL

- Temperature Range	−54° to +93°C (−65° to +200°F)
- Relative Humidity	up to 100%
- Case	Fungus proof and corrosion resistant

PHYSICAL

- Dimensions	See Figure 2
- Weight	1.75 kgs (3.85 lbs)
- Mounting	Any position (See Installation Page 9)

RELIABILITY

- Tested	100%

MATING CONNECTOR

- Actuator	EC1249-2 (6 pins)/MS3106R14S-6S
- Wiring harness (includes both connectors prewired)	CB679

VARIATIONS

- AGD 130 E4 CECO P.N. 3019635	With temperature probe and standard fuel metering valve
- AGD 130 E5	High temperature coil and standard fuel metering valve −54° to +107°C (−65° to +225°F)
- AGD 130 F2	High temperature electro-mechanical section with a low fuel limiting valve (prevents engine shutdown)
- AGD 130 G4	Reverse acting with fuel metering valve (Use CU 673C-9 speed control unit)

REBUILD KITS

- KT 6723	For all AGD 130 Series Actuators
- contains	Fuel Metering Valve, Actuator Lever Assembly, Dust Boot
- KT 6724	For VA 671A and VA 673A valves
- contains	Valve Plunger Assembly, Actuator Lever Assembly, Dust Boot "O" Ring Gasket,(2) Aluminum Gaskets
- KT 6726	For AGD 100A1 and AGD 130D1 actuator
- contains	Fuel Metering Valve, Actuator Lever Assembly, Dust Boot Spacer Plate, (4) Screws, Gasket
- KT 6732	For AGD 130 E4/F1 (High Temperature Coils)
- contains	Housing Assembly, Plate - Ident, Gasket

ENGINE GOVERNING SYSTEMS

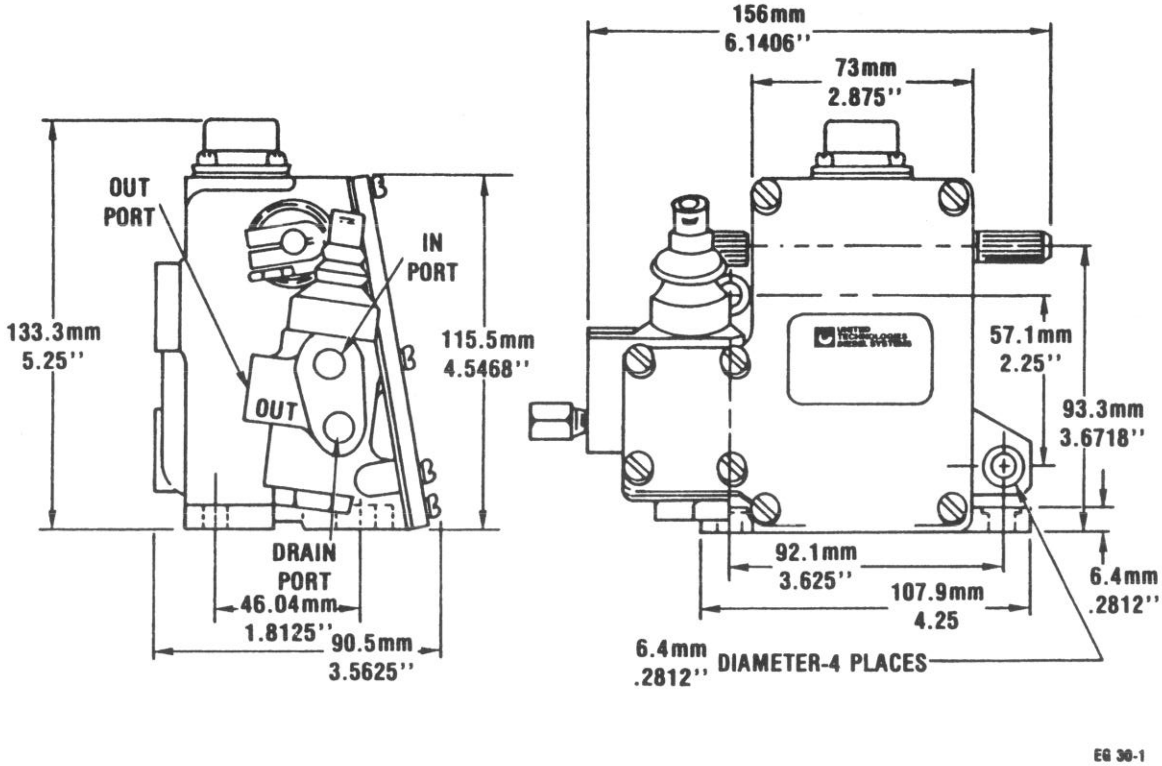


Figure 2. AGD 130 actuator dimensions

SPECIFICATIONS

MAGNETIC SPEED SENSOR

- Dimensions . . . . . See Figure 3 and Table A
- Thread Size . . . . . 5/8 - 18 UNF-2A
- Tap Drill Size . . . . . 37/64"
- Proximity to Gear Teeth . . . . . 0.75mm (0.030 in.)
- Temperature Range . . . . . −55° to + 105°C (− 65° to + 225°F)
- Output . . . . . 0.50 to 30 volts RMS is recommended to input to the speed control unit
- Resistance . . . . . 50 to 500 ohms

ENGINE GOVERNING SYSTEMS

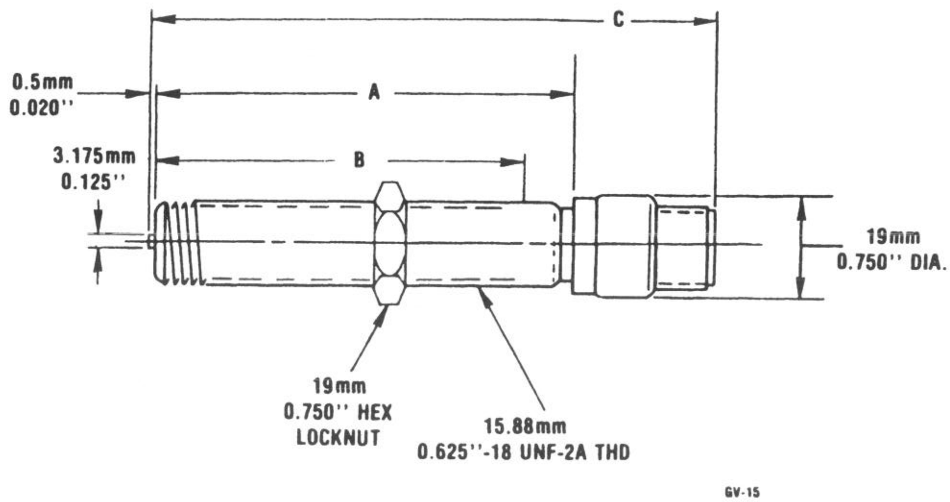


Figure 3. Shielded magnetic speed sensor dimensions

SHIELDED MAGNETIC PICKUP CAT. NO.	DIMENSION A	DIMENSION B MAX. USABLE THD LENGTH	DIMENSION C PICKUP LENGTH	ADDED LENGTH OF CONNECTOR AND CABLE CLAMP
MP 677*	76mm 3 inches	67mm 2-5/8 inches	102mm 4 inches	
MP 678*	127mm 5 inches	118mm 4-5/8 inches	152mm 6 inches	
MP 679**	76mm 3 inches	67mm 2-5/8 inches	102mm 4 inches	60.325mm 2.375 inches
MP 6710A**	127mm 5 inches	118mm 4-5/8 inches	152mm 6 inches	60.325mm 2.375 inches

*Magnetic speed sensors are without connector and clamp.
**Magnetic speed sensors are complete with connector (EC 1267-1) and cable clamp (AD 673). A 2 wire-shielded cable cut to the desired length is required. Slide the cable clamps on to the cable and solder each wire to the connector plug.

Table A
Shielded magnetic speed sensor dimensions

ENGINE GOVERNING SYSTEMS

SYSTEM DESCRIPTION

LOAD SHARING PANEL

The control panel accepts connections from the battery supply, actuator, magnetic speed sensor and generator set to achieve precise load sharing of paralleled engines. All the control panel components are pre-wired for ease of installation, and a common 30 position terminal trip is provided to accept all connections from accessories and other generator set control panels.

The control panel consists of these three components:

SPEED CONTROL UNIT (CU 673C-17)

The speed control unit is designed to operate on 12, 24 or 32 VDC systems. For 12 volt operation, one jumper connection is added externally. For 12 volt operation, the speed control unit will operate from 11 to 18 volts. In the 24 - 32 volt connections, the speed control unit will operate from 13 to 40 volts.

The speed control unit compares the engine high frequency speed signal
with the frequency of the reference oscillator signal. Frequency variations of these two signals cause the unit to adjust the current in the actuator, thus metering the fuel flowing through the valve to control the engine at a predetermined speed. The speed control unit is fail-safe in respect to loss of magnetic speed sensor signal as the actuator will position the metering valve to drain rail fuel to tank if the speed sensor voltage falls below 0.5 volt RMS.

The speed control unit has an operating speed adjustment and two performance adjustments — gain and stability. Remotely closing the contacts at terminals 23 and 24 will cause the engine to idle.

IDLE/RUN KIT (KT 6722A)

The idle/run module permits an engine to be run at either idle speed or rated speed by the use of an integral selector switch. Adjustment of idle speed is provided. During idle operation a small amount of droop is introduced in the governor to insure stable operation. The module also includes a speed trim control for precise speed adjustment.

LOAD SHARING UNIT (LS 671A)

A single engine generator set operating on an isolated load may run well isochronously. Thus, under all load conditions, the steady state frequency of the generator is the same. The only deviations from this steady state frequency are caused momentarily by sudden load changes or transients. However, if two or more engine generator sets are used to supply power in parallel to a single load, the two generators are forced to run at exactly the same speed and in phase with each other. When two or more generators are connected in parallel and supplying a common load, any tendency of one unit to get out of phase with the other is resisted by the magnetic forces (synchronizing torques) within the generators as if they were connected together with a chain drive.

If each of the two engines in parallel was controlled by an isochronous governor each would try to force its speed to be the same as its reference. Although two isochronous governors could be set to nearly the same frequency, it is not possible for their references to be exactly the same. Under these circumstances the two engines must run at some average speed. The first engine whose governor reference is at a slightly higher frequency will try to increase its power generation. On the other hand, the second engine with its governor set slightly below the average speed, will keep decreasing throttle in order to slow down. The net result is that in a short time, the first engine will be taking all the load it can and the second engine will be dropping off as much as it can until its generator begins acting as a motor which will drive the second engine.

This module takes the voltage and current of each of the three phases of the generator and develops a DC voltage proportional to true power. The voltages of the several sets are averaged and the voltage difference between the average power and the actual power of each set is sent to the reference point of each speed control unit. Thus, if a given engine generator set tends to generate at a power level different from its proportionate share, a correction voltage is sent to its governor reference to correct its power. Since there is as much positive as negative correction, the overall system remains isochronous. This system is very accurate and is independent of actuator and throttle characteristics. However, it can be applied only where each set has as its principal load, a single generator.

ACTUATOR (AGD 130)

An AC frequency signal (proportional to speed), generated by a magnetic speed sensor is constantly fed into the speed control unit and compared with a preset frequency. If the frequencies do not remain identical, a change in current from the speed control unit changes the magnetic force in the actuator which causes angular rotation of the actuator shaft and, in turn, linear movement of the metering valve. Fuel metering is proportional to the amount of current flowing through the actuator and is counterbalanced by an internal spring. The valve is used to meter fuel quantities up to

ENGINE GOVERNING SYSTEMS

(1700 lbs. per hour) 771 kg per hour, which is ample for all Cummins engines and is installed in series between the outlet of the fuel pump and the common rail which feeds the injectors. By regulating fuel pressure in the rail, the valve determines the engine power output. The valve also has a drain port, which relieves pressure in the rail line quickly when the engine load is suddenly decreased. This feature considerably improves the engine transient response on load rejection. The actuator housing is sealed against engine environment with gaskets at all openings so steam or other water based cleaning will not affect the system's operation. **No maintenance is necessary.**

MAGNETIC SPEED SENSOR

The magnetic speed sensor is an electro-magnetic device that is mounted in the flywheel housing. As the flywheel gear teeth pass the speed sensor, AC voltage is induced, one cycle for each tooth. The input signal strength from the magnetic speed sensor may be as low as 0.5 volts RMS or as high as 30 volts RMS. A value of 1 volt RMS at cranking speed is adequate. Terminal 18 on the speed control panel is connected to ground, hence one side of the speed sensor is internally grounded.

POWER SOURCE

The source voltage is 12, 24 or 32 VDC.

CAUTION
DO NOT CONNECT THE SPEED CONTROL UNIT TO A BATTERY CHARGER.

Most Cummins engines will have a 24 volt battery supply. The circuits are isolated from the case. The maximum input current at 24 volts is approximately 3 amps.

REMOTE SPEED TRIM CONTROLS (Optional)

Should remote minor adjustment of speed be desired, provisions have been made for the inclusion of a 10 turn control. (See Section EG 70-1). It is connected to terminals 20, 21, and 22.

AUTOMATIC SYNCHRONIZER'S (CU 6714D OR SYN 671) (Optional)

Should automatic synchronizing of the engine generators be required, provisions have been made for the inclusion of a synchronizer.

When synchronizing engine generator sets to an infinite bus or other engine generator sets, proper voltage, frequency and phasing must be observed.

The function of the synchronizer is to sense the speed and phase of its engine drive generator and to adjust this speed and phase to match the phase of the main bus. When the generator frequency and phase are matched to the bus, the internal relay contacts in the synchronizer are automatically closed to initiate load contactor closure. The synchronizer is fast; typical speed and phase adjustment can be obtained in 3 seconds from a near speed condition.

Request publication EG 70-8 or EG 70-8A for the CU 6714D or SYN 671 synchronizer from United Technologies Diesel Systems.

SYSTEM INSTALLATION

LOAD SHARING PANEL

CAUTION
THE ENGINE SHOULD BE EQUIPPED WITH AN INDEPENDENT OVERSPEED SHUTDOWN MECHANISM TO PREVENT RUNAWAY WHICH CAN CAUSE EQUIPMENT DAMAGE OR PERSONNEL INJURY.

The load sharing panel may be mounted in any position where vibration and temperature extremes are minimal. The control panel will provide excellent control at temperatures from − 55 °C to 85 °C (− 65 °F to 185 °F). The power resistors on the load sharing module will develop some heat which must be dissipated.

The three panel components are pre-wired into the top row of the 30-position terminal strip.

CAUTION
HIGH VOLTAGE IS PRESENT ON THE TERMINAL STRIP ONCE WIRING IS COMPLETED.

All connections from the other components such as battery, actuator, magnetic speed sensor, parallel cable, and connections from the generator (alternator) must be made to the lower row of the terminal screws on the 30-position terminal strip (see wiring diagram, Figure 6 and/or Cummins diagram 212213, or Figure 7 or by using Table B as a guide).

ENGINE GOVERNING SYSTEMS

Load Sharing Panel Terminals		
*1, 2, 3	Voltage connections phase A, B, C respectively	Caution: High Voltage present when in operation
*(4, 5) (6, 7) (8, 9)	C.T. secondary, 5 amp. max.	Caution: Accidental open circuits on CT's cause high voltage
10	Parallel line (+)	
11	Parallel line (−)	
12	Battery (+)	
13	Battery (−)	
15	Connects to terminal 12 for 12 VDC operation only	
16 17	Actuator Connector pin A Actuator Connector pin D	See Figure 4 or actuator publication for proper wiring of actuator connector
18, 19	Magnetic pickup	Shield connected to terminal 18
20, 21, 22	Remote speed trim control (optional)	See Figure 6
23, 24	Contacts close at idle	May be used to disconnect voltage regulator
27, 28	Isochronous/droop mode switch	Required for droop operation only

*Proper phasing must be observed, refer to Figure 6 or Cummins drawing 212213 or Figure 7.

Table B
Wiring chart for LSP 672B load sharing panel

Panel mounted load sharing modules are pre-wired for 416V (high range) service. To operate on low range service (208V), relocate terminal wires on load sharing module (LS 671A) from 1, 3 and 5 to 2, 4 and 6. Do not move any wires on the 30-position panel barrier strip. If other voltages must be used, external transformers will be required.

ACTUATOR

The actuator should be mounted as closely as possible to the outlet of the fuel injection pump. The actuator may be mounted in any position. However, the preferred mounting position is with the electrical connector at the top. The actuator should be located in an air stream if possible. No adjustment of the valve linkage is necessary.

Actuator bracket, BK 6726 may be used to facilitate preferred mounting on all Cummins engines. The fuel valve is connected into the fuel line to the injectors. The valve inlet (marked "in") on the actuator is connected to the outlet of the PT fuel pump. The valve outlet (marked "out") is connected to the rail leading to the injectors. Steel tubing or single wire braided rubber hose may be used for all fuel lines. Use 5/16" I.D. tubing for all engines except the 12 and 16 cylinder units which require 3/8" I.D. lines. The valve ports are 1/4" NPTF.

The drain port (marked drain) is 1/8" NPTF. It should be connected to the injector fuel return line. A normal back pressure on the drain of 2-4 PSI is acceptable. Higher back pressures may cause external fuel leakage. Additionally, all fuel valve fittings should be hand tightened and then wrench tightened 1 to 1-1/2 turns. If sealant is used it should be liquid type and not tape.

Right angle bends in fuel lines and fittings should be avoided near the fuel pump and actuator; use 30° or 45° fittings, or tubing with gradual sloping bends.

On original installations made at the factory, the fuel pumps have been calibrated to compensate for a small pressure drop across the actuator valve. On installations made in the field, it will be necessary to re-adjust the throttle stop as required to obtain rated h.p. However, on engines where the

ENGINE GOVERNING SYSTEMS

h.p. is marginal for the load at the outset, it will be necessary to compensate for the pressure drop by adding shims to the PTR pumps. On AFC pumps, it will be necessary to replace the throttle shaft, and turn in the adjusting screw until the required rail pressure is obtained. The pressure drop should be measured only at rated speed. This adjustment is necessary only for engines that have no reserve power.

AFC fuel pumps with turbo-charger fuel limiting will limit the transient response of the engine.

The leads used for actuator connections should be at least #18 wire for 24 volt and 32 volt operation and #16 wire for 12 volt operation.

24 VOLT OPERATION

Connect the following actuator terminals together with jumpers at the mating half of the connector (see Figure 4).
1. B to C
2. A & D to the respective terminals to the load sharing panel. (See Table B)

MAGNETIC SPEED SENSOR

The magnetic speed sensor is mounted in the gear case or flywheel bell housing. The speed sensor can be screwed in (with the engine stopped) until the tip strikes the top of the gear tooth, then backed out ¾ of a turn and secure it by the locknut. The threaded hole should be relatively perpendicular to the centerline of the crankshaft and a spot face should be provided for a flat surface to anchor the locknut securely. Any ferrous gear may be used as long as the frequency and amplitude meet the speed control unit specification.

The wire leads from the speed sensor should be twisted for their entire length up to the load sharing panel. The speed sensor leads may need to be shielded if they are exceptionally long 3 meters (10 feet) or if external interference from spark ignited engines or external equipment is encountered.

Do not ground either of the speed sensor leads. Only the shielded wire is to be grounded, fused, to one specific terminal on the speed control unit. See Table B. The shield should not be connected at the speed sensor end.

SPEED TRIM CONTROL (Optional)

Connections to the Load Sharing panel for a remote speed trim control can be made as shown in Figure 6.

AUTOMATIC SYNCHRONIZER (Optional)

Connections for an automatic synchronizer can be made as shown in Table C for CU 6714D or Table D for the SYN 671A synchronizer.

Wire sizes are as follows:

Terminals	
1, 2	High voltage, low current min 600 V cable
3, 4, 5, 6, 8, 9, 10, 11	#22 gauge wire

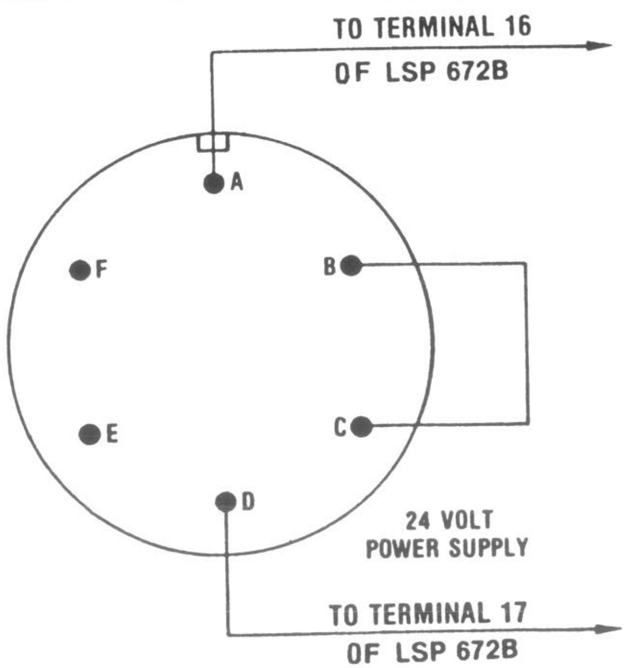


Figure 4. Wiring to AGD 130 actuator for 24 volt operation

ENGINE GOVERNING SYSTEMS

SYNCHRONIZER TERMINALS	
1	Slave input (Phase A of generator side of main circuit breaker)
2	Master input (Phase A of main bus side of main circuit breaker)
3, 4	Internal relay contacts (N.O.) for main contactor closure (Internal relay contacts made to close main circuit breaker when generator set is synchronized.)
5	Auxiliary N.C. main circuit breaker contact to terminal 16 of load sharing panel
6	Auxiliary N.C. main circuit breaker contact to terminal 26 of load sharing panel
8	Battery supply positive (Terminal 12 of load sharing panel)
9	Jump to terminal 8 of synchronizer for 12 volt operation
10	Battery supply negative (Terminal 13 of load sharing panel)
11	Temporarily jump to terminal 10 of synchronizer during synchronizer adjustment period.

Table C
Wiring chart for CU 6714D automatic synchronizer

SYNCHRONIZER TERMINALS	
1	Master input (Phase A of main bus side of main circuit breaker)
2	Master input (Phase B of main bus side of main circuit breaker)
3	Slave input (Phase A of generator side of main circuit breaker)
4	Slave input (Phase B of generator side of main circuit breaker)
5	AC enable signal
6	DC output signal (digital signal)
7	DC output signal (analog signal)
8	Synchronizer disable signal
9	Battery supply (positive)
10	Battery supply (negative)
11	Relay disable (place temporary jumper from Terminal 10 to 11 to prevent breaker closure during synchronizer adjustment period)
12	DC enable signal
13 14	Synchronizer relay (to voltage supply)
15 16	Dead Bus feature (maintain a permanent jumper from Terminals 15 to 16 if the dead bus feature is voided)

Table D
Wiring chart for SYN 671A automatic synchronizer

ENGINE GOVERNING SYSTEMS

SYSTEM ADJUSTMENTS

PRELIMINARY CONTROL PANEL ADJUSTMENTS

The speed control unit (CU 673C-17) has been adjusted at the factory for starting conditions and will control the engine at approximately 450 RPM. If it is desirable to reset the speed control unit, turn the "Freq. Adjust" on the end plate. This will provide control of the engine to any desired speed.

1. Set the gain control at 2.5 on the scale of the speed control unit (CU 673C-17).
2. Set the stability control at midrange (5) on the scale of the speed control unit (CU 673C-17).
3. Set the frequency trim control to midrange position on the idle/run module (KT 6722A).
4. Set the idle/run switch to "run" on the idle/run module (KT 6722A)
5. Increase speed setting of the fuel pump by rotating lever to its maximum high idle position. Lock the throttle lever on the fuel pump in this wide open position (maximum CCW).
6. Apply DC power to the engine governing system through the wiring connections at the terminal block by closing a switch in the battery circuit.

> CAUTION
> DO NOT CONNECT TO A BATTERY CHARGER.

7. Momentarily connect the insulated nut on the side of the speed control unit (CU 673C-17) with a jumper wire to battery negative. This should cause the actuator valve to snap to the full fuel position. If not, check for wiring defects in the actuator or battery wiring.
8. Set the sensitivity control on load sharing unit to the full CW position (LS 671A).
9. Set the load anticipation adjustment full CW (LS 671A).

STARTING THE ENGINE INITIALLY

> CAUTION
> THE ENGINE SHOULD BE EQUIPPED WITH AN INDEPENDENT OVERSPEED SHUTDOWN MECHANISM TO PREVENT RUNAWAY WHICH CAN CAUSE EQUIPMENT DAMAGE OR PERSONNEL INJURY.

The throttle lever on the fuel pump has been fastened in the wide open position. However, it may be used to manually control the engine during the first startup, if preferred. Starting the engine may now proceed normally. During cranking, but before the engine starts, the actuator will push its valve open. Once started, the engine will be controlled at low idle by the speed control unit. The throttle lever on the fuel pump should be fastened wide open at this time if it has not been fastened earlier.

Raise the engine speed to the desired operating speed by turning the frequency adjust control, located under the end plate of the speed control unit (CU 673C-17), in a CW direction, usually about four turns. Final precise speed adjustment is made by using the "frequency trim" control on the idle/run module (KT 6722A). If the governor becomes unstable, stability can be recovered by turning the gain and stability adjustments on the speed control unit CCW. Place the idle/run switch at "idle" position. The idle speed may now be adjusted to the desired RPM by turning the idle speed control CW.

ENGINE PERFORMANCE ADJUSTMENTS

Once the engine is at operating speed, the stability and gain adjustments can be made as follows:

1. At no load, turn the gain adjustment on the speed control unit CW until the system becomes unstable.

   Turn the gain control CW until instability results. Then back-off slightly CCW (one major division) beyond the point where stability returns.

2. Turn the stability control CW until instability results. Then back-off slightly CCW (one major division) beyond the point where stability returns. Tap the throttle to be sure the system is truly stable. If system is slightly unstable, turn gain CCW. Recheck stability by tapping.

3. Load may now be applied to the engine. If necessary, repeat steps 1 and 2 above until optimum performance is obtained. Normally, the critical point for gain and stability adjustment is at no load.

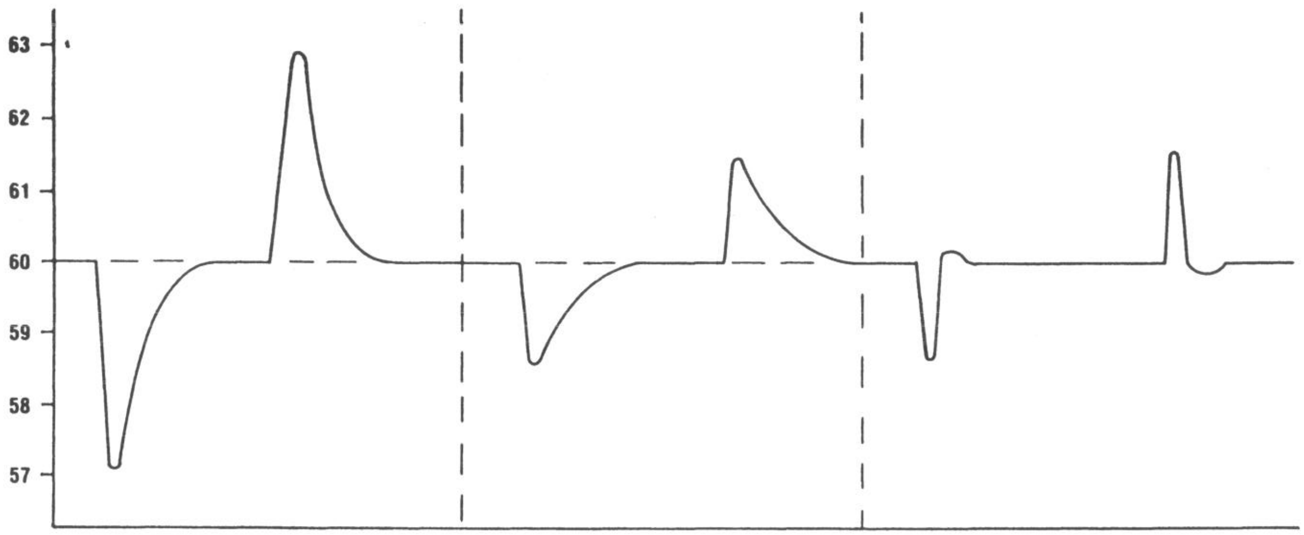
   CW adjustment of the gain control shortens the response time after a load change. CCW adjustment causes more sluggish action.

   CW adjustment of the stability control shortens the recovery time after a load change. CCW adjustment lengthens the recovery time.

   The optimum adjustment of both controls is in the maximum CW position where the best response and stability are obtained under all operating conditions. It is well to back off slightly from that position to allow for changing conditions that may affect the dynamic response of the engine. If stability problems are encountered, see Troubleshooting information on Page 8.

4. Final Trimming of the Governor

If a load bank and a recorder are available, use them to make traces per Figure 5.



INITIAL GAIN AND STABILITY CONTROL ADJUSTMENTS GIVE A TRACE INDICATING, FROM THE EXCURSION OF THE TRANSIENT, THE GAIN SHOULD BE INCREASED BY TURNING THE GAIN CONTROL CW. NOTE: TIME IS CONSTANT FOR ALL CONDITIONS.

INCREASED GAIN RESULTED IN A NEW TRANSIENT WITH REDUCED EXCURSION. IT IS APPARENT FROM THE LONG TAIL ON THE TRANSIENT THAT THE STABILITY CONTROL MUST BE TURNED CW.

READJUSTING BOTH GAIN AND STABILITY CONTROLS GIVES A TRACE, INDICATING GOOD TRANSIENT AT FULL LOAD AND GOOD STABILITY. THE SPEED CONTROL UNIT IS NOW PROPERLY ADJUSTED AND THE LOCKNUTS CAN BE TIGHTENED.

EG-10

Figure 5. Typical performance chart

ENGINE GOVERNING SYSTEMS

LOAD SHARING CHECKS AND ADJUSTMENTS

Before proceeding with load sharing adjustments, all engine generator set governors should be adjusted to the desired speed and trimmed with the external or load sharing panel frequency trim control.

1. Check load sharing unit for proper CT phasing and polarity by measuring with a DC voltmeter on the load sharing panel the voltage across the parallel cable on terminals 10 (+) and 11 (−) with a load applied to the generator. A voltage of about + 8 VDC will represent full load with 5 amps CT input. Instrument polarity must be observed. Then, momentarily short the individual CT connections with the load sharing panel (4 to 5, 6 to 7, 8 to 9) one at a time with an insulated lead. The parallel cable voltage will fall by about ⅓ for each individual shorting of a CT. If a voltage rise occurs instead of a voltage drop, this indicates improper CT phasing and/or voltage connections which must be corrected. Make sure power is off before making corrections.

   NOTE: During CT phasing, the parallel cable voltage output can also be measured conveniently at test points on the LS 671A load sharing module. The red post (+) is on the right next to the load sharing sensitivity adjustment

2. Generator sets may now be synchronized manually with the speed trim control or with the United Technologies automatic phasing synchronizer. Once synchronized, the generator sets can be paralleled.

3. At no load adjust the external load sharing panel frequency trim control for zero real power. Adjust the voltage regulator to trim the reactive current to zero.

4. Apply a constant load (preferably 100%). If instability occurs, see "Troubleshooting".

5. Check the power output of each generator set. The engine carrying the least load can be adjusted by turning that engine's load sharing sensitivity adjustment CCW until the load is balanced.

LOAD ANTICIPATION ADJUSTMENT

The load sharing modules (LS 671A) have a load anticipation circuit to improve transient responses. This function is factory set at zero sensitivity (full CW). Load anticipation should be adjusted while the engines are parallel.

Carefully turn the control CCW while occasionally poking the valve of the actuator with about 50% load applied to the engine. Instability may result if the control is advanced too far. Usually a ¼ turn CCW will be close to optimum.

DROOP ADJUSTMENT

When paralleling with an infinite bus, droop is often used. Adjustable droop with load is obtainable by connecting terminals 27 and 28 by placing either a jumper or a switch between these terminals. An internal control is provided for droop adjustment and is located under the dot plug on the cover of the LS 671A. Adjust the droop control to the desired droop level by CW rotation of droop adjustment. The droop is linear and may be set at any level. The parallel cable must be disconnected during droop operation.

CAUTION WHEN THE SET IS IN OPERATION, HIGH VOLTAGE IS PRESENT ON TERMINALS.

AUTOMATIC ELECTRONIC SYNCHRONIZER ADJUSTMENTS (Optional)

Once the section on installation, operation and wiring have been completed, terminal 6 of the CU 6714D synchronizer may be connected. Then turn the phase sensitivity control of the synchronizer full CW. This will prevent terminals 3 and 4 from closing. Start the engine(s) and turn the synchronizer "on". The synchronizer will now synchronize the system but will not close the circuit breaker (terminals 3 and 4 will remain open). Adjust the gain control CW until instability results, then back off the gain control until stability is restored. Tap the engine throttle to be sure the system is stable and the response is fact. If instability or response is not as good as desired, refer to the section below on stability. Once the synchronizer gain has been adjusted, the phase error should be within 6°. Further CCW adjustment will result in wide window and shorter synchronizing times. When satisfactory, lock both cover adjustments. If SYN 671A synchronizer is being used consult Section EG 70-8A.

A phase error adjustment is located behind the rear end cover on the near left side (to the right of the stability control as viewed from the rear end). This control is factory adjusted for phase error of less than 6°. If a small phase error is desired, this control may be adjusted for minimum obtainable error.

When the phase angle difference is reduced to a minimum by the synchronizer, the phase detection circuit will close the internal relay (terminals 3 and 4). The phase angle difference can be adjusted by the phase angle sensitivity control (located on the cover). CW rotation of this control will reduce the phase error window to near zero. All synchronizers are factory set for 6° window. CCW rotation can increase this window to 20°.

ENGINE GOVERNING SYSTEMS

Contact closure (terminals 3 and 4) indicates that the synchronizer is holding the speed and phase of the generator so that the line contactor may be closed either manually or automatically. Oil pressure and voltage regulator sensing devices may be added in series with the internal relay contacts (terminals 3 and 4) to insure proper conditions before paralleling the generators.

At the same time the generators are paralleled, the synchronizer must be disconnected from the control panel by the opening of the NC main circuit auxiliary contacts, since the speed is held by the bus. When the synchronizer is disconnected from terminals 16 and 26 of the control panel, the speed controls revert to normal operation.

STABILITY

If optimum stability cannot be obtained or if it is difficult to stabilize the system, the internal synchronizer stability adjustment is behind the rear cover to the far left. A CW adjustment will reduce the time constant.

TROUBLESHOOTING

GOVERNOR INOPERATIVE

While cranking, measure the voltage from ground (#13 of terminal strip) to the speed control unit terminals (CU 673C-17) in sequence as indicated below (terminals F, G, H and T also are ground terminals located on the speed control unit):

STEP	TERMINALS OF CU 673C-17	NORMAL VALUE	PROBABLE CAUSE OF NON-NORMAL READING
1	S	1.0 volt AC-RMS min. while cranking	1. Defective magnetic speed sensor 2. Gap too large between speed sensor and gear teeth 3. Improper or defective wiring to the speed sensor
2	K	10.1 ± 0.20 VDC while energized (Internal regulated DC supply)	1. DC power not connected or low battery voltage 2. Speed trim control shorted, grounded or miswired 3. Wiring error 4. Defective speed control unit
3	L	Above 5.1 VDC while cranking (Inverse speed error signal) Above 5.1 volts is under/speed signal Below 5.1 volts is over/speed signal On speed will indicate a steady 5.1 volts	1. Frequency adjust set too low. Turn CW 2. Defective speed control unit
4	N	8.5 to 9.5 VDC while cranking (Proportional actuator voltage)	1. Battery voltage may be too low while cranking 2. Defective speed control unit
5	B	2.5 VDC maximum while cranking (Transistor voltage)	1. Error in wiring to actuator 2. Defective actuator (See page 16) 3. Output transistor open (defective speed control unit)

If all 5 voltage tests indicate normal values, the defect must be in the actuator or in the wiring to the actuator. See "Defective Actuator" on Page 15.

ENGINE GOVERNING SYSTEMS

OTHER TROUBLESHOOTING TESTS

STEP	SYMPTOM	TEST	PROBABLE TROUBLE IF TEST FAILED
1	Engine overspeeds	Determine voltage on terminal "L" — should be less than 5.1 VDC when at overspeed.	1. Frequency set too high. Turn frequency adjust CCW 2. Defective speed control unit
2	Engine overspeeds	With engine stopped apply battery power to the system. Measure the voltage at the insulated nut located on the side of the speed control unit. Should be battery voltage.	1. Wiring to actuator incorrect 2. Output transistor shorted (defective speed control unit)
3	Engine overspeeds	Disconnect actuator electrical connector and try to start engine (Engine should not start)	1. Fuel metering valve or actuator sticking. Clean valve.
4	Fuel metering valve does not open	Measure battery voltage at the battery while cranking. Must be 8.0 VDC minimum	1. Insufficient battery voltage. Put a momentary connection from terminal 16 on the load sharing panel to battery ground while cranking (Terminal 13 is ground) 2. Replace with battery of higher amp hour rating
5	Fuel metering valve does not open	Temporarily connect the insulated nut located on the side of the speed control unit to battery negative. Fuel metering valve should move to full fuel position.	1. Wiring to actuator or battery incorrect 2. Fuel metering valve or actuator sticking 3. Defective actuator

ERRATIC OR UNSTABLE GOVERNING

A. Insufficient Magnetic Speed Sensor Signal
Although the speed control unit will govern well on 0.5 volts RMS signal if it is a clean sine wave, a signal from the magnetic speed sensor of 3 volts RMS at full speed will eliminate any possibility of missed or extra pulses. This signal is measured at terminals 18 and 19. Signal strength must not exceed 30 volts RMS.

B. Electrical Noise or Unwanted Droop
If noisy electrical devices are present, such as magnetos, solid state ignition systems, battery chargers or regulators which emit radio frequency interference (RFI), the unstable governing or droop may be noticed. The speed control unit has internal filters which provide some protection from radio frequency interference. Excessive levels of RFI must be treated separately. A metal shield placed around the emitting source will help. Placing the governor harness and speed control unit as far away as possible from the emitting source will help.

Raise the magnetic speed sensor voltage by reducing the gap between the speed sensor and the ring gear. A gap of 0.030" will provide a strong signal, 30 volts RMS maximum. If noise is still present, a capacitor (1,000 mfd, 12-20 volts) may be connected across the speed trim control terminal 20 (+) to terminal 21 (−) to reduce external interference coming from the DC power supply. The best solution is usually to relocate the panel to a position where less noise is experienced.

C. Fuel Material Valve/Actuator Sticking
If the valve or the actuator is sticking, as determined by hand, this can cause erratic behavior. If the cause is dirt in the valve, the valve can be cleaned. Otherwise, replace the valve or actuator. If the valve stem is binding, replace valve plunger assembly. Recheck plumbing to be sure drain circuit is connected to the injector return. A 1-2 psi pressure at the drain port is required.

D. Defective Actuator
The resistance beteen the wires normally connected at terminals 16 and 17 of the control panel, should be about 8 ohms. Also measure the resistance from these same wires and battery (−) should be greater than 100,000 ohms. If it is not, the coils in the actuator should be checked directly. Remove the cable and check between pins A and B and between C and D on the actuator. Each coil should have about 4 ohms resistance. Then check the resistance between each pin and the actuator housing should be greater than 100,000 ohms. If not, replace the actuator. If the coils have the correct resistance, the wiring or connectors are defective.

ENGINE GOVERNING SYSTEMS

E. Low Speed Surging or Poor Stability
Stability problems that cannot be eliminated with the gain and stability adjustments usually can be improved by adding a jumper across terminal M and H of the speed control unit terminal strip. This modifies the dead time filter compensation and is required for KTA 2300 and KT(A) 3067 engines.

Note the frequency of instability. In the instance of slow speed surging of about 1-3 oscillations per second, modifying the speed control for added dead time compensation (derivitive) will improve performance and stabilize the system. Connect a jumper from terminals "M" to "H" (if serial number is less than 2R 6239, an external capacitor is required -- see Service Letter EG-3 for details). Readjust the gain and stability as mentioned above. Some improvement must be noticed or the cause of instability lies elsewhere.

If the frequency of instability is very fast, such as 8-10 oscillations per second, then the dead time compensation can be reduced. Jumper "M" to "N". Readjust the gain and stability as above. This modifies the dead time filter compensation and is required for KTA 2300 and KT(A) 3067 engines.

If the governor system allows for stable operation but speed overshoot is experienced because the gain control is almost fully CCW, a modification can be made to extend the gain control setting. Apply a 6.8K ohm resistor from terminal "L" to terminal "P". This will center the gain adjustment and improve its stability.

F. Fuel Metering Valve Leaking
If there is leaking at the pin on the valve, there is too great a pressure at the drain port (Max. 5 PSI). Temporarily disconnect the drain line. Plug the line coming from the injectors. Allow the drain fuel to flow externally. If the leakage does not stop, the check valve (VA 678) may be plugged. Remove, clean, and recheck the check valve operation.

Leakage at the upper cap nut is probably due to defective gaskets (GA 678) which should be replaced. Torque to 120 -150 lbs. in.

G. Low Frequency Instability
For four and six cylinder engines which exhibit low frequency surging (about 1 Hz.), replacing the jumper next to the stability control (Figure 1) should eliminate this problem.

NOTE: Fuel system problems that may cause instability.

1. The AFC feature of the fuel pump must be modified by the Cummins Engine Co. for proper operation.
2. If air is suspected in the fuel line, use a sight glass to check for bubbles at the fuel pump inlet.

H. Readjustment of Linkage
If the linkage on the actuator is ever removed or replaced, follow these instructions for resetting. Roll the boot up over the plastic link on the lever. Place the actuator with its label flat down on a table. Rotate the lever on its shaft till all the play is just removed between the fuel valve ball and the plastic link. Tighten the lever holding nut and unroll the boot. No preload or play should exist on the valve stem for proper setting.

I. Reverse Power Condition
Recheck phasing of voltage and current transformer per instructions on Page 14. Also check the voltage regulator operation.

LOAD SHARING LS 671 TROUBLESHOOTING

Inoperative or erratic (measure the following voltages under single unit isochronous operation at load, preferably 100%). *The terminals at which the voltages are to be measured are the 18 terminals on the load sharing unit (shown in Figure 1). Do not attempt to measure at the 30-position terminal block.)

ENGINE GOVERNING SYSTEMS

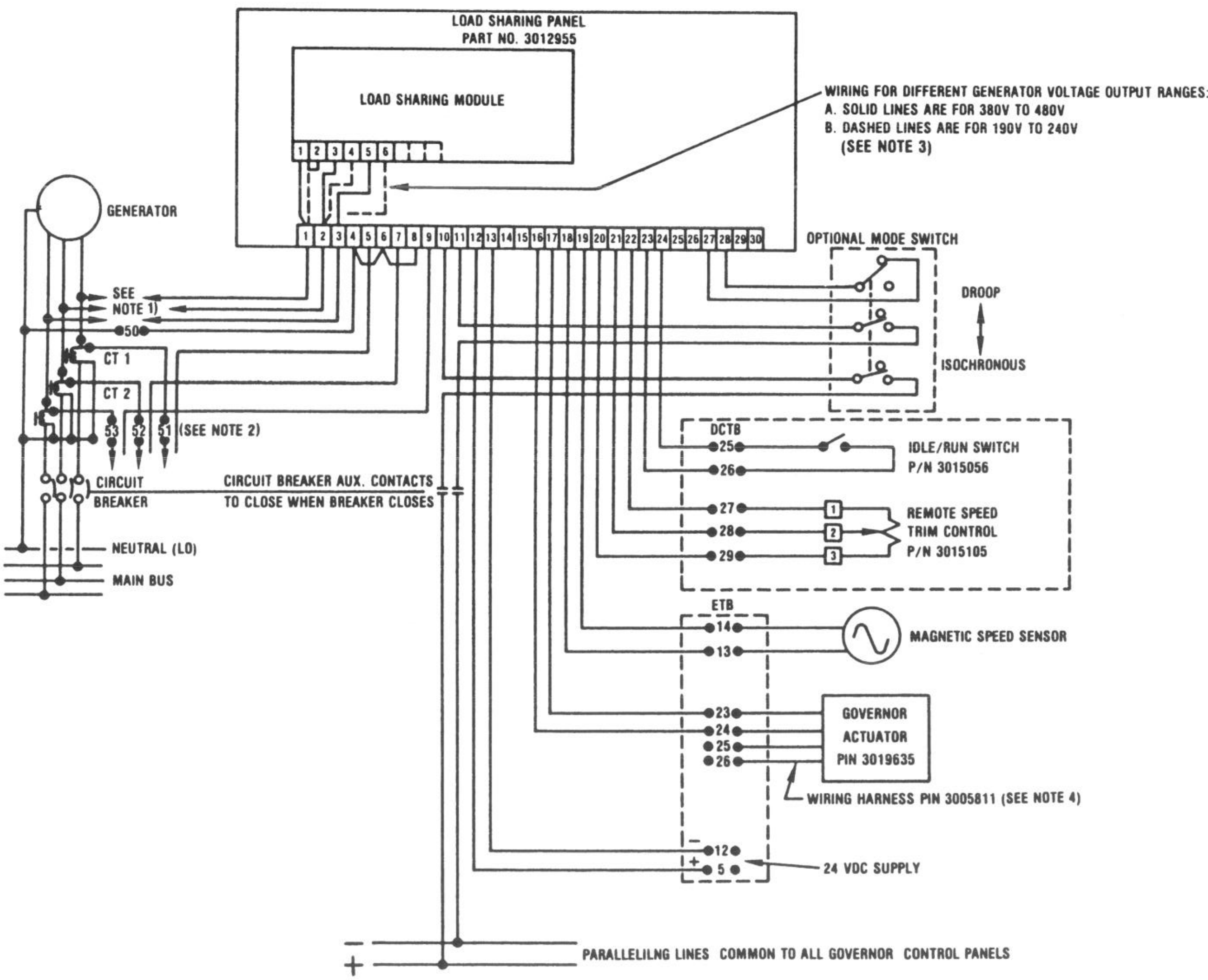
STEP	LOAD SHARING *TERMINALS	NORMAL VALUE	PROBABLE CAUSE OF NON-NORMAL READING
1	1 to 3 3 to 5 5 to 1	340-500 VAC (at 60 Hz.) line voltage CAUTION: HIGH VOLTAGE	1. Improper wiring of terminals 1, 3 or 5 to generator
1a	2 to 4 4 to 6 6 to 2	170-250 VAC (at 60 Hz.) line voltage CAUTION: HIGH VOLTAGE	1. Improper wiring of terminals 2, 4 or 6 to generator
2	7 to 8 9 to 10 11 to 12	Up to 2.5 VAC (Voltage across the burden resistors (0.5 ohm) proportional to line currents	1. Current transformers open circuited, short circuited or miswired to load sharing panel
3	14 to 15	0 to approx. 8 VDC proportional to load, 14 positive, 15 negative	1. Incorrect phasing of current transformers 2. Defective load-sharing unit
3a	14 to 15	Short 7 - 8 will reduce the voltage at 14 - 15 about 30%	1. Defective load-sharing unit
3b	14 to 15	Short 9 - 10 will reduce the voltage at 14 - 15 about 30%	1. Defective load-sharing unit
3c	14 to 15	Short 11 - 12 will reduce the voltage at 14 - 15 about 30%	1. Defective load-sharing unit
4	16 to 17	With no load on engine 5.1 VDC ± 0.2 volt 16 (+), 17 (−)	1. Terminal 26 improperly wired at the 30-position terminal block

IDLE/RUN MODULE (KT 6722) TROUBLESHOOTING

Inoperative. (Measure the following voltages at the 6-terminal strip on the idle/run module).

STEP	IDLE/RUN TERMINALS	NORMAL VALUE	PROBABLE CAUSE OF NON-NORMAL READING
1	K to F (−)	10.2 VDC	1. Improper wiring or problem associated with the control unit. See Troubleshooting of Speed Control Unit
2	J to F (−)	8 VDC at idle speeds	1. Improper wiring of idle/run kit 2. Defective control in idle/run kit
3	J to F (−)	6 VDC at operating speed	1. Improper wiring of idle/run kit 2. Defective control in idle/run kit

ENGINE GOVERNING SYSTEMS



THE OPTIONAL IDLE/RUN SWITCH AND REMOTE SPEED TRIM CONTROL ARE WIRED THROUGH THE DCTB WHEN THE APPROPRIATE GENERATOR MOUNTED CONTROL PANEL OPTION IS SPECIFIED.

NOTES:

1. PHASING OF THE VOLTAGE AND CURRENT SENSING INPUTS TO THE GOVERNOR CONTROL PANEL IS CRITICAL FOR CORRECT OPERATION.
2. CONNECTIONS TO ACTB TERMINALS 50, 51, 52 & 53 ARE APPLICABLE FOR GEN-SETS WITH GENERATOR MOUNTED CONTROL PANEL.
3. CONNECT TERMINALS 1,2,&3 ON THE LOAD SHARING PANEL TO EITHER TERMINALS 1, 3 & 5 OR TERMINALS 2, 4 & 6 ON THE LOAD SENSING MODULE DEPENDING UPON THE GENERATOR OUTPUT VOLTAGE. (SEE TABLE ON PAGE 2)
4. WIRING HARNESS 3005811 INTERNALLY JUMPERS TOGETHER ACTUATOR TERMINALS "B" and "C"

Figure 6. Multi-engine precise load sharing system UTDS No. LSP 672B Cummins No. 212213

ENGINE GOVERNING SYSTEMS

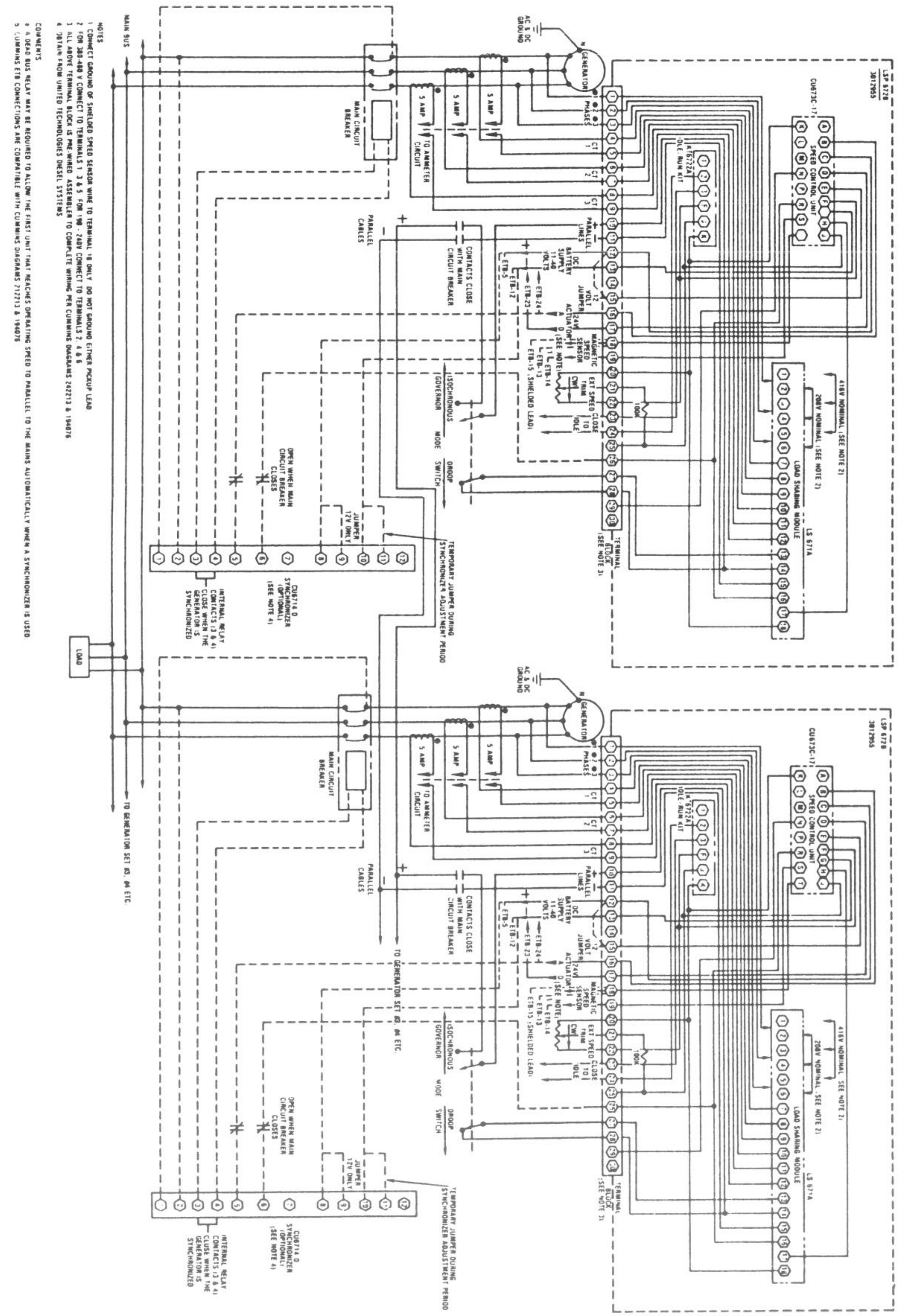
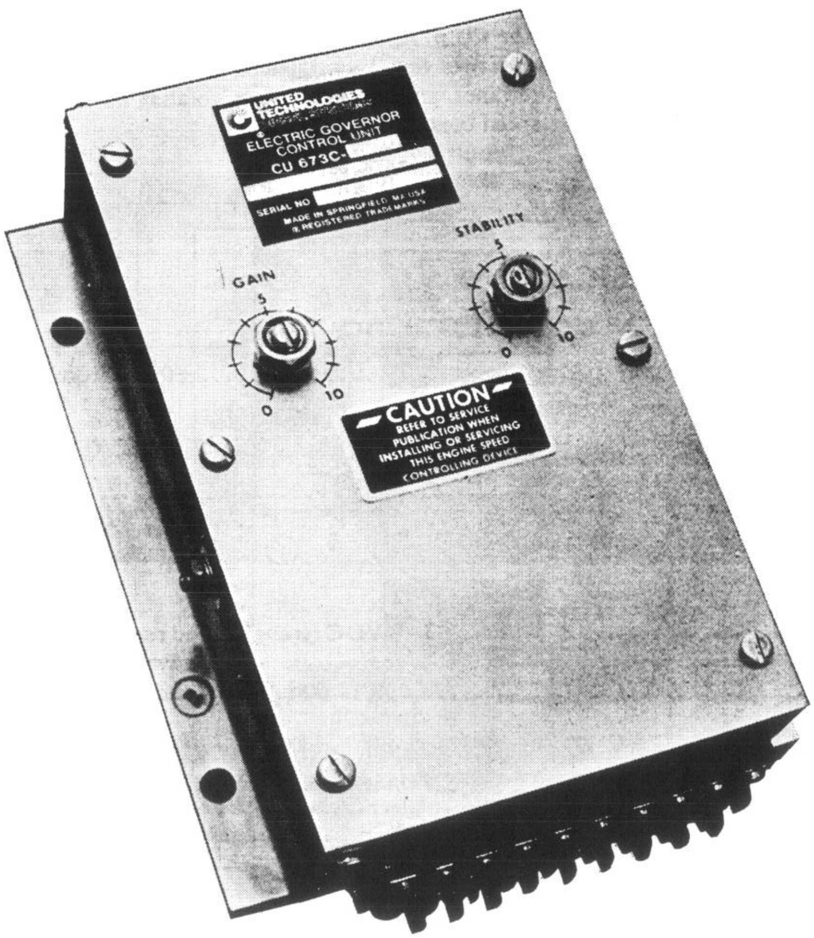


Figure 7. UTDS wiring diagram and Cummins diagram 3012955

SPEED CONTROL UNIT
CU 673C SERIES



ENGINE GOVERNING SYSTEMS

INTRODUCTION

The speed control unit contains all solid state electronic circuits which sense speed from a magnetic speed sensor or other suitable signal source. A controlled output current is provided by the speed control unit to a proportional electric actuator for throttle control. The performance is isochronous.

Three integral adjustments are provided to achieve the desired performance. A "Frequency Adjust" which can adjust the speed control range by 30:1 and "Gain" control to increase or decrease governor response sensitivity and a "Stability" control to match the time constant of the governor to that of the engine. All adjustments are accessible from the top of the speed control unit (see Figure 1).

The CU 673C-speed control unit is adaptable to a wide variety of diesel, carbureted gas and gasoline engines, gas turbines, and practically any rotating device that must be speed controlled.

SPECIFICATIONS

CU 673C SERIES SPEED CONTROL UNIT PERFORMANCE CHARACTERISTICS

- Isochronous .... ±0.25% regulation or better
- Droop .... 0-5% regulation
- Steady-state Stability .... ±0.25% or better
- Frequency Range .... 300-10K Hz continuous
- Speed Drift With Temperature .... ±1% maximum
- Speed Trim Range .... ±200 Hz.

POWER INPUT

- Magnetic Speed Sensor Signal .... 0.25-30 volts rms
- Supply .... 11-40 VDC (transient and reverse voltage protected)
- Polarity .... Negative Ground (Case isolated)
- Power Consumption .... 60mA (continuous) plus actuator current

ENVIRONMENTAL

- Temperature Range .... −55° to +85°C (−65° to +180°F)
- Relative Humidity .... up to 100%
- Case .... Fungus proof and corrosion resistant

PHYSICAL

- Dimensions .... See Figure 1
- Weight .... 1.13 kgs (2.5 lbs)
- Mounting .... Any position (See Installation Page 5)

RELIABILITY

- Tested 100%
- Vibration .... All printed circuit boards are conformally coated on both sides

MATING CONNECTOR

- Use .... CB 6711A

ENGINE GOVERNING SYSTEMS

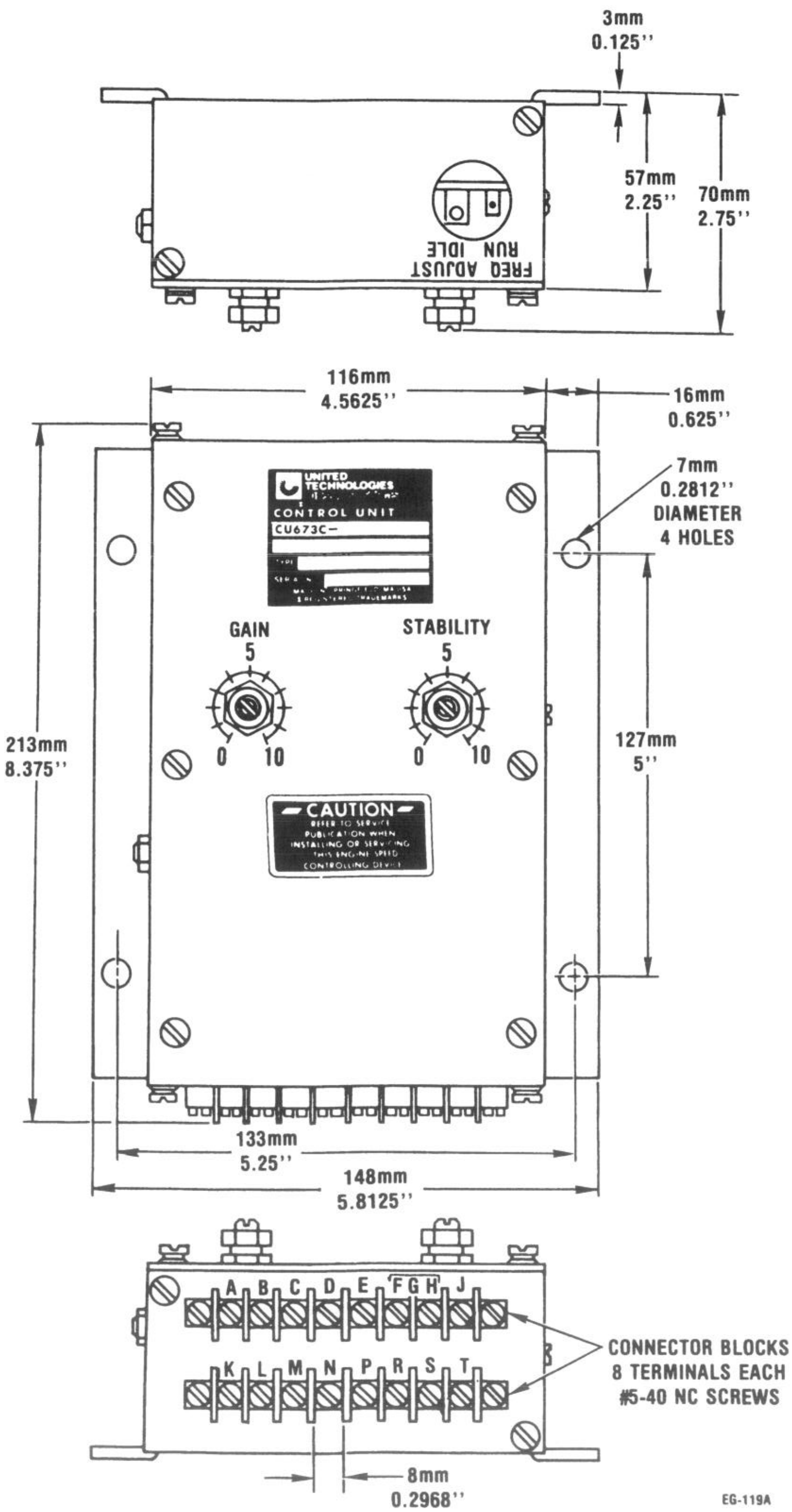


Figure 1. CU 673C speed control unit dimensions

ENGINE GOVERNING SYSTEMS

DESCRIPTION

The speed control unit is designed to operate on 12, 24 or 32 VDC systems. For 12 volt operation, one jumper connection is added externally. For 12 volt operation, the speed control unit will operate from 11 to 18 volts. In the 24 - 32 volt connections, the speed control unit will operate from 13 to 40 volts. The speed control unit has sufficient current capacity to handle the AGB, AGC or the AGD actuators.

The speed control unit is available in several types reflected as dash (–) numbers to suit various engine application needs (see Table A). These variations should be considered when the governor systems are designed.

The speed control unit compares the engine high frequency speed signal with the frequency of the reference speed signal with the frequency of the reference oscillator signal. The speed control unit supplies the proper current to the electric actuator which, in turn, controls the engine power to minimize the difference between the frequency of the two signals. (See Figure 2).

TYPE	VARIATION	APPLICATION
CU 673C-7	• Standard Unit	Diesel, Turbocharged, Carbureted Engines
CU 673C-10	• High Current Output up to 30A	Used with AGC 500 Electric Actuator
CU 673C-15A	• Extended Governor System Control Freq. Range 450 - 15K Hz.	Engines to be operated at high RPM
CU 673C-17	• Provision for Remote Variable Speed Operation	Used with these Accessories: • Multiple Variable Speed Control (CU 6721A) • Idle/Run Kit (KT 6722A) • Ramp Generators (CU 6713A & RGC 671)
CU 673C-23	Idle/Run Feature Built-In	For systems requiring engine warm-up or maintenance at engine idle

Table A
CU 673C Series speed control unit variations

Pickup Signal and Amplifier

The engine speed signal is usually obtained from a magnetic speed sensor mounted in close proximity to the teeth of a ferrous gear that is driven by the engine. The frequency of the speed sensor signal is proportional to engine speed. The flywheel ring gear is normally used because of the ease of speed sensor installation and because of the high frequency speed sensor signal.

Other signals may be used for a speed signal instead of the output of the flywheel. The governor will accept any signal if the frequency is proportional to engine speed, and in the frequency range of the governor (300 to 10K Hertz). The signal strength must also be within the range of the input amplifier (.25 volts rms to 30 volts rms for approximately sinusoidal signals). The input amplifier is very tolerant to signal wave form. It is required only that a non-sinusoidal signal have a minimum of 0.8 volts peak-to-peak and a maximum of 30 volts rms at all engine speeds from cranking to maximum. The speed control unit has an input impedence of 5000 ohms between terminal "S" and terminal "T". Terminal "T" is connected internally to the battery negative.

The input amplifier protects the system if the input signal is not strong enough. In the absence of any signal from the magnetic speed sensor, the speed sensor amplifier goes into a local oscillation of about 12K Hertz. Since this frequency is above the maximum reference frequency, the phase detector considers the engine in "overspeed" and the actuator moves to the fuel shutoff position. This provides inherent fail safe protection against loss of speed sensor signal.

Since there is no speed sensor signal with the engine stopped, the oscillation of the speed sensor signal amplifier keeps the actuator in the fuel shut-off position until the engine is cranked. After a few teeth have passed the magnetic speed sensor, enough signal is provided to block the input amplifier oscillation. At this time, the actuator moves to the full fuel position and remains there during starting and acceleration of the engine.

ENGINE GOVERNING SYSTEMS

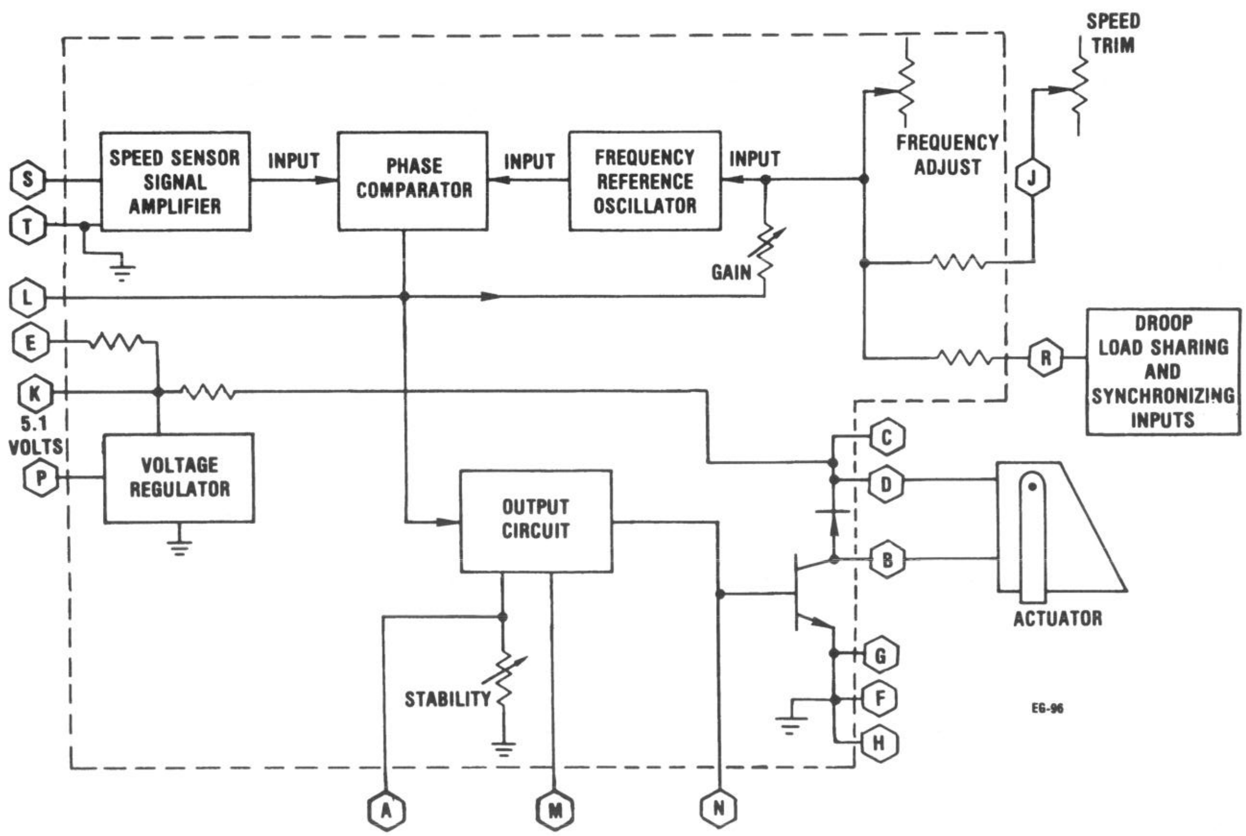


Figure 2. Functional Schematic

Frequency Reference Oscillator

A wide range, temperature compensated, voltage controlled oscillator is used as the speed reference for the speed control system. The frequency setting is adjusted by applying 0 to 10 volts at the frequency reference oscillator input. Zero volts represents a frequency of 10K Hz. while 10 volts represents a frequency of 300 Hz. The internal frequency adjust provides this voltage setting. If an external remote speed control is desired, a reconnection of internal jumpers can be made. (Refer to Section EG 70-7 for detailed instructions.)

Two other external inputs are available to adjust the frequency reference oscillator. Terminal "J" is the input from the speed trim control which provides minor trimming of engine speed. Terminal "R" is the input from accessories such as load sharing, droop, or automatic synchronizing. When the speed control unit is controlling an engine, the reference oscillator does not maintain a constant frequency but deviates from its nominal RPM which occurs during load changes. The reference oscillator is forced by the phase comparator to track the engine speed sensor input, described below. Thus, the voltage representing speed error is the amount of voltage required to drive the reference oscillator off frequency as far as the engine is off speed at that moment.

Phase Comparator Circuit

This circuit is used to force the reference oscillator to track the engine speed sensor signal. The phase comparator circuit detects the phase difference between the input signal through the input amplifier and the signal from the reference oscillator. When the engine changes speed, the signal from the input amplifier changes frequency. The phase comparator circuit measures the amount the engine signal is ahead or behind the reference oscillator signal. Its voltage output is used to force the reference oscillator to the the same frequency as the signal from the engine. In this way, the phase comparator output is proportional to the speed error. (When used in this way, the phase comparator and the reference oscillator make up a "Phase Lock Loop"). The gain control is used to couple the phase comparator output to the reference oscillator. By increasing the coupling, for example, a small voltage deviation from the phase comparator corresponds to a large frequency deviation, and vice versa. (See Figure 3.)

ENGINE GOVERNING SYSTEMS

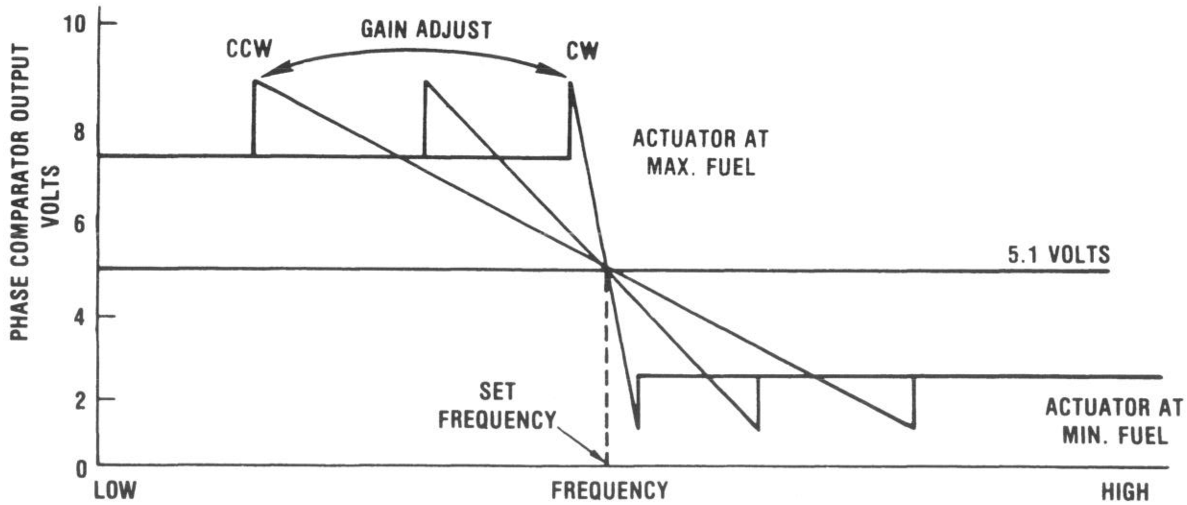


Figure 3. Phase comparator output versus frequency

The phase comparator output is measured at terminal "L". This is an important terminal, it is used to monitor governor performance and function. The voltage on terminal "L" can be measured with a voltmeter. A reading of 5.1 VDC indicates the engine is on governed speed. A reading in excess of 5.1 VDC indicates an under-speed condition while readings of less than 5.1 VDC indicate overspeed conditions.

Figure 3 indicates voltage at terminal "L" with different gain settings. As indicated by the curve, the gain should be turned CW as far as possible without causing instability.

Dynamic Control and Output Circuit

This circuit allows isochronous governing by introducing temporary droop during a load change for stability purposes. It provides an adjustable means to control the magnitude and time constant of the temporary droop to match the dynamic characteristics of the engine.

The output current switching portion of the circuit provides current to drive the actuator. The output transistor is alternately switched off and on at a frequency of 200 Hz which is well beyond the natural frequency of the actuator. The actuator responds to the average current from the transistor and moves in proportion to this average current to position the engine throttle. The output transistor is switched to reduce power dissipation. The output of the circuit provides up to 15 amps at voltages up to 40 VDC, except for the "C" series (– 10) which can provide up to 30 amps at voltages up to 40 VDC.

CAUTION:
ON "C" SERIES (– 10) UNITS
DO NOT
SHORT THE INSULATED NUT TO GROUND

A large insulated nut, holding an internal diode, is located at the side of the speed control unit housing. From the nut to ground is the voltage across the output transistor. Shorting this nut to ground **momentarily** will apply full voltage across the actuator and will force the actuator to the full fuel position, except for the "C" series (– 10) which can accept a momentary short from the speed control unit terminals "B" to "F" to force the actuator to the full fuel position. Measuring the voltage from terminals "B" to "D" indicates the voltage across the actuator.

INSTALLATION

The speed control unit is rugged enough for mounting in the control cabinet or engine mounted enclosure. Care should be taken to insure that the speed control unit is not subjected to extreme heat, as the life of electronic devices is always related to heat. If it is expected that water or mist will come in contact with the speed control unit, mount it vertically so the condensation will not accumulate in the speed control unit.

Wiring to the speed control unit should as shown in Figure 4.

ENGINE GOVERNING SYSTEMS

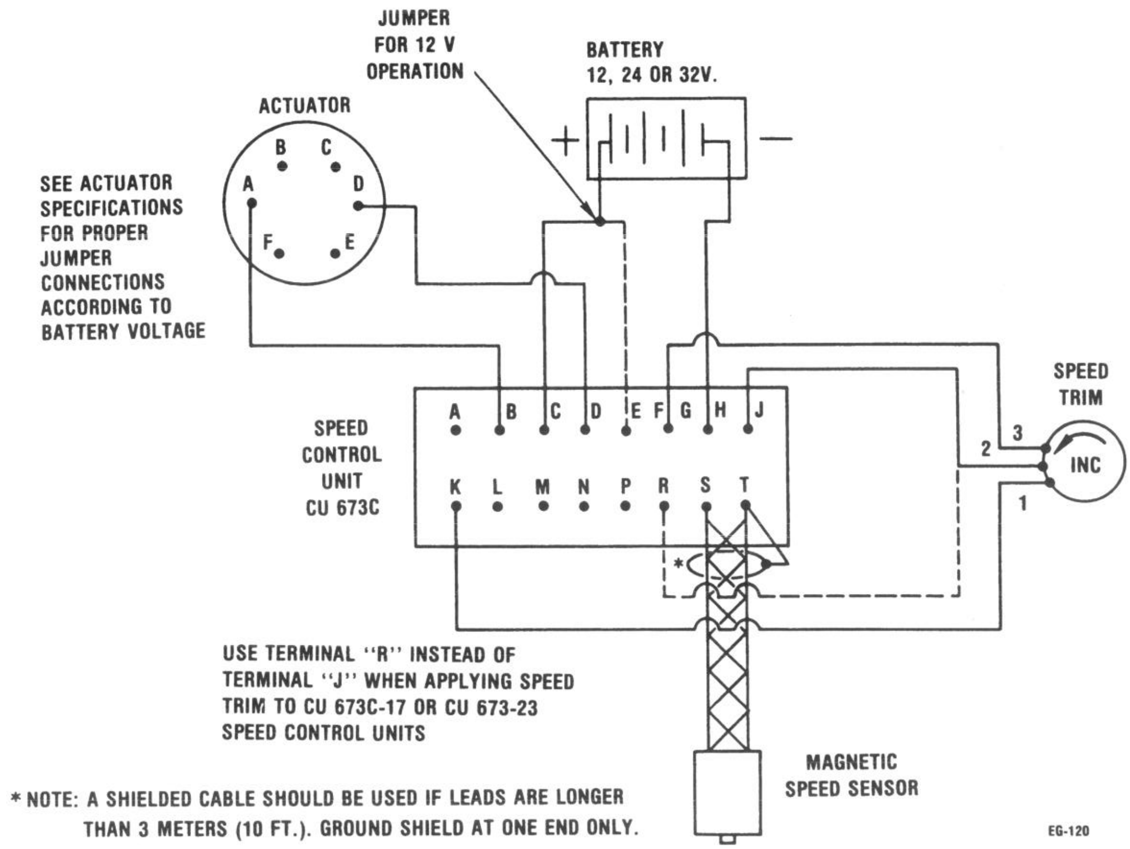


Figure 4. Wiring to CU 673C series speed control unit

The leads from the battery to the speed control unit and from the speed control unit to the actuator should be #16 or larger. These are the leads that are connected to terminals B, C, D, E and G of the speed control unit. In 5-lb. ft. systems, the leads from the battery to the speed control unit and from the speed control unit to the actuator should be at least #14 if they are over 3 meters (10 ft.). If these leads are over 9 meters (30 ft.) long, they should be at least #12 wire. All other leads may be any convenient size consistent with the mechanical integrity of the cable. Even though the maximum actuator currents exist for only short intervals, the wiring must be capable of handling this current or the transient performance of the governor will suffer.

Twist the leads from the magnetic speed sensor for their entire length. The speed sensor leads may need to be shielded if they are longer then 3 meters (10 ft.) or if external interference becomes a problem in governing. The shield is to be grounded **only** to terminal "T" of the speed control unit. Do not ground either of the speed sensor leads.

ADJUSTMENTS

CAUTION DO NOT CONNECT THE SPEED CONTROL UNIT TO A BATTERY CHARGER

BENCH ADJUSTMENTS-REQUIRES TEST SET TSE 671C

All speed control units are factory set at approximately 1000 Hz. (usually 450-500 engine RPM's). If it is desired to reset the frequency of the speed control unit before it is installed on the engine, it can be done as follows:

1. Count the number of teeth on the gear to be used for the frequency signal. If the number of teeth cannot be easily ascertained, assume a number less than the probable actual number. This can be corrected when the engine is running.

ENGINE GOVERNING SYSTEMS

2. Determine the required operating frequency from the formula:

$$\text{Frequency (hz)} = \frac{\text{Gear RPM x number of teeth}}{60}$$

3. Use United Technologies Test Set TSE 671C.
   a) Set the test stand control switches as per instructions in Section EG 100-1.
   b) Turn the selector switch on the test stand (position 11) to "frequency". The frequency setting will be indicated on the meter. If the frequency is other than as calculated per paragraph 2 above, insert a small screwdriver through the opening in the speed control unit rear cover marked "FREQ. ADJUST". Turn the control CW to increase frequency and CCW to reduce the frequency set point.
   c) Set the gain control at mid-range position and stability control at full CCW position.
   d) The speed control unit is now ready for installation on the engine. If the bench adjustment has been properly performed, governed engine speed will be close to the desired value. Final stability and gain adjustments must be made with the engine running because they involve the response characteristics on the individual engine. (See next section "On Engine Adjustments".)
4. If the United Technologies Test Set is not available, adjust the frequency as per instructions below.

ON ENGINE ADJUSTMENTS

CAUTION: THE ENGINE SHOULD BE EQUIPPED WITH AN INDEPENDENT OVERSPEED SHUTDOWN MECHANISM TO PREVENT RUNAWAY WHICH CAN CAUSE EQUIPMENT DAMAGE OR PERSONNEL INJURY.

1. **Speed Control Unit Frequency Adjustment**

   If the speed control unit fequency has been preset as in Bench Adjustment above, move on to Section 2. If bench type test equipment was not available, proceed as follows to adjust the speed control unit frequency on the engine.

   a) Plan to overcome the actuator manually until adjustment is completed and the speed control unit is in control. Two people are usually required for this method.
   b) Adjust the gain control to its approximate midrange position. The stability control should be adjusted to its extreme CCW position.
   c) If the speed setting is unknown, turn the 22 turn frequency adjust control on the speed control unit CCW to obtain the lowest possible reference oscillator frequency. This will give the lowest possible engine governed speed. Start the engine, operating the throttle manually. Turn the frequency adjust control CW until the desired governed speed is obtained. If the engine is very unstable, it may be necessary to decrease the gain control (CCW) before the frequency adjustment can be completed.

2. **Performance Adjustments**

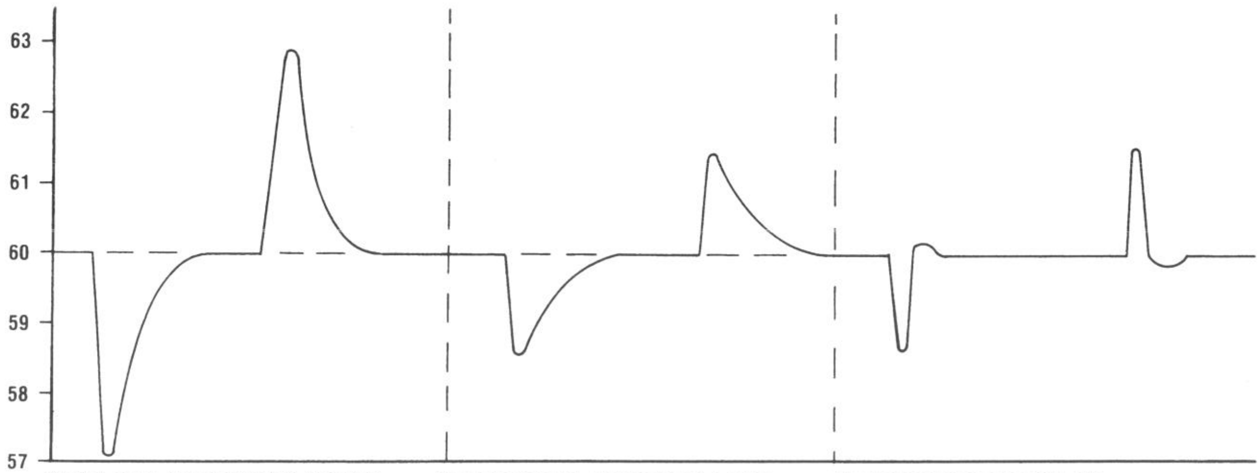
   This speed control unit has the desirable characteristics of being quickly and easily adjusted to a good initial operating point as follows:

   a) Check that the stability control is in its extreme CCW position.
   b) Start engine. While observing normal precautions, allow the governor to control the engine. If the engine is unstable, turn the gain control CCW until stability is obtained. Adjust governor frequency control to the proper engine speed.
   c) Turn the gain control CW until instability results. Then back-off slightly CCW (one major division) beyond the point where stability returns.
   d) Turn the stability control CW until instability results. Then back-off slightly CCW (one major division) beyond the point where stability returns.
   e) Excellent performance should result from these adjustments. Trimming of all adjustments, i.e. gain stability and frequency, can be made under various load conditions and load changes to get exactly the desired governing characteristics.

3. **Final Trimming of the Governor**

   If a load bank and a recorder are available, use them to make traces per Figure 5.

ENGINE GOVERNING SYSTEMS



INITIAL GAIN AND STABILITY CONTROL ADJUSTMENTS GIVE A TRACE INDICATING, FROM THE EXCURSION OF THE TRANSIENT, THE GAIN SHOULD BE INCREASED BY TURNING THE GAIN CONTROL CW. NOTE: TIME IS CONSTANT FOR ALL CONDITIONS.

INCREASED GAIN RESULTED IN A NEW TRANSIENT WITH REDUCED EXCURSION. IT IS APPARENT FROM THE LONG TAIL ON THE TRANSIENT THAT THE STABILITY CONTROL MUST BE TURNED CW.

READJUSTING BOTH GAIN AND STABILITY CONTROLS GIVES A TRACE, INDICATING GOOD TRANSIENT AT FULL LOAD AND GOOD STABILITY. THE SPEED CONTROL UNIT IS NOW PROPERLY ADJUSTED AND THE LOCKNUTS CAN BE TIGHTENED.

Figure 5. Typical performance chart

TROUBLESHOOTING

LOW SPEED SURGING

When low frequency instability or surge (0.5 to 3 Hz.) is experienced, a simple jumper wire connection can be installed between terminal 'H'' and terminal ''M''. Older speed control units with serial numbers below 2R 6240 require a polarized, 10 mfd., 10 VDC capacitor to be installed between terminal ''M'' (+) and terminal ''H'' (−). This will increase the engine dead time filter compensation and tend to eliminate low frequency instability or surge.

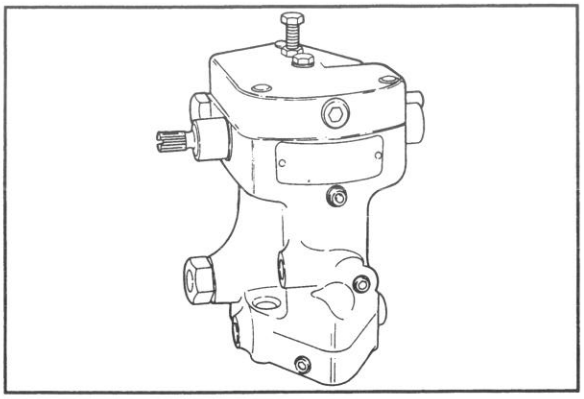
RAPID SPEED SURGING

When rapid instability or surge (about 8 Hz.) occurs, a jumper connection can be made between terminal ''M'' and ''N''. This will decrease delay compensation and tend to eliminate the instability. For slight instability problems place a 5.1K resistor from terminals M to N.

UNSATISFACTORY ENGINE PERFORMANCE

When poor transient performance caused by the speed control unit gain adjustment being at or near its lowest point, a 6.2 K ohm resistor can be applied between terminals L and P. This will expand the range of the gain control.

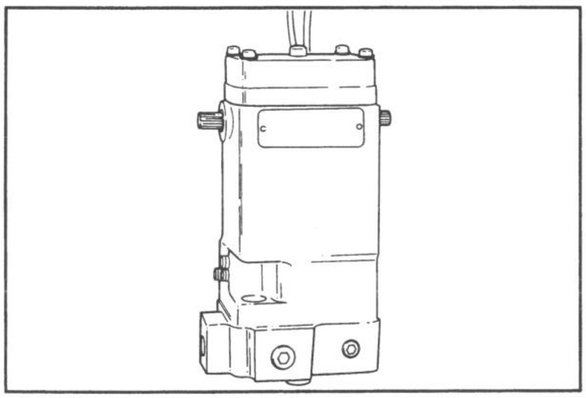
NOTE: Do not install both M to H and M to N jumper connection - no improvement in performance will result.



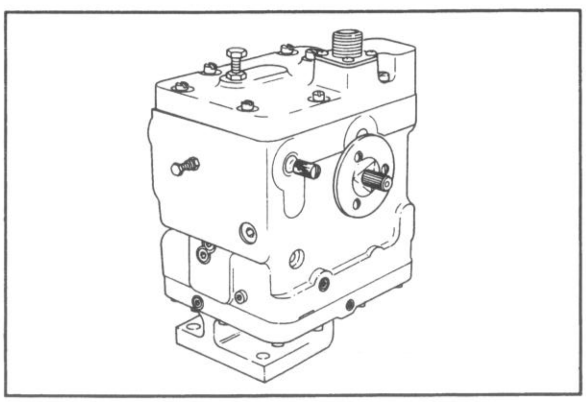
Woodward Governor Linkage - Check (4-20)

This section covers the linkage adjustment for the following products manufactured by the Woodward Governor Co.

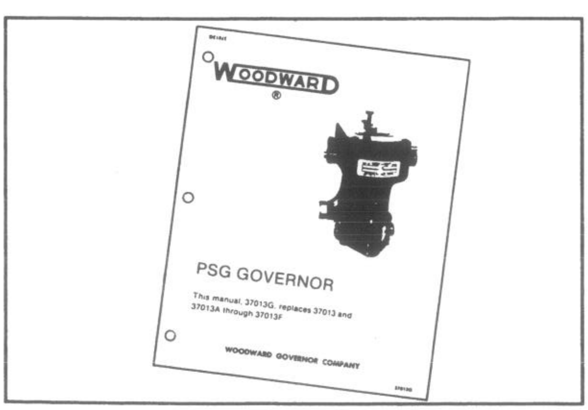
PSG governor - This is a Pressure compensated Speed Governor (PSG), hydraulically actuated, which uses flyweights to sense speed. The present PSG governors have an internal spring which forces the governor output shaft to the minimum fuel position.



EG-1PC actuator - This is an Electric Governor actuator which has a work output of one (1) ft. lb. The output shaft position is Proportional to the actuator input voltage and the actuator has been Compensated to operate on multi-viscosity oils. (EG-1PC). This actuator shaft is moved hydraulically to increase or decrease fuel. There is no force on the actuator output shaft in either direction when the actuator is at rest. This actuator has no speed sensing flyweights.



EGB-2P actuator - This is an Electric Governor actuator which also contains flyweights for hydraulic Backup operation. This actuator has a work output of two (2) ft. lb. The output shaft position is inversely Proportional (reverse acting) to the actuator input voltage. This actuator is also usable on multi-viscosity oils. This actuator shaft is moved hydraulically to increase or decrease fuel. There is no force on the actuator output shaft in either direction when the actuator is at rest. When the electric signal to this actuator is interrupted, the electrical portion of the actuator attempts to go to maximum fuel. The flyweight portion of the actuator then takes control and governs the engine at a speed 50 to 100 RPM above the isochronous speed.

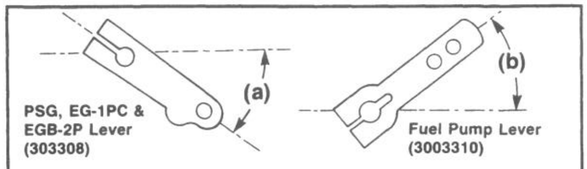


Note: All Woodward Governors are not covered in this manual. For the SG, 2301 Load Sharing & Speed Control, EG-3P Actuator, PSG Governor and the EG-B2P Governor/Actuator, see Bulletin No. 3379179.

Stop the engine. To check the EG-1PC or EGB-2P actuators, move the linkage to the minimum fuel position.

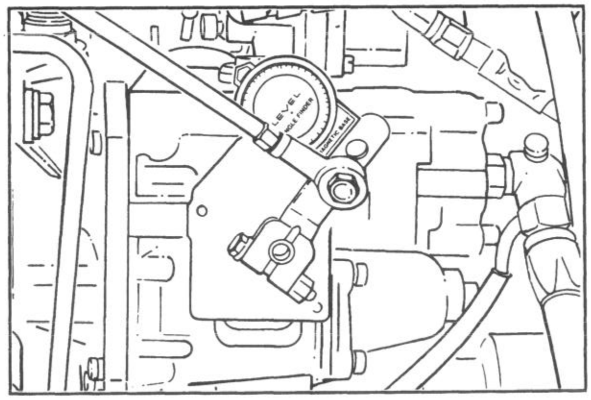
Note: The PSG governor has an internal return spring which forces the linkage to the minimum fuel position when the engine is stopped.

Use a Service Tool Part No. 3375855 Indicator, Level and Angle, to check the PSG governor or EG-1PC/EGB-2P actuator lever angles as shown in the lever adjustment chart.



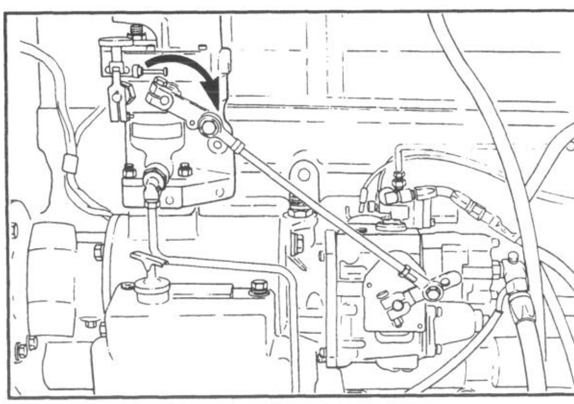
	PSG	EG-1PC	EGB-2P
Governor Lever Angle, Min. Fuel Position (a)	25	60	60
Fuel Pump Lever Angle, Min. Fuel Position (b)	25	45	55
Distance Between Uniball Centers - mm (Inch)	286 (10 1/4)	294 (11 9/16)	254 (10)

If the fuel pump has been rebuilt, install the fuel pump automotive throttle lever and check the angular travel of the fuel pump automotive throttle. This travel **must** be 27 to 29 degrees. Have the fuel pump recalibrated if the automotive throttle travel is not within 27 to 29 degrees. Do **not** adjust the automotive throttle stops. Adjusting the automotive throttle stops changes the fuel pump calibration.

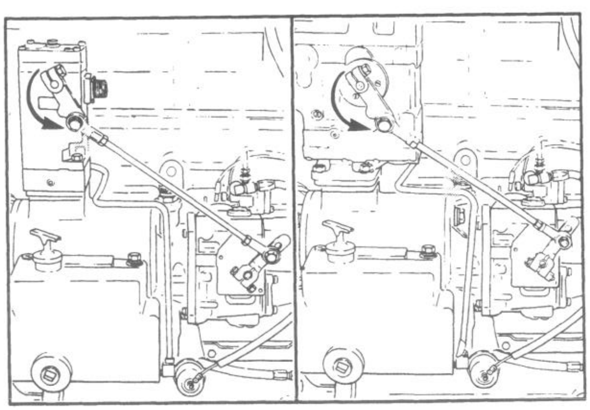


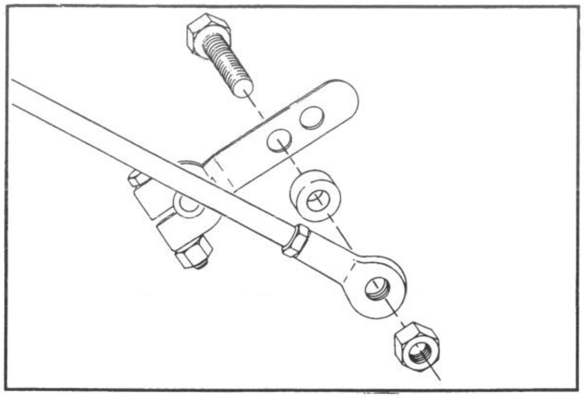
Move the fuel pump automotive throttle shaft and the governor or actuator output shaft to the minimum fuel position. Position the automotive throttle shaft lever and the governor/actuator lever as shown in the Lever Adjustment Chart. Tighten the lever locking bolts to 7 N•m (5 ft.lb.)

Note: The minimum fuel position of the PSG governor output shaft is full clockwise. The PSG governors now supplied by Cummins have an internal return spring which holds the PSG output shaft in the minimum fuel position. Earlier PSG and SG governors required an external return spring which was locked in the governor lever.

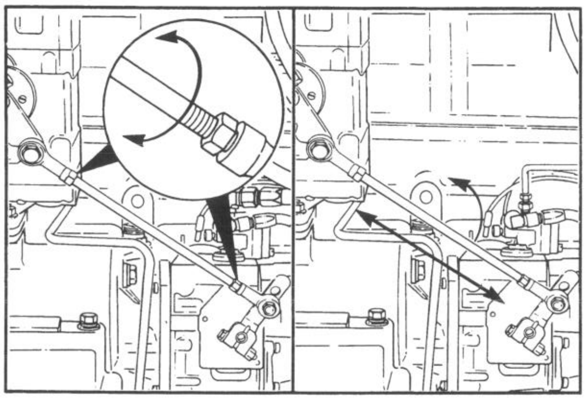


The minimum fuel position of the EG-1PC and EGB-2P actuators is full **Counterclockwise**. When the actuators are correctly mounted and viewed from the fuel pump side of the engine. In operation, the actuator output shafts are hydraulically moved in both directions. At rest, there is no restoring force in either direction.





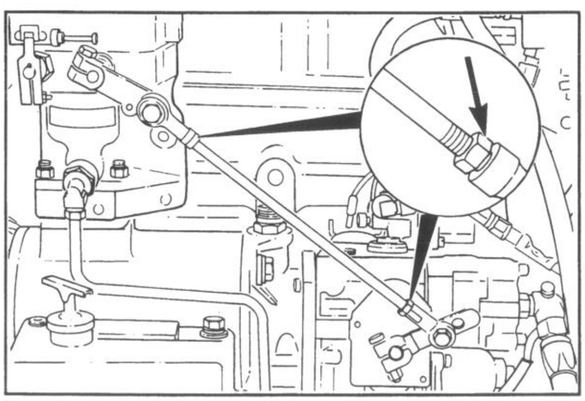
Install the uniball to the innermost hole of the automotive throttle shaft lever. Use a 6 mm (1/4 in.) spacer Part No. 114850 or flat washers between the throttle lever and the uniball when installing a PSG governor.



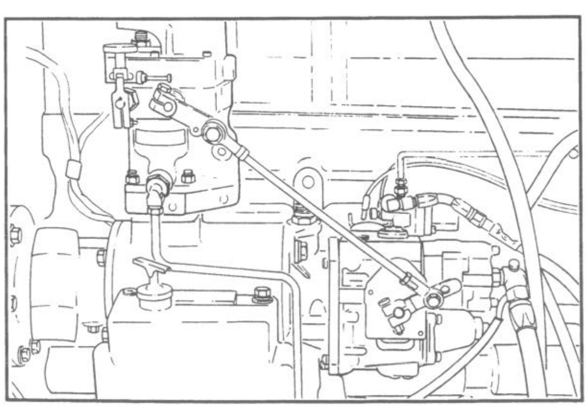
Tighten the uniball bolts in both levers to 7 N•m (5 ft.lb.).

Loosen both uniball locknuts on the control rod.

Rotate the control rod just enough to move the governor lever from its minimum fuel stop.

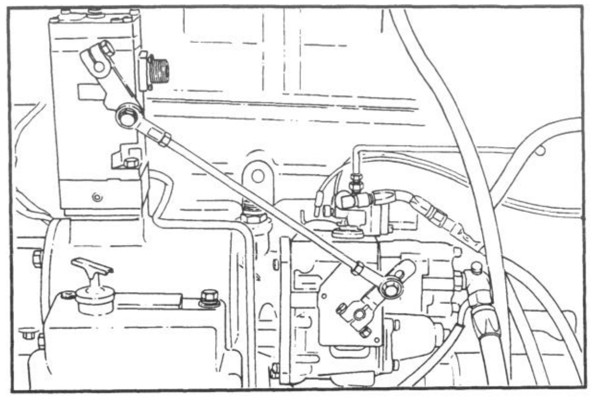


Tighten the uniball locknuts. Make sure the control rod does not rotate when the locknuts are tightened. Check the linkage for full free travel. Check for binding between the levers and the uniballs. Check for binding at the minimum and maximum fuel positions.

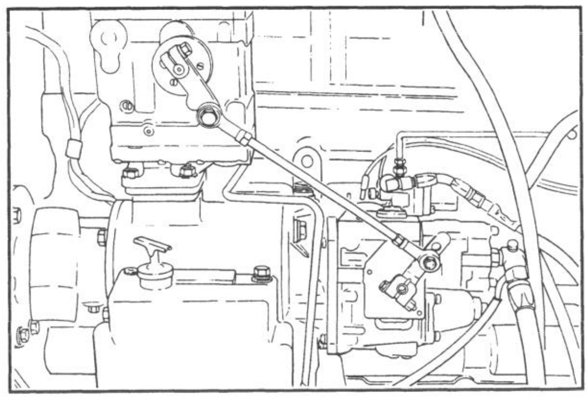


PSG Governor and fuel pump.

EG-1PC Actuator and fuel pump.

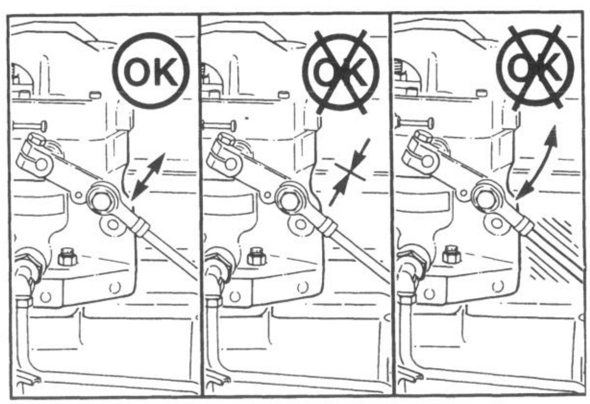


EGB-2P Actuator and Fuel Pump.



Woodward Governor Drive Backlash - Check and Adjust (4-21)

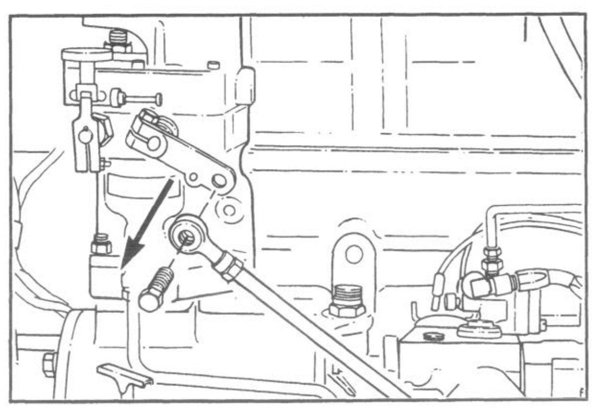
There must be some backlash in the Woodward governor drive. No backlash is worse than too much. No backlash can cause excessive wear of the gears in the governor drive. Excessive backlash can cause excessive action (which appears as a vibration) of the governor linkage. This action can cause rapid wear of the linkage uniballs as well as the automotive throttle shaft.

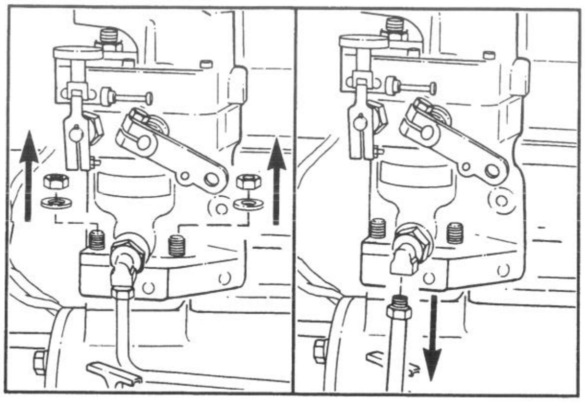


The Woodward Governor or Actuator must be removed to check or adjust the governor drive backlash.

Disconnect the linkage. Remove the capscrew that holds the top uniball to the governor terminal lever.

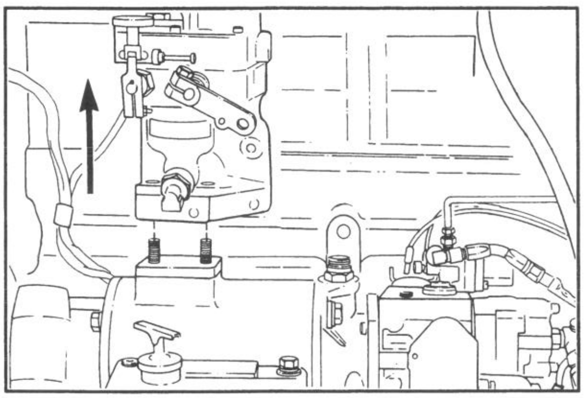
Disconnect any electrical connections to the governor or actuator.



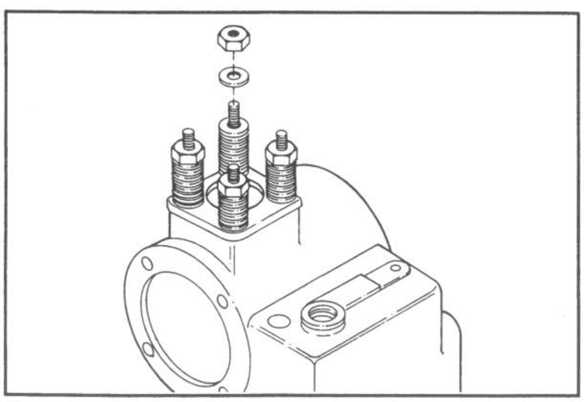


Remove the nuts and lockwashers that hold the governor or actuator to the governor drive housing.

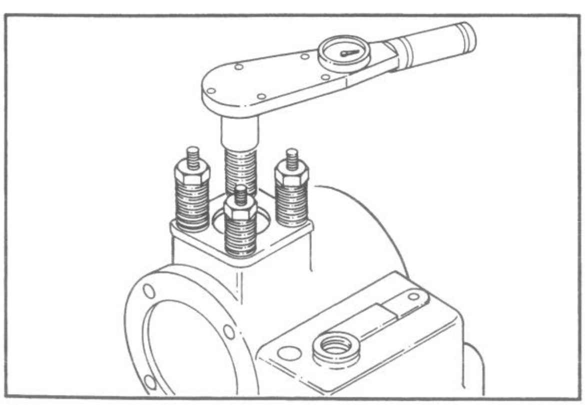
Remove the oil supply line from the governor or actuator.



Lift the governor or actuator from the governor drive housing.

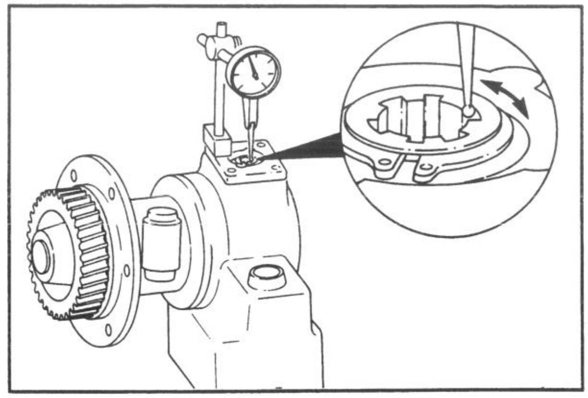


The thickness of the gasket(s) between the governor drive assembly and the governor drive housing determine the backlash in the governor drive. The gaskets are compressible. To compress the gasket(s) the proper amount, install enough flat steel washers on each stud so that the nut will not bottom on the stud shoulder when it is tightened.



Tighten the nuts to 13.6--20.4 N•m [10--15 ft.-lbs.].

Install a dial indicator, Service Tool Part No. ST-1325 and 3376050, to check the backlash of the internally splined shaft. The backlash must be 0.10 to 0.36 mm (0.004 to 0.014 in.). Gaskets can be added to increase the backlash or removed to reduce the backlash. A minimum of one 102992 gasket, nominally 0.18 mm [0.007 in.] must be used to prevent oil leaks.



Section (4-22)

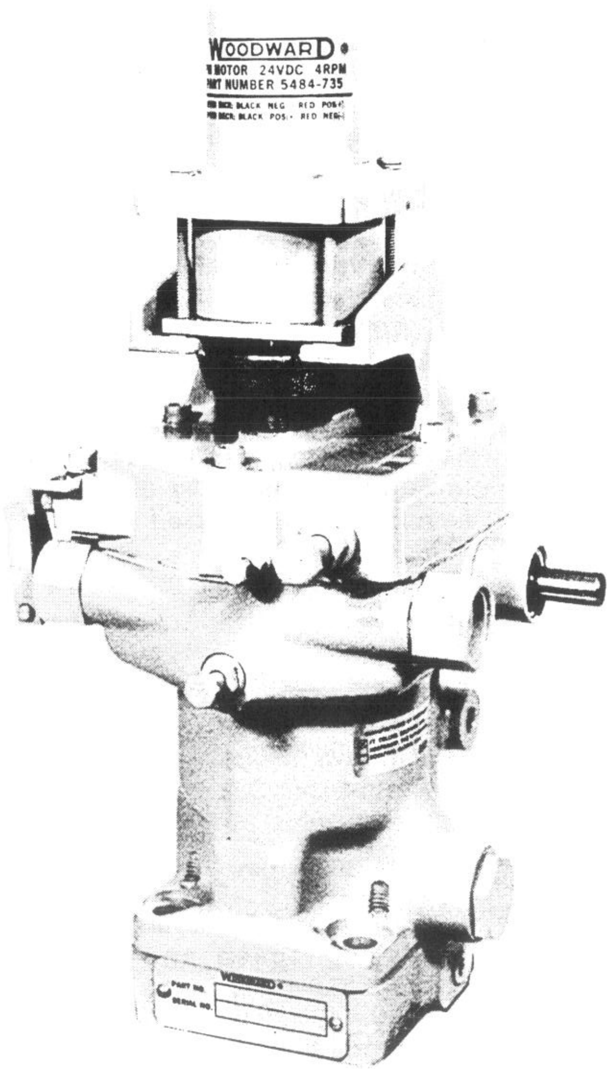
Woodward
PSG
Governor

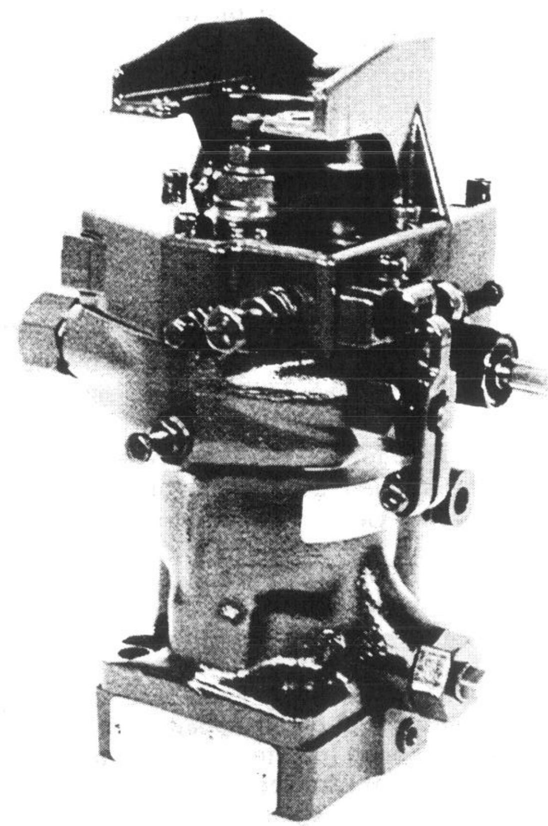
The following section (4-22) is a reprint of the Woodward PSG Governor Manual with the permission of Woodward Governor Company. Therefore Cummins Engine Company assumes no responsibility of its contents or accuracy therein.

WOODWARD ®

PSG GOVERNOR

- **Isochronous or Droop Control**
- **Pressure Compensated**
- **Lever, Motor, or Pneumatic Speed Setting**
- **Temperature Compensated**
- **Torsional Vibration Filter**
- **Rotary Output**





APPLICATION

The PSG Governor is a speed droop governor for controlling speed of small diesel, gas, and gasoline engines or small steam and industrial gas turbines isochronously or with droop.

WOODWARD GOVERNOR COMPANY

PRINCIPAL APPLICATIONS

The PSG Governor is used for controlling the speed of small diesel, gas, and gasoline engines or small steam and industrial gas turbines driving alternators, dc generators, pumps or compressors. It controls either isochronously or with speed droop.

STANDARD FEATURES

The key feature of the PSG Governor is pressure compensation. It provides the governor the necessary stability to control isochronously. Optimum adjustment is attained by the proper opening of the needle valve. The temperature compensated speeder spring minimizes speed drift caused by temperature change.

The governor has its own oil pump powered by the drive shaft, and requires oil from an external source. The relief valve regulates the oil at the correct operating pressure. Rotation of the drive shaft can be in either direction. The manual speed setting shaft can be on either side of the case. The low speed stop screw is in the cover and the high speed stop screw is in the back of the case. An internal speed droop adjustment is just beneath the cover. The terminal shaft can be from either or both sides of the case.

Engine lubricating oil or an oil supply from a separate sump is required to be furnished by the engine manufacturer. Because the power servo is single acting, a return spring exerting a torque in the minimum fuel direction is required. The return spring can be supplied by the customer or by Woodward Governor Company.

WARNING

The engine, turbine, or other type of prime mover should be equipped with a separate overspeed (overtemperature, or overpressure, where applicable) shutdown device(s), to protect against runaway or damage to the engine, turbine, or other type of prime mover with possible personal injury or loss of life should the mechanical-hydraulic governor(s) or electric control(s), the actuator(s), fuel control(s), the driving mechanism(s), the linkage(s), or the controlled device(s) fail.

SPECIAL FEATURES

Remote control of the governor can be attained by using either a speed adjusting motor or a pneumatic speed setting cover assembly. The pneumatic speed setting can be direct (speed setting increase with pressure signal increase) or reverse (speed setting decrease with pressure signal increase). External speed droop adjustment on either side of the case is available. A subcap can be supplied with an internal return spring. Spring and oil damped ballheads are available to filter out torsional vibrations. A special temperature compensated needle valve can be supplied to compensate for temperature effect on stability.

SPEED SETTING

Manual: Either side of case; plain or serrated shaft; less than 45 degrees shaft rotation for full speed range.

Motor: 12 or 24 Vdc Pittman Motor. The following converter boxes are available:

24 Vdc	P/N 8272-515
110 Vdc	P/N 8272-518
110 Vac	P/N 8272-516
220 Vac	P/N 8272-517

Pneumatic: Direct or reverse; 3 to 15 psi most common signal; other signal ranges 6 to 30 psi, 9 to 15 psi, 3 to 20 psi, 5 to 60 psi; hydraulically damped against hunting caused by air compressibility.

GOVERNOR DRIVE

Shaft:	Splined.
Speed Range:	1200 to 4000 rpm.
Recommended Constant Speed Operation:	2400 to 3600 rpm.
Minimum Power:	1/3 hp to turn drive shaft at normal operating speed and temperature.
Rotation:	CW or CCW.

OUTPUT

Terminal Shaft:	Plain or serrated.
Angular Travel:	36 degrees total available.
Stalled Torque:	25 or 50 lb-in at operating pressure of 100 or 200 psi, respectively.
Rated Work Capacity:	8 or 15.5 in-lb at operating pressure of 100 or 200 psi, respectively.
Max Work Capacity:	15.5 or 31 in-lb at operating pressure of 100 or 200 psi, respectively.

NOTE

The torque, work capacity, and maximum work values quoted are based on 25 psi supply pressure to the governor. These values will vary, depending on the oil supply pressure.

Linkage:	Use approximately 2/3 output shaft travel from no load to full load. Relation between engine torque output and terminal shaft travel should be approximately linear.
Return Spring:	25 or 50 lb-in. torque at operating pressure of 100 or 200 psi, respectively.

PILOT VALVE

Plunger Movement:	Balanced between ballhead centrifugal force and speeder spring force.
Bushing:	Rotated as integral part of governor drive shaft.
Porting:	Gain selection of 1, 2 or 4 round or 3 slotted.

CONTROL QUALITIES

Steady State Speed Band:	± 1/4 of 1% rated speed.
Typical Optimum Response:	6.5% off speed with 0.8 sec. recovery time with full load change on a 50% per second accelerated engine.
Recommended Variable Speed Control Range:	1200 to 4000 rpm.
Pressure Compensation:	Buffer spring 4.5 to 16 lb-in with 9.6 lb-in standard. Effective needle valve opening up to 3 turns from closed.
Droop:	From zero to 7% over full output travel; internal and external adjustments about 1/2 inch slider movement away from terminal shaft centerline to increase; external adjustment includes knurled lock knob and max and min stop screws.
Spring and Oil Damped Ballheads:	Undamped natural frequency selections of 100, 180, 200, 290, 400 and 550 cpm.
Operating Temperature:	Oil viscosity at operating temperature must stay within the 50 to 3000 SUS (Saybolt Universal Seconds) range. Ideal oil viscosity at operating temperature is between 100 to 300 SUS. Measure the temperature of the governor on the outside lower part of the case. The actual oil temperature will be slightly warmer, approximately 10 degrees F (6 degrees C). The ambient temperature range is -20 degrees F (-29 degrees C) to 200 degrees F (93 degrees C). Consult Woodward Governor Company if operating beyond these limits. Hydraulic fluid pour point must be below lowest expected starting temperature.

HYDRAULIC SYSTEM

Oil:	From engine lubricating system or separate sump with foot valve.
Supply Pressure:	Min of 25 psi with max of 75 psi from engine lubricating system, and max of 12 inches of suction lift from separate sump, with torque and work capacity values varying accordingly.

NOTE

Consult Woodward Governor Company when supply pressures must exceed 75 psi.

Relief Valves:	175 or 275 psi.
Operating Pressures:	Relief valve pressures plus supply pressure.
Flow at Normal Viscosity:	Peak demand of 2 gpm during transients: 0.35 gpm during steady state.
Filter:	40 micron (nominal) for 2 gpm.
Viscosity:	Must be between 50 to 3,000 SUS, but normal performance is based on 100 to 300 SUS.
Oil Inlet:	0.125-27 NPTF (2); optional 1/4 diameter hole in base.
Drain:	0.303 and 3/8 inch diameter holes in base; hole under pilot valve; 1/4 NPT in cover for horizontal mounting of governor.

WEIGHT

Basic Manual Speed Setting Type:	9 1/2 lbs approximately.
With Speed Setting Motor Cover:	Add 1 1/2 lbs approximately.
With Pneumatic Speed Setting Cover:	Add 1 1/2 lbs approximately..

CONSTRUCTION

Case:	Aluminum.
Base:	Cast Iron.
Cover:	Cast aluminum or cást iron.

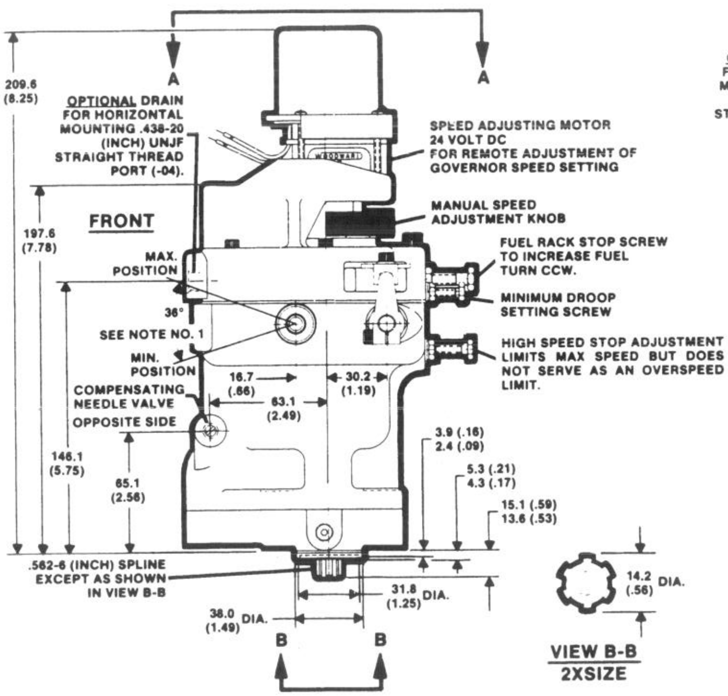
MOUNTING

Attitude:	Vertical; or horizontal with power servo down
Studs:	5/16 inch diameter (4).

REFERENCES

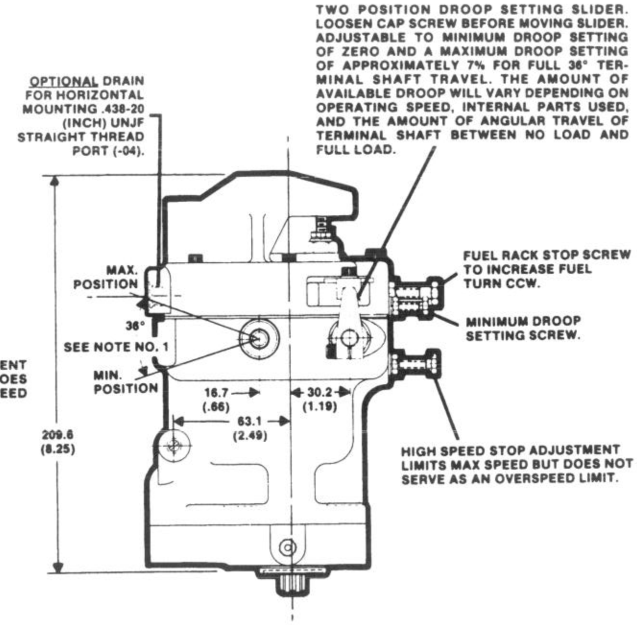
Manual 37013	PSG Governor
Manual 04018	Speed Adjusting Motor Cover Assembly
Manual 03505	Speed Adjusting (Synchronizing) Motor
Manual 04028	Pneumatic Speed Setting Assembly. (Direct Type)
Manual 04030	Pneumatic Speed Setting Assembly. (Reverse Type)

PSG GOVERNOR
WITH PM MOTOR AND EXTERNAL RIGHT HAND DROOP



VIEW B-B
2XSIZE

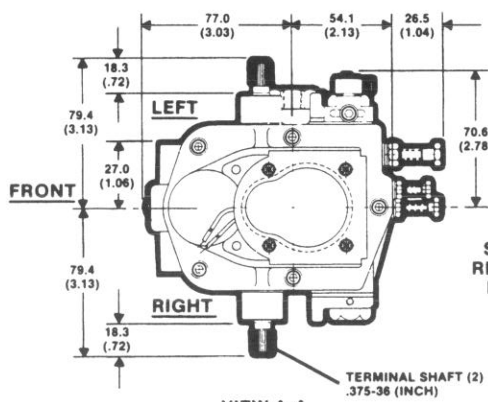
PSG GOVERNOR OPTIONS



WITHOUT SPEED SETTING MOTOR

NOTE:
1. 36° MAXIMUM USABLE STROKE AVAILABLE.

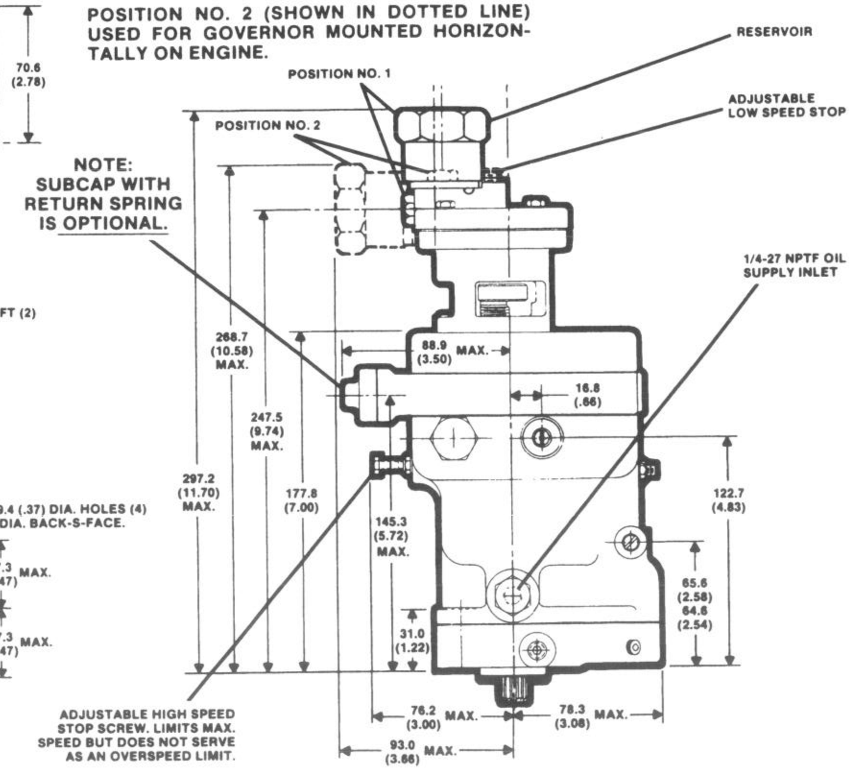
RECOMMENDED TRAVEL BETWEEN NO LOAD AND FULL LOAD IS 24°.



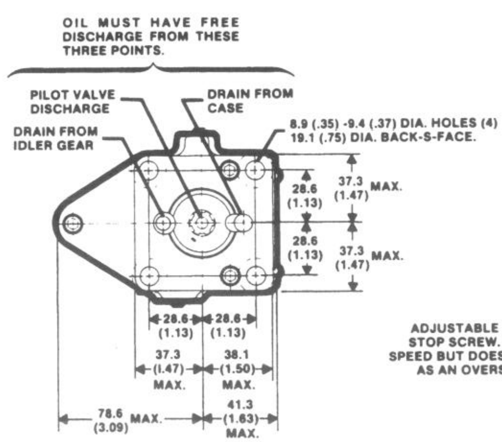
VIEW A-A

NOTE:
POSITION NO. 1 OF OIL RESERVOIR AND PLUG USED FOR GOVERNOR MOUNTED VERTICALLY ON ENGINE.

POSITION NO. 2 (SHOWN IN DOTTED LINE) USED FOR GOVERNOR MOUNTED HORIZONTALLY ON ENGINE.



WITH PNEUMATIC SPEED SETTING ASSEMBLY



OUTLINE DRAWINGS (DO NOT USE FOR CONSTRUCTION)
METRIC (INCHES SHOWN IN PARENTHESES)

at the heart
of the system

since 1870

WOODWARD GOVERNOR COMPANY

CORPORATE HEADQUARTERS
AIRCRAFT & HYDRAULIC TURBINE
CONTROLS DIVISIONS
5001 N. Second St.
P.O. Box 7001
Rockford, IL 61125 - 7001, U.S.A.
phone (815) 877-7441, Telex: 25-7410

ENGINE & TURBINE CONTROLS
DIVISION
P.O. Box 1519
Fort Collins, CO 80522-9990, U.S.A.
phone (303) 482-5811, Telex: 4-5691

ADDITIONAL MANUFACTURING
OPERATIONS
Stevens Point, WI

INTERNATIONAL OPERATIONS
DIVISION

Woodward Governor (U.K.) Ltd.
P.O. Box 15
Slough, SL1 4DD, England
phone 753-26835, Telex: 848181

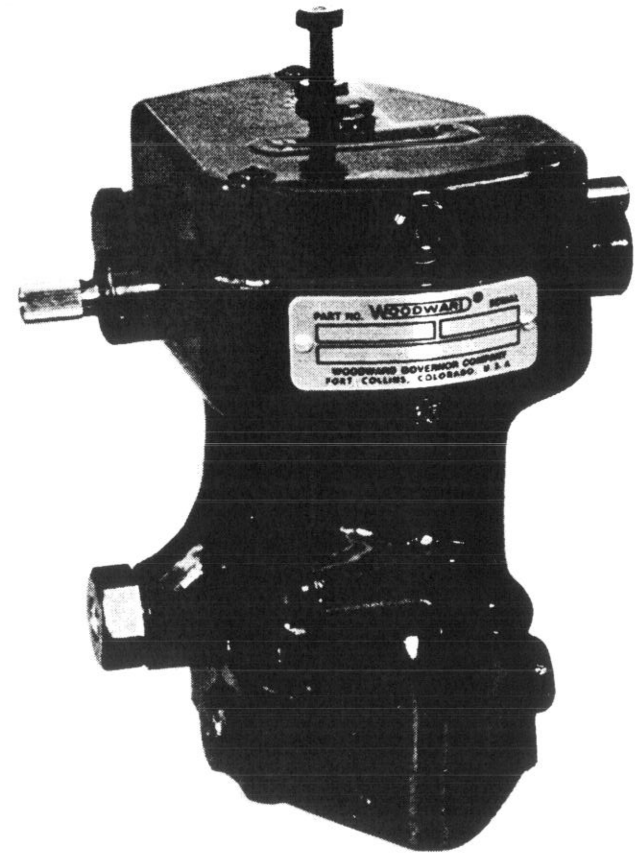
Woodward Governor Nederland B.V.
P.O. Box 34
Hoofddorp, The Netherlands
phone 2503-1-3241, Telex: 74508

Woodward Governor (Japan) Ltd.
Tomisato P.O. Box 1
Inba-gun, Chiba-ken, 286-02, Japan
phone 4769-3-4661, Telex: 3762-164

Woodward Governor Company
Unit 1, 1 Wirega Ave.,
P.O. Box 319
Kingsgrove N.S.W. 2208, Australia
phone 61 2 758-2322, Telex: AA 24175

Woodward Governor (Reguladores) Ltda.
Rua Fernao Pompeu De Camargo, 1306,
Caixa Postal 1785
13100 Campinas, S.P., Brazil
phone 192-31-4977, Telex: 191844

WOODWARD®



PSG GOVERNOR

This manual, 37013H, replaces 37013 and 37013A through 37013G.

WOODWARD GOVERNOR COMPANY

37013H

WARNING

READ THIS ENTIRE MANUAL AND ALL OTHER PUBLICATIONS PERTAINING TO THE WORK TO BE PERFORMED BEFORE INSTALLING, OPERATING, OR SERVICING THIS EQUIPMENT. PRACTICE ALL PLANT AND SAFETY INSTRUCTIONS AND PRECAUTIONS. FAILURE TO FOLLOW INSTRUCTIONS CAN CAUSE PERSONAL INJURY AND/OR PROPERTY DAMAGE.

The letter designation following the manual number is changed to the next letter in alphabetical order when an important revision is made to the manual.

TEXT CHANGES ARE INDICATED BY A BLACK LINE ALONGSIDE THE TEXT.

TABLE OF CONTENTS

SECTION 1
GENERAL INFORMATION AND INSTALLATION

INTRODUCTION

This manual is arranged into five sections. These sections cover General Information and Installation, Principles of Operation, Maintenance, Replaceable Parts, and Auxiliary Equipment.

GENERAL INFORMATION

The basic PSG (Pressure Compensated Simple Governor) is a hydraulic speed governor with buffer type compensation. It is normally isochronous, that is, if the engine is not overloaded it maintains the same speed regardless of load, except momentarily at the time load change occurs.

The governor uses engine lubricating oil or an oil supply from a separate sump furnished by the engine manufacturer. If the latter is used, lift should not exceed 12 inches and a foot valve should be furnished.

WARNING

The engine, turbine or other type of prime mover should be equipped with a separate overspeed (overtemperature, or overpressure, where applicable) shutdown device(s), to protect against runaway or damage to the engine, turbine or other type of prime mover with possible personal injury or loss of life should the mechanical-hydraulic governor(s), or electric control(s), the actuator(s), fuel control(s), the driving mechanism(s), the linkage(s), or the controlled device(s) fail.

REFERENCES

Sales, Service and Product Information for the PSG Governor can be obtained from the Woodward locations listed on the back cover of this manual.

NO	*TITLE*
04018	Speed Adjusting Motor Cover Assembly Manual.
25071	Oils for Hydraulic Controls.
37010	Product Specification, PSG Governor.
50007	Recommended Sizing of Drain Lines from Hydraulic Controls.
50504	Shutdown Methods for EG-B2P and EG-B2C Governor/Actuators and SG and PSG Governors.
50517	Recommended Engine Oil Supply System for small Governor and Actuators.

INSTALLATION

Place a gasket between the base of the governor and the engine mounting pad. The gasket must not block any holes in the governor base. Install the governor on the engine, taking particular care to mount it squarely on the engine.

Be sure that the drive connection is properly aligned. Connect the fuel control linkage for 2/3 travel from no-load with overtravel at both ends and check that fuel flow is completely closed off when the governor is in its no fuel position. See figure 1-2. Also check and insure that maximum fuel flow is provided when the governor's terminal shaft is at its full load position (2/3 travel). The linkage must be free from friction and looseness.

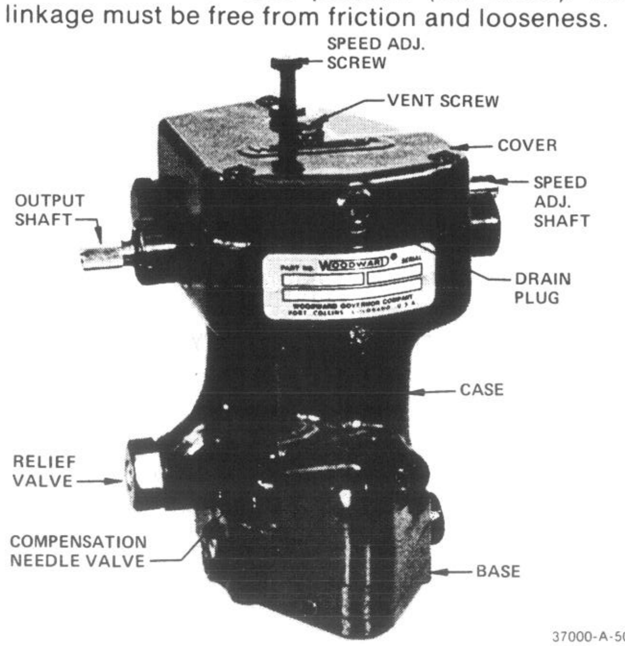


Figure 1-1. External Features of Basic PSG

Note

Governor rotation, either clockwise or counterclockwise, is determined by facing the top of the governor and viewing the direction the drive rotates.

OIL SUPPLY

The PSG is a single acting governor, that is, it utilizes oil pressure in one direction only and depends upon spring force to move the fuel control linkage in the fuel off direction. Some models incorporate a spring within the governor's cover, but most governors require an external spring which exerts a torque of 25 or 50 lb. - in. on the terminal shaft in the return direction.

Install a 3/8" oil line from the governor to either the engine lubricating oil pump pressure line, or a separate sump, unless the engine's mounting pad is drilled for an oil supply. Use a 40 micron (nominal) filter with a minimum capacity of 2 gallons per minute.

NOTE

A permissible oil supply pressure range is a maximum of 12 inches suction lift from a separate sump to a maximum of 75 psi from the engine lube oil system. Torque and work values vary accordingly. Consult Woodward Governor Company when supply pressures must exceed 75 psi.

Allow free drainage of oil from the governor pilot valve by providing adequate drain holes from the drive coupling (1/4" diameter or equivalent in multiple holes). Provide free drainage through the engine adapter housing for the governor ballhead cavity's drain passage.

If the governor is mounted horizontally, the needle valve must be on the bottom. Horizontal mounting also requires that a 1/4" pipe tapped hole be provided in the upper part of the governor case and connected to the engine sump or to the separate sump.

Use the information given in Tables 1-1 and 1-2 as a guide in the selection of a suitable lubricating/hydraulic oil. Oil grade selection is based on the operating temperature range of the governor. Also, use this information to aid in recognizing and correcting common problems associated with oil used in products manufactured by the Engine and Turbine Controls of Woodward Governor Company.

For applications where the Woodward governor shares the oil supply with the engine, use the oil recommended by the engine manufacturer.

Governor oil is both a lubricating oil and a hydraulic oil. It must have a viscosity index that allows it to perform over the operating temperature range and it must have the proper blending of additives that cause it to remain stable and predictable over this range.

Note

Primary concern is for the oil properties in the governor.

Governor oil must be compatible with seal materials, i.e., nitrile, polyacrylic, and fluorocarbon. Many automotive and gas engine oils, industrial lubricating oils, and other oils of mineral or synthetic origin meet these requirements. Woodward governors are designed to give stable operation with most oils with the viscosity, at the operating temperature, between 50 and 3000 SUS (Saybolt Universal Seconds). At the normal operating temperature, the viscosity should be between 100 to 300 SUS. Poor actuator response or instability may be an indication that the oil viscosity is outside this range.

Excessive component wear or seizure in a governor indicates the possibility of:

1. Insufficient lubrication caused by:
   a. An oil that flows slowly when it is cold especially during start-up.
   b. An oil line with restrictions caused by either obstructions within or bends in the line (for external supply governors only).
   c. No oil in the governor.
2. Contaminated oil caused by:
   a. Dirty oil containers.
   b. A governor exposed to heating up and cooling down cycles, which creates condensation of water in the oil.

ANY OIL LISTED IS MERELY A SUGGESTION. USE THE OIL OF YOUR CHOICE WITH THE CORRECT VISCOSITY AS INDICATED IN THE CHART.

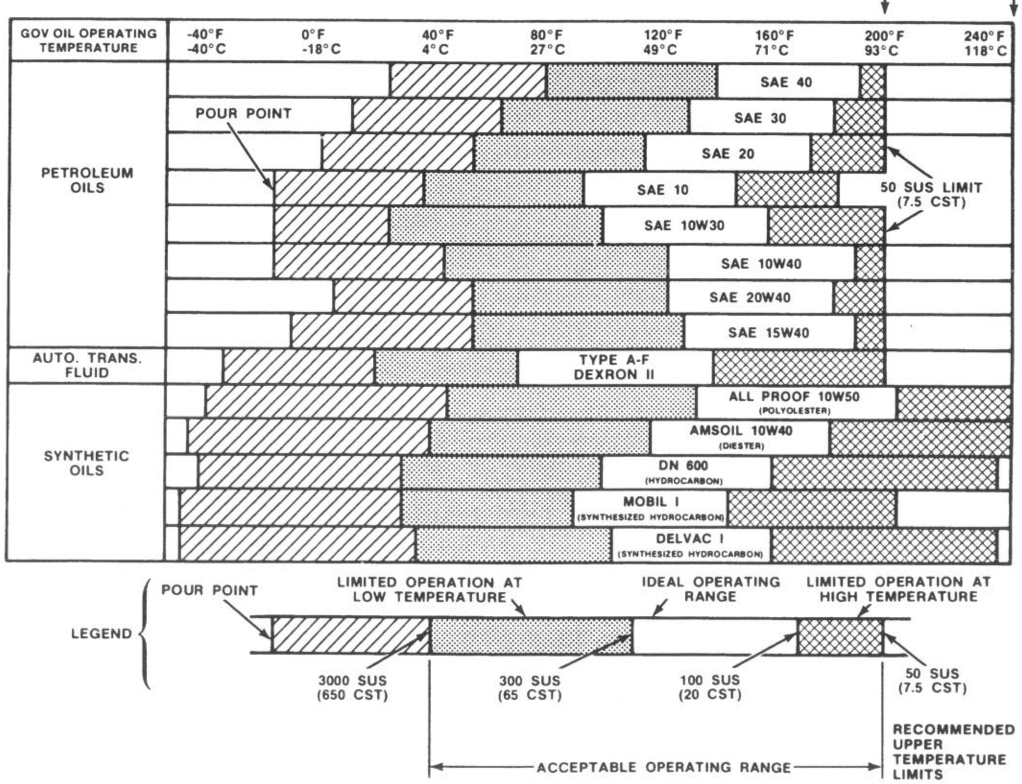


Table 1-1. Oil Chart

VISCOSITY COMPARISONS				
CENTISTOKES (CST, CS, OR CTS)	SAYBOLT UNIVERSAL SECONDS (SUS) NOMINAL AT 100°F	SAE MOTOR (APPROXIMATE)	SAE GEAR (APPROXIMATE)	ISO
15	80	5W		15
22	106	5W		22
32	151	10W	75	32
46	214	10	75	46
68	310	20	80	68
100	463	30	80	100
150	696	40	85	150
220	1020	50	90	220
320	1483	60	115	320
460	2133	70	140	460

25000-A-87

Table 1-2. Viscosity Comparisons

3. Oil not suitable for the operating conditions caused by:

   a. Changes in ambient temperature.

   b. An improper oil level which creates foamy, aerated oil.

Operating a governor continuously beyond the high limit temperature of the oil will result in oil oxidation. This is identified by varnish or sludge deposits on the governor. To reduce oil oxidation, lower the actuator operating temperature with a heat exchanger or other means, or change to an oil more oxidation resistant at the operating temperature.

WARNING

A loss of stable governor control and possible engine overspeed may result if the viscosity exceeds the 50 to 3000 SUS range.

Specific oil viscosity recommendations are given on the Oil Chart (Table 2-1). Select a readily available good brand of oil, either mineral or synthetic, and continue using that same brand. Do NOT mix the different classes of oils. Oil that meets the API (American Petroleum Institute) engine service classification in either the "S" group or the "C" group, starting with "SA" or "CA" through "SF" and "CD" is suitable for governor service. Oils meeting performance requirements of the following specifications are also suitable: MIL-L-2104A, MIL-L-2104B, MIL-L-2104C, MIL-L-46152, MIL-L-46152A, MIL-L-46152B, MIL-L-45199B.

Replace the governor oil if it is contaminated, also change it if it is suspected of contributing to the governor instability. Drain the oil while it is still hot and agitated; flush the governor with a clean solvent having some lubricity (such as fuel oil or kerosene) before refilling with new oil. If drain time is insufficient for the solvent to completely drain or evaporate, flush the governor with the same oil it is being refilled with to avoid dilution and possible contamination of the new oil. To avoid recontamination, the replacement oil should be free of dirt, water, and other foreign material. Use clean containers to store and transfer oil.

WARNING

Observe manufacturer's instructions or restrictions regarding the use of solvents. If no instructions are available, handle with care. Use the cleaning solvent in a well ventilated area away from fires or sparks.

Oil that has been carefully selected to match the operating conditions and is compatible with governor components should give long service between oil changes. For governors operating under ideal conditions, i.e., minimum exposure to dust and water and within the temperature limits of the oil, oil changes can be extended to two or more years. If available, a regularly scheduled oil analysis is helpful in determining the frequency of oil changes.

Any persistent or reoccuring oil problems should be referred to a qualified oil specialist for solution.

The recommended continuous operating temperature of the oils is 140°F (60°C) to 200°F (93°C). The ambient temperature limits are -20°F (-30°C) to 200°F (93°C). Measure the temperature of the governor on the outside lower part of the case. The actual oil temperature will be slightly warmer, approximately 10°F (6°C).

SPEED ADJUSTMENT

There are several types of speed adjustments available for the PSG. Some governors have a lever attached to the external end of the speed adjusting shaft. This lever is used in conjunction with the high and low speed stop screws. Utilizing a linkage arrangement with the lever provides a remote speed adjustment for the governor. The screw in the cover is used to set the minimum speed stop while the screw in the case controls the maximum speed stop of the governor.

The governor can also be equipped with either a pneumatic speed adjustment head or an electric motor for remote speed adjustment. The pneumatic speed adjustment head mounts on the cover as does the electric motor. Both pneumatic and electric speed adjustments utilize a high speed stop screw.

The motor is a split field universal motor which drives the speed adjusting shaft through a worm and gear with a friction clutch to protect the motor if the adjustment is run against the stops.

SPEED DROOP

Speed droop is provided and is internally adjustable between zero and seven percent, depending on speed setting, speeder spring, flyweights, and terminal shaft travel. Speed droop permits load division between two or more engines driving generators in parallel or connected to a single shaft. If the engine is operated alone or on a dc system with proper generator compounding, the governor may be set for zero droop (isochronous operation).

For ac generating units tied in with other units, set the droop sufficiently high to prevent interchange of load between units. If one unit in the plant or system has enough capacity, set its governor on zero droop and it will regulate the frequency of the entire system. This unit then takes all load changes within the limits of its capacity and controls the frequency if its capacity is not exceeded.

Adjust the system frequency by changing the speed setting of the governor having zero droop. Load distribution between units is accomplished by changing the speed setting of the governor having speed droop.

INITIAL OPERATION AND ADJUSTMENT

Normally, the governor adjustments for speed, droop, and compensation needle valve are set at the factory. Minor adjustments are required after installation due to engine or turbine variances. Normal factory settings of the various governor adjustments are given in Table 1-3 below.

WARNING

TO PROTECT AGAINST POSSIBLE PERSONAL INJURY, LOSS OF LIFE, and/or PROPERTY DAMAGE WHEN STARTING the engine, turbine, or other type of prime mover, BE PREPARED TO MAKE AN EMERGENCY SHUTDOWN to protect against runaway or overspeed should the mechanical/hydraulic governor(s), or electric control(s), the actuator(s), fuel control(s), the driving mechanism(s), the linkage(s), or the controlled device(s) fail.

Table 1-3. Factory Adjustments

ADJUSTMENT	FACTORY (TEST) SETTING
Speed Setting:	Preset at the factory to specified full-load rated speed.
Droop setting (internally adjusted):	Set at designated droop percentage as specified for the particular application.
Compensation needle valve:	Factory preset 1/2 turn open (nominal). Normally requires adjustment to suit the particular installation.

Make certain the speed is set to minimum (idle). Start the engine or turbine under manual control according to the engine manufacturer's recommendations, and allow it to warm up. Transfer the engine or turbine to governor control, but be prepared to resume manual control until satisfied that the governing system is fully operative.

Adjust the governor for no-load rated speed. Open the compensation needle valve (2 to 3 turns) until the engine or turbine begins to hunt or surge. Allow the engine or turbine to hunt for approximately 1/2-minute to purge trapped air from the internal passages in the governor. Gradually close the needle valve until hunting just stops. Closing the needle valve further than necessary results in a slow return to speed following a change in load. Test the governing action by manually disturbing engine or turbine speed. The engine should return promptly to original steady state speed with only a small overshoot.

STORAGE

In cases where governors are being stored, take precaution for proper storage. Flush the governor with a corrosion preventative oil. Protect or cover all open ports and wrap the governor in a barrier material. Store it in a suitable container. Refer to Woodward's Specification Procedure 25075.

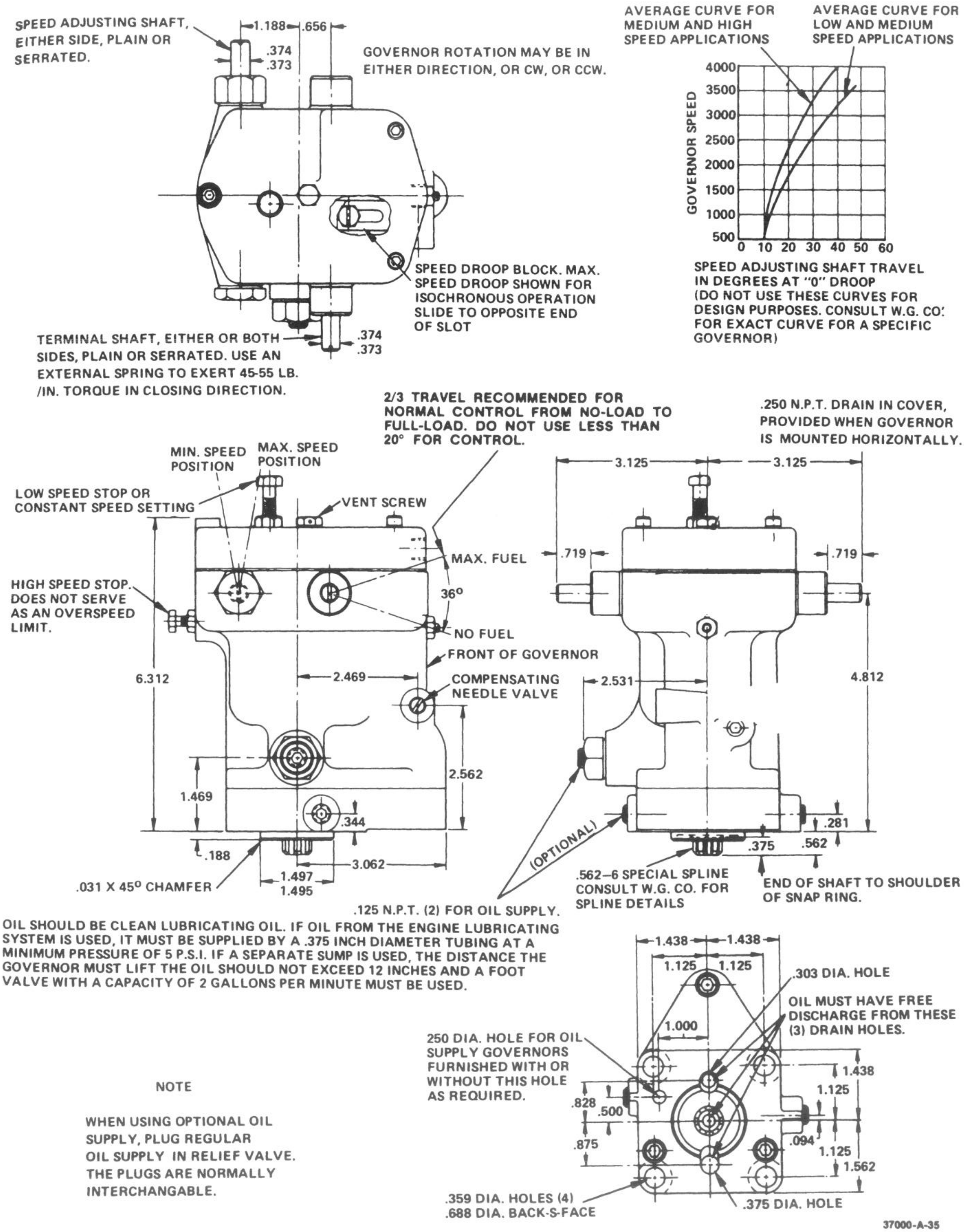


Figure 1-2. Outline Drawing, Basic PSG (Do not use for construction)

SECTION 2
PRINCIPLES OF OPERATION

INTRODUCTION

This section covers the description of operation of the PSG governor. This includes a description of the hydraulic system and the way it operates.

The cutaway schematic, figure 2-1, shows the relationship of the various parts.

OPERATION

MECHANICAL HYDRAULIC SYSTEM

The schematic diagram, figure 2-1, shows the oil supply coming from the engine lubricating system. It by-passes the relief-valve into the governor oil pump where its pressure is increased to either 75, 175, or 225 psi above inlet pressure. Four check-valves, two of which are shown, permit rotation of the governor in either direction. Some models have two of the passages plugged for rotation in one direction only, depending on the particular application. Relief-valve discharge is back to supply, so unused oil is recirculated within the governor.

Pressured oil is supplied through oil passages to the pilot valve system. The pilot valve system is a three way spool valve. It applies pressured oil to the power cylinder when an under speed signal is received or releases trapped oil from the power cylinder when an overspeed signal is received.

BALLHEAD SYSTEM

Flyweights are attached to the pilot valve's rotating bushing by pivot pins. The pilot valve bushing is driven by an external drive from the engine. A thrust bearing, located under the speeder spring, rides on the toes of the flyweights. This allows the flyweights and pilot valve bushing to rotate without extreme friction.

As the pilot valve bushing rotates, the centrifugal force increases and the flyweights pivot outward. This centrifugal force is opposed by the downward force of the speeder spring. Speeder spring compression, and therefore the speed at which the governor must run is adjusted by the position of the speed adjusting system (e.g. lever, electric motor, or pneumatic). On speed occurs when the centrifugal force of the flyweights balances the downward force of the speeder spring, with the flyweights exactly vertical, and the pilot valve plunger control land covering the control port of the rotating bushing.

COMPENSATION SYSTEM

The compensating system consists of, a buffer piston, two buffer springs, a needle valve, and a compensating land on the pilot valve plunger. It provides temporary speed droop and must be properly attuned to the particular engine and load to provide stable operation.

LOAD INCREASE EXAMPLE

The governor increases fuel to the engine with an increase in governor speed setting, or a decrease in engine speed due to an increase in load. Either the increase in the downward force of the speeder spring, or the decrease in centrifugal force of the flyweights allows the pilot valve plunger to move downward. Pressured oil is applied through the control port to the buffer system and into the power cylinder area. The power piston has two concentric areas, both of which are exposed to the pressured oil metered by the pilot valve. The lower smaller diameter is acted upon directly, and the upper annulus is connected through the bore in the power piston in which the buffer piston is carried.

Oil flow into the power cylinder forces the power piston upward against the force of the return spring (shown in figure 2-2 only). Pressured oil displaces the buffer piston and forces oil into the upper annulus. The buffer piston, springs located in the power piston, and needle valve in the hydraulic circuits between the pilot valve plunger and power cylinder make up the buffer compensation system. This system stabilizes the governing action by minimizing over or undershoot following a change in governor speed setting, or a change in load on the prime mover. It establishes a temporary negative feedback signal (temporary droop) in the form of a pressure differential which is applied across the compensation land of the pilot valve plunger. The flow of oil into or out of the buffer system displaces the buffer piston in the direction of flow. This movement increases the loading on one spring while decreasing the other and creates a slight difference in the pressures on either side of the piston with the higher pressure on the side opposite the spring being compressed. These pressures are transmitted to opposite sides of the plunger compensation land and produce a net force, upward or downward, which assists in recentering the plunger whenever a fuel correction is made.

LOAD DECREASE EXAMPLE

The governor decreases fuel to the engine with a decrease in governor speed setting or an increase in engine speed due to a decrease in load on the engine.

Due to the decrease in speed setting or decrease in load, the centrifugal force of the flyweights overcomes the speeder spring force and lifts the pilot valve plunger. Upward movement of the pilot valve plunger opens the control port to drain and the power piston is forced in the reduced fuel direction by the return spring. At the same time, flow of oil output of the annular space between the two diameters of the power piston uncenters the buffer piston in the downward direction. The pressure difference on each side of the buffer piston, acts on the compensating land, and recenters the pilot valve plunger. Oil leaks by the needle valve, and dissipates this pressure difference. As the engine returns to steady state speed, the centrifugal force of the flyweights is again balanced with the downward force of the speeder spring.

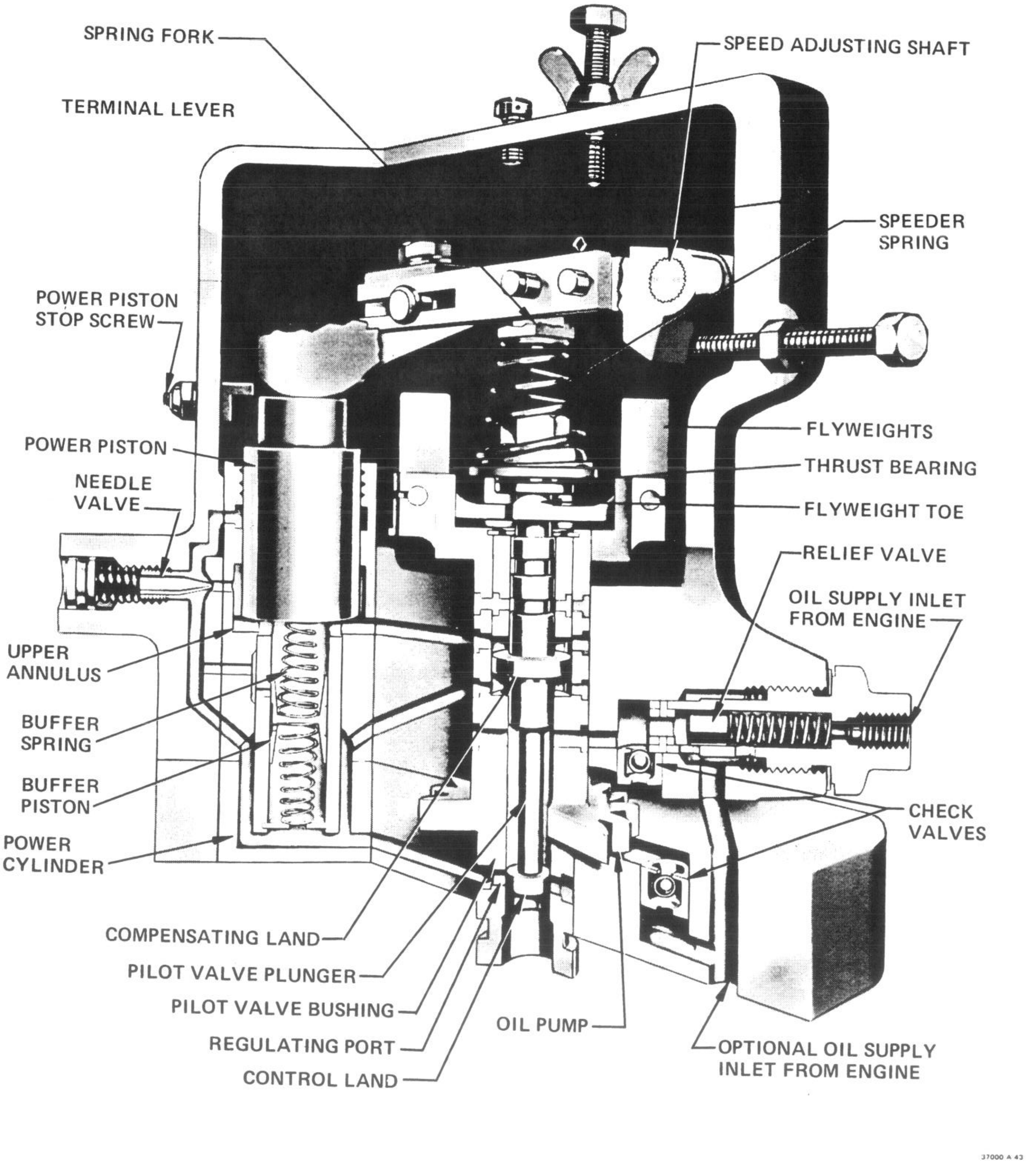


Figure 2-1. Cutaway schematic, Basic PSG

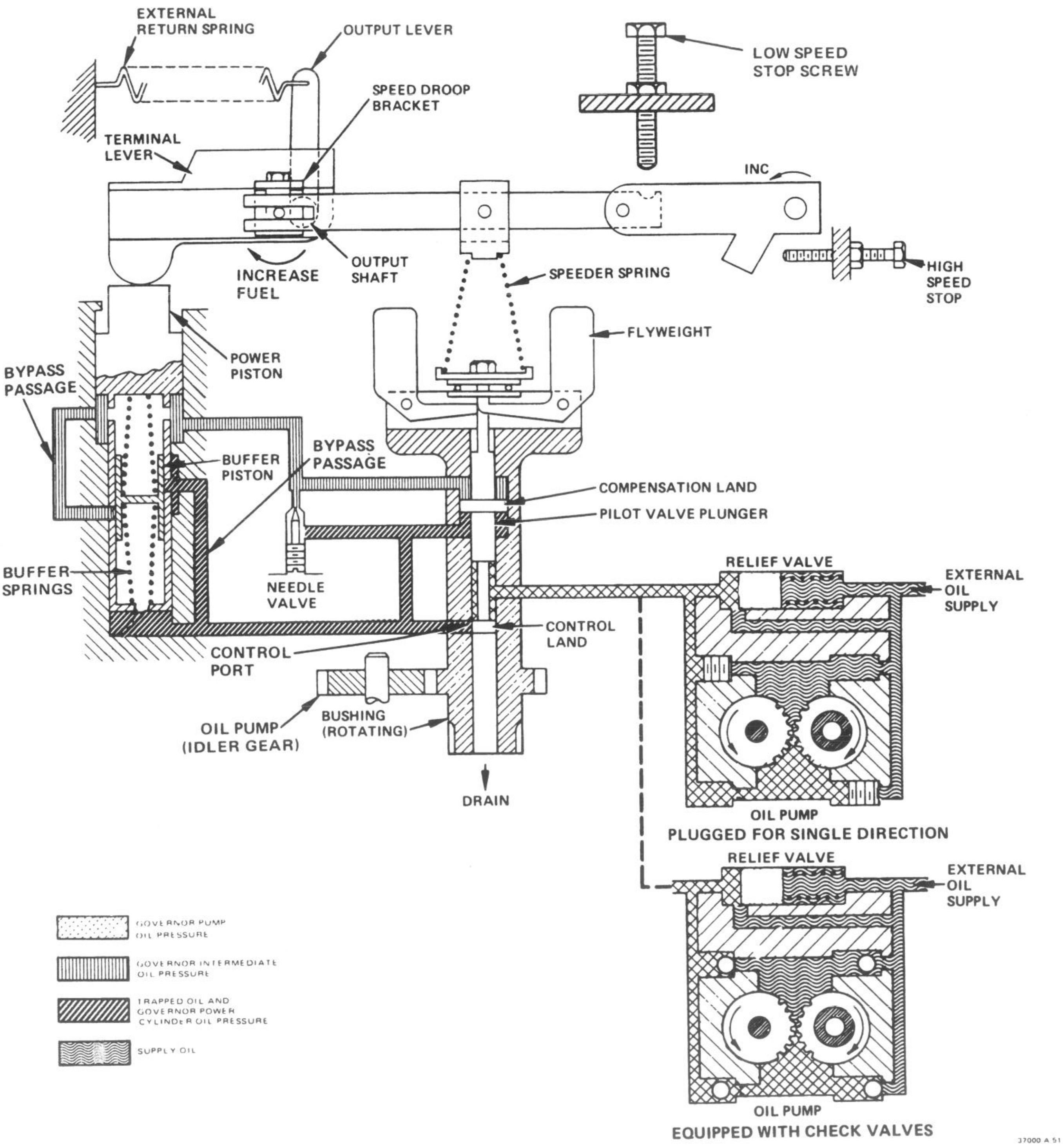


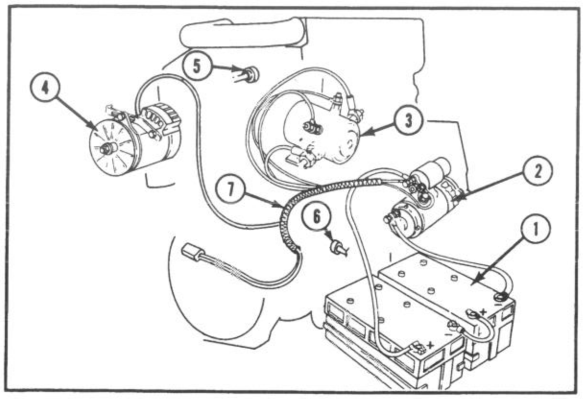
Figure 2-2. Schematic Diagram, PSG with External Return Spring

Section 5 - Engine Electrical System

Table of Contents

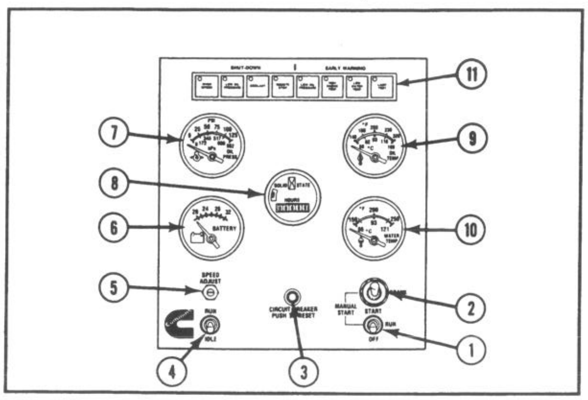
System Troubleshooting and Repair List

General Information - (5-01)



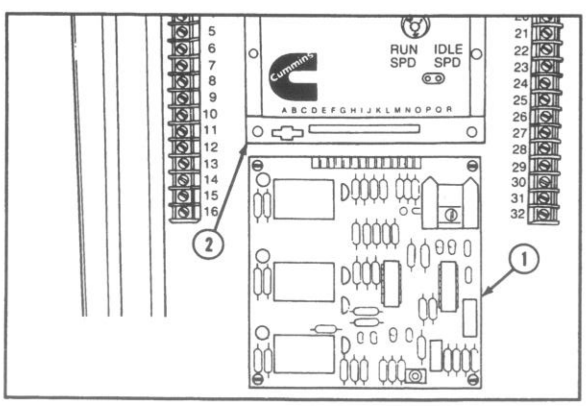
The basic heavy-duty electrical system consists of:

1. Batteries (1) (usually two 12 volt batteries connected in series. On larger units, the two batteries in series are paralleled with two additional batteries connected in series).
2. Starter Motor (2) (One motor on NT-855, KT-19 and VTA-28 series. Two motors on KT-38 and KTA-50 series).
3. Auxiliary Magnetic Switch (3).
4. Alternator (4) (Frequently omitted on units for standby duty).
5. Safety Switch for high coolant temperature shutdown (5).
6. Safety Switch for low oil pressure shutdown (6).
7. Engine Wiring Harness (7).



The engine instrument panel consists of:

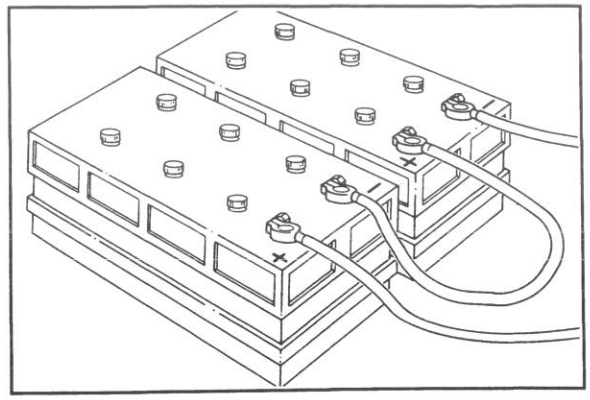
1. Permissive start switch
2. Toggle crank switch
3. Circuit breaker
4. Idle - run switch
5. Speed adjust control
6. Battery voltmeter
7. Engine oil pressure gauge
8. Hourmeter
9. Engine oil temperature gauge
10. Water temperature gauge
11. Alarm and shutdown lights



The speed switch circuit baord assembly and the governor control are located behind the instrument panel.

1. Speed Switch
2. Governor Control

This illustration shows two 12 volt batteries connected in series to produce 24 volts.



Engine Electrical System Specifications - (5-02)

All NT-855 and larger generator sets use a nominal 24 volt electrical system.

	Minimum Recommended Lead - Acid Battery Capacity						Minimum Ni-Cad Cell Amp. Rating
Engine family	-18° to 0° C [0° to 32° F]		0° to 10° C [32° to 50° F]		10° C and above [50° F and above]		10° C and above [50° F and above]
	CCA*	AH**	CCA*	AH**	CCA*	AH**	Ampere
NT(A)-855 series	900	200	640	150	600	140	670
KT(T)(A)-19 Series	900	200	640	150	600	140	750
VT(A)-28 Series	1800	400	1280	300	1200	280	800
KT(T)(A)-38 Series	1800	400	1280	300	1200	280	1060
KT(T)(A)-50 Series	1800	400	1280	300	1200	280	1250

*CCA = Cold cranking amperes. **AH = Ampere hours.

Battery cable sizes - American wire gauge (Maximum total length in cranking motor circuit)

For NT(A)-855, KT(T)(A)-19, VT(A)-28, KT(T)(A)-38 and KT(T)A-50 series engines with a separate set of cables to each starter:

24 to 32 Volts	
No. 00	6.1 Meters [20 feet]
No. 000	8.2 Meters [27 feet]
No. 0000 or Two No. 0*	10.7 Meters [35 feet]
Two No. 00	13.7 Meters [45 feet]

* Two strands of No. 0 cable may be used in place of one No. 0000 cable, providing all connections are carefully made to ensure equal current flow in each parallel cable.

Note: When separate cables are run to each of the KT(T)(A)-38 and KT(T)A-50 starters, use a No. 00 jumper cable to interconnect the two negative starter terminals. Use an additional No. 00 jumper cable to interconnect the two positive starter terminals.

For KT(T)(A)-38 and KT(T)A-50 series engines with a single set of cables to both starters:

24 to 32 Volts	
No. 00	3.1 Meters [10 feet]
No. 000	4.0 Meters [13 feet]
No. 0000 or Two No. 0**	5.2 Meters [17 feet]
Two No. 00**	6.7 Meters [22 feet]

** When two strands of No. 0 or No. 00 cable are used, all connections must be carefully made to ensure equal current flow in each parallel cable.

Cold Weather Starting Data - Generator Set Engines (For Prime Power Applications)

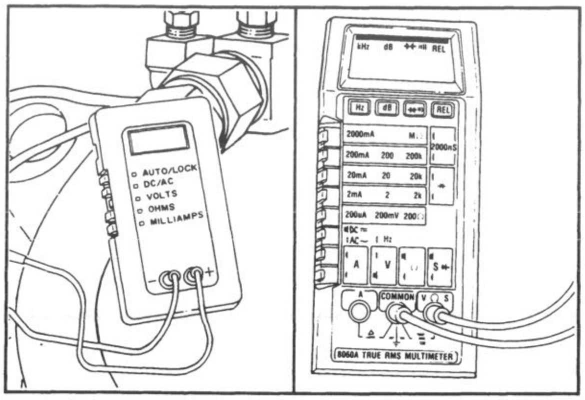
	Minimum Ambient Temperature for Combustion	
Engine Series	Unaided	Aided (Ether)
NT(A)-855	4° C [40° F]	-32° C [-25° F]
KT(T)(A)-19	4° C [40° F]	-32° C [-25° F]
VT(A)-28	4° C [40° F]	-32° C [-25° F]
KT(T)(A)-38	4° C [40° F]	-32° C [-25° F]
KT(T)A-50	4° C [40° F]	-32° C [-25° F]

Note: The above minimum ambient temperatures are quoted on the basis that the electrical system (particularly the battery capacity and cable sizes), lubrication and fuel specifications (particularly the cetane rating) and fuel system meet Cummins recommendations. Starting an engine below -18° C [0° F] requires additional battery capacity or battery heaters. See Cummins Bulletin No. 3379002, Lubricating Oils for Cummins Engines, for recommendations on lubricating oil for engines operating in low temperatures.

Note: At these minimum temperatures, combustion will occur and the engine will run at low idle (550 to 650 RPM). After running at this speed for five to twenty minutes, the engine may be brought up to rated speed by momentarily switching the Idle-Run switch to the Run position. Repeat this procedure for progressively longer periods of time until the engine will maintain rated speed.

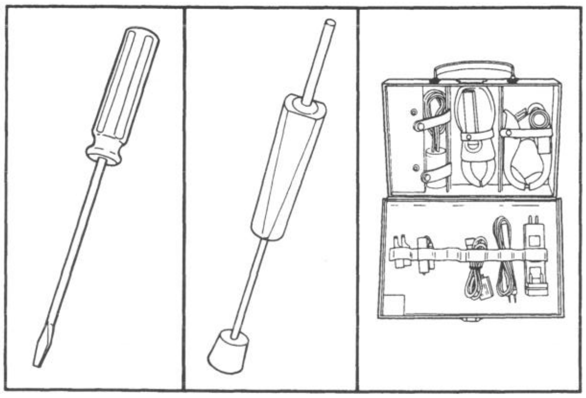
Note: A tank type jacket water heater is required on all aftercooled standby applications.

Cummins Service Tools - (5-03)



Part No. 3376898 Digital Multimeter. This meter is used to measure volts, ohms, and milliamperes.

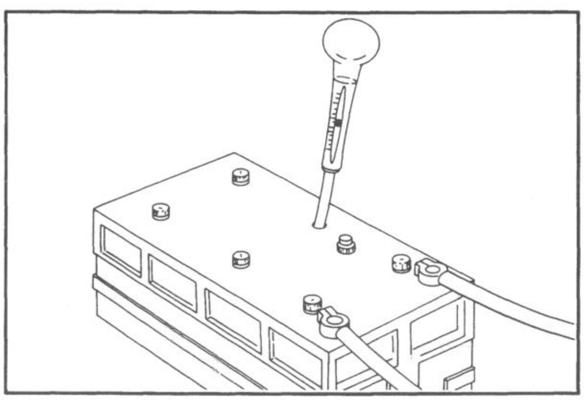
Digital multimeter - Fluke, model 8060A. This meter is used to measure frequency, volts, ohms and milliamperes.



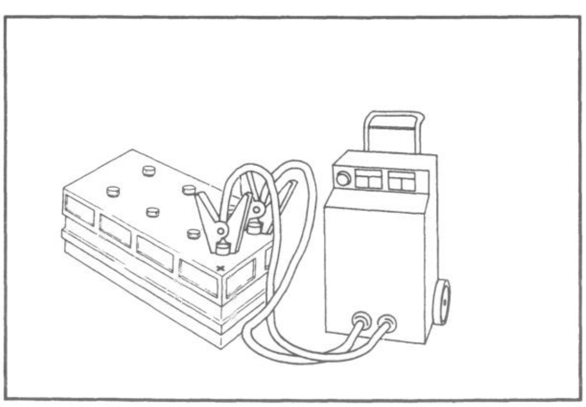
Part No. 3376313 Potentiometer screwdriver. This tool is used to adjust small control potentiometers.

Part No. 3822206 Molex plug service tool. This tool is used to remove pins from Molex plugs.

Part No. ST-1324 Clamp-on volt - ammeter. This tool is used to measure A.C. amps on generator sets.



The battery hydrometer is used to check the specific gravity of individual battery cells (for batteries with removable cell caps or covers).

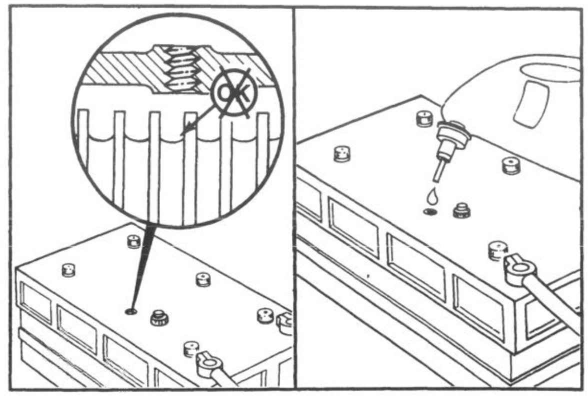


The battery charger is used to restore the state of charge of a battery.

Batteries - Check (5-04)

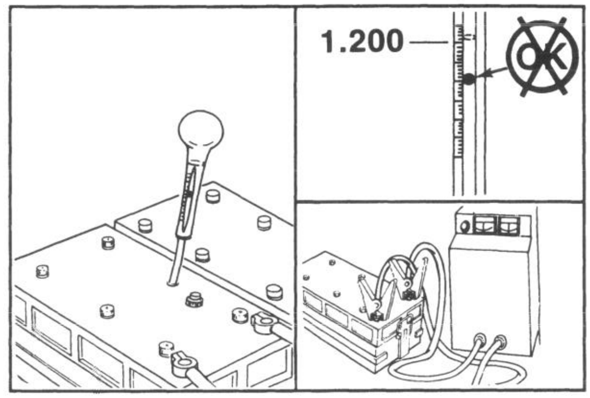
Conventional lead-acid batteries

1. If conventional lead acid batteries are used, remove the cell caps and check the electrolyte (water and sulfuric acid solution) level.
2. Check the electrolyte (potassium, lithium, hydroxide and water) level of nickel-cadmium batteries by observing the level through the plastic cell walls or by removing the cell caps.



3. Fill each battery cell with distilled water. Refer to the battery manufacturers instructions for the correct level of the electrolyte.
4. After charging the battery, measure the specific gravity of each cell of a conventional lead-acid battery with a hydrometer. Replace any battery that has a cell with a specific gravity below 1.150.

Note: Maintenance-free batteries are sealed. Water can not be added to the cells.

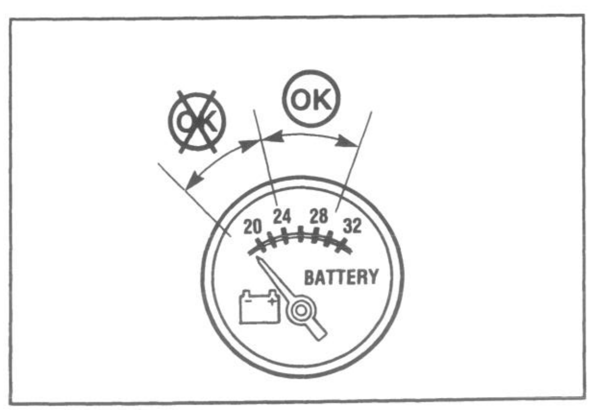


Caution: Do not measure the specific gravity of a nickel-cadmium battery. The specific gravity of the electrolyte is not a good indication of the state-of- charge of the battery. Any sulfuric acid remaining in the hydrometer from testing a conventional battery would destroy a nickel-cadmium cell.

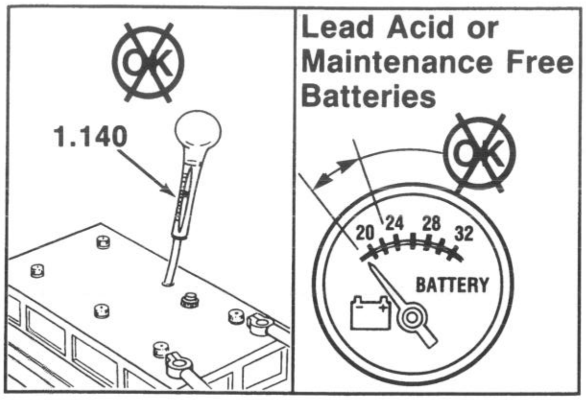
If the specific gravity of any cell of a conventional lead-acid battery is below 1.200, recharge the battery. Refer to the accompanying chart to determine lead-acid battery state-of-charge based on the specific gravity.

Battery State of Charge	Specific Gravity @ 27°C [80°F]
100%	1.260-1.280
75%	1.230-1.250
50%	1.200-1.220
25%	1.170-1.190
Discharged	1.110-1.130

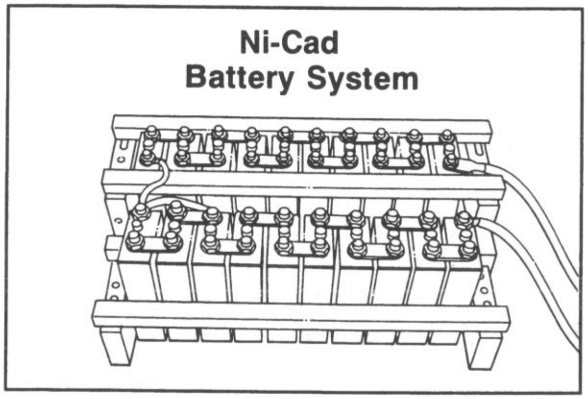
5. Observe the battery indicator gauge on the engine control panel to check the state-of-charge of a conventional battery. A reading of 26 volts is normal when the battery is not being charged (engine stopped and utility powered charger "off"). A reading of 24 volts or below indicates that the battery must be charged.
6. Replace a lead-acid battery if it will not maintain a charge.



Note: Battery voltage should never drop below 18 VDC during cranking to prevent autostart timer problems.



Normal life of conventional lead-acid batteries without maintenance is 2 to 3 years and up to 5 years if maintained correctly (correct electrolyte level and charge is maintained). Normal life of maintenance-free sealed batteries is 5 to 6 years. Many different problems can cause hard engine starting. However, a likely cause can be conventional batteries approaching the end of their life cycle.

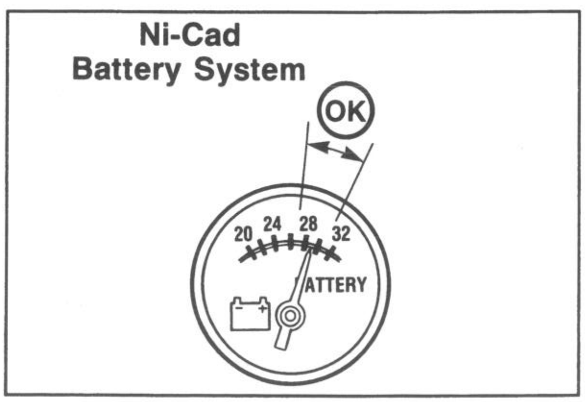


Ni-Cad batteries

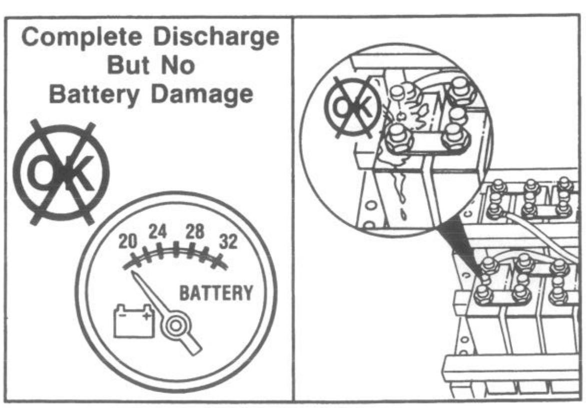
Ni-Cad (nickel cadmium) batteries are frequently used for starting generator sets because of their long life (10 to 20 years) and less maintenance. Ni-Cad batteries are similar to conventional batteries in that they must be recharged and distilled water must be added to maintain electrolyte level.

There are some important differences between Ni-Cad and conventional batteries.

1. The normal Ni-Cad battery system has 20 individual cells.
2. Electrolyte level can be observed without removing the cell caps.



3. Normal Ni-Cad system voltage is 28 to 29.4 volts. It may be as high as 31 volts during recharging.
4. Pilot and indicator lamps have a much shorter life on Ni-Cad systems.
5. A normal engine driven battery charging alternator will not recharge a 20 cell Ni-Cad system. An alternating current, 120 or 240 volt input, two rate charger specifically made for Ni-Cad batteries is required.

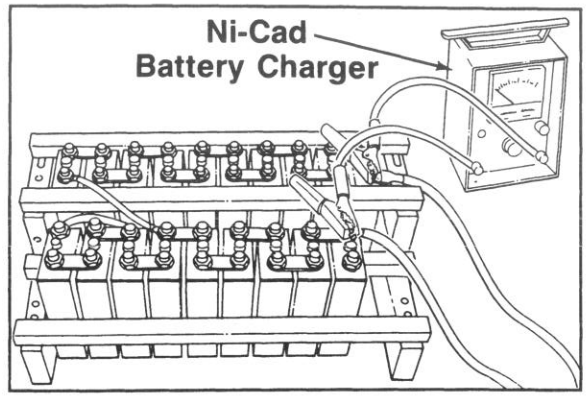


6. Complete discharge (usually considered as less than 17 volts at no load for a 20 cell system) will not damage a Ni-Cad battery system. The system should be recharged at 30 to 31 volts.

Caution: Ni-Cad cells near discharge (either new or cells which have not had a high charge rate for six months) can reverse polarity and discharge electrolyte from the cell vent during cranking. The electrolyte (potassium hydroxide) is corrosive to most metals. The electrolyte can be neutralized with vinegar or lemon juice and flushed away with large quantities of water.

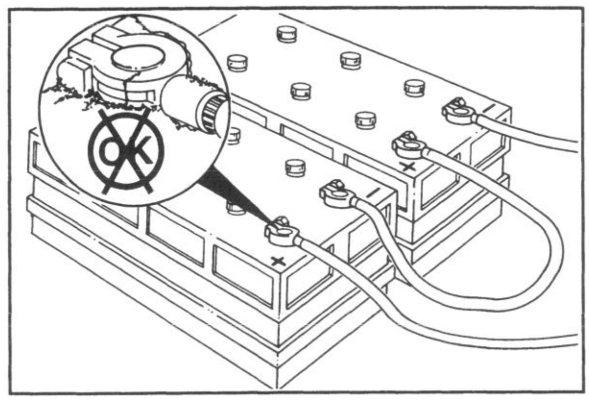
Reversed cells that have not ruptured can be reconditioned by the supplier or manufacturer. Individual ruptured cells must be replaced.

In an emergency, the Ni-Cad battery system can be operated with 19 cells. The battery charger should be kept on a "low" rate.

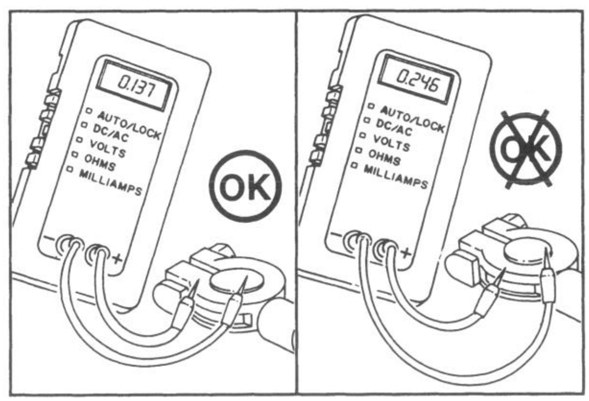


Battery Terminal Connections - Check (5-05)

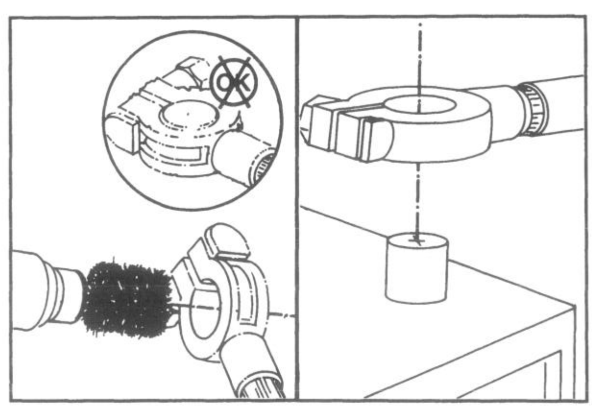
1. Visually inspect the battery terminals for loose, broken or corroded connections. Repair or replace broken cables or terminals.



2. Use multimeter Part No. 3376898 and set it to measure d.c. voltage. Check the voltage between the battery post and the cable clamp during cranking. The voltage drop should not exceed 0.2 volts.

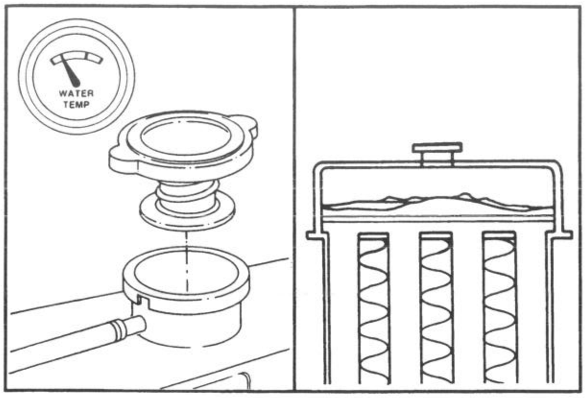


3. If the connections are corroded, remove the cables and use a battery brush to clean the cables and battery terminals.
4. Install and tighten the battery cables. Use grease to coat the battery terminals to prevent corrosion.
5. After installing the cables, re-check the connections as shown previously.

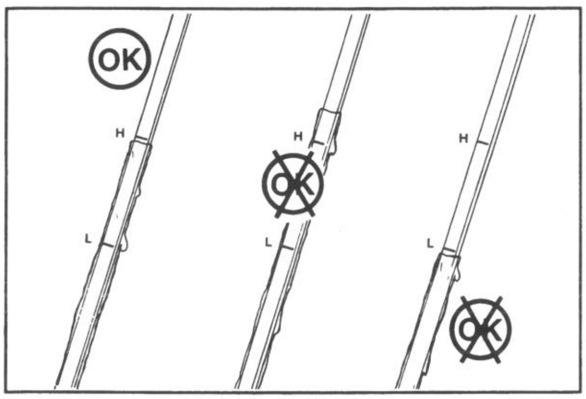


Pre-Start-up procedures (5-06)

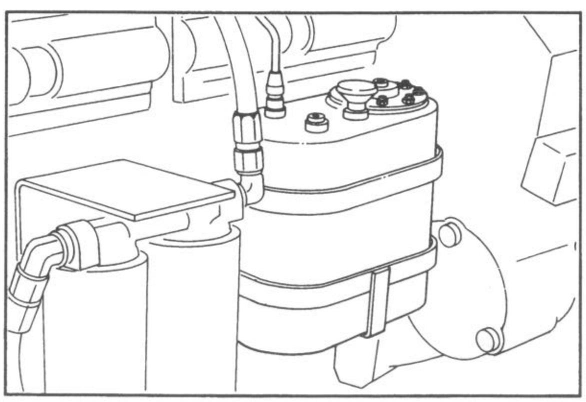
Note: This procedure is based on an installation start-up test having been successfully completed.



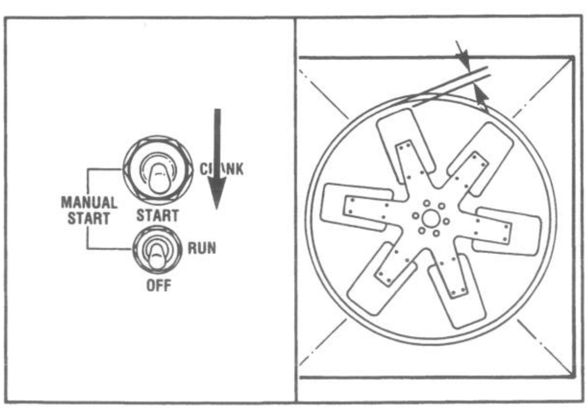
1. Remove the radiator or fill cap and check the coolant level. Add coolant if necessary.



2. Check the oil level. Add oil as necessary to bring the level up to the "H" (high) mark on the dipstick.



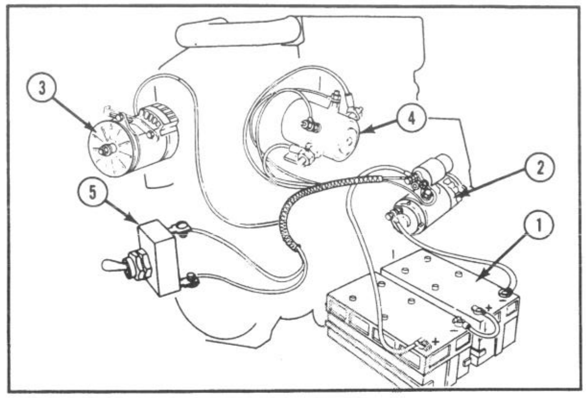
3. Verify that the fuel lines are connected and that fuel is available to the engine.
4. Check the level of fuel in the float tank (if the unit has a float tank).



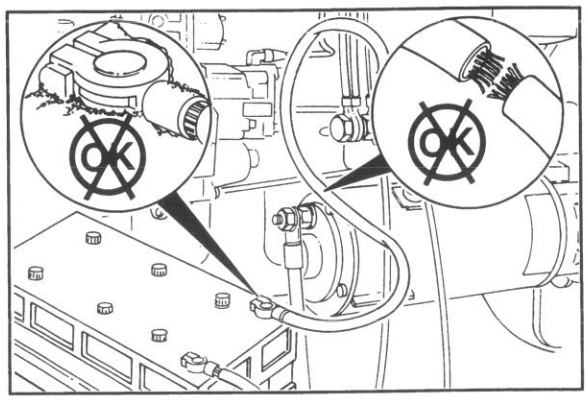
5. Verify that the "off-run-start" switch is in the "off" position.
6. Push the crank switch to crank the engine one revolution.
7. Check the generator fan and engine fan shroud clearance. Check all other rotating components for obstructions.

Starting Circuit - Check (5-07)

The starting circuit includes the batteries (1), starting motor (2), alternator (3), auxiliary magnetic switch (4), toggle crank switch (5), wiring harness and engine control panel circuit breaker.



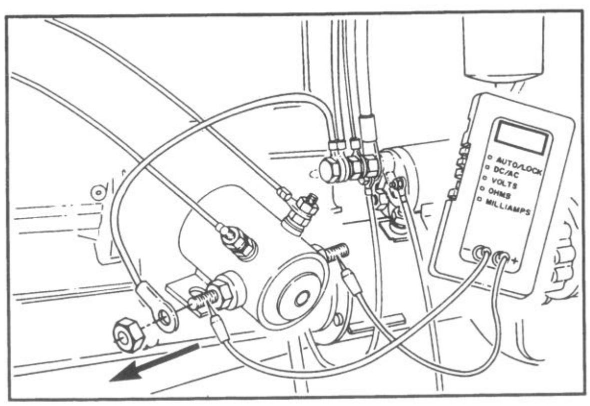
Before checking specific starting system components with a mulimeter, visually inspect all terminals for loose, broken, or corroded connections. Repair or replace broken wires or terminals.



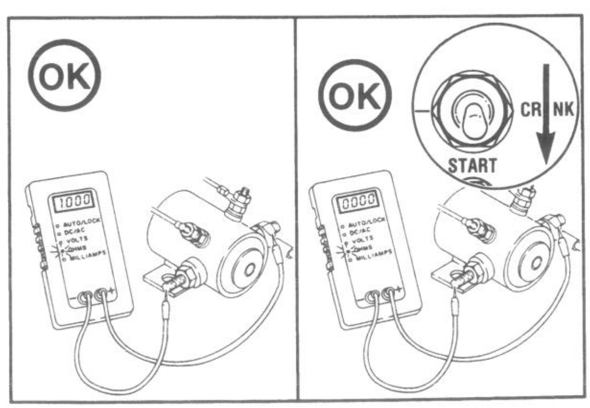
Auxiliary Magnetic Switch - Check

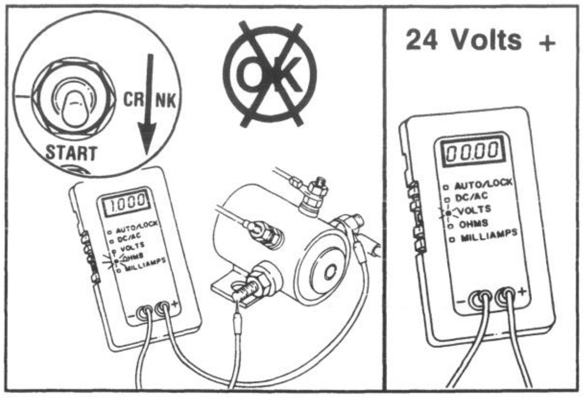
Note: KTA-38 and KTA-50 series engines have two starting motors.

1. Remove the cables connecting the auxiliary magnetic switch to the starter solenoids from the magnetic switch terminal.
2. Use multimeter Part No. 3376898 and set it to measure ohms. Connect the leads of the meter to the two large switch terminals. The meter must indicate resistance at infinity.

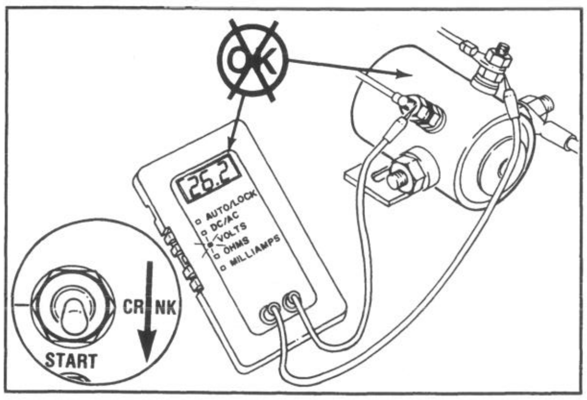


3. Push the engine crank switch down (crank position). The meter must indicate zero ("0") or very little resistance.

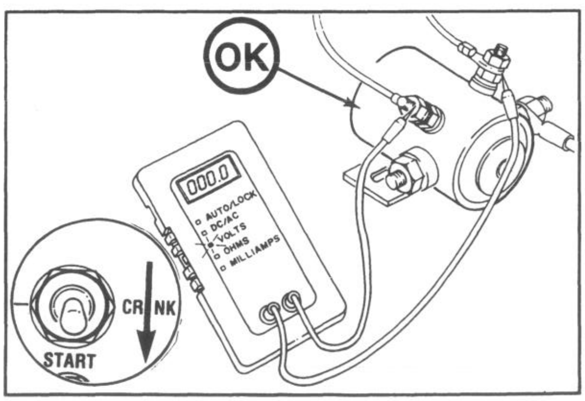




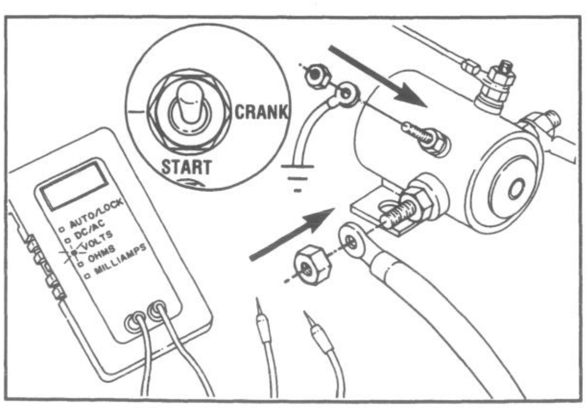
4. If the meter indicates resistance at infinity with the switch in the " crank" position, release the switch. Set the multimeter to read D.C. voltage.



5. Connect one meter lead to the auxiliary magnetic switch ground wire terminal (wire 12) and the other lead to the other small terminal.
6. Press the " crank" switch. If the meter indicates system voltage, the magnetic switch is malfunctioning and must be replaced.



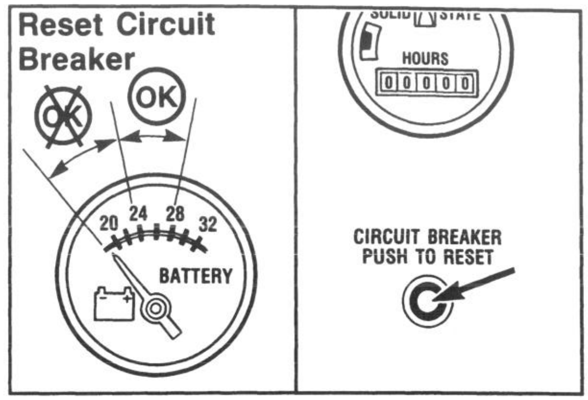
7. If the meter indicates no voltage, the magnetic switch is not the cause of the complaint. Refer to " Crank Switch - Check" procedure.



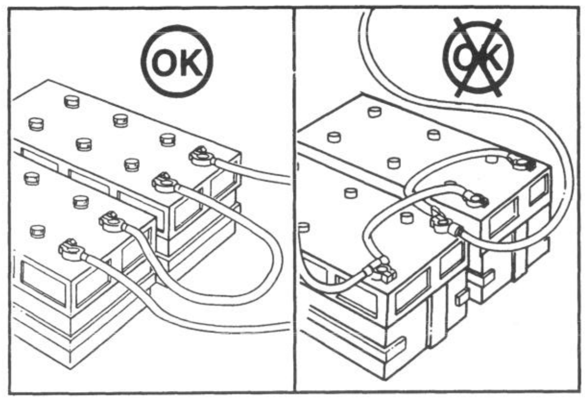
8. Release the " crank" switch. Remove the multimeter leads and re-connect the starter solenoid wire #73 to the magnetic switch terminal.

Crank Switch - Check

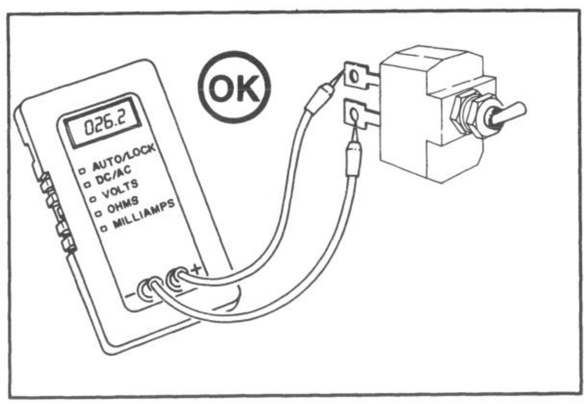
1. Verify that the battery gauge indicates system voltage (24 to 28 volts).
2. If the battery gauge does not indicate system voltage, reset the engine control panel circuit breaker. The white button on the circuit breaker should stay depressed.



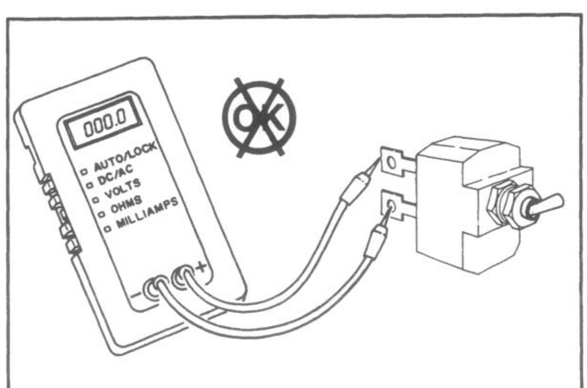
3. Verify that the batteries are connected for a nominal 24 volts and that the batteries are charged. Refer to Procedure 5-04 and 5-05.



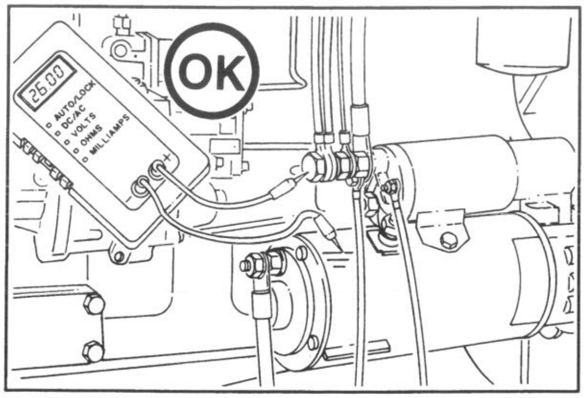
4. Use multimeter Part No. 3376898 and set it to measure D.C. voltage. Connect the leads of the meter to the crank switch terminals. The meter should indicate system voltage.



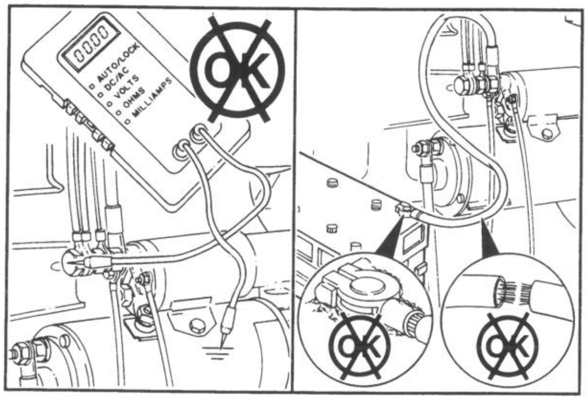
5. If the meter does not indicate voltage, there is a defective connection in wire #2 between the crank switch and the auxiliary magnetic switch.
6. Check for a defective connection in each of the following plugs used: Plug J, Plug E, Plug A, Plug G, and Plug C. Repair or replace defective connections.



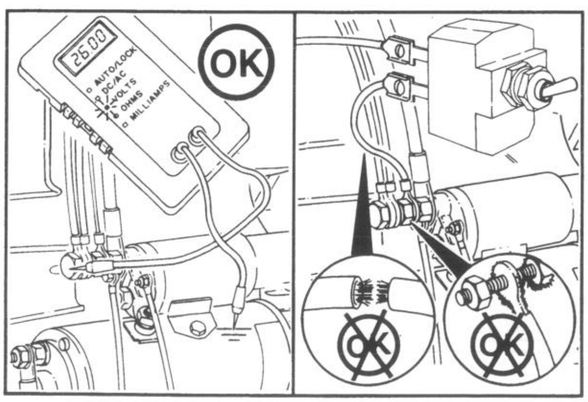
Starter Solenoid and Starter - Check



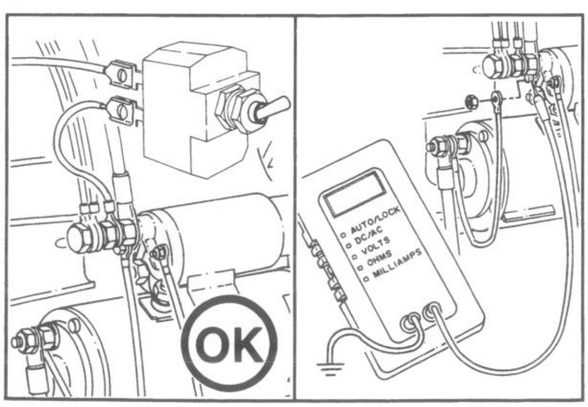
1. Use multimeter Part No. 3376898 and set it to measure D.C. voltage. Connect the meter positive lead to the starter solenoid positive terminal and the negative lead to the battery ground connection at the starter. The meter must indicate system voltage.



2. If the meter does not indicate system voltage, check the cable connecting the starter solenoid and battery for breaks, loose, or corroded connections.



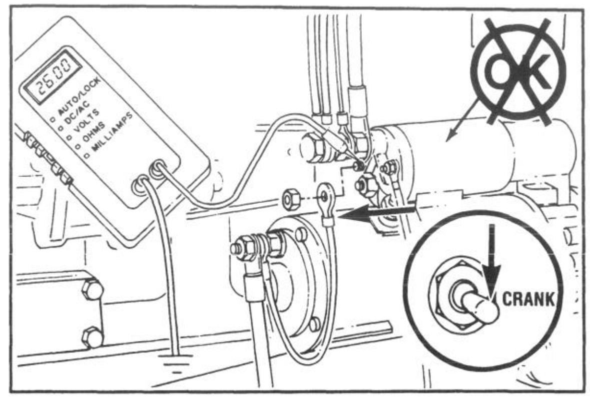
3. If the meter indicates system voltage but the starter will not operate, check the wire connecting the starter solenoid to the starter switch for breaks, loose or corroded connections.
4. If the starter does not crank the engine, manually bar the engine to check for a hydraulic lock. Refer to specific engine troubleshooting and repair procedures to correct the problem.



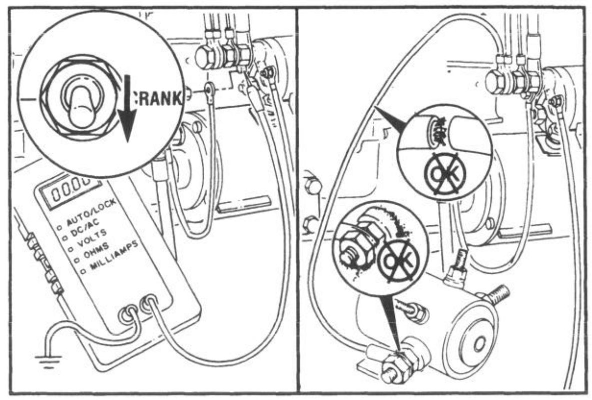
5. If the wire connecting the starter solenoid and starter switch is not loose or damaged and the starter will not operate:

   a. Remove the cable connecting the starter and starter solenoid from the solenoid terminal. Connect the meter positive lead to the solenoid positive terminal and the negative lead to a chassis or engine ground location.

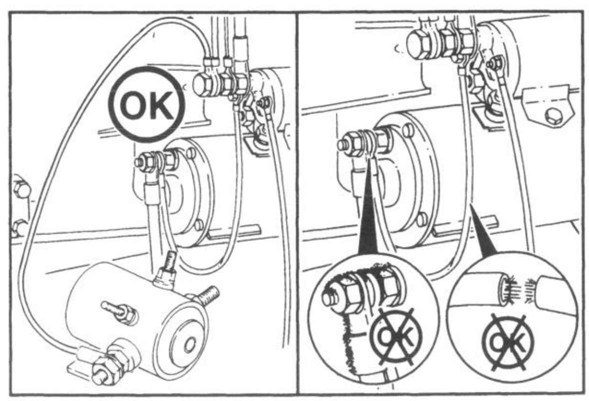
b. Press the "crank" switch. If the meter indicates voltage, the starter solenoid is malfunctioning and must be replaced.



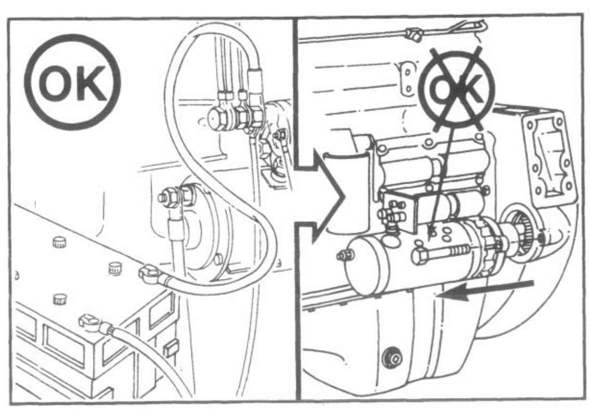
c. If the meter does not indicate voltage, check the wire connecting the starter solenoid to the magnetic switch for breaks, loose or corroded connections.



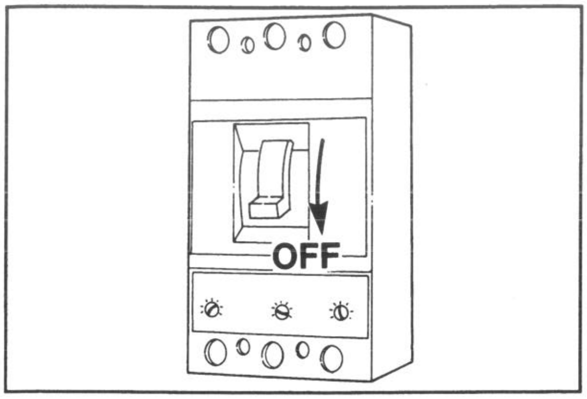
d. If the wire connecting the starter solenoid to the magnetic switch is not loose or damaged and the starter will not operate. Check the cable connecting the starter solenoid to the starter motor for breaks, loose or corroded connections.



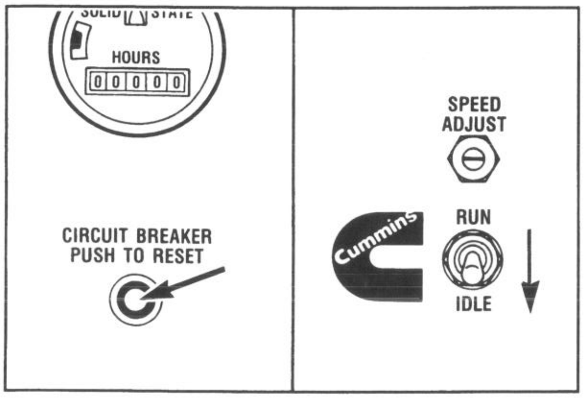
e. If the starter will still not operate, check the cable connecting the starter motor to the battery for breaks, loose or corroded connections. If the cable is not loose or damaged, the starter motor is defective and must be replaced.



Manual Starting (5-08)



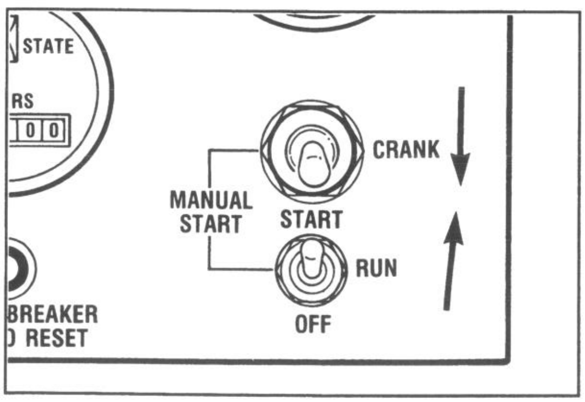
1. Perform pre-start-up procedures if the engine has not been started for more than a day.
2. Open the generator circuit breaker (if equipped).



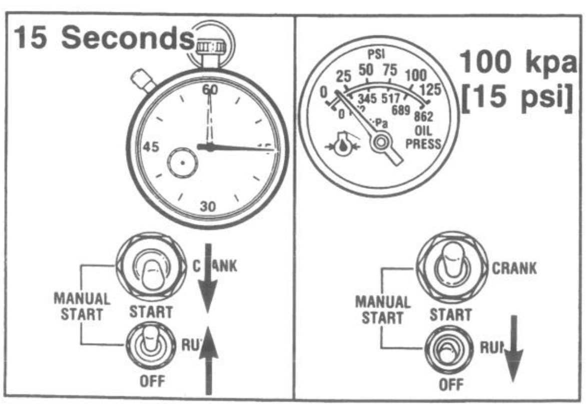
3. Check to see if the control panel D.C. circuit breaker is closed.
4. Move the engine control panel idle-run switch to the "idle" position, unless it is desired to operate the engine at rated speed immediately.

Note: Standby generator sets have coolant (and sometimes oil) heaters to assure rapid starting.

Prime power generator sets usually do not have auxiliary power available to heat the engine. Such units should be operated at low idle (550 to 650 RPM) for 5 to 20 minutes before bringing the engine up to rated speed.



5. Hold the engine control panel permissive start (off-run-start) switch in the "start" position, and press the "crank" switch to crank the engine.

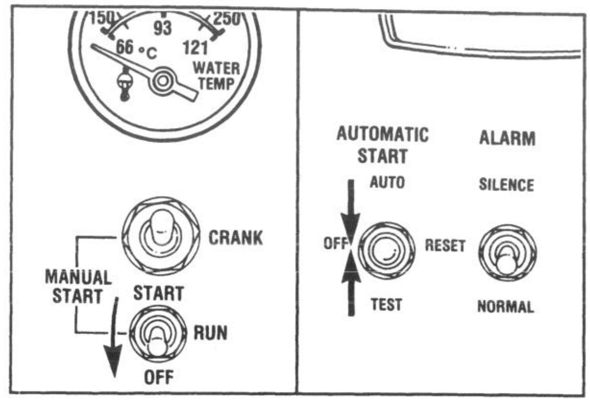


6. Crank the engine for 15 seconds or until the engine starts, then release the "crank" switch.
7. Hold the permissive start switch in the "start" position until the engine develops approximately 100 kPa [15 PSI] oil pressure, then allow the switch to return to the "run" position.

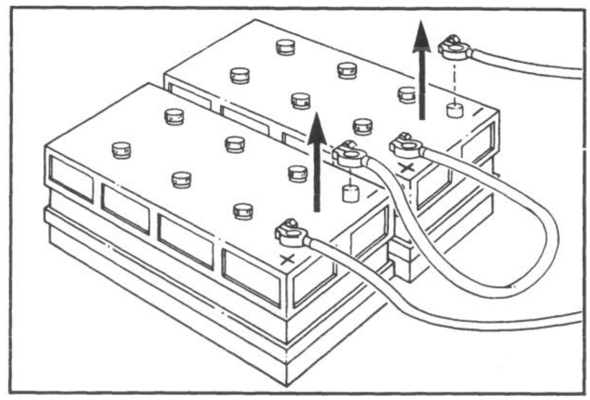
Automatic Starting Panel - Test (5-09)

Note: This applies only when an automatic starting control is included.

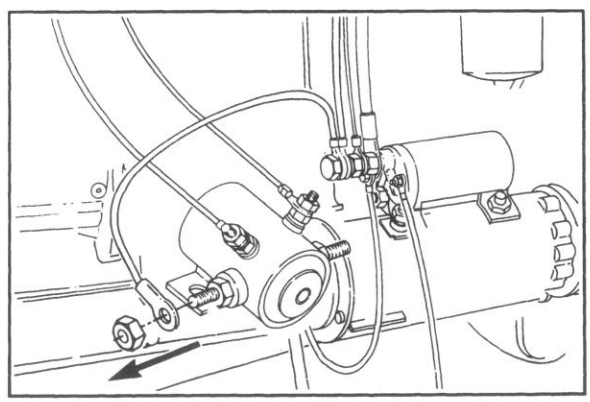
1. Place the off-run-crank switch on the engine control panel in the " off" position.
2. Place the automatic start switch in the " off-reset" position.



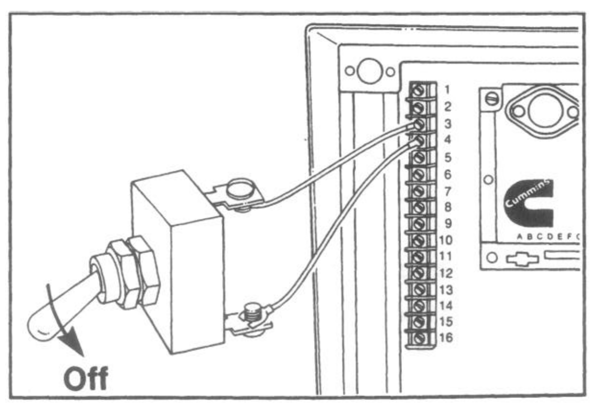
3. Remove the cable(s) from the negative battery terminal(s).

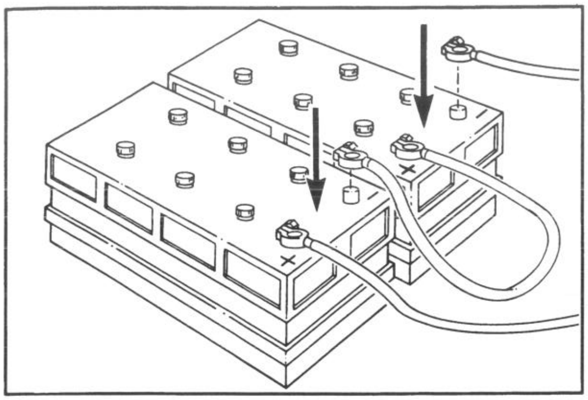


4. Remove the orange cable (#73) from the large terminal of the auxiliary magnetic switch.

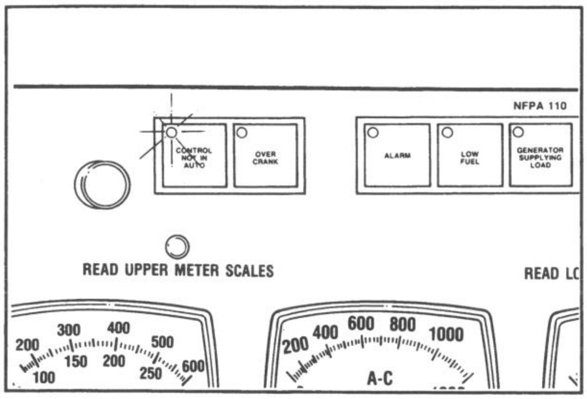


5. Install temporary leads from an on-off switch to the engine control panel terminals #3 and #4. Make sure the switch is in the " off" position.

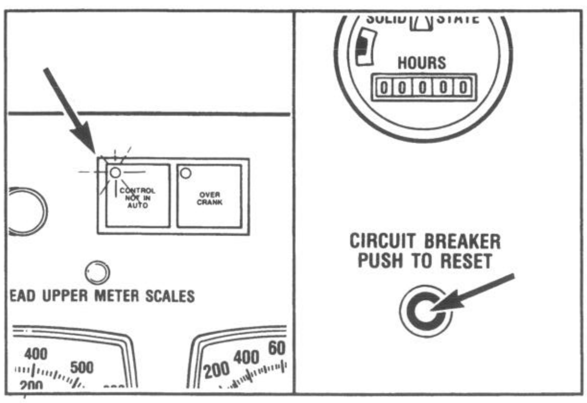




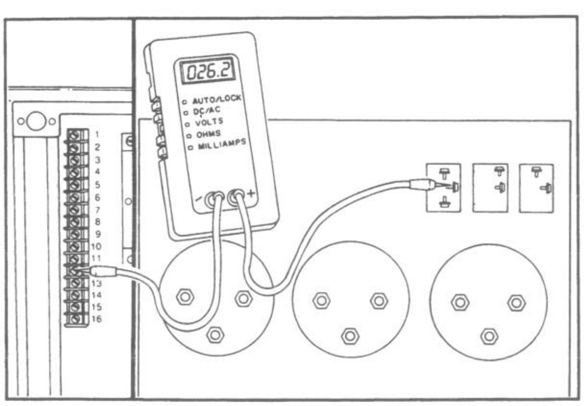
6. Re-connect the cable(s) to the negative battery terminal(s).



7. Observe the control panel " control not in auto" LED, it should be blinking.



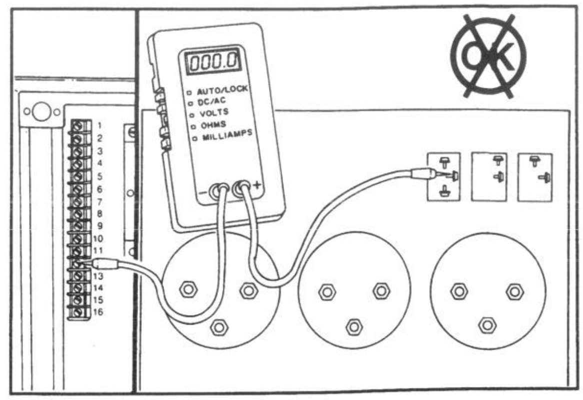
8. If the indicator light is not blinking, push the engine control panel circuit breaker to reset.



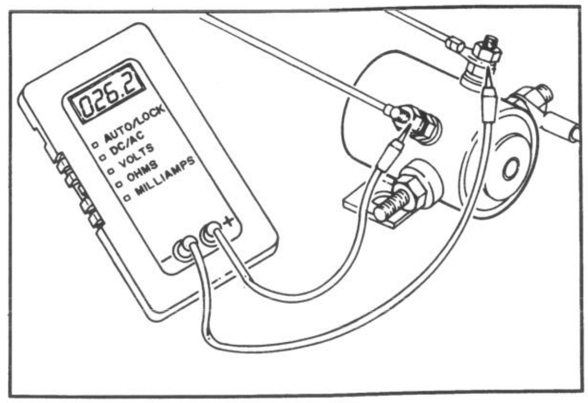
9. If the indicator light still is not blinking, test for system voltage. Use multimeter Part No. 3376898 and set it to measure D.C. voltage. Measure the voltage between the center terminal of the automatic start switch and terminal #12 (ground) of the engine control panel terminal strip.

10. The meter should indicate system voltage (24 to 28 volts).

11. If the meter does not indicate system voltage, there is a defect in wire #4 (red). Check plugs A, C, E, G, and L. Repair or replace the defective connection.

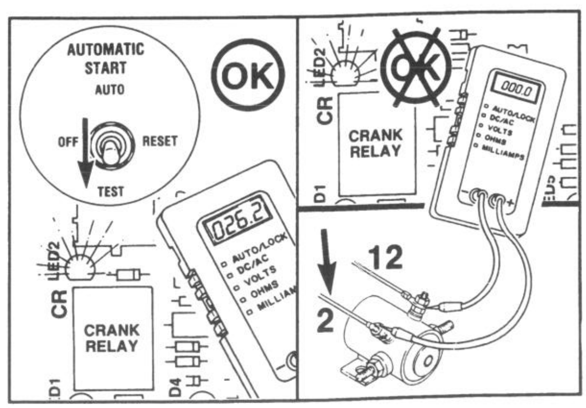


12. Make a crank cycle check. Use the multimeter Part No. 3376898 and set it to read D.C. voltage. Connect the meter leads to two small terminals on the auxiliary magnetic switch. Position the meter so it can be viewed from the generator control panel.

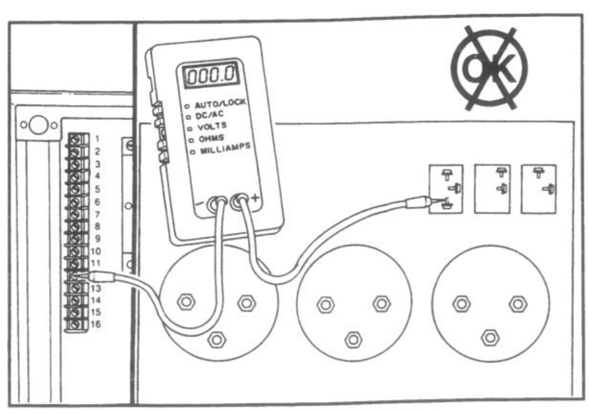


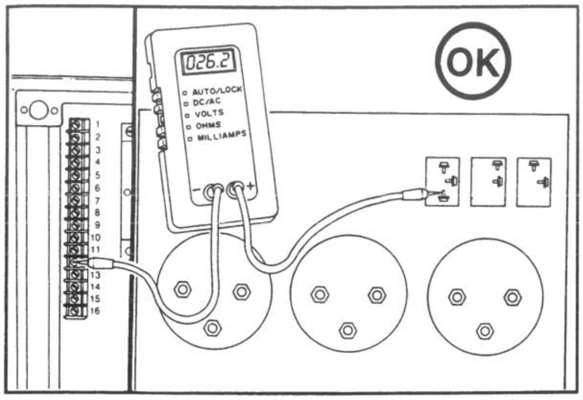
13. Move the automatic start switch to the " test" position. The meter should indicate 24 to 28 volts and the red CR (cranking relay) LED (light emitting diode) on the automatic starting panel should light.

14. If the red CR relay LED lights, but the meter indicates no voltage, check for a defective connection in wire #2 (brown), pin 2 of plugs A, C, E and G.

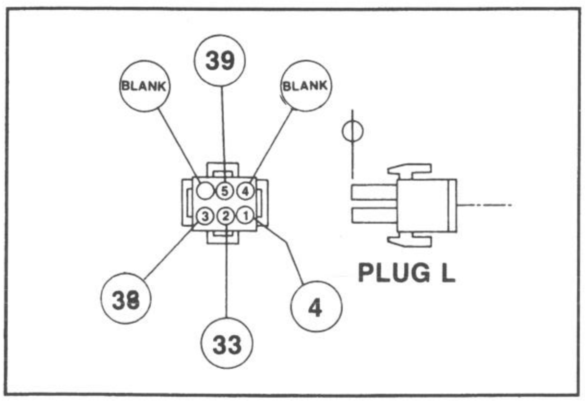


15. If the red CR relay LED does not light, use the meter and check for system voltage. Measure the voltage between the automatic start switch (top terminal when the panel is closed) and terminal #12 (ground) of the engine control panel terminal strip.

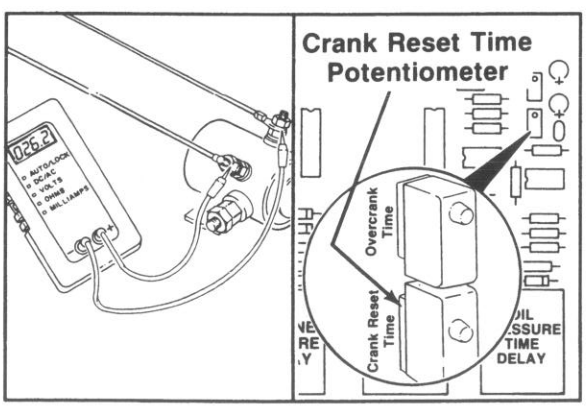




16. If there is no voltage to the top terminal of the automatic start switch, but there is system voltage at the center switch terminal, the switch is either defective or not in the "test" position. Check and repair or replace as required.

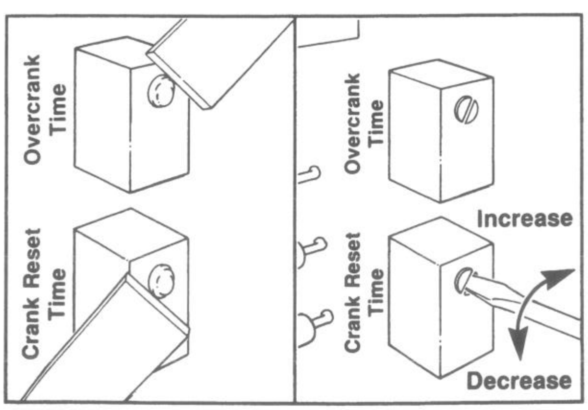


17. If there is system voltage at the top terminal of the automatic start switch, but the red CR relay LED is not on, there is either a defective connection in plug L pin #5 or the automatic start panel is defective. Check and repair or replace as required.



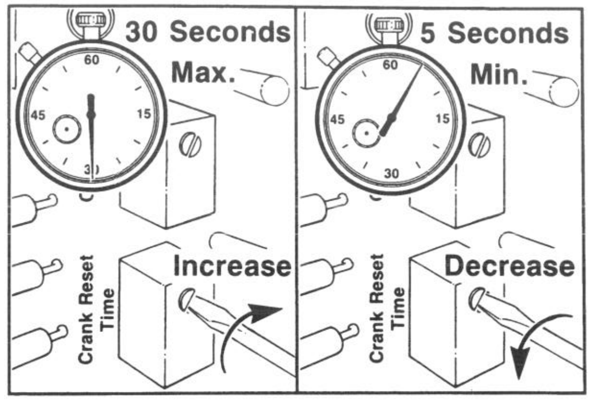
18. Re-connect the meter to the small terminals of the auxiliary magnetic switch. The voltage between the terminals should be 24 to 28 volts for the selected cranking cycle (usually 15 seconds). The red CR relay LED should remain lighted during this time.

19. The cranking and rest periods are approximately equal. They are adjusted by the lower blue soft plastic encapsulated 10 turn potentiometer labeled "Crank-Rest Time". This potentiometer is located in the upper right quarter of the automatic cranking panel circuit board.

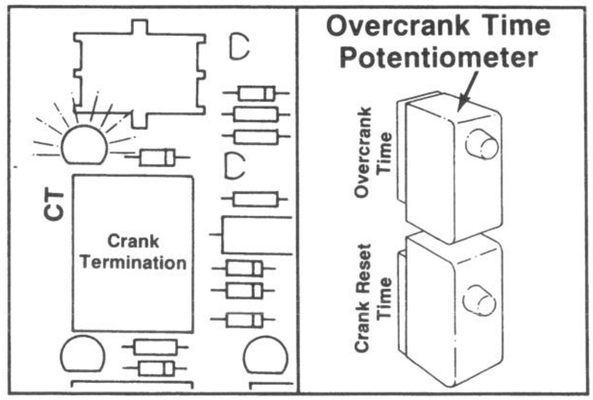


20. To change the cranking and rest periods, remove the encapsulation with a knife. Use the Part No. 3376313 potentiometer screwdriver to adjust the potentiometer.

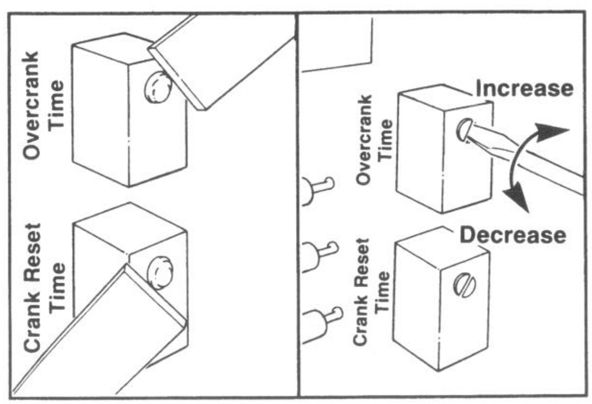
21. Turn the potentiometer clockwise to increase the cranking and rest time. Maximum time is approximately 30 seconds.
22. Turn the potentiometer counter-clockwise to decrease the cranking and rest time. Minimum time is approximately 5 seconds.
23. Replace the automatic cranking panel if the crank and rest periods can not be adjusted to the desired time, if within these limits.



24. The overcranking time is set for 80 to 90 seconds. This period allows for approximately 3 cranking and 2 1/2 rest periods. When an overcranking condition has occurred, the red CT relay LED will light. The overcrank time is a time delay relay. It does NOT count cranking attempts.
25. The overcranking time period can be adjusted by the blue soft plastic encapsulated 10 turn potentiometer labeled " Overcranking Time". This potentiometer is located above the " Crank-Reset time potentiometer.



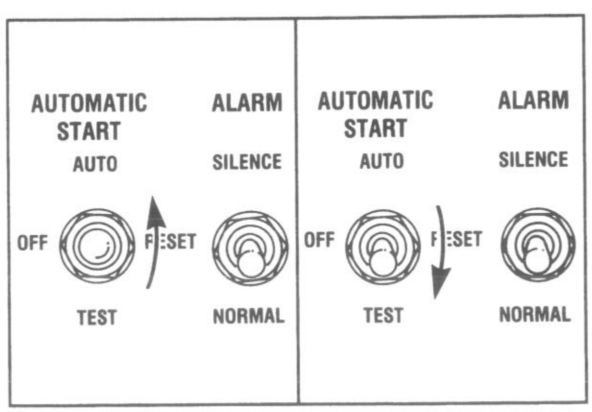
26. To change the overcranking time, remove the encapsulation with a knife. Use the Part No. 3376313 potentiometer screwdriver to adjust the potentiometer.
27. Turn the potentiometer clockwise to increase the overcranking time. Maximum time is approximately 240 seconds.
28. Turn the potentiometer counter-clockwise to decrease the overcranking time. Minimum time is approximately 35 seconds.
29. Replace the automatic cranking panel if the overcranking time can not be adjusted to the desired time, if within these limits.

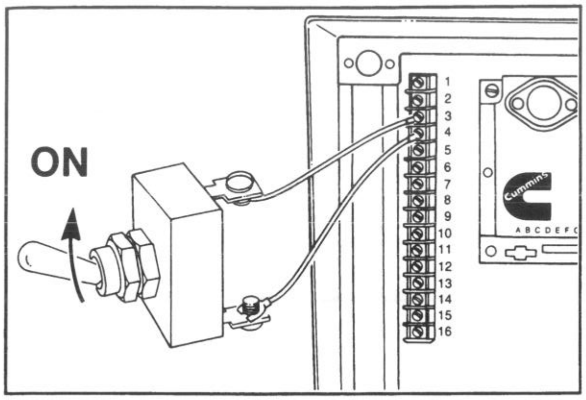


Oil Pressure Time Delay Check (OPTD)

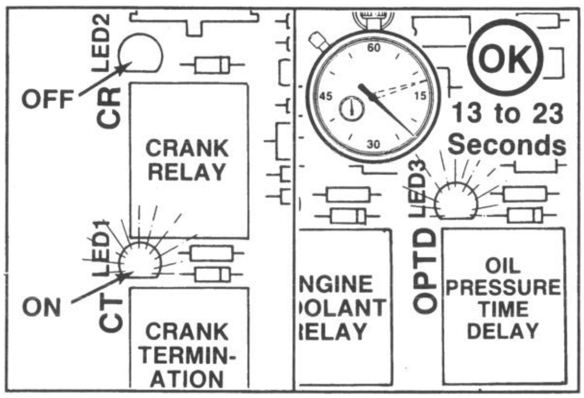
Test the oil pressure time delay circuit as follows:

1. Move the automatic start switch on the generator control panel to the " Off-Reset" position, and then back to the test position.

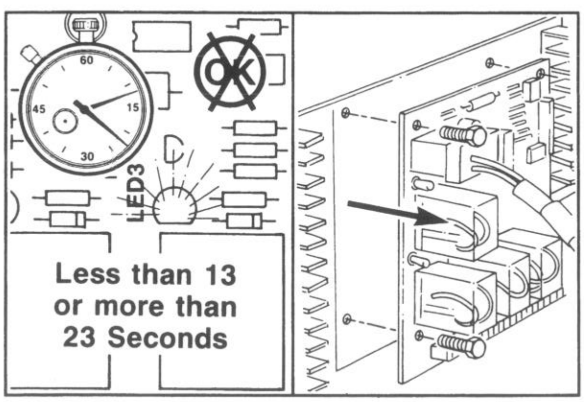




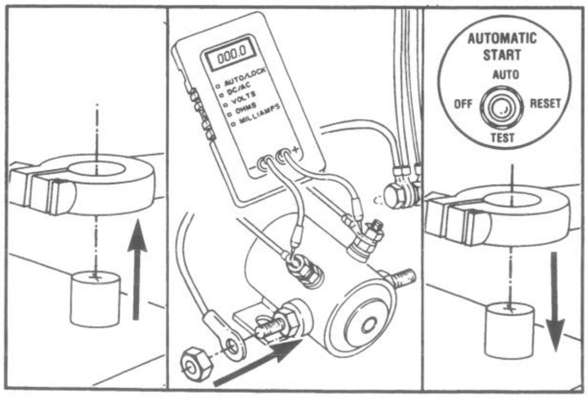
2. While the CR relay LED is lighted, move the auxiliary switch connected to the engine control panel terminal strip terminals #3 and #4 to the "On" position. This provides a signal to the automatic cranking panel that indicates the engine is running.



3. The CR relay LED should go off immediately and the CT (crank termination) relay LED should light.
4. Measure the time from when the auxiliary switch was turned on until the oil pressure time delay relay LED lights.
5. The oil pressure delay circuit is functioning satisfactory if this delay is 13 to 23 seconds.



6. Replace the automatic starting panel if the oil pressure time delay is less than 13 seconds or more than 23 seconds. This time delay is not adjustable.
7. Test a new automatic cranking panel to verify correct operation.

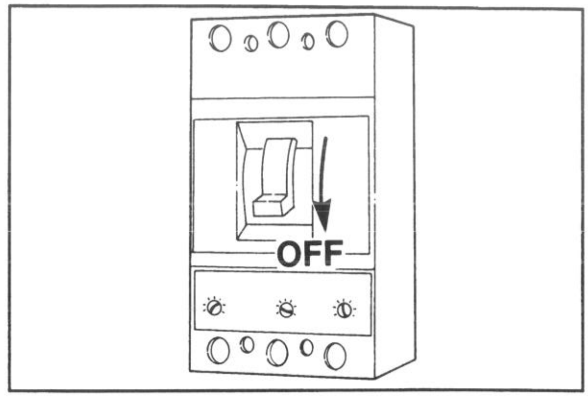


8. Remove the negative cable at the battery and the multimeter from the auxiliary magnetic switch.
9. Remove the auxiliary On-Off switch. Re-install wire #73 on the auxiliary magnetic switch. Place the automatic start switch in the "Off-Reset" position.
10. Re-install the negative cable to the battery.

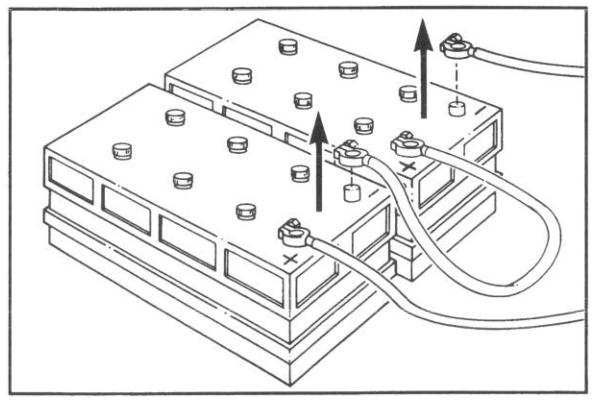
Automatic Starting - Check (5-10)

Note: This procedure applies only when an automatic starting control is included.

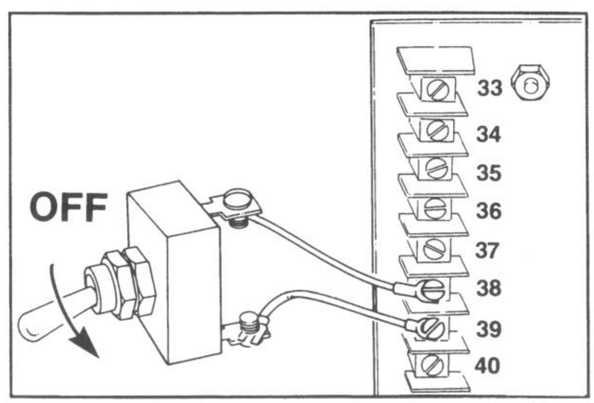
1. Perform pre-start up procedures if the engine has not been run for a day or more.
2. Open the main line circuit breaker (if the unit is equipped with one).



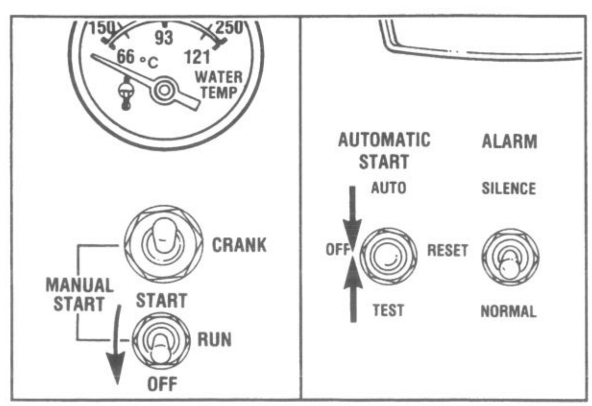
3. Remove the negative battery cable from the battery.

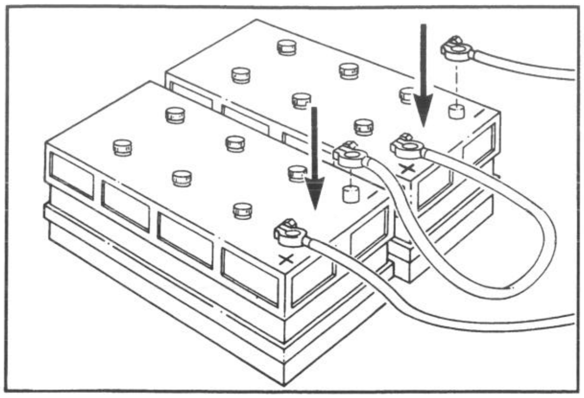


4. Open the generator control panel and install 380 to 760 mm [15 to 30 inch] leads from an auxiliary " On-Off" switch to the generator control panel terminals #38 and #39. Place the switch in the " Off" position. Close the generator control panel.

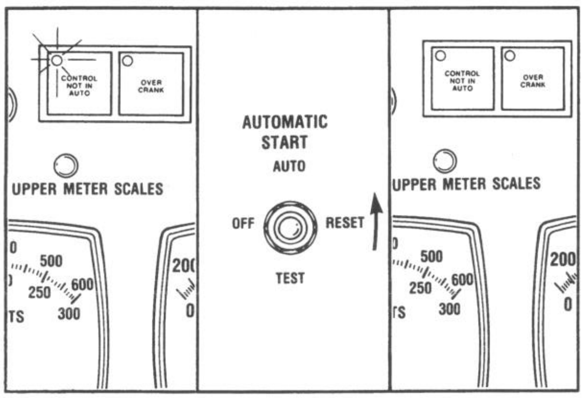


5. Verify that the automatic start switch on the generator control panel is in the " Off-Reset" position.
6. Verify that the " Off-Run-Start" switch on the engine control panel is in the " Off" position.

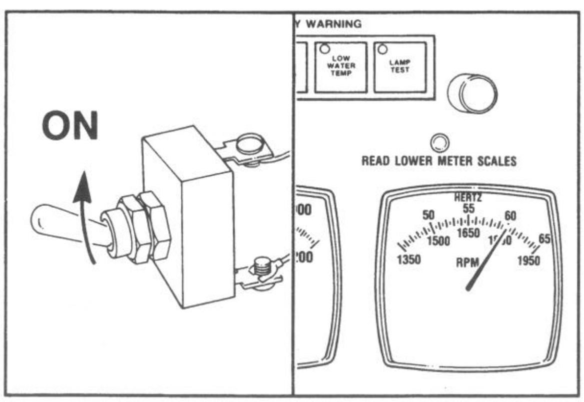




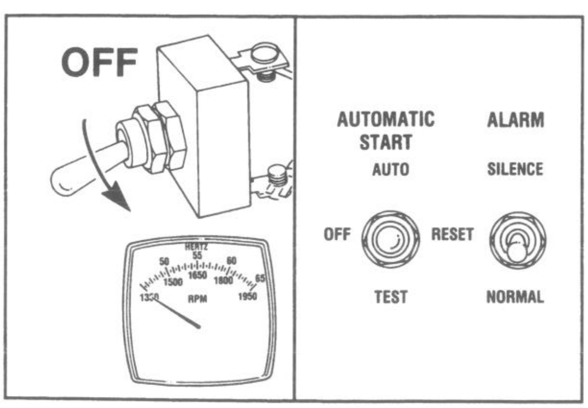
7. Re-connect the batteries.



8. The "Control not in automatic" light should be blinking.
9. Move the automatic start switch up to the "Auto" position. The "Control not in automatic" light should stop blinking and remain off.

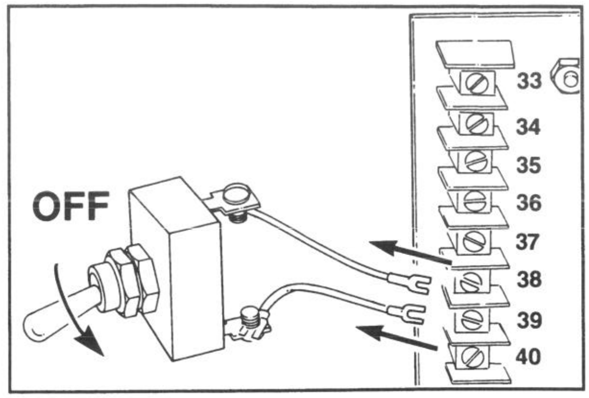


10. Turn the auxiliary switch, which has been added, to the "On" position. The engine should start cranking immediately. It should then start and continue running.



11. After testing, move the switch to the "Off" position. The engine should stop. If the engine does not stop, refer to troubleshooting procedure (Engine will not stop) for help.
12. Move the automatic starting switch to the "Off-Reset" position.

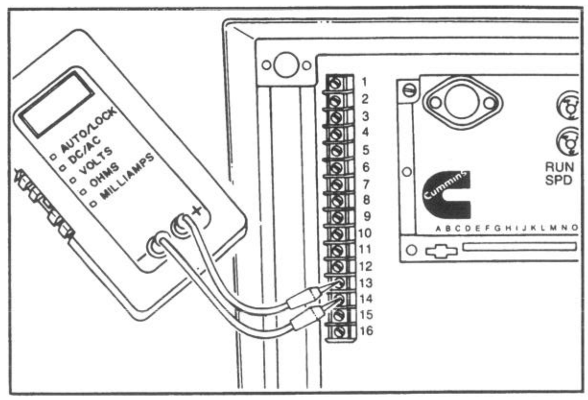
13. Remove the auxiliary switch leads from the generator control panel terminals #38 and #39.



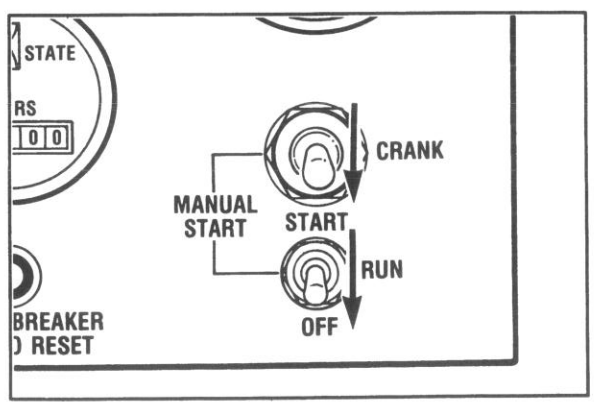
Speed Switch - Check and Calibration (5-11)

Note: The speed switch receives a speed signal from the magnetic pickup. A minimum of 1.5 volts A.C. during cranking is required.

1. Use multimeter Part No. 3376898 and set it to read a.c. voltage. Connect the meter to terminals #13 and #14 on the engine control terminal strip inside the engine instrument panel.

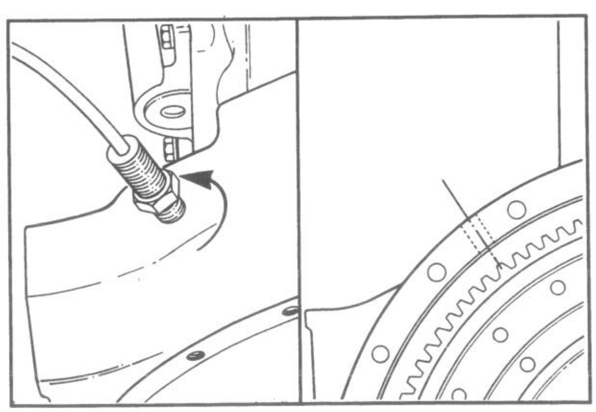


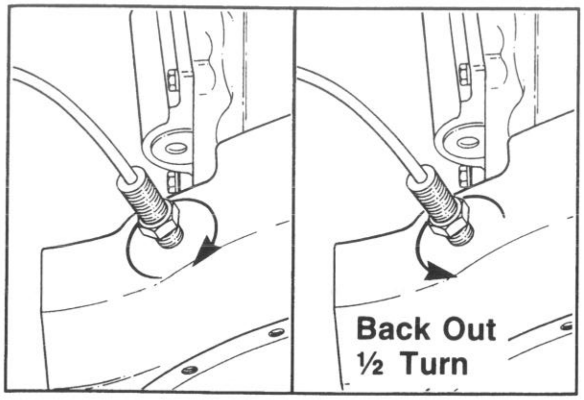
2. Make sure the "Off-Run-Start" switch is in the "Off" position. Press the engine crank toggle switch. Measure the voltage at the terminal strip.



3. If the magnetic pickup signal is less than 1.5 volts A.C. while cranking, remove the pickup from the flywheel housing.

4. Rotate the flywheel until a ring gear tooth is directly below the pickup hole.

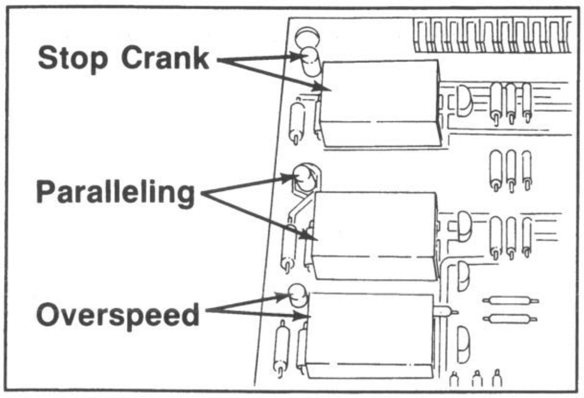




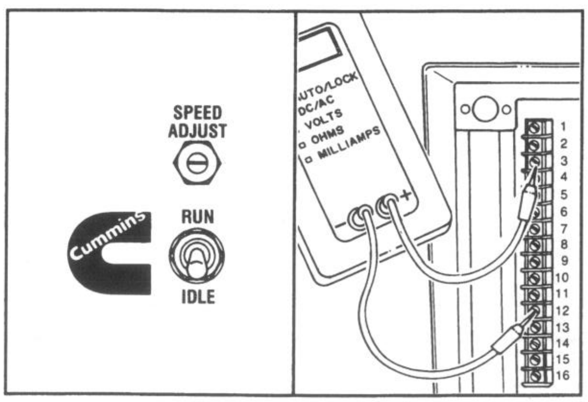
5. Screw the pickup in until it contacts the ring gear tooth. Do not use excessive force when installing the pickup.

Note: If the pickup does not screw in with light finger force, check the hole and pickup threads. Clean up the threads if necessary.

6. Back the pickup out 1/2 turn and tighten the lock nut.
7. Re-check the pickup voltage output at terminals #13 and #14. If the voltage is less than 1.5 volts A.C., screw the pickup in 1/8 to 1/4 turn and tighten the lock nut.



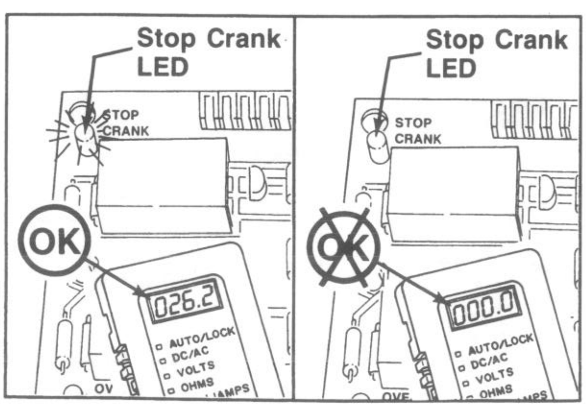
8. The current speed switch contains three separate relays and three LED's . The LED's light when their corresponding relay is energized. The relays and LED's are designated " Stop Crank" , Paralleling" and " Overspeed" .



Speed Switch Stop Crank Relay - Check

Check the " Stop Crank" portion of the speed switch as follows:

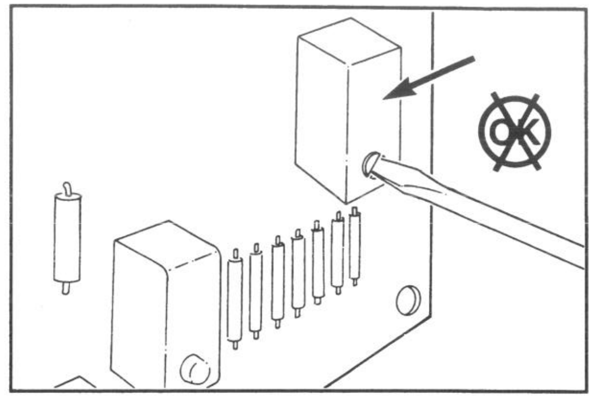
1. Move the " Idle-Run" switch to the " Idle" position.
2. Use multimeter Part No. 3376898 and set it to read D.C. voltage. Connect the meter to terminals #3 and #12 of the engine terminal block.
3. Manually start the engine.



4. The meter should indicate 24 to 28 volts and the stop crank LED should light as the engine comes up to idle.
5. Replace the speed switch if the meter does not indicate battery voltage when the engine is idling at 550 to 650 RPM.

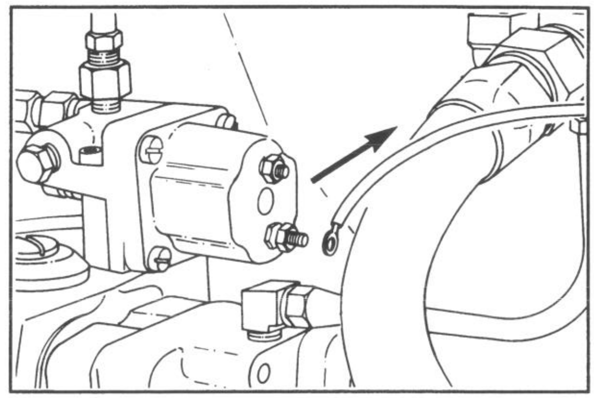
Note: The stop crank circuit is designed to operate at 325 to 375 RPM. This operating speed is not adjustable.

Caution: Do not attempt to adjust any of the calibration speeds by means of the blue soft rubber encapsulated potentiometer designated R8. This is a factory calibration and affects the trip point of all relay circuits.

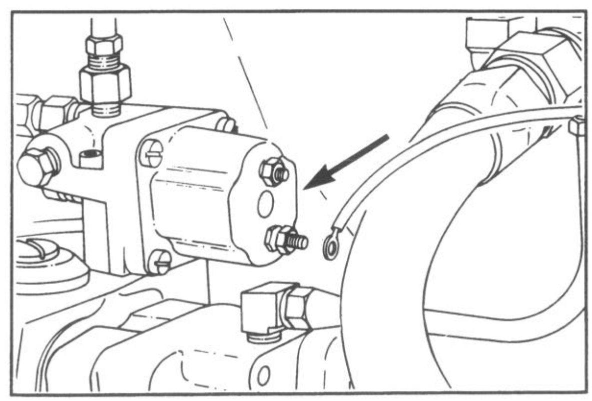


Note: Moving the "Off-Run-Start" switch to the "Off" position, resets the switch.

6. Remove the wire from the fuel solenoid valve. The stop crank LED should go off (the relay should reset) as the engine stops. The design reset speed is 125 to 175 RPM.
7. Replace the speed switch if the stop crank LED is lighted when the engine is stopped.



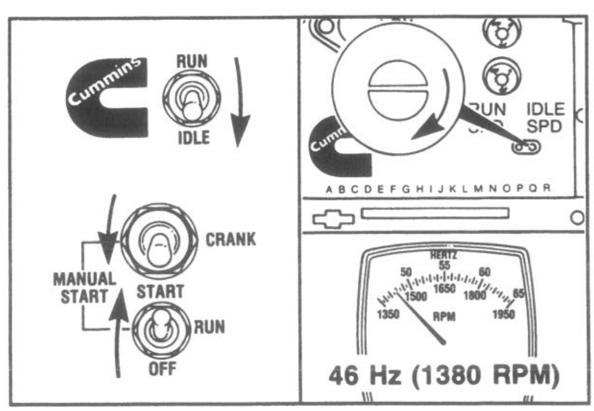
8. Move the "Off-Run-Start" switch to the "Off" position.
9. Replace the wire on the fuel solenoid valve.

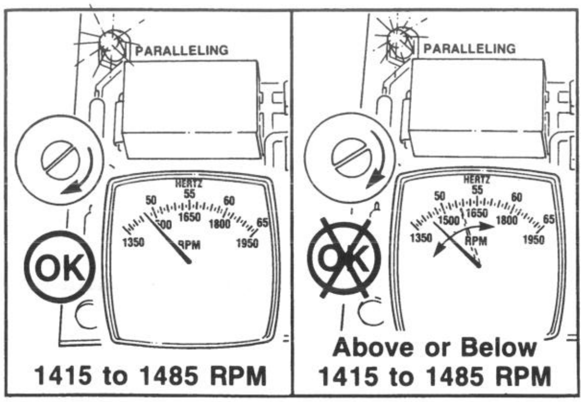


Speed Switch Paralleling Relay - Check

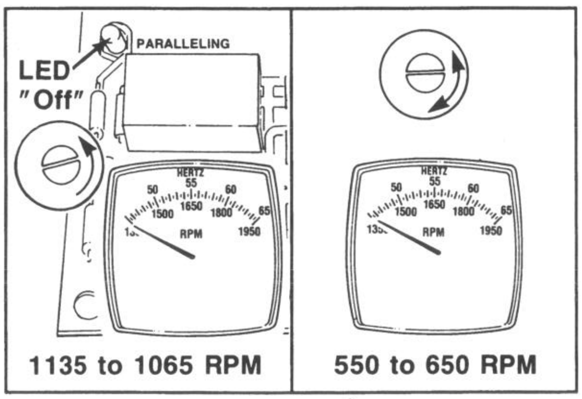
Check the Paralleling portion of the speed switch as follows:

1. Move the "Idle-Run" switch to the "Idle" position.
2. Start the engine.
3. Turn the "Idle" speed control on the governor clockwise until the generator control panel frequency meter reads 46 Hz (1380 RPM) or the engine control panel tachometer reads 1380 RPM.

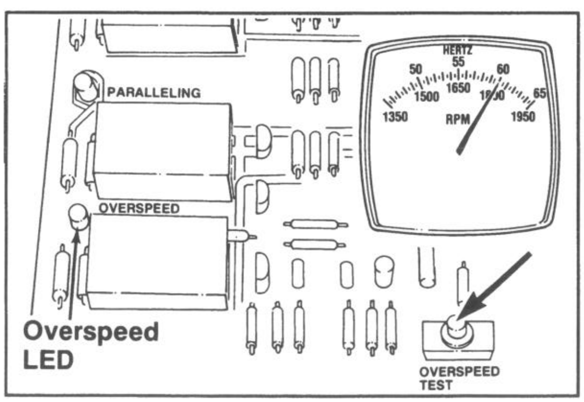




4. Continue to turn the idle speed adjustment clockwise slowly until the paralleling LED lights. Note the engine RPM or generator frequency at the time the LED lights.
5. The paralleling relay circuit is designed to operate at 47.17 to 49.5 Hz. (1415 to 1485 RPM). The paralleling relay trip speed is not adjustable.
6. Replace the speed switch if the switch operation is required for the control circuit and outside of the 1415 to 1485 RPM range.

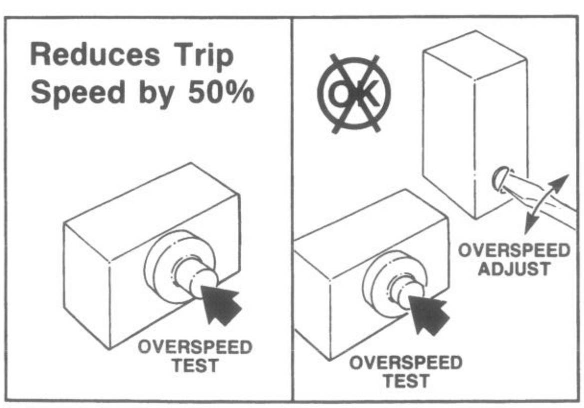


7. Turn the idle speed control counter-clockwise to decrease engine speed.
8. The paralleling relay control circuit is designed to reset (paralleling LED "Off") at 1135 to 1065 RPM. The actual speed at which the relay resets is usually not important. The relay reset speed is usually considered satisfactory if the relay resets above idle.
9. Adjust the idle speed to 550 to 650 RPM.



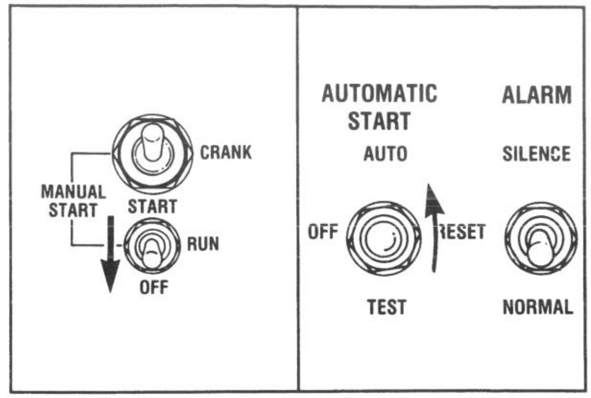
Speed Switch Overspeed Relay - Check and Calibration

1. Operate the engine at rated speed, either 1500 or 1800 RPM.

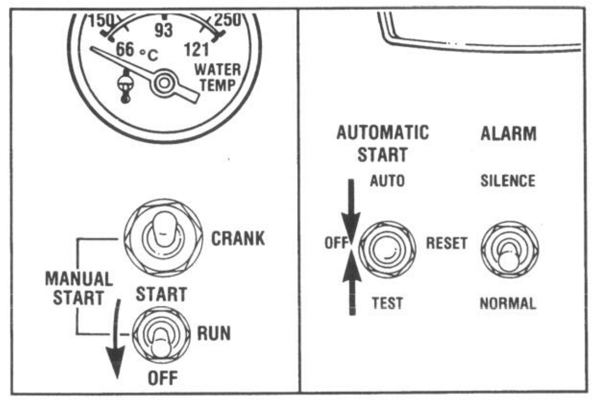


2. Press the "Overspeed Test" pushbutton in the bottom center section of the speed switch circuit board.
3. The Overspeed LED should light immediately and the engine should start coasting to a stop.
4. Replace the speed switch if the engine does not shut down when the Overspeed pushbutton is depressed.

Note: Pressing the "Overspeed Test" pushbutton switch reduces the trip speed of the Overspeed portion of the speed switch to one-half of its normal value. Example: Trip speed normal = 2070 RPM. With "Overspeed Test" pushbutton depressed, trip speed = 1035 RPM. This ratio is only an approximation and changes when the "Overspeed Adjust" pot is adjusted. Do not attempt to calibrate the Overspeed trip speed with the "Overspeed Test" pushbutton depressed.

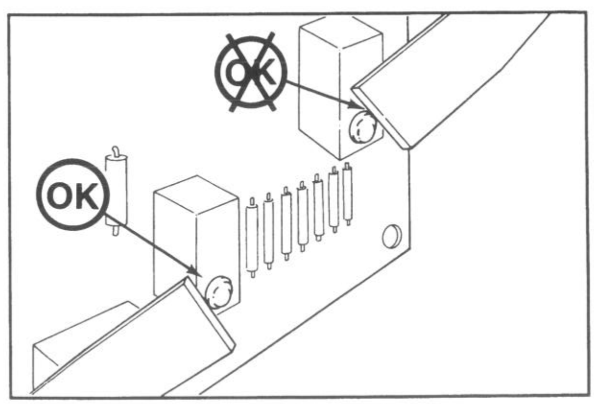


5. If the unit has been started manually, reset the overspeed by moving the "Off-Run-Start" switch to the "Off" position.
6. If the unit has been started by means of the automatic start panel, reset the overspeed by moving the automatic start switch to the "Off-Reset" position.



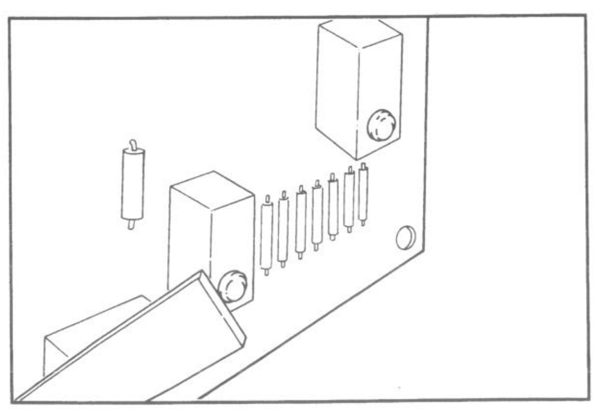
7. The normal overspeed trip setting is 2020 to 2070 RPM. The "Overspeed Adjust" (soft blue rubber encapsulated, 10 turn pot, next to the "Overspeed Test" pushbutton) is used to adjust the overspeed trip point. The "Overspeed Adjust" range is from 1725 to 2400 RPM.

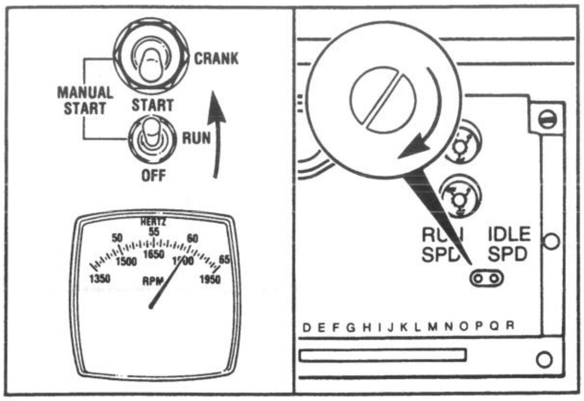
Note: Do not remove the encapsulation from the other pot on the right, as this will change all trip speeds - unequally.



Adjust the overspeed portion of the speed switch as follows:

1. Remove the encapsulation from the "Overspeed Adjust" pot with a knife.





2. Start the engine and bring it up to rated speed.
3. Adjust the run speed on the electric governor to the desired overspeed trip speed.
4. The engine speed can be measured at the engine control panel tachometer or with a hand held tachometer on the permanent magnetic exciter. Refer to Procedure 6-05 to remove the cover.

Chart 5

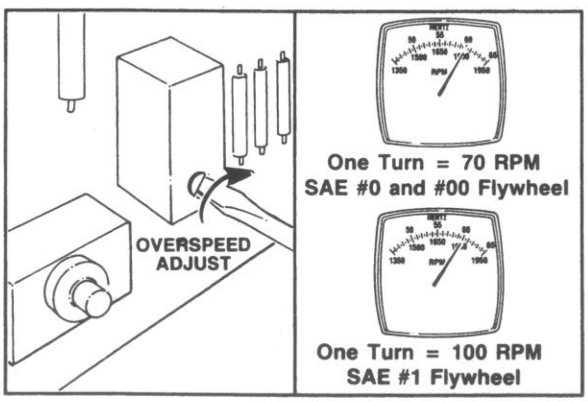
SAE Fly-wheel	Ring Gear Teeth	325	375	550	650	1380	1415	1485	1500	1800	2020	2070
		Magnetic Pick-up Frequency										
#1	118	639	737	1082	1278	2714	2783	2783	2950	3450	3373	4169
#0	142	769	888	1302	1538	3266	3349	3349	3550	4260	4781	5017
#00	168	910	1050	1540	1820	3864	3962	3962	4200	5040	5656	5936

(Column headings 325–2070: Engine RPM)

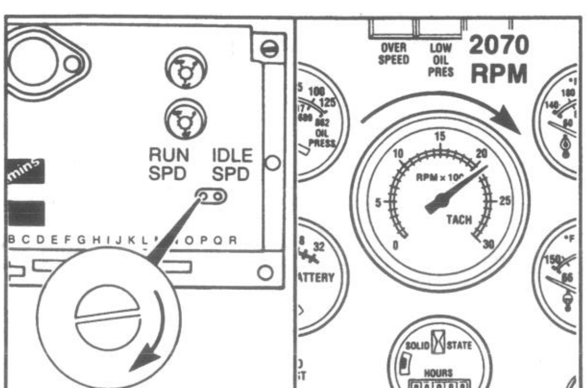
$$\text{Magnetic Pick-up Frequency} = \frac{\text{RPM} \times \text{Ring Gear Teeth}}{60}$$

$$\text{RPM} = \frac{\text{Magnetic Pick-up Frequency} \times 60}{\text{Ring Gear Teeth}}$$

5. The engine RPM can also be measured using a meter connected to terminals #13 and #14 of the magnetic pickup. Use a Fluke, model 8060A, in conjunction with Chart 5.

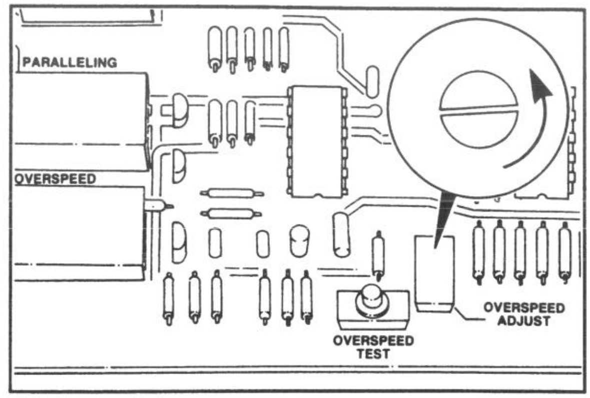


6. If the overspeed trips before the desired engine speed is reached, adjust the overspeed pot. Use Part No. 3376313 potentiometer screwdriver to turn the Overspeed Adjust" pot. One turn clockwise will increase the speed approximately 70 RPM with an SAE #0 or #00 flywheel or 100 RPM with an SAE #1 flywheel.
7. Move the " Off-Run-Start" switch to the " Off position or the Automatic start switch to the " Off-Reset" position to reset the speed switch.



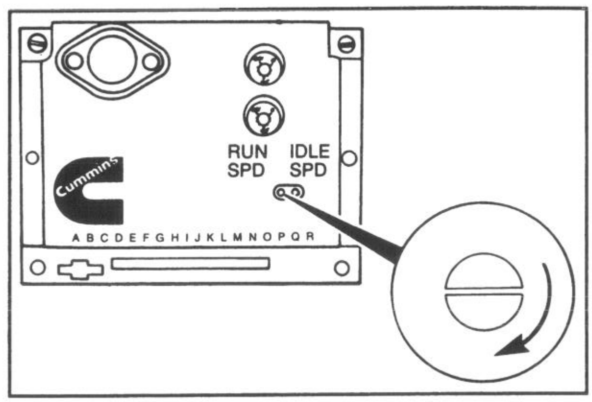
8. Restart the engine. Adjust the engine RPM to the desired overspeed trip point RPM.

9. Turn the "Overspeed Adjust" pot counter-clockwise slowly until the overspeed trips.

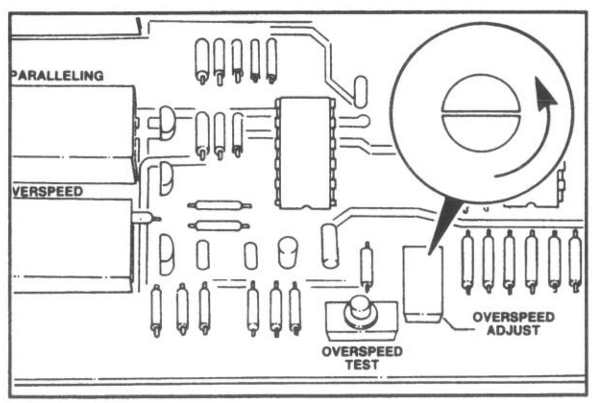


10. It may not be possible to raise the engine speed of some engines to the desired overspeed trip RPM because of the fuel pump governor. When this happens:

    a. Run the engine at maximum RPM and note the speed.

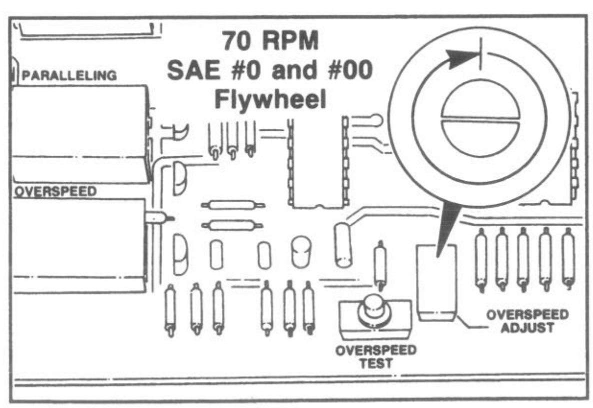


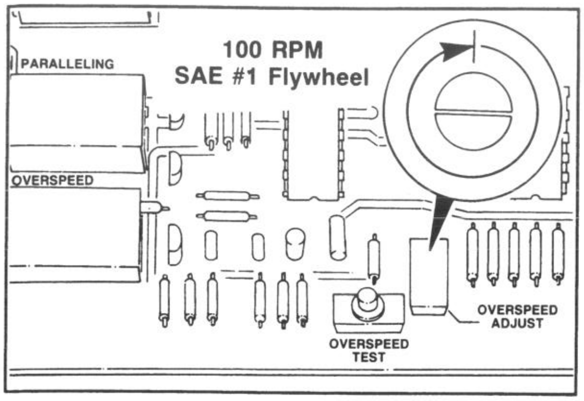
    b. Turn the "Overspeed Adjust" pot counter-clockwise slowly until the overspeed trips.



    c. For engines with an SAE #0 or #00 flywheel, turn the "Overspeed Adjust" clockwise one turn for each 70 RPM required to reach the desired overspeed trip RPM.

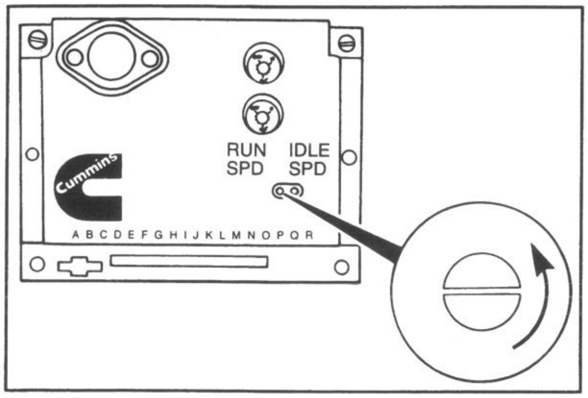
    Example: Maximum no load engine speed = 1950 RPM. Engine has #0 flywheel. Desired overspeed trip = 2070 RPM. 2070 RPM - 1950 RPM = 120 RPM. Overspeed has been turned down to trip at 1950 RPM. 120 RPM / 70 RPM per turn = 1.7 turns. Turn "Overspeed Adjust" clockwise 1.7 turns.



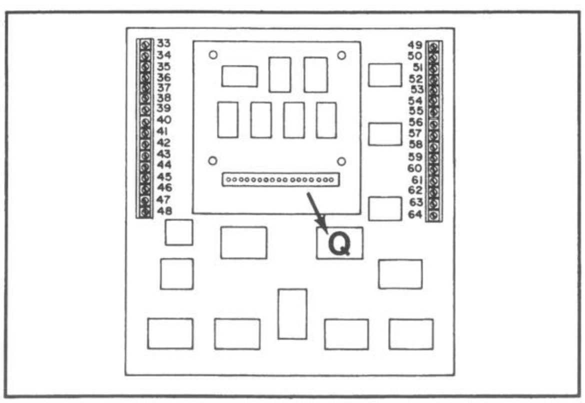


For engines with an SAE #1 flywheel, turn the " Overspeed Adjust" clockwise one turn for each 100 RPM required to reach the desired overspeed trip RPM.

Example: Maximum no load engine speed = 2010 RPM. Engine has #1 flywheel. Desired overspeed trip = 2070 RPM. 2070 RPM - 2010 RPM = 60 RPM. Overspeed has been turned down to trip at 2010 RPM. 60 RPM / 100 RPM per turn = 0.6 turns. Turn " Overspeed Adjust" clockwise 0.6 turns.



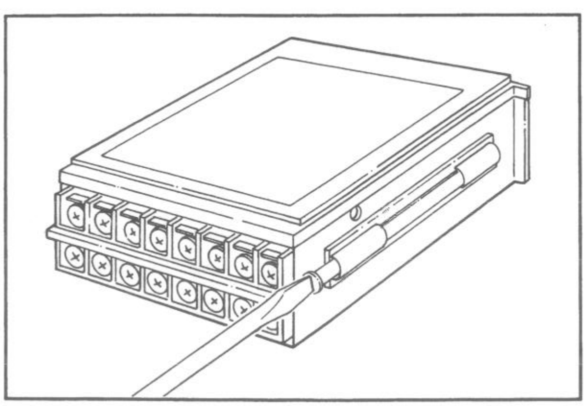
Adjust the no load engine speed back to the original speed by means of the run speed pot on the governor.



Kilowattmeter - Removal, Installation and Calibration (5-12)

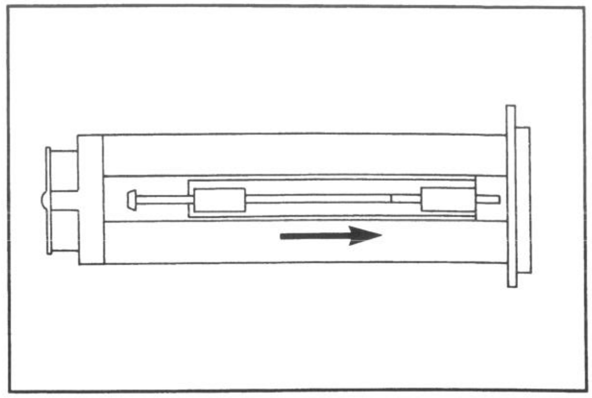
Remove the kilowattmeter from the generator control panel as follows:

1. Working inside the generator control panel, remove plug Q from the circuit board under the lower right hand corner of the automatic cranking panel.

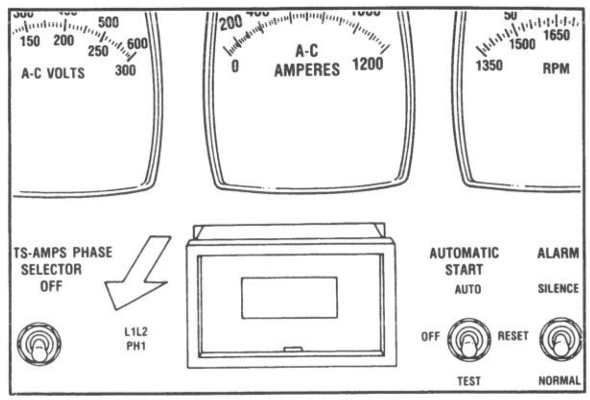


2. Unscrew the panel mount screws on each side of the kilowattmeter until there is 8 mm [5/16 inch] clearance between the end if each screw and the panel.

3. Push each panel mount towards the panel while holding the kilowattmeter bezel against the panel. The panel mounts slip towards the kilowattmeter bezel and out of the T slots in the kilowattmeter case.

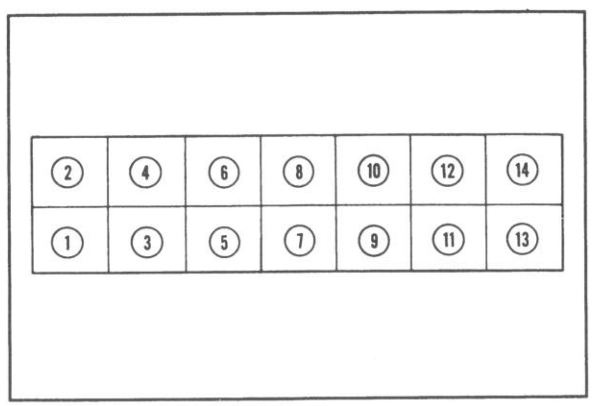


4. Pull the body of the kilowattmeter and leads through the control panel hole.

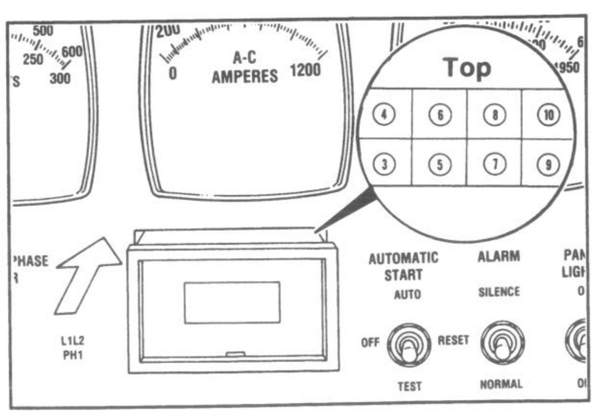


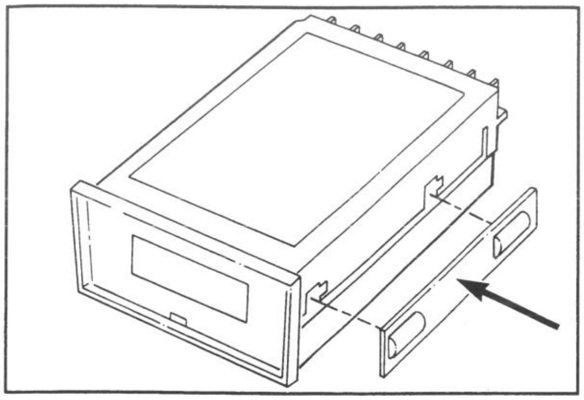
Install the kilowattmeter as follows:

1. Install the wires from plug Q harness on the corresponding terminals at the rear of the kilowattmeter. There are 11 wires in the harness. Terminals 8,9 and 11 are not used.

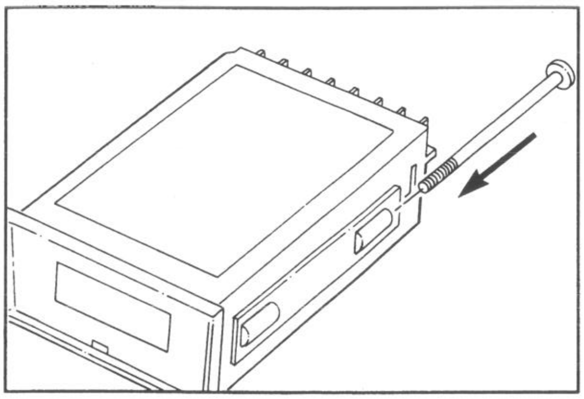


2. Insert the kilowattmeter in the generator control panel opening. Even terminal numbers must be at the top.

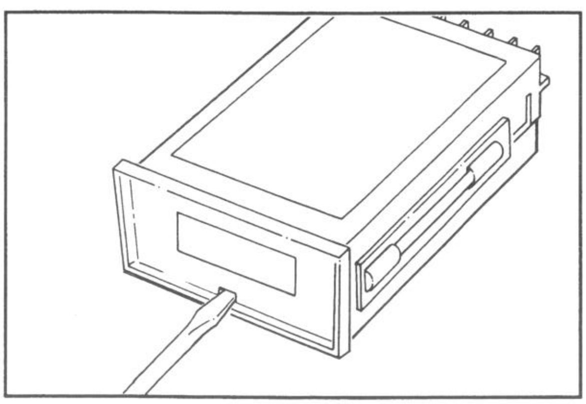




3. Place the plastic panel mounts in the T slots on each side of the kilowattmeter. Slide the panel mounts towards the rear of the kilowattmeter case as far as they will go.



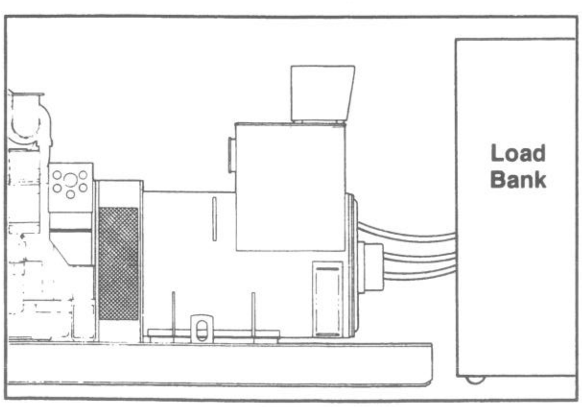
4. Install the panel mounts screws in the panel mounts. Turn the screws to draw the front bezel of the kilowattmeter up against the panel.



Note: A unity (1.0) power factor resistive load bank capable of loading the generator set to approximately full load is required for calibration of the kilowattmeter.

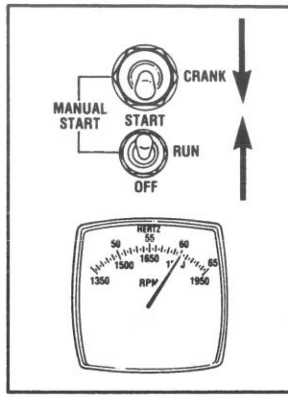
Calibrate the kilowattmeter as follows:

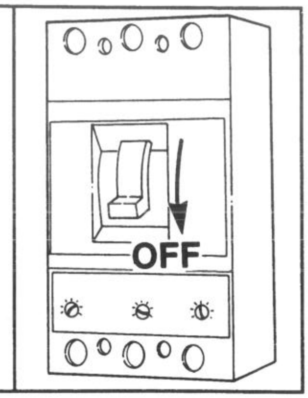
1. Remove the plastic front face of the kilowattmeter. Insert a small pointed tool into the notch at the bottom of the face and snap the face out.



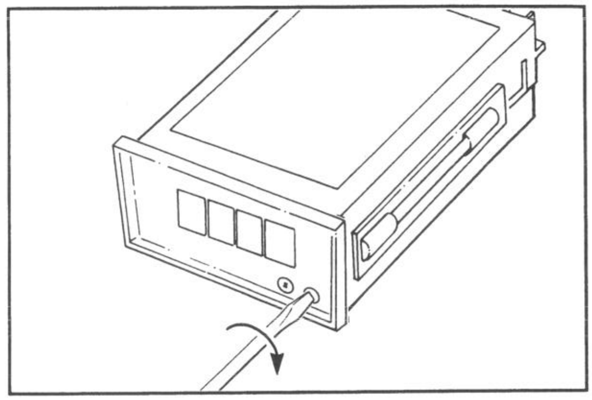
2. Connect the load bank to the circuit breaker output connection.

3. Start the engine and bring it up to rated speed. Adjust the voltage to its rated output. Leave the circuit breaker open.

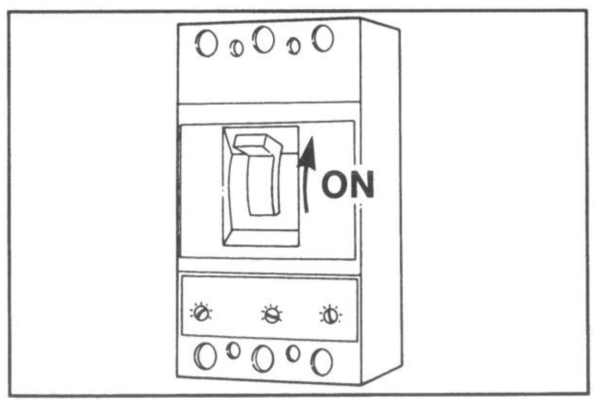




4. Adjust the kilowattmeter to display "0" by turning the small adjusting pot immediately over the letter "Z" (zero) in the lower right corner of the case.

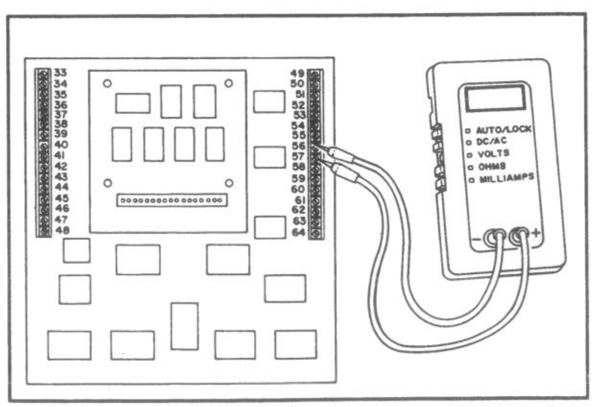


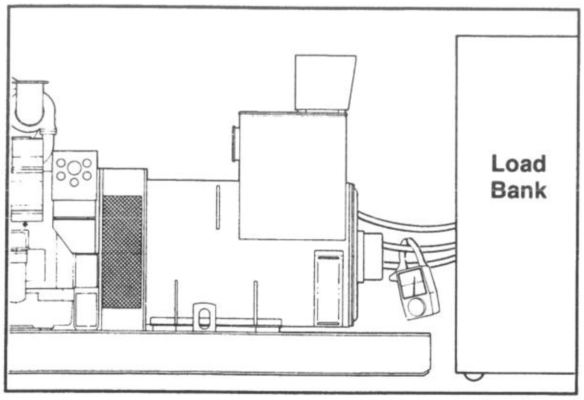
5. Close the generator circuit breaker. Add load until the generator set is delivering approximately rated KW.
6. Read the KW load on the load bank KW meter (if the load bank has a meter).



7. If no kilowattmeter is available, calculate the load as follows:
   a. Read and record the three line to line voltages on the generator control panel meter.

Note: A more accurate value may be obtained by using a multimeter and measuring line output. Use multimeter Part No. 3376313 and set it to measure A.C. voltage. Check the output at the control panel terminal strip terminals 56-57,57-58 and 56-58.





b. Read and record the three line currents on the generator control panel meter.

Note: A more accurate reading may be obtained with Part No. ST-1324 clamp-on ammeter. Measure the current of each line.

Terminals 56-57, V = 484 volts
Terminals 57-58, V = 486 volts
Terminals 56-58, V = 485 volts
Total = 1455

Divide by 3: $\frac{1455}{3} = 485 =$ Average

Line 1 Amps = 585
Line 2 Amps = 580
Line 3 Amps = 580
Total = 1745

Divide by 3: $\frac{1745}{3} = 581.7 =$ Average

c. Determine the average voltage by adding the three voltages and dividing by 3.

d. Determine the average line current by adding the three currents and dividing by 3.

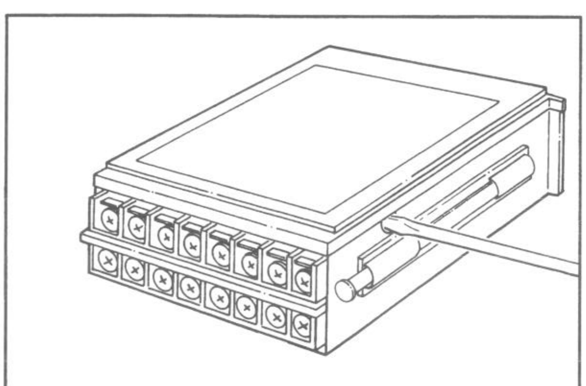
$$KW = \frac{485 \times 581.7 \times 1.732}{1000}$$

$$KW = 488.6$$

e. Determine the kilowatts by the following formula:

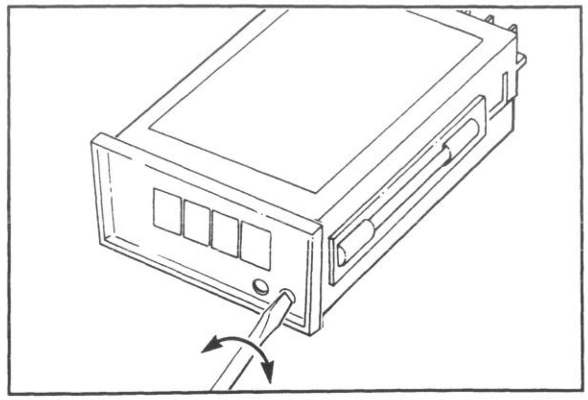
$$\text{Kilowatts} = \frac{\text{Average Volts x average Amps x 1.732}}{1000}$$

Note: This calculation is based on a pure resistance load. The value is correct, within the accuracy of the instruments, even if the load bank fan motor is powered by the generator. The value determined will NOT be accurate if other motors, flourescent lights, battery chargers, or other non 1.0 power factor devices are used for the load.



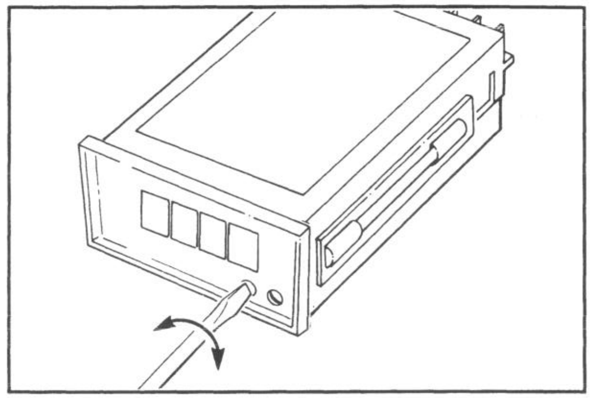
f. The coarse kilowattmeter adjustment is in the hole on the left side towards the rear of the case. Use a Part No. 3376313 potentiometer screwdriver to adjust the potentiometer so that approximately the correct value of kilowatts is displayed.

g. Adjust the kilowattmeter to read the correct value by turning the small adjusting screw over the letters FS (full scale) in the lower right corner of the face.

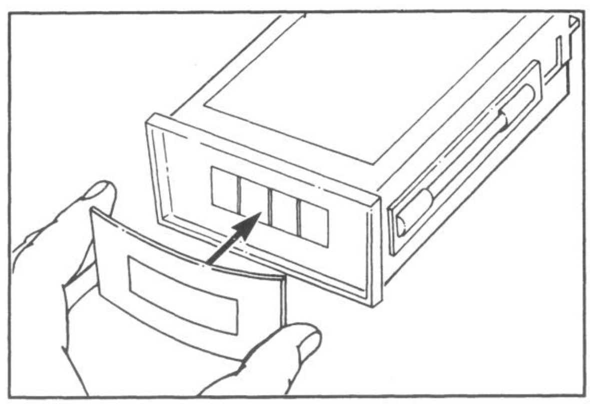


h. Remove the load from the generator. If the load bank fan is powered by the generator, allow the fan to run for 5 minutes before opening the circuit breaker.

i. Open the generator circuit breaker. Re-adjust the "Z" adjustment if necessary to make the kilowattmeter display a zero reading.



j. Re-install the plastic front face on the kilowattmeter. Bow the face and insert it into the sides of the kilowattmeter.



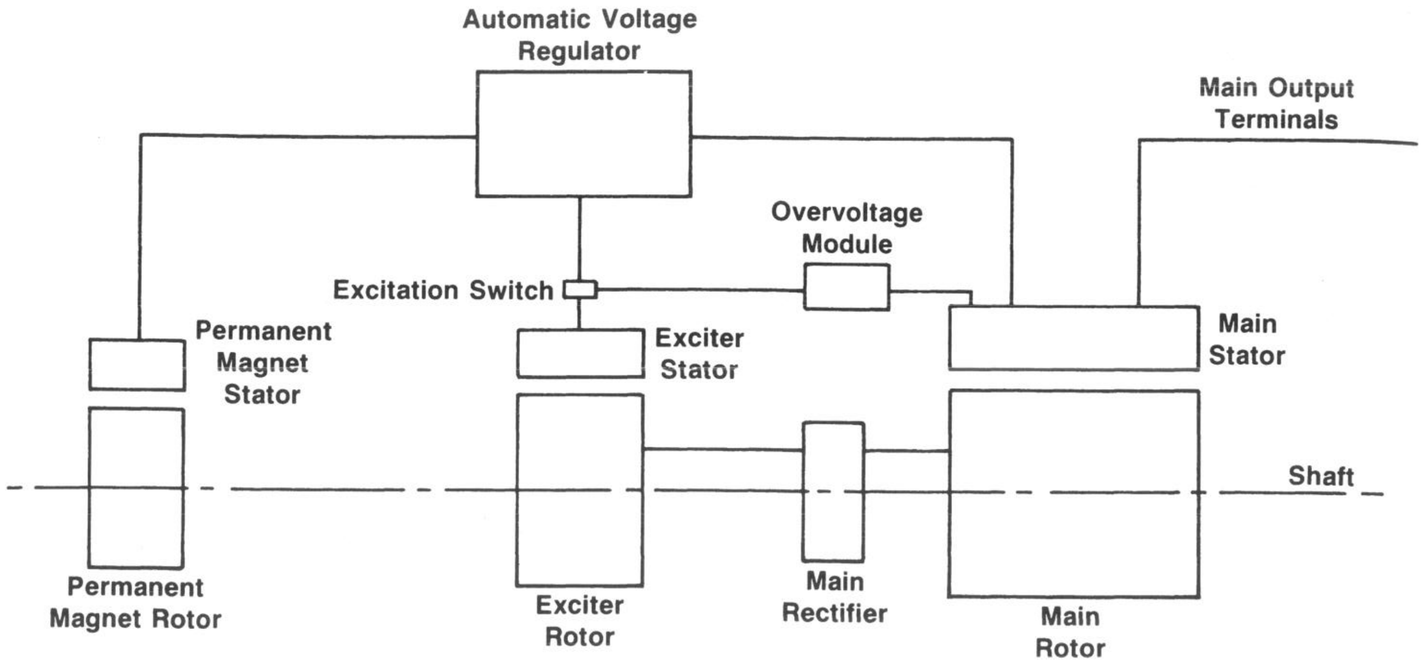
Section 06 - Generator

Table of Contents

System Troubleshooting and Repair List

General Information (6-01)

Operation



Permanent Magnet Exciter

To provide a source of excitation power independent of the main stator winding a rotating field permanent magnet exciter is provided. It is mounted at the non drive end co axial with the main shaft. The stator consists of a three phase winding and feeds power to the exciter stator via the automatic voltage regulator. The output of the stator winding is constant at the operational speed of the A.C. generator and is sufficient to give high forcing excitation required to provide good motor starting characteristics and sustained short circuit current.

Automatic Voltage Regulator (AVR)

The A.V.R. is an all solid state unit utilizing high quality printed circuit boards and components. It consists essentially of a power circuit, which rectifies the permanent magnet stator output to provide D.C. power to the main exciter stator, reference and feedback circuits, and a protection circuit. The reference circuit derives an error signal from the main stator output voltage which is used to control the firing angle of a thyristor in the power circuit, thus controlling the power fed to the exciter stator. Large changes in power level to the stator are reflected through the feedback circuit to give high stability during large load changes.

The level of power supplied to the exciter stator controls the output from the 3 phase exciter rotor which is fed via rotating diodes to the main rotor, which in turn controls the output from the main stator windings.

Protection Circuit

The permanent magnet exciter has high excitation forcing capabilities. This can have detrimental effects if the machine is misused or misapplied. Severe damage often results from overloading or by operating the machine into saturation by running at a reduced speed at full voltage. To eliminate these possibilities a protection unit is fitted to de-excite the machine under such conditions. The protection circuit is actuated by main exciter stator voltage level via a timing circuit fed from a potentiometer chain across the exciter stator.

The timing circuit allows high overloads of short duration thereby allowing for motor starting conditions. Once the protection circuit has been activated the excitation circuit will remain de-energized until such time as the prime mover is stopped, when the circuit will automatically reset.

Frequency Sensing Circuit

A frequency sensing circuit is incorporated into the A.V.R. which functions only when the shaft speed falls below approximately 97% of the rated speed. The voltage then reduces proportionally to any future reduction in speed, thus assisting the engine to recover after the application of high starting torque motor loads or high kilowatt load changes. This also provides low speed protection to the main rotor by ensuring the excitation does not exceed the safe operating level at all speeds.

Main Rectifier and Surge Suppressor

The rotating rectifier assembly rectifies 3 phase A.C. output of the main exciter rotor using 6 silicon diodes mounted on 2 heat-sinks forming + and - plates to feed the main rotor. The diodes are all liberally rated to withstand the normal overload and short circuit conditions which may arise. However, if the a.c. generator is misused, for example out of phase paralleling, a voltage transient can be fed back to the rectifier assembly from the main rotor due to the current surge produced in the main stator winding. The assembly is fitted with a surge suppressor, which limits its voltage transients to a definite level, thereby providing full protection to the diodes.

Overvoltage Protection

This is fitted as standard on all Cummins PMG generators. The system comprises two separate items:

a. An Overload Module - Type OVM 1 and

b. An Excitation Switch - a miniature magnetic circuit breaker fitted with a relay release coil.

The OVM is an electronic protection unit designed for use with PMG generators. In conjunction with an excitation switch, the unit provides over-voltage protection to both the A.C. generator and its service load.

The OVM is completely solid-state and is designed for direct machine mounting. Screwdriver adjustments are available for setting both tripping voltage and time delay which is incorporated to prevent nuisance tripping due to transient conditions. (See Section 6-16 for calibration).

When inter-linked with the machine windings and the excitation switch supplied, the system acts to de-excite the a.c. generator under over-voltage fault conditions. Provisions are made at the unit's terminal to link further protection modules or external devices. To simplify setting up, a tapped input circuit is provided which allows the unit to be set to nominal +25% without changing the operating voltage of the overall generator system, and without the need for setting calibrated potentiometers.

Generator Specifications (6-02)

Maximum Ratings in KW at 0.8 Power Factor, Three Phase

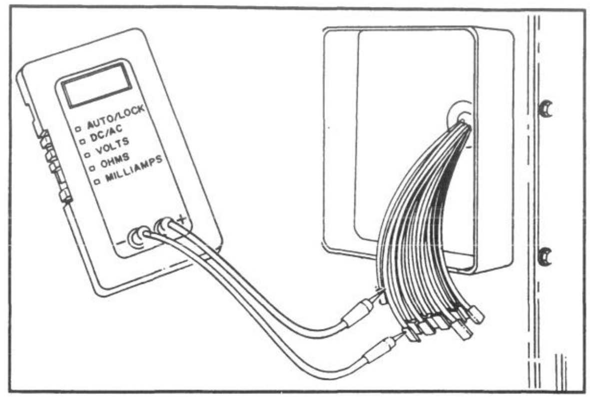
Part No.	Option No.	Model No.	Leads	480 Volt 60 Hertz GS kW	480 Volt 60 Hertz GC kW	415 Volt 50 Hertz GS kW	415 Volt 50 Hertz GC kW	Weight kg.	Weight [lbs.]
3052020	MG 8301	CC334A-114	12	135	125	110	100	504	1110
3052021	MG 8302	CC334B-114	12	165	155	135	120	558	1230
3052022	MG 8303	CC334C-114	12	180	175	150	135	620	1370
3052023	MG 8304	CC334D-114	12	205	200	165	150	680	1500
3052024	MG 8305	CC434C-114	12	250	225	210	190	812	1790
3052025	MG 8306	CC434D-114	12	285	260	225	205	893	1970
3052026	MG 8307	CC434E-114	12	335	305	270	245	968	2130
3052027	MG 8308	CC434F-114	12	380	350	300	275	1023	2260
3052028	MG 8309	CC434D-018	12	285	260	225	205	829	1830
3052029	MG 8310	CC434E-018	12	335	305	270	245	910	2010
3052030	MG 8311	CC434F-018	12	380	350	300	275	985	2170
3052031	MG 8312	CC534C-114	12	475	430	375	335	1107	2440
3052032	MG 8313	CC534D-114	12	515	470	425	385	1231	2710
3052033	MC 8314	CC534E-114	12	600	540	490	450	1381	3040
3052034	MG 8315	CC534F-114	12	650	590	530	480	1435	3160
3052035	MG 8316	CC534C-018	12	475	430	375	335	1118	2460
3052036	MG 8317	CC534D-018	12	515	470	425	385	1220	2690
3052037	MG 8318	CC534E-018	12	600	540	490	450	1370	3020
3052038	MG 8319	CC534F-018	12	650	590	530	480	1424	3140
3052065	MG 8320	CC634AS-018	6	700	650	570	525	1718	3790
3052039	MG 8321	CC634A-018	6	800	730	650	600	1780	3920
3052040	MG 8322	CC634B-018	6	900	820	720	660	2018	4450
3052041	MG 8323	CC634C-018	6	1050	950	840	765	2242	4940
3052042	MG 8324	CC634D-018	6	1150	1050	920	850	2317	5110
3052043	MG 8326	CC634A-018	12	800	730	650	600	1782	3930
3052044	MG 8327	CC634B-018	12	900	820	720	660	2023	4460
3052045	MG 8328	CC634C-018	12	1050	950	840	765	2322	5120
3052046	MG 8329	CC634D-018	12	1150	1050	920	850	2445	5390
3052047	MG 8330	CC734A-018	6	1250	1150	1075	975	2537	5590
3052048	MG 8331	CC734B-018	6	1500	1375	1180	1075	2839	6260
3052049	MG 8332	CC734C-018	6	1875	1800	1600	1450	3387	7470

Part No.	Option No.	Model No.	Leads	4160 or 2400 Volts 60 Hertz GS kW	4160 or 2400 Volts 60 Hertz GC kW	3300 or 1905 Volts 50 Hertz GS kW	3300 or 1905 Volts 50 Hertz GC kW	Weight kg.	Weight [lbs.]
3052050	MG 8333	CM734A-018	6	540	500	430	400	1325	2920
3052051	MG 8334	CM734B-018	6	810	750	650	600	1745	3850
3052052	MG 8335	CM734C-018	6	1080	1000	860	800	2565	5660
3052053	MG 8336	CM734D-018	6	1620	1500	1300	1200	3315	7310

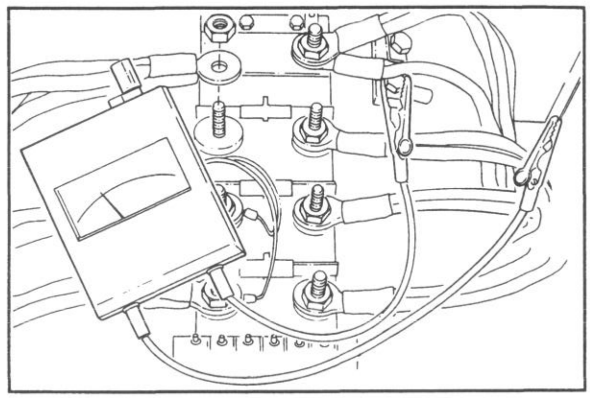
Service Tools (6-03)

The following service tools are recommended to perform generator set troubleshooting and repair.

1. Multimeter, Part No. 3376898. Used to measure volts, ohms, and milliamperes (B&K Precision 2845, auto-ranging digital multimeter).

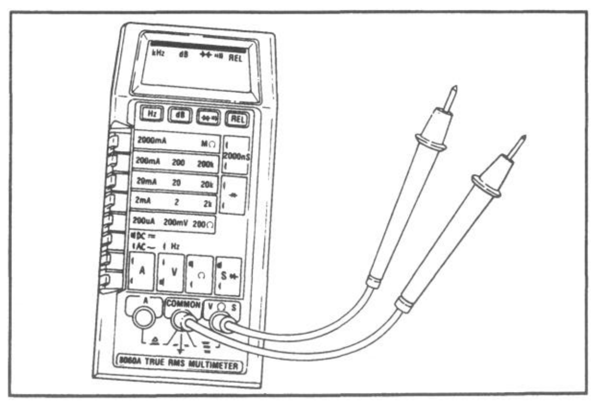


2. Megger Part No. 3376304. Used to measure generator insulation resistance. Range, 0 to 100 megohms and 0 to 500 megohms.



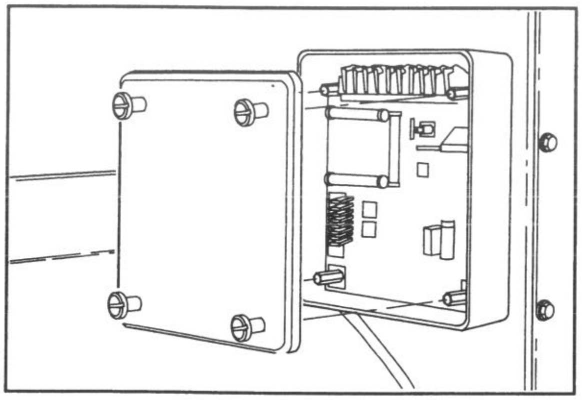
Other Tools

3. Fluke, model 8060A, handheld multimeter. Used to measure frequency, volts, ohms and milliamperes.

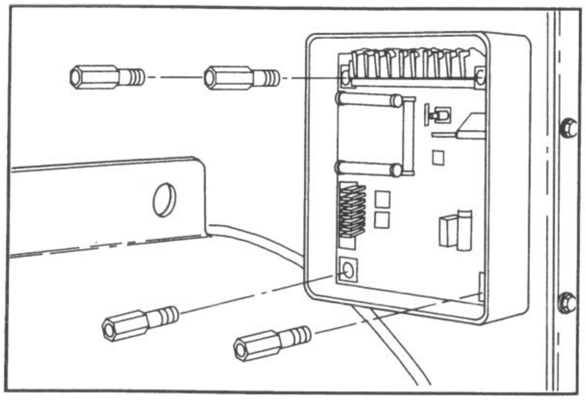


Automatic Voltage Regulator (AVR) - Replace (6-04)

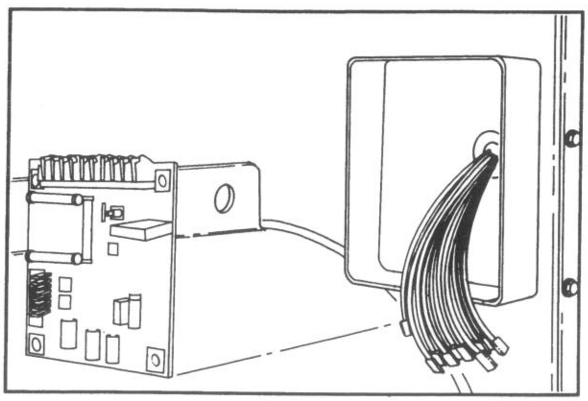
Remove



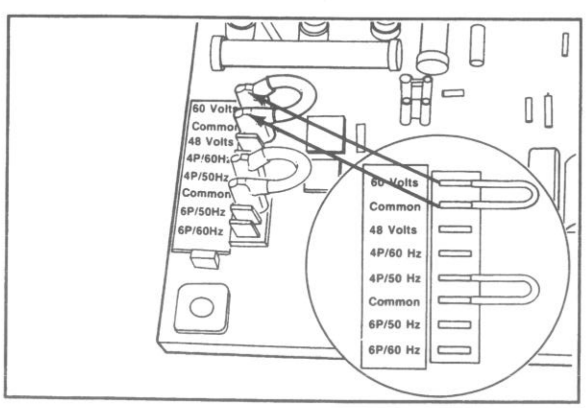
1. Remove the four captive screws and the cover from the AVR box.



2. Remove the four threaded pillars holding the AVR in place.



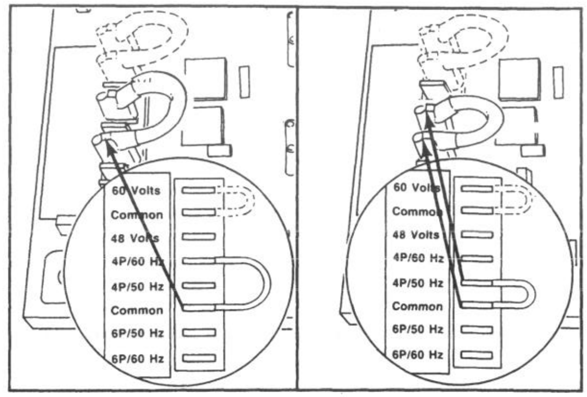
3. Pull the AVR from the box and remove all of the external leads.



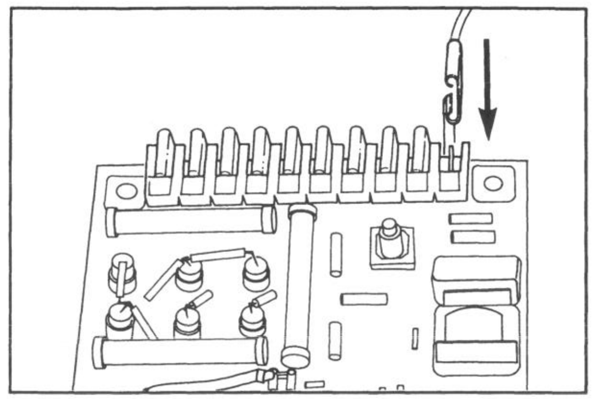
Install

1. Install a jumper wire between the upper "Common" terminal post and the adjacent "60 Volts" terminal post for the voltage protection selection.

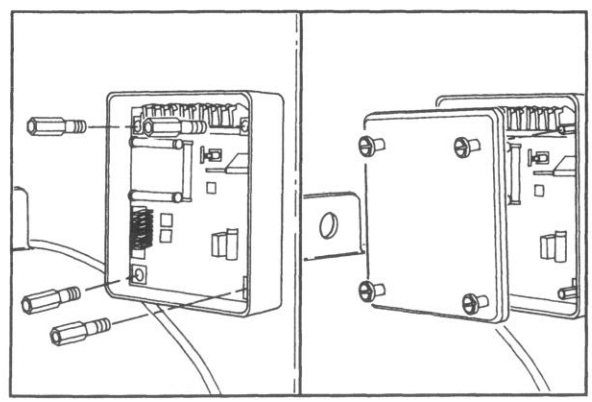
2. Install the poles and frequency selection jumper. Install the jumper from the lower "common" terminal post to:
   a. Terminal post "4P/60 Hz." for a 4 pole generator operating at 60 Hz.
   b. Terminal post "4P/50 Hz." for a 4 pole generator operating at 50 Hz.
3. The "6P/50 Hz." and "6P/60 Hz." terminals are for 6 pole generators operating at 50 and 60 Hz.



4. Attach all of the external leads to the AVR.



5. Position the AVR in the box and install the four threaded pillars.
6. Install the AVR lid.

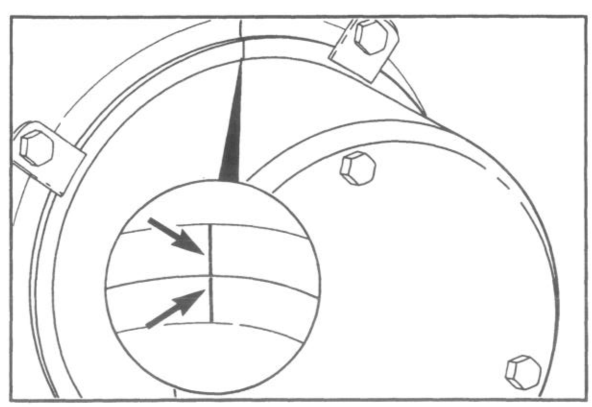


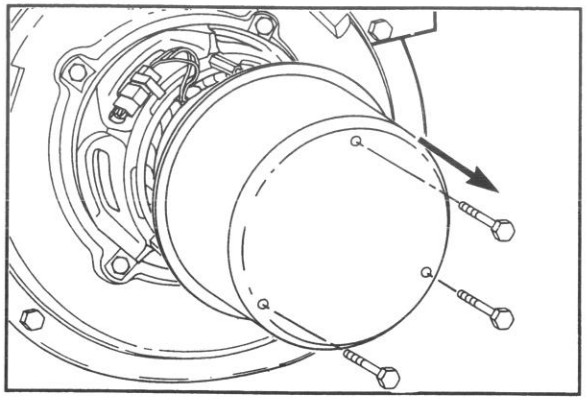
Permanent Magnet Exciter - Replace (6-05)

Remove

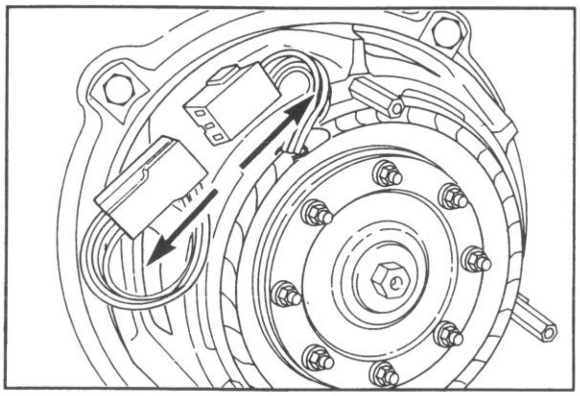
Note: The angular position of the permanent magnet exciter is set during the final electrical test prior to shipping. A mark indicating the correct position is made on the stator housing and the non-drive end bracket at approximately the 12 o-clock position. The stator must be returned to this exact same position when reassembling. Identify the marks before disassembling the generator.

Note: The above is true for one phase sensing generators only. The locating marks can be at any position on three phase sensing generator.

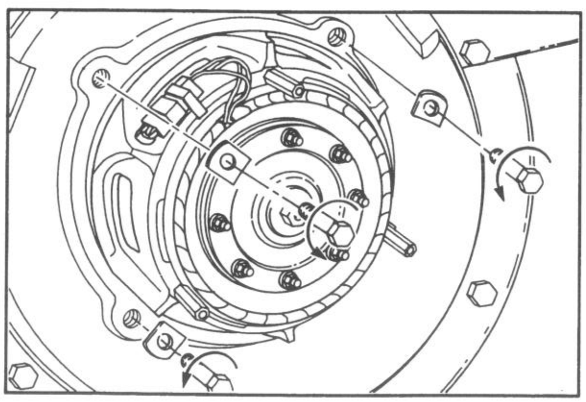




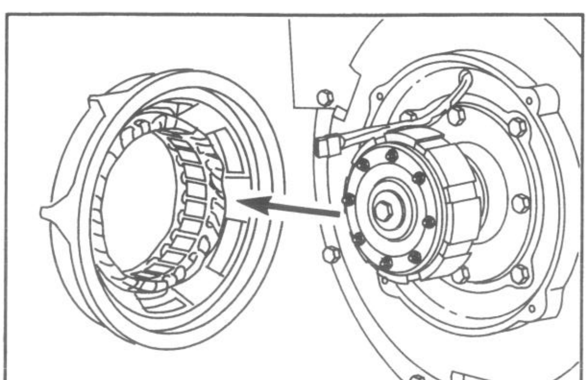
1. If the position marks are not clear or are not aligned, mark the permanent magnet stator and non-drive end bracket so the stator can be returned to the exact same location. Remove the three capscrews and access cover.



2. Disconnect the plug inside the permanent magnet exciter access cover. This plug connects the stator to the leads going into the generator rear end bracket.



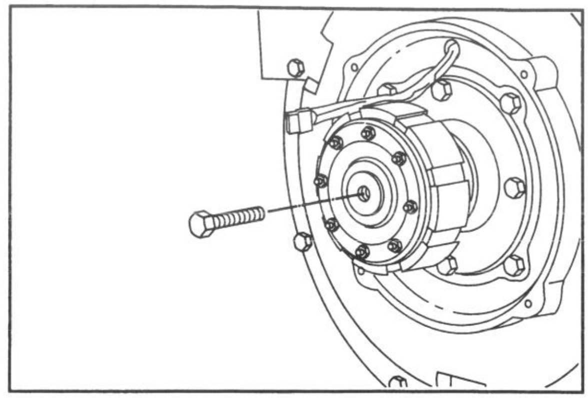
3. Remove the four capscrews and clamps that hold the permanent magnet exciter stator to the end bracket.



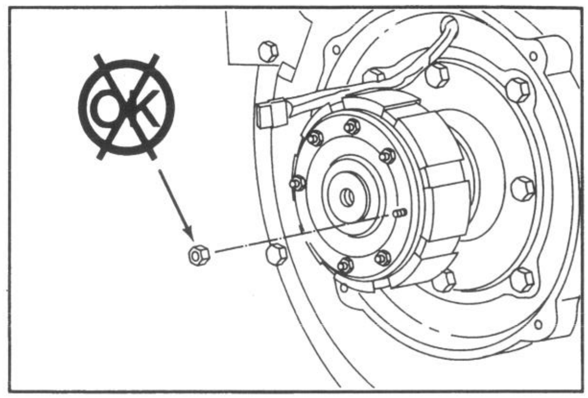
4. Pull the permanent magnet exciter stator housing out of the recess in the end bracket. It may be necessary to tap the housing to loosen it. Some pulling force may also be required.

Caution: The rotor is highly magnetic and attracts the stator. Use care not to damage the stator winding as the stator is removed.

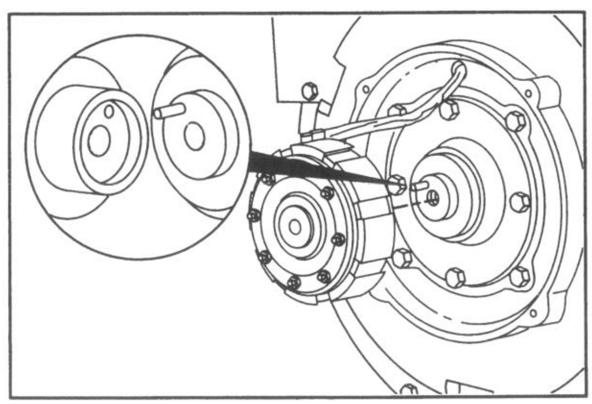
5. Remove the shaft centerline capscrew from the end of the rotor shaft.



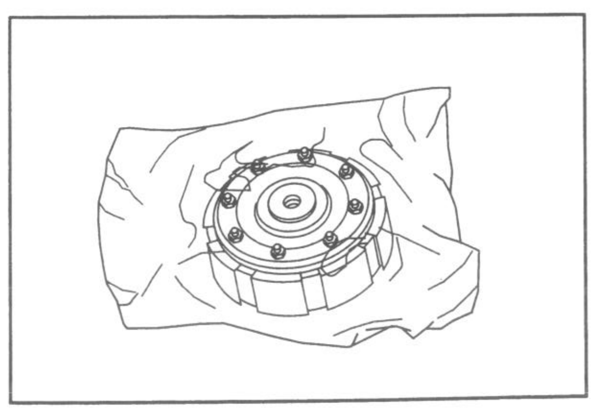
Caution: Do not attempt to take the permanent magnet rotor apart. The magnet properties of the rotor will be destroyed.

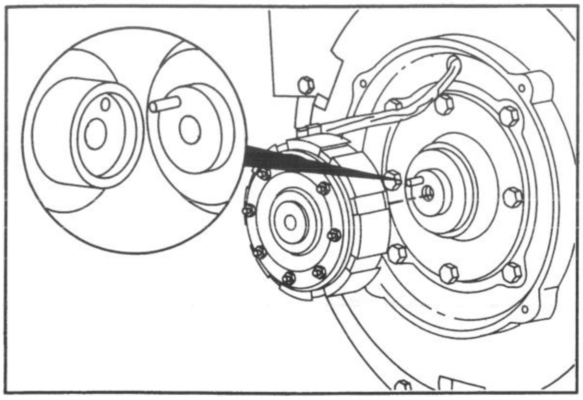


6. Pull the complete rotor assembly from the shaft. The rotor is located with a dowel pin. A firm pull may be required to remove the rotor.



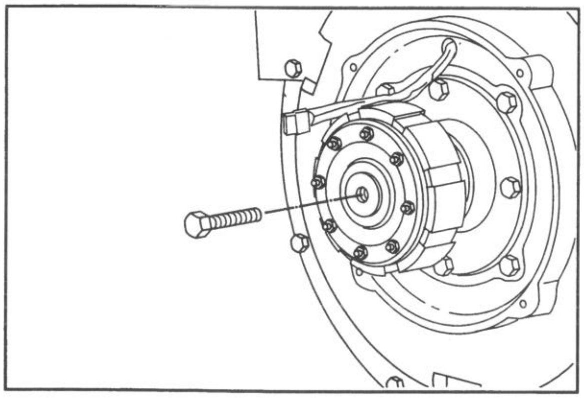
7. Wrap the magnetic rotor in a protective cover to keep it clean and prevent metallic particles from collecting on the magnets.



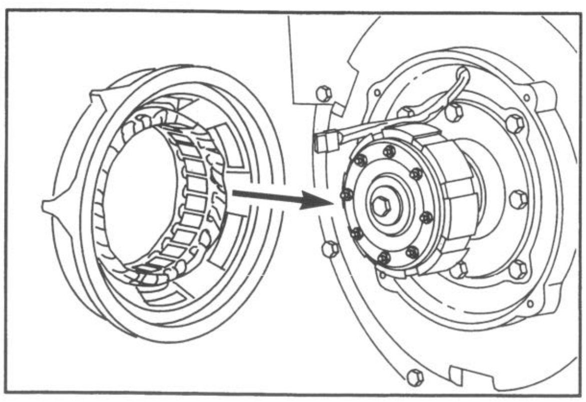


Install

1. Place the permanent magnet exciter rotor on the generator shaft. Align the dowel pin in the shaft with the locating hole in the rotor and push rotor into position.

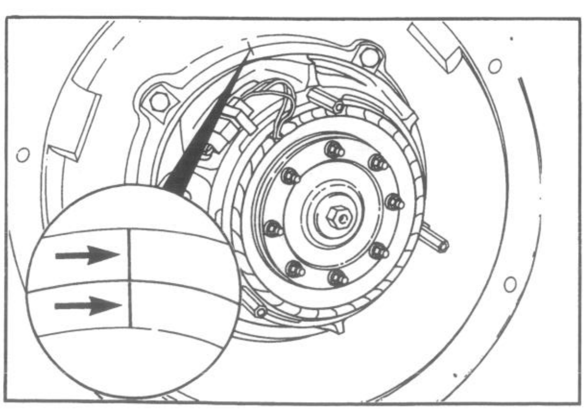


2. Install the center rotor retaining capscrew and torque it to 20 to 27 N•m [15 to 20 ft-lbs].



3. Install the permanent magnet exciter stator housing in the end bracket recess with the stator leads at the top. Tap the housing lightly to seat it into the recess.

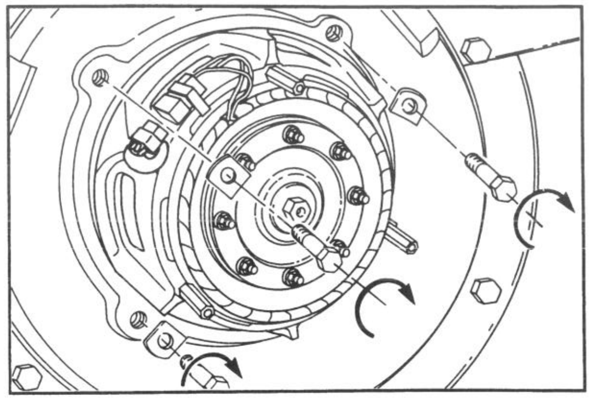
Caution: The rotor is highly magnetic and attracts the stator. Use care not to damage the stator winding during installation. Also be careful not to get your fingers pinched in the installation process.



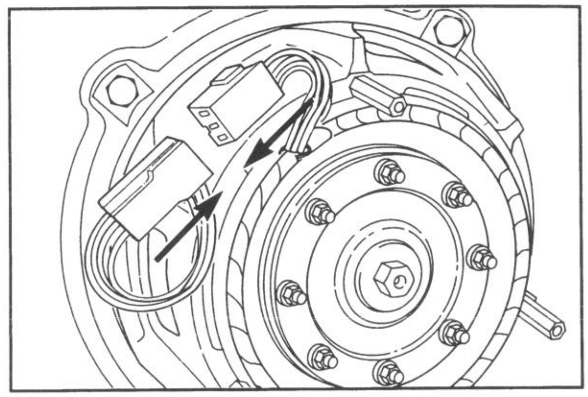
4. Align the location mark on the permanent magnet exciter stator housing with the location mark on the endbracket.

Note: If a new or rewound permanent magnet stator housing is being installed, the housing may not have a location mark or the mark may be in the wrong location. Refer to Procedure 6-06 to properly locate a new or rewound permanent magnet exciter stator housing.

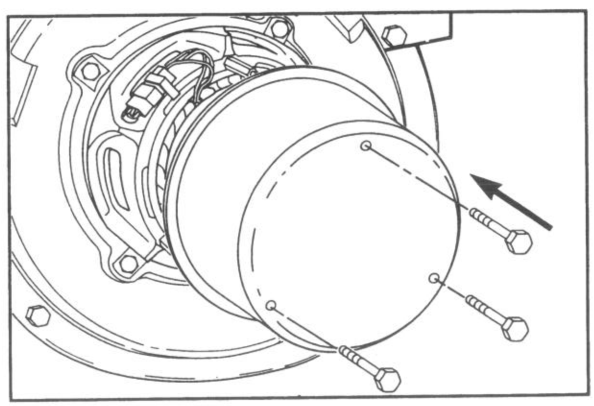
5. Install the four capscrews and clamps that hold the permanent magnet exciter stator housing to the end bracket. Torque the capscrews to 20 to 27 N•m [15 to 20 ft-lbs].



6. Pull the plug, attached to the leads extending from the generator rear end bracket, through the stator opening. Insert the plug into the receptacle attached to the stator windings.



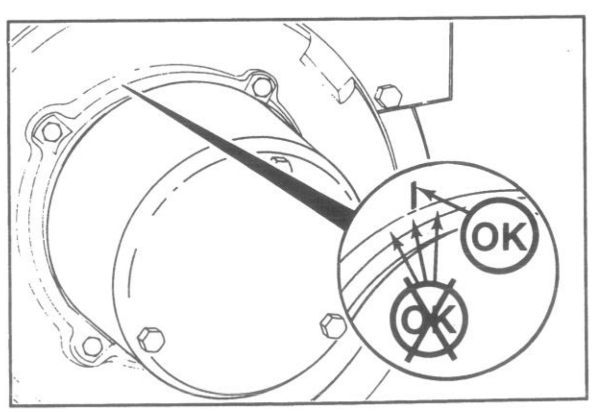
7. Install the access cover.

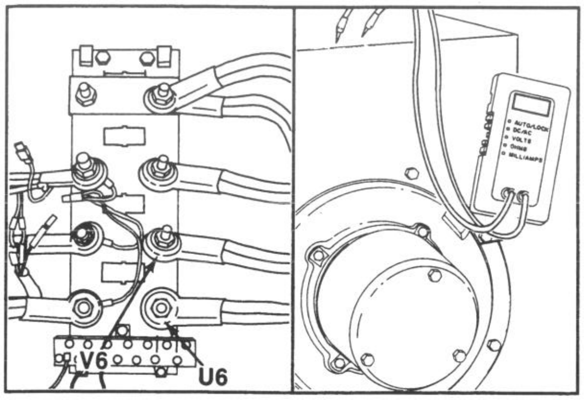


Permanent Magnet Exciter Stator Housing - Orientation (6-06)

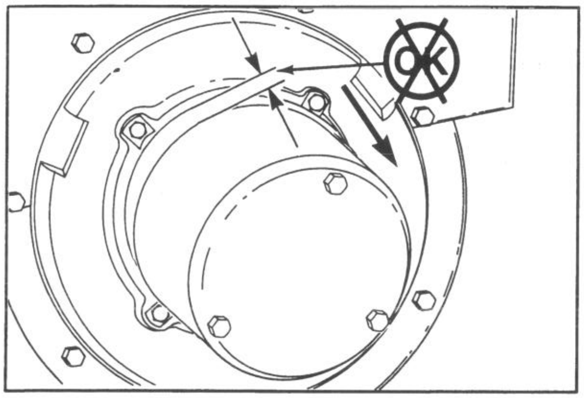
Note: Permanent magnet exciter stator orientation has no effect on the performance of a three phase sensing AVR (Automatic Voltage Regulator). The procedures described in this Section apply Only to the single phase sensing AVR, which normally senses voltage from the main generator terminals U and V.

If a new rewound permanent magnet exciter stator is installed, the stator housing may not have a location mark, or the location mark may be in the wrong position. In these cases, it may be beneficial to relocate (turn) the permanent magnet exciter stator housing to obtain optimum performance from a single phase sensing AVR.



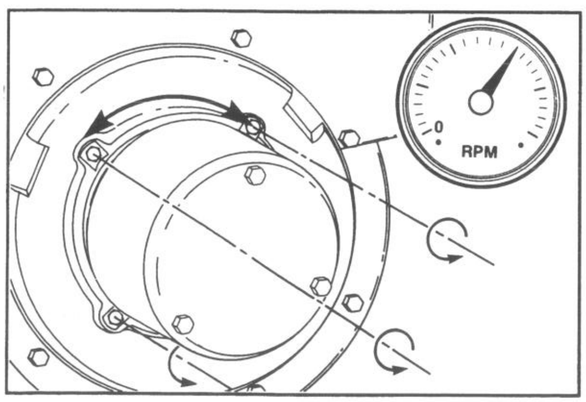


1. Use a multimeter and set it to measure voltage. Connect the meter to the main generator output terminals (normally U6 and V6 or U and V). Locate the meter so it can be observed while making the adjustment.

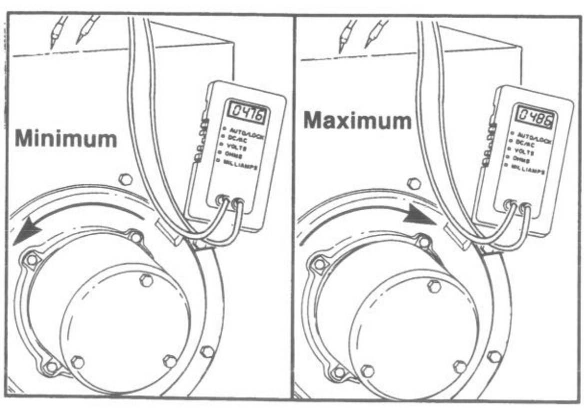


Do not allow the permanent magnet exciter stator housing pilot to move out of the end bracket recess. The exciter rotor would rub on the stator.

Caution: If there is any doubt, setting the angular position of the stator housing can be done by two people, one person holding the stator housing while the other person loosens the clamping capscrews.



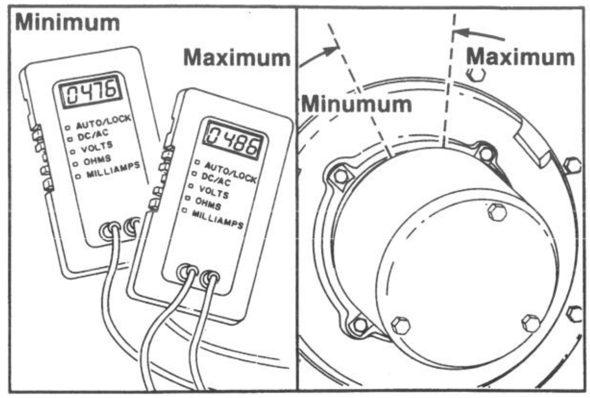
2. Run the unit at rated speed. Hold the stator firmly in position and loosen the four clamping capscrews. Loosen the capscrews approximately one turn or until the stator can be slightly rotated.



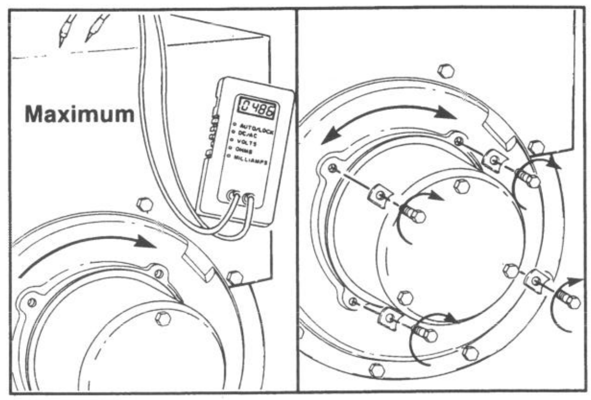
3. Rotate the stator housing counter-clockwise until the meter reading is at its minimum level. Make a temporary identification mark on the stator housing adjacent to the location mark on the endbracket.
4. Rotate the stator housing clockwise until the meter reading is at its maximum. Make a temporary identification mark on the stator housing adjacent to the location mark on the end bracket.

5. Observe the meter closely. The voltage variation will not exceed 5% from maximum to minimum.

   The maximum movement required (between minimum and maximum voltage) is approximately 80 mm [3 in] or 25 degrees.

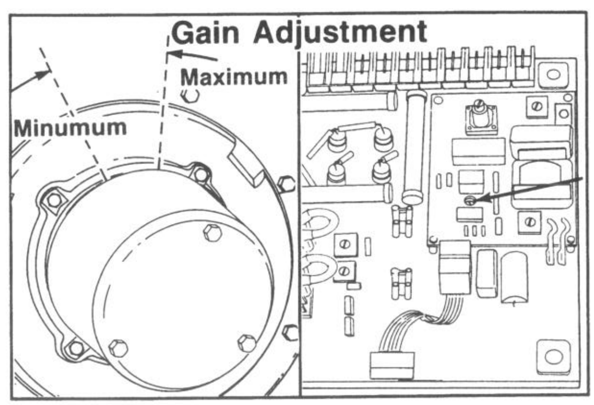


6. With the stator housing in the position giving the highest voltage, tighten the clamping capscrews.

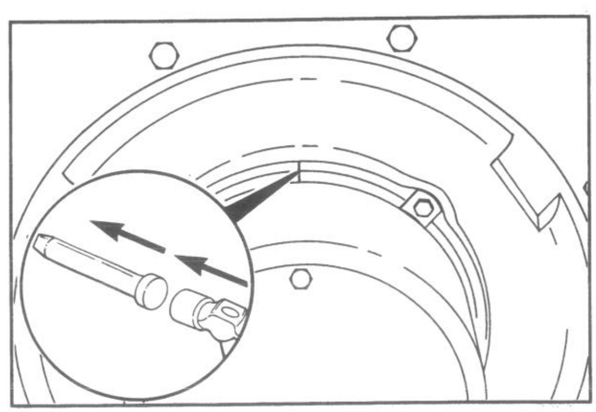


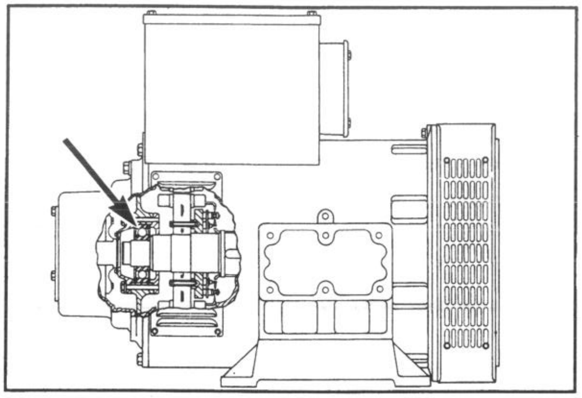
Note: Rotation of the permanent magnet exciter stator housing changes the gain of the voltage regulation system. The location that produces the maximum generator output voltage is the maximum gain position. This position produces the minimum voltage regulation or voltage droop and the minimum time required for the generator to return to rated voltage after a load change. To reduce the tendency of the voltage to oscillate or become unstable after a load change, turn the "stability" control on the AVR counter-clockwise.

Rotating the stator housing counter-clockwise from the maximum voltage position reduces the gain of the voltage regulation system. The tendency for voltage oscillation is reduced and the time for recovery to rated voltage is increased. These characteristics may be desirable in some installations.



With the stator housing in the optimum position, permanently mark the housing with a punch or chisel. The mark made on the housing should be aligned with the mark already on the end bracket.





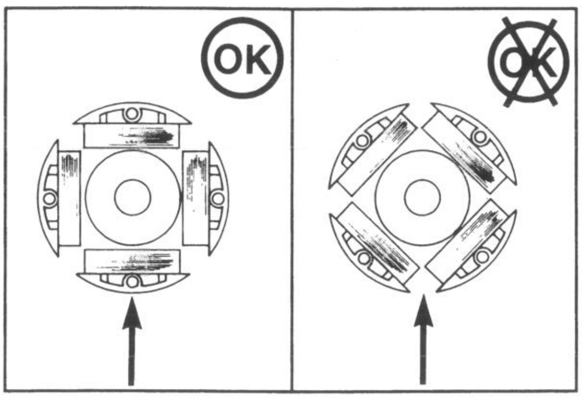
Generator Bearing - Replacement and Greasing (6-07)

Remove

Note: The generator bearing assembly in single bearing frames 4 through 7 generators is prepacked with grease for a calculated life of 30,000 hours in an ambient temperature of 40° C [104° F]. The bearings in frames 4 through 7, are enclosed in a cartridge housing. This housing should not be disassembled unless necessary for replacement of the bearing. Generator bearing replacement is considered a normal procedure during a major engine overhaul.

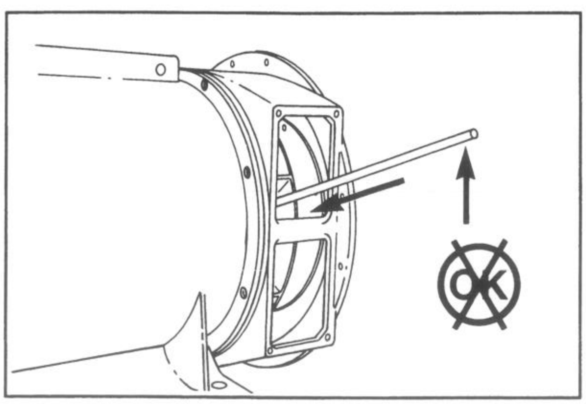
The generator bearing in single bearing frame 3 generator, is a sealed bearing. It is held in the non-drive end bracket by an inner and outer bearing cap. Frame 3 bearings do not require any additional grease.

The non-drive end bracket must be removed in order to replace the bearing on all frame sizes.



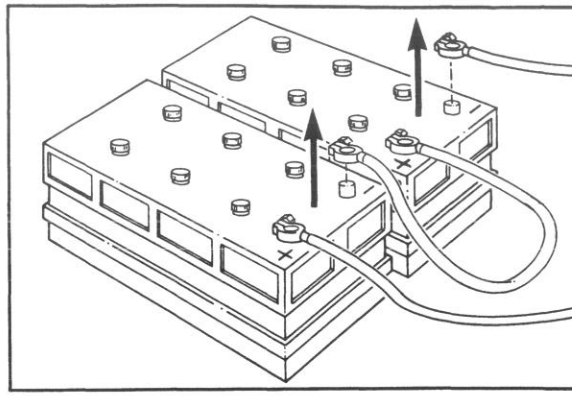
1. Remove the permanent magnet exciter stator and rotor. Refer to Procedure 6-05.

   Remove the non-drive end access cover, terminal box sides, lid and support bracket. Bar (rotate) the engine so that a main generator rotor pole is at the bottom of the frame.

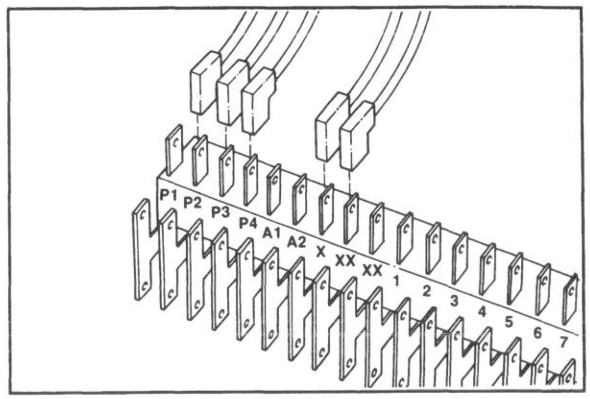


Caution: Do not pry on the generator fan to rotate the engine, the fan blades can be easily bent and broken. The entire generator rotor must be disassembled (normally at the factory) to replace a generator fan.

2. Disconnect the batteries or air supply line to the air starter to prevent accidental engine starting.



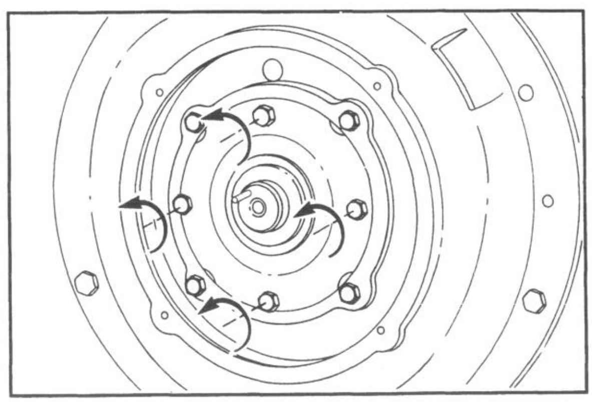
3. Disconnect exciter leads X and XX as well as P2, P3, and P4 at the auxiliary terminal block. Bring the leads back into the non-drive endbracket.



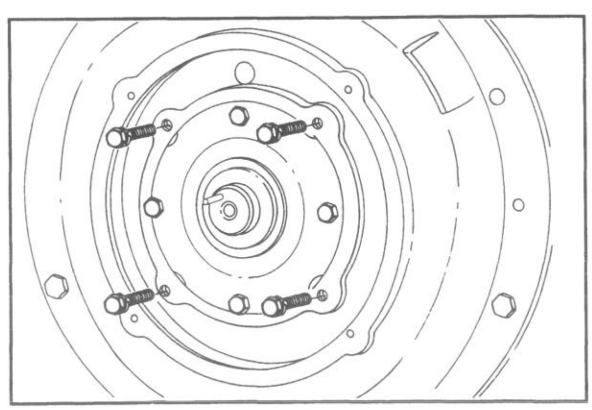
4. On generator frames 4 through 7, loosen the 4 inner capscrews that hold the bearing housing cap to the bearing cartridge.

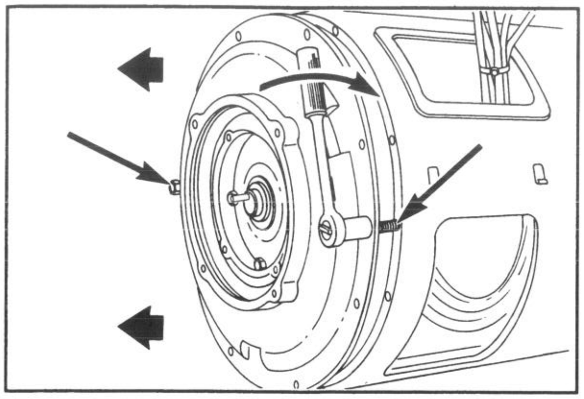
   It is difficult to keep the bearing cartridge from rotating after the 4 outer capscrews have been removed.

5. On generator frame 3, remove the outer bearing cap.

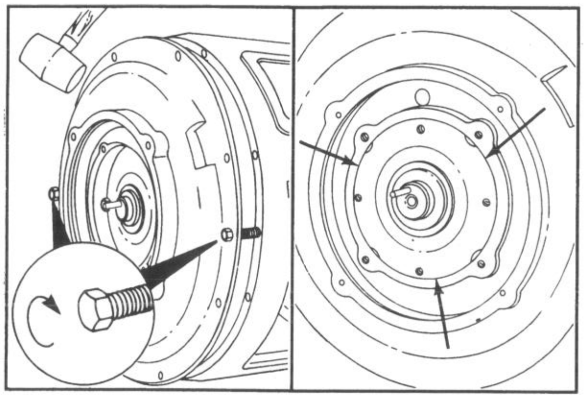


6. On all frame sizes, remove the 4 capscrews that hold the bearing cartridge or inner bearing cap to the end bracket.

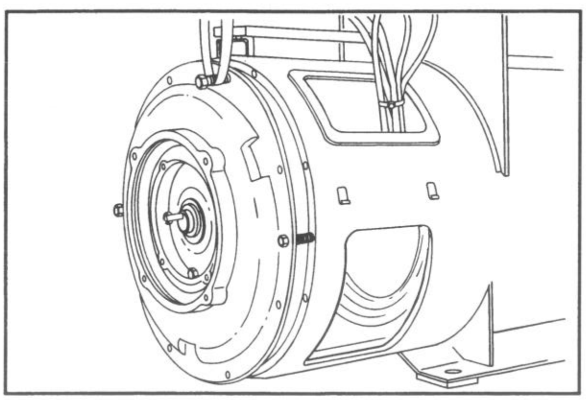




7. Remove all of the capscrews that hold the non-drive endbracket to the frame.
8. Thread two of the capscrews into the jacking holes on the end bracket horizontal center line. Screw these capscrews in to pull the end bracket pilot from the locating recess in the main generator frame.

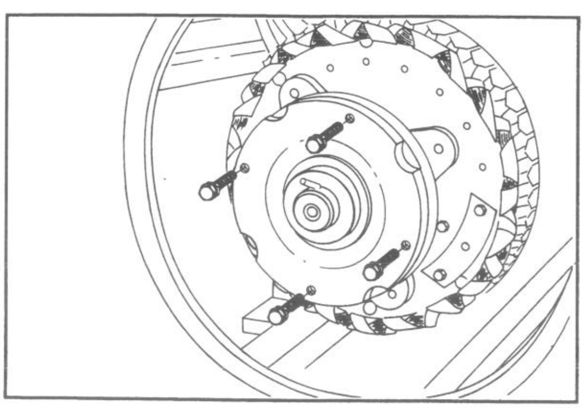


9. Tap the end bracket lightly while turning the jacking screws in. Check to make sure the bearing cartridge (frame 4,5,6 and 7) or bearing (frame 3) is not stuck in the end bracket.



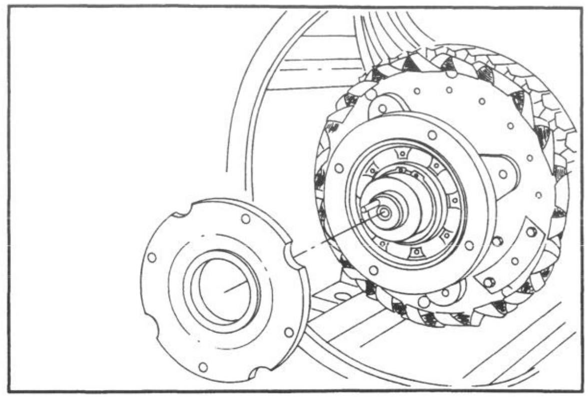
Caution: The main exciter stator is attached to the endbracket and comes out when the endbracket is removed. Use extreme care not to damage the main exciter stator as the endbracket is removed.

10. The endbracket (frame 6 or 7) should be supported as it is removed from the bearing cartridge.

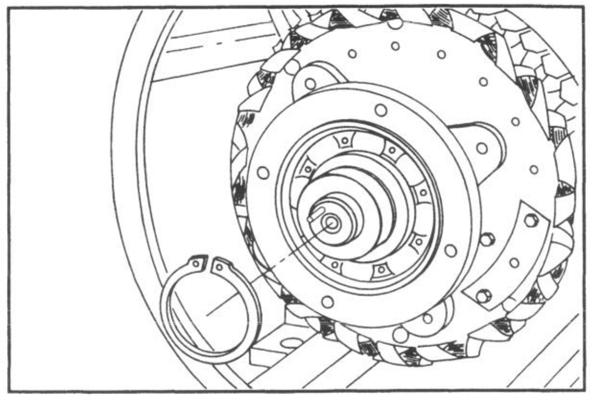


11. On frames 4 through 7 remove the capscrews that hold the bearing cap to the bearing cartridge.

12. On frames 4 through 7, remove the bearing cap.

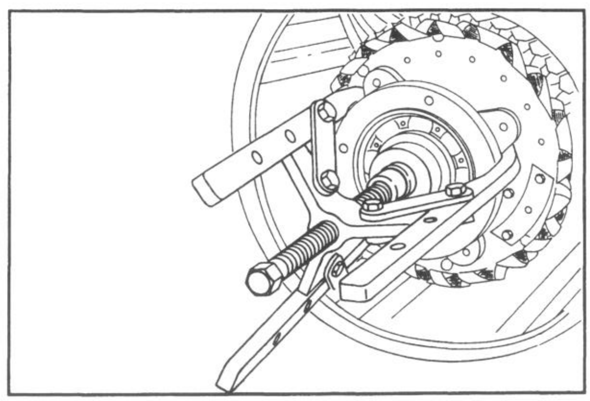


13. Remove the large snap ring from the generator shaft.



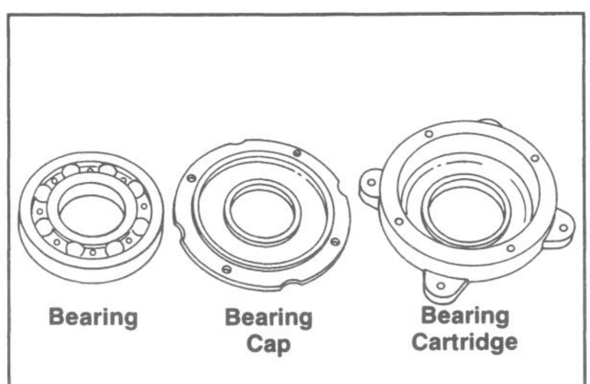
14. Use a puller to remove the bearing.

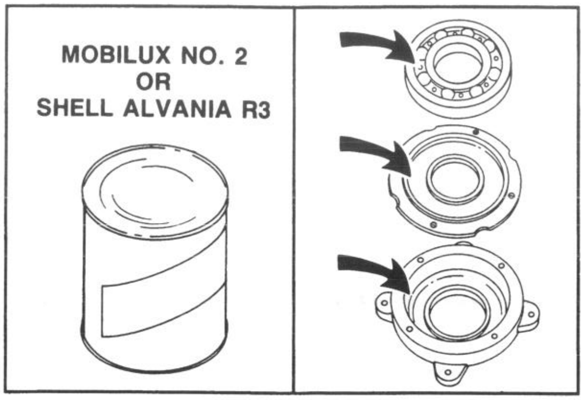
Caution: Use two or more flat washers or a spacer between the puller and the end of the shaft to avoid damaging the threads in the end of the shaft.



15. On generator frames 4 through 7, press the old bearing from the bearing cartridge. Use solvent to clean the old grease from the bearing cartridge and end cap.

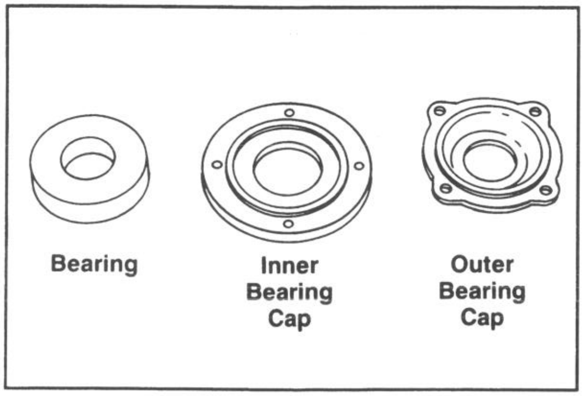
Note: The outer race of the bearing is a light press fit in the bearing cartridge.



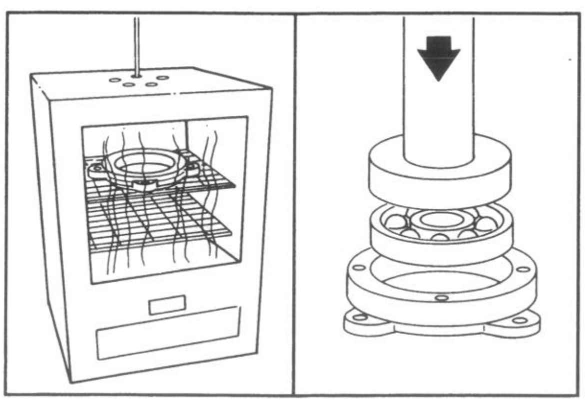


Install

1. On generator frames 4 through 7, pack 27 ml [1 fluid oz] of the recommended lubricant into the bearing and put the same amount of lubricant into the bearing cartridge and end cap.



2. Generator frame 3 has a sealed bearing which requires no additional lubricant.

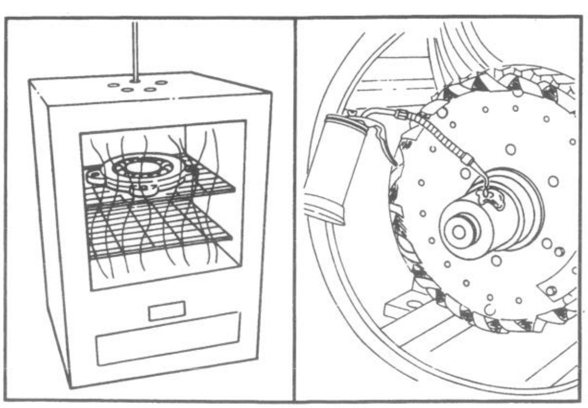


3. On generator frames 4 through 7, press the bearing into the bearing cartridge.

Note: The bearing will be easier to install in the cartridge, if the cartridge is heated. Heat the cartridge in an oven at 100° C [212° F] for one hour.

Caution: Use insulated gloves to handle the cartridge.

Caution: When installing the bearing in the cartridge, press on the OUTER race only, to avoid damage to the bearing.

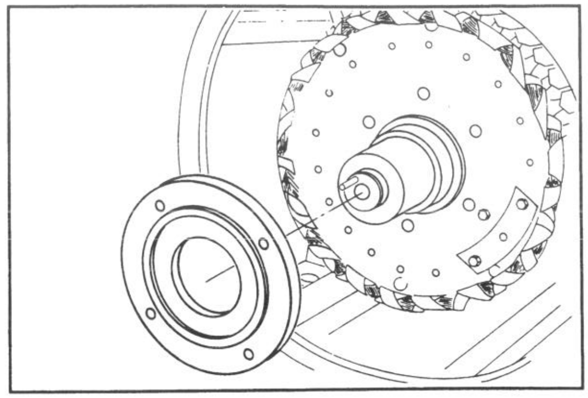


4. Heat the new bearing (frame 3), or bearing and cartridge (frame 4 through 7) in an oven at 100° C [212° F] for two hours.

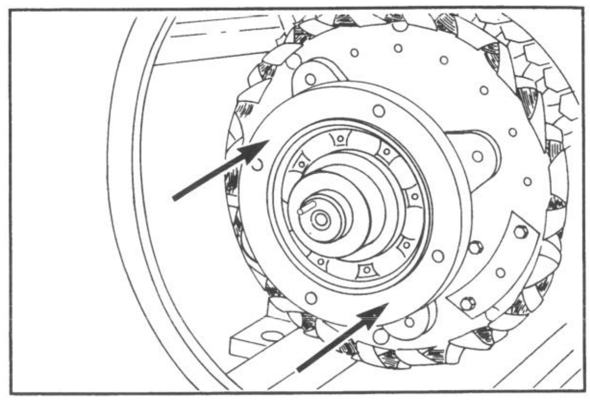
Note: The maximum oven temperature should not exceed 120° C [248° F].

5. Apply a thin coat of clean oil to the press fit (bearing journal) area of the generator shaft.

6. On generator frame 3, place the inboard bearing cap on the shaft with the cap pilot towards the bearing.

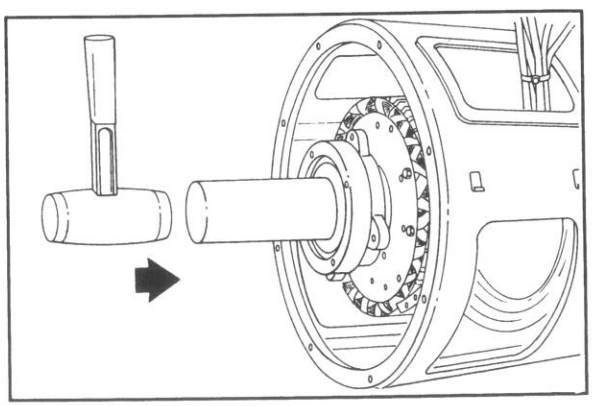


7. Use insulated gloves. Install the bearing on the shaft. Quickly push the bearing on the shaft until it seats against the shaft shoulder. The bearing should slide on the shaft and be seated without excessive force.

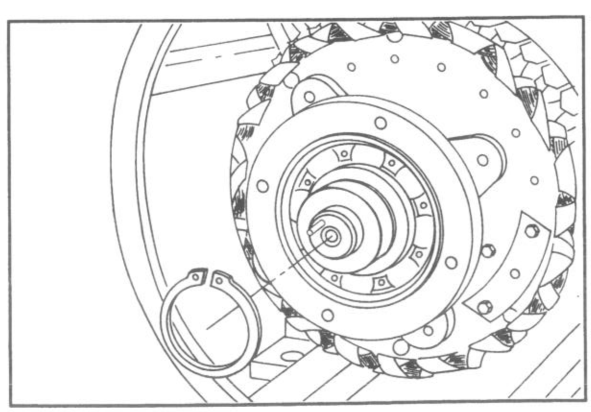


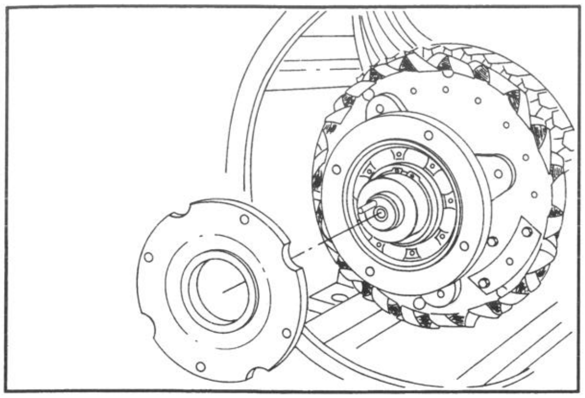
8. If the bearing binds on the shaft before being fully seated, use a length of pipe with an inside diameter slightly larger than the shaft to drive the bearing against the shaft seat. Apply pressure to the inner race of the bearing only.

Caution: Applying pressure to the outer bearing race can damage the bearing.

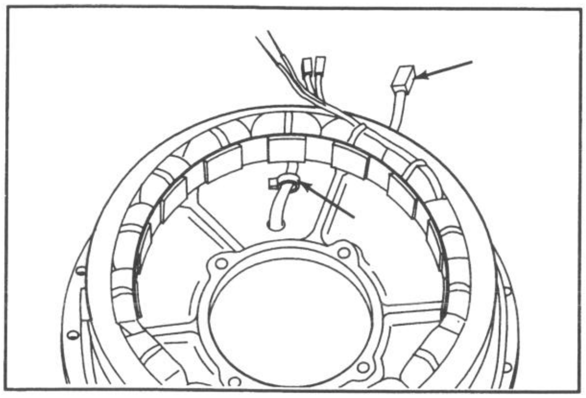


9. Install the large snap ring on the generator shaft next to the inner race of the bearing. Make sure that the snap ring is seated in the grove.



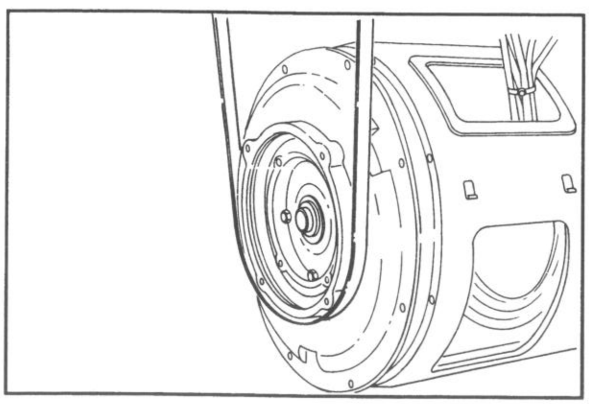


10. On generator frames 4 through 7, install the bearing cap.

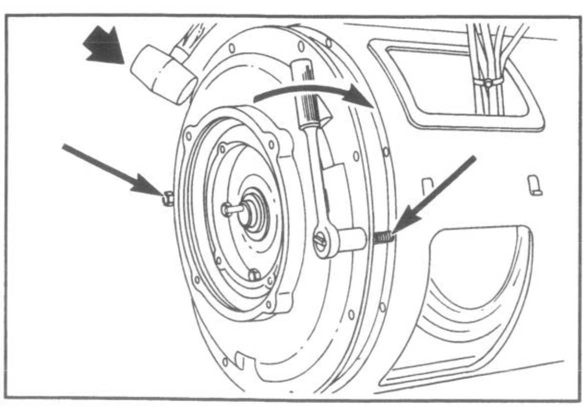


Note: Make sure that the end plug of the three wire harness attached to the permanent magnet exciter stator is through the end bracket and the harness is retained by the internal wire clamp. The harness is difficult to install when the end bracket is on the generator.

11. Install the end bracket on the bearing (frame 3), or on the bearing cartridge (frames 4 through 7).

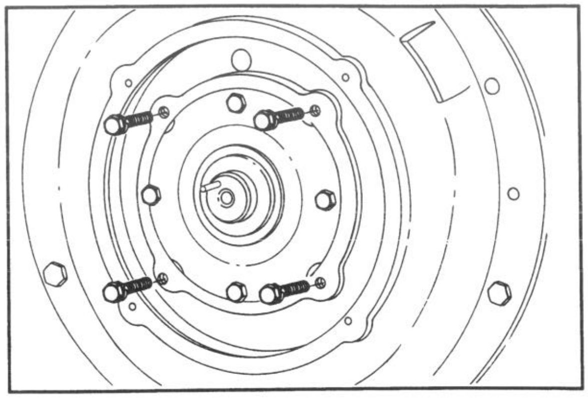


12. Lift the end bracket and rotor to pilot the end bracket into the generator frame recess. Frames 3 and 4 can normally be lifted by one person. Frames 5 through 7 will require a hoist and sling. Place the sling around the exciter mounting surface.

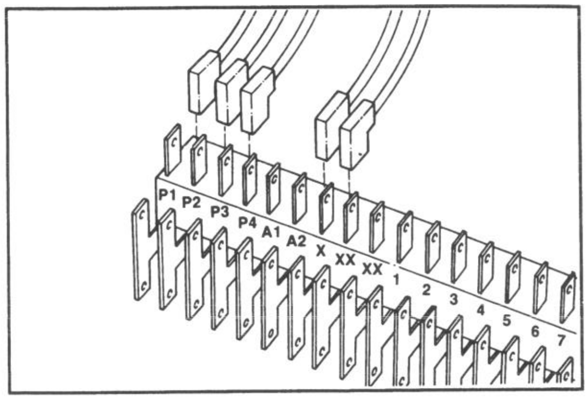


13. Install the capscrews which hold the end bracket to the generator frame. Tap the end bracket with a dead-blow hammer as the capscrews are tightened.

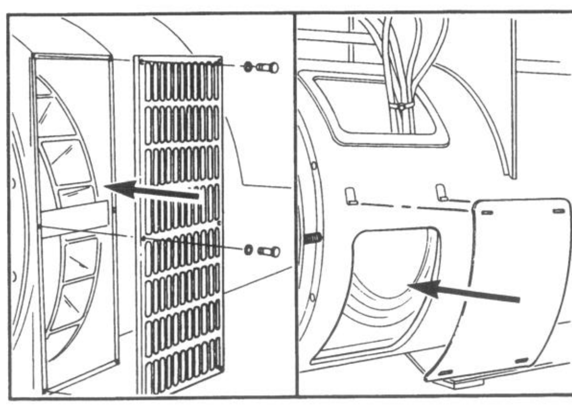
14. On generator frame 3, install the 4 capscrews through the outboard bearing cap and end bracket and into the inboard bearing cap.
15. On generator frames 4 through 7, align the bearing cartridge threaded capscrew holes with the holes in the end bracket by turning the bearing end cap. The bearing cartridge will rotate in the end bracket.
16. Install the bearing cartridge capscrews.



17. Pull the main exciter leads (X and XX) and the permanent magnetic exciter stator leads (P2,P3 and P4) through the hole in the frame terminal box.
18. Connect the leads to the corresponding terminals on the auxiliary terminal block.



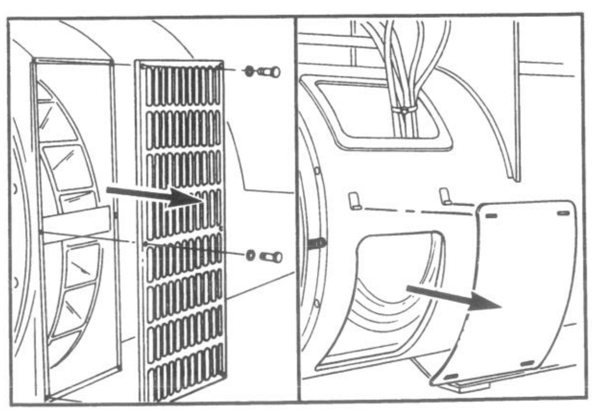
19. Install the permanent magnetic exciter. Refer to Procedure 6-05.
20. Install the non-drive end access cover, the terminal box sides, lid and support brackets.

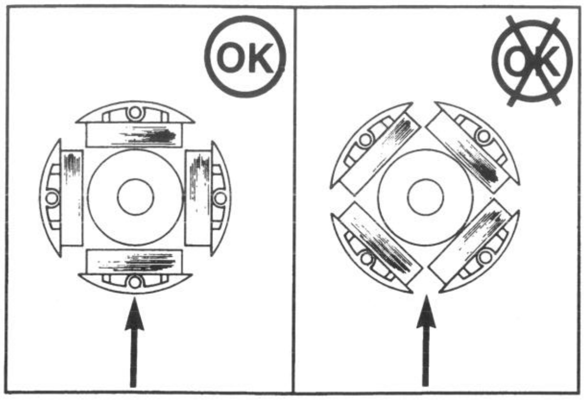


Remove Generator From Engine (6-08)

Remove

1. Remove the air screens from the drive end of the generator. Remove the access cover from the non-drive end of the generator main frame.

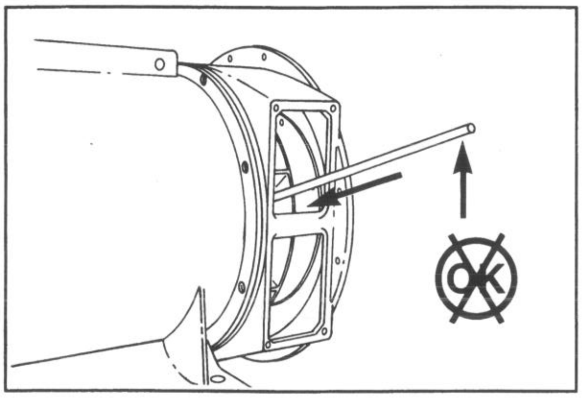




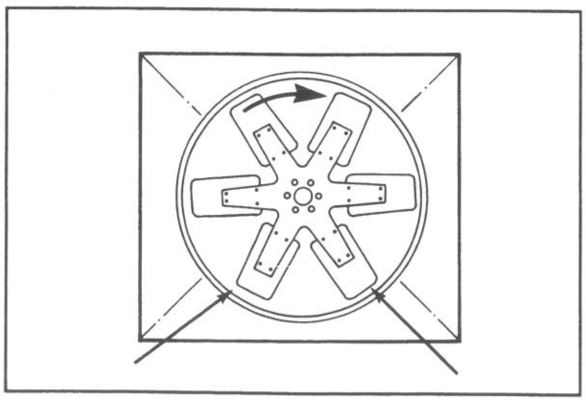
2. Bar (rotate) the engine crankshaft so that a generator main rotor pole is at the bottom of the generator frame.

   The only way to bar a K6 gen set engine is with the starter motor, so disconnect the batteries after rotating the engine.

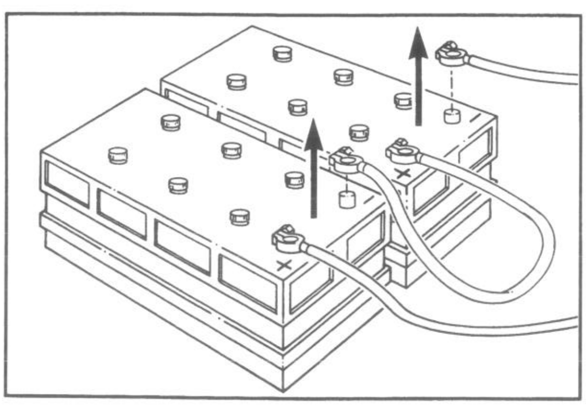
Note: Loosen the fan belts on the NT-855 to rotate the fan. The KT-19 fans can be rotated in the direction of rotation.



Caution: Do not pry on the generator fan to rotate the engine, as the fan blades can be easily bent and broken. The entire generator rotor must be disassembled (normally at the factory) to replace a generator fan.

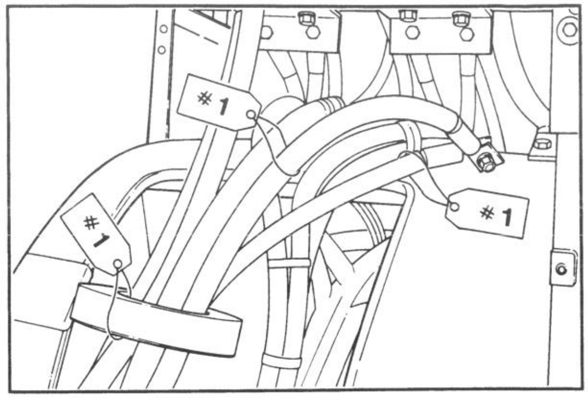


Caution: If the generator set has a set mounted radiator and fan, rotate the fan so that none of the fan blades are at the bottom of the ring shroud. Contact between a fan blade and shroud can cause damage to the components when the generator and engine are lifted.

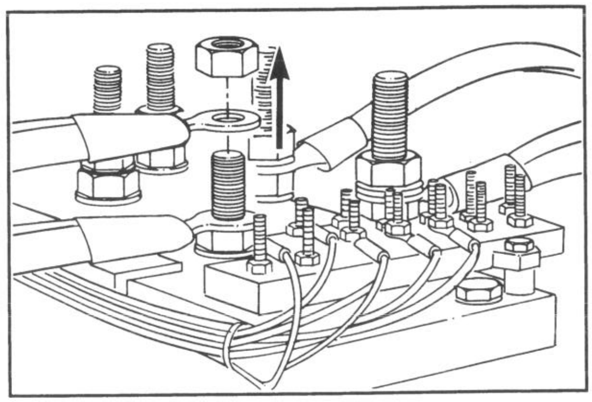


3. Disconnect the batteries or air supply line to the air starter to prevent accidental engine starting.

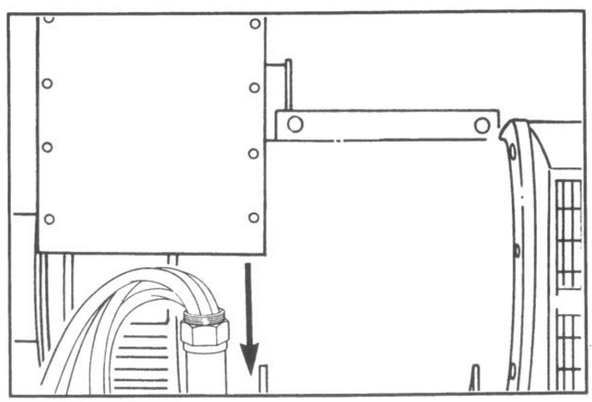
4. Identify the mounting location of the current transformers (CT'S). Carefully mark each current transformer and the corresponding generator load cable. Mark the side of the current transformer that the cable enters from as it comes from the generator. This is EXTREMELY important IF a load sensing governor, a wattmeter or a paralleling module is used. Identify any cables that are looped more than once through a current transformer.



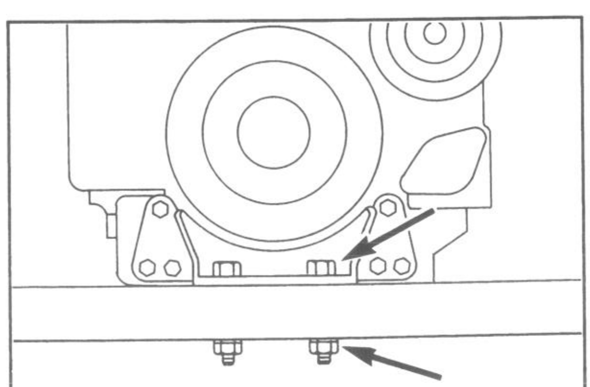
5. Disconnect the load cables from the circuit breaker or the generator terminals. Mark all leads and their corresponding connection points.

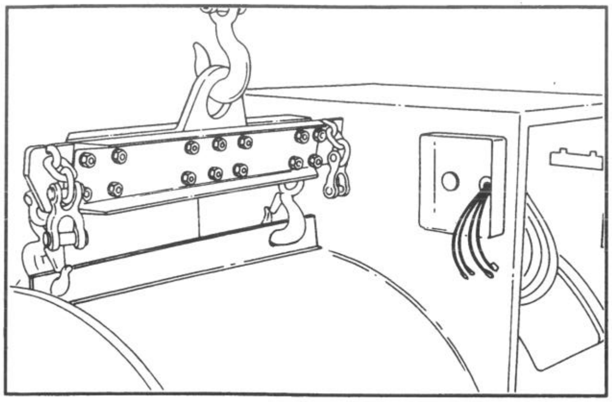


6. Remove the cable conduit(s) from the generator terminal box.

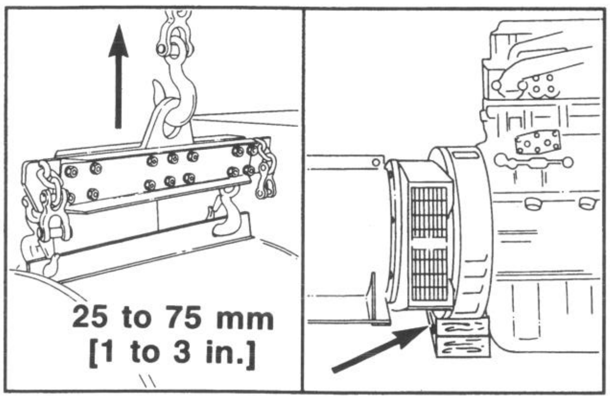


7. Loosen the two large capscrews that hold the front engine support to the crossmember.

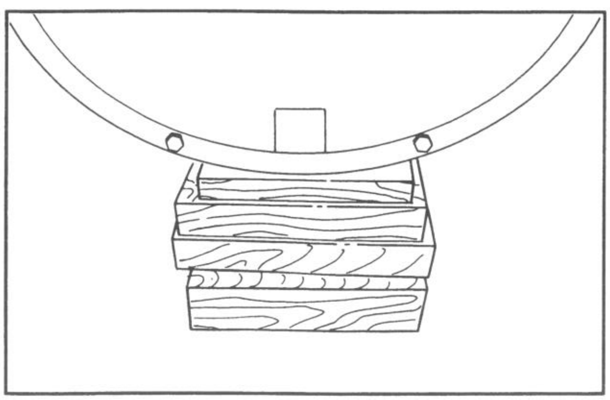




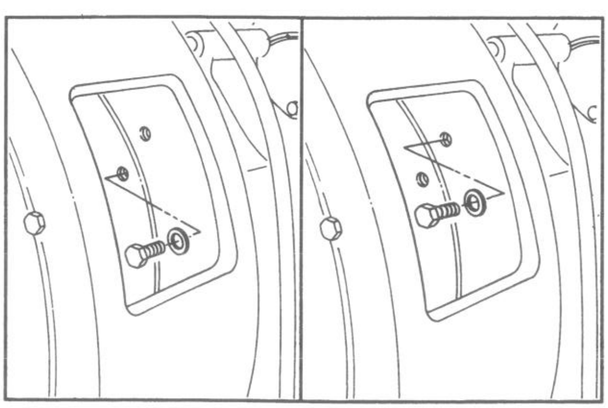
8. Place the hooks of a lifting chain in the two generator lifting eyes. Raise the hoist just enough to put tension on the chain.



9. On generator sets without a support at the flywheel housing (NT-855 and some KT-19 series units), lift the generator end of the unit 25 to 75 mm [1 to 3 inches] and place blocks under the flywheel housing. Lower the weight of the unit on to the blocks.



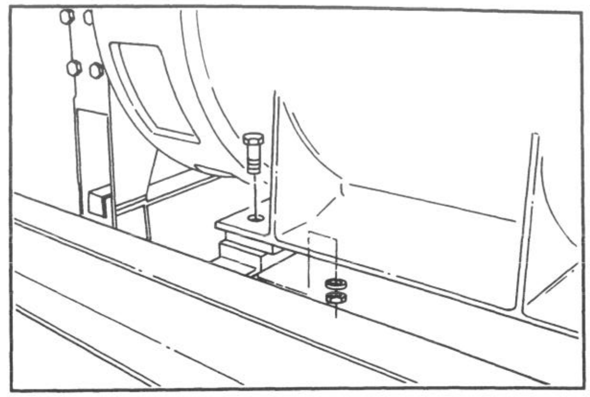
Note: The non-drive end of some generators will drop when the generator is suspended by the lifting eyes. To avoid personal injury and possible damage to equipment, stack boards under the non-drive end of the generator. Leave approximately 6 mm [1/4 inch] of clearance between the boards and the generator.



10. Remove the capscrews holding the flexible discs to the flywheel.

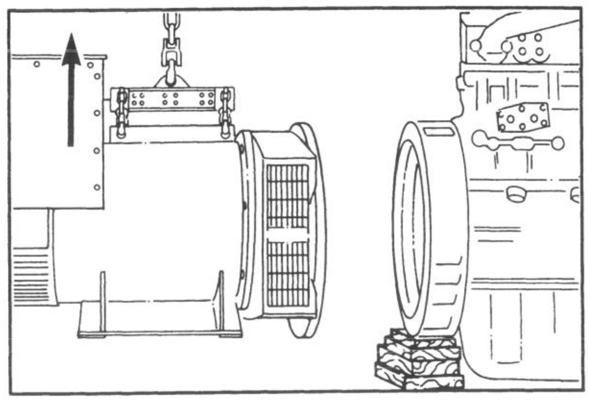
11. Remove the capscrews holding the generator flywheel housing adapter (drive endbracket) to the flywheel housing.

12. Remove the capscrews holding the generator feet to the subbase. The nuts under the subbase cross-member must be held to remove the capscrews.



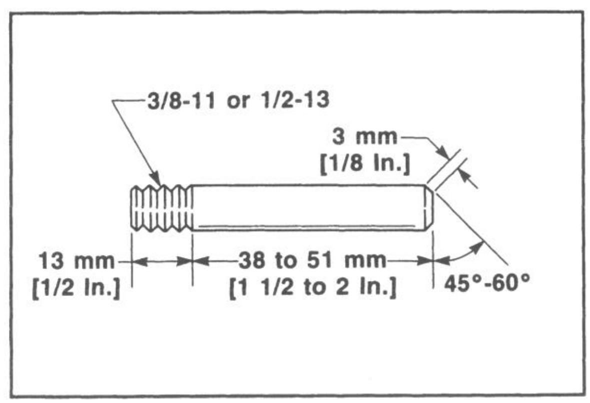
13. Lift the generator slightly and move it slowly away from the engine. Pull the generator housing adapter from the flywheel housing recess and the drive discs from the flywheel recess.

Caution: Be careful, as the generator may not be balanced from the lifting eyes. One end or the other may drop and cause personal injury or possible damage to equipment.

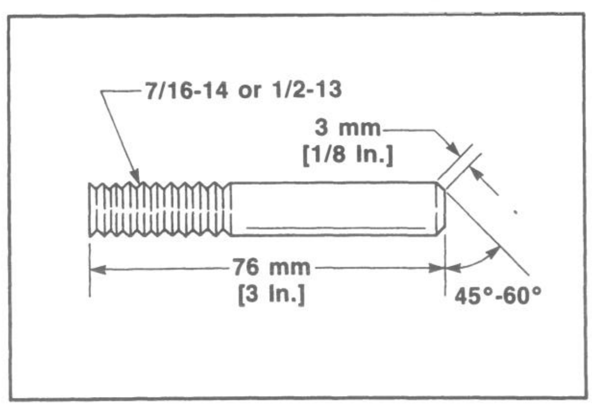


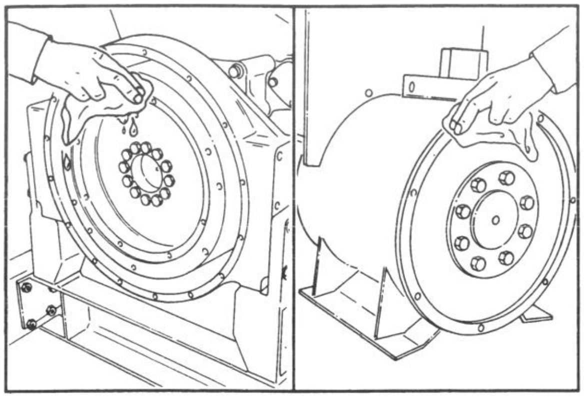
Install

1. Make two guide studs for the flywheel as shown. It will be helpful if the unthreaded length of the studs are different lengths, so that the studs can be individually guided into the generator drive disc holes. Make sure all burrs are removed from the studs.

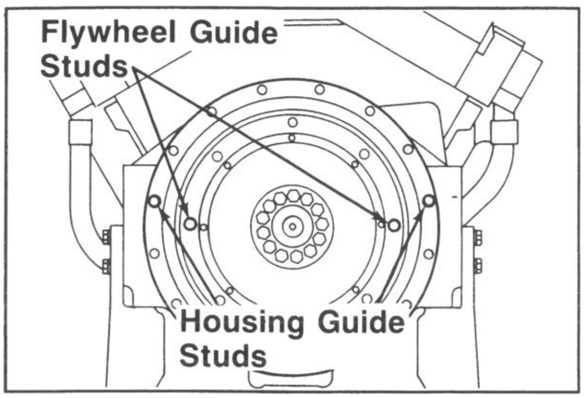


2. Make two additional guide studs for the flywheel housing as shown.

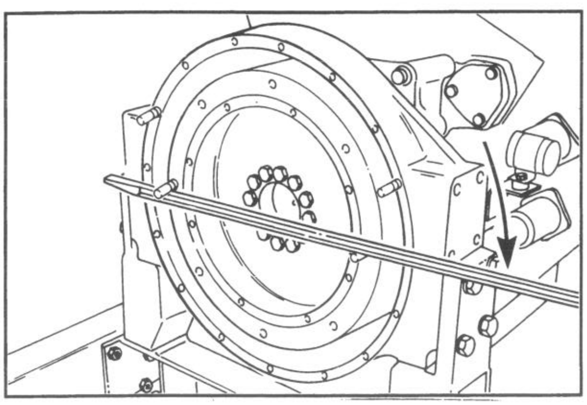




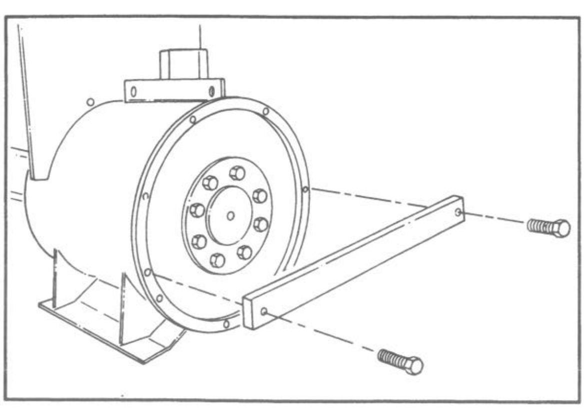
3. Coat the flywheel, housing and drive disc with a light film of oil. Remove any rust or scale.



4. Thread the flywheel guide studs into the flywheel at the 3 o'clock and 9 o'clock positions. Tighten the studs finger tight then back out 1/4 turn.
5. Thread the flywheel housing guide studs into the flywheel housing at the 2:30 o'clock and 9:30 o'clock positions. Thread the flywheel housing studs in until finger tight (all of the stud threads will not screw into the housing), then back out 1 turn.



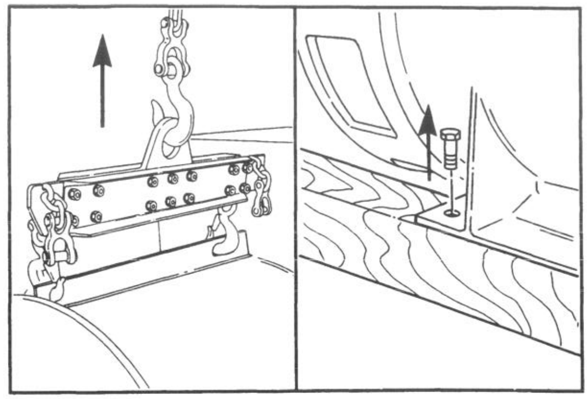
6. Observe the position of the holes in the generator drive discs.
7. On NT-855, KT-19 and VT-28 series engines, bar the engine with a pry bar on the flywheel guide studs to align the guide studs with the holes in the generator drive discs. Bar KT-38 and KTA-50 series engines with the engine barring device.



8. If the generator has a rotor blocking bar, remove the blocking bar.

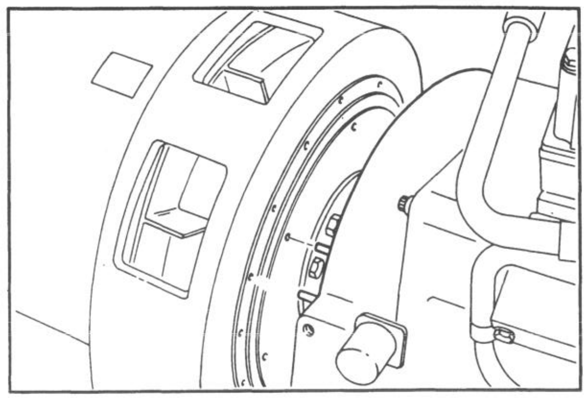
9. Place the hooks of a lifting chain in the two generator lifting eyes.

10. Remove the capscrews holding the generator feet to the shipping skid.



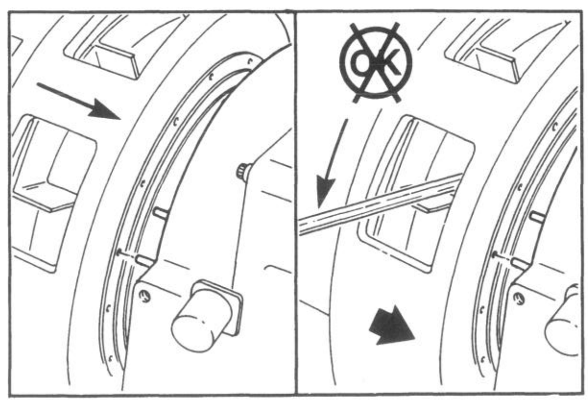
11. Carefully hoist the generator into position. The flywheel guide studs must slide into the generator drive disc holes.

Caution: The inner generator drive discs can be damaged if hit by a guide stud.

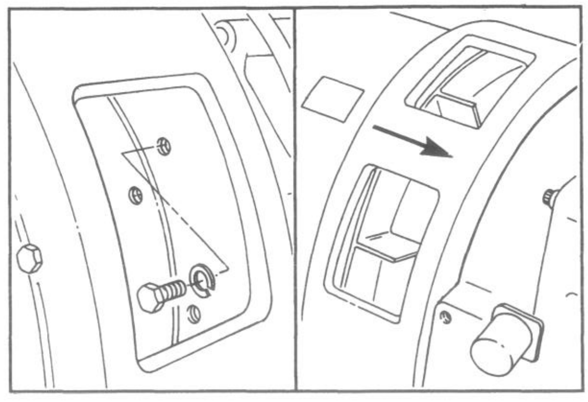


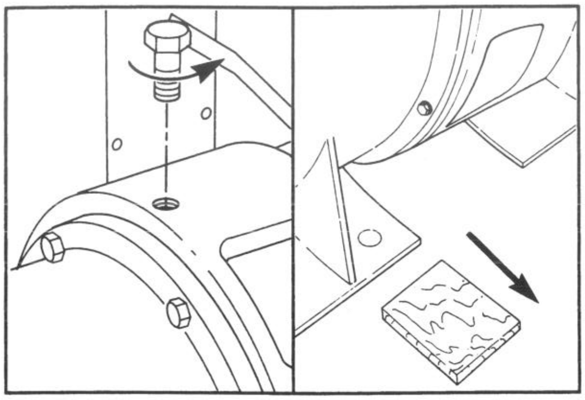
12. Carefully position the generator to line up flywheel housing studs with the generator drive-end bracket holes.

Caution: Do not use the generator fan for lifting or rotating the rotor assembly. Do not force the alignment of the generator. Move the generator from side to side or up and down to align.

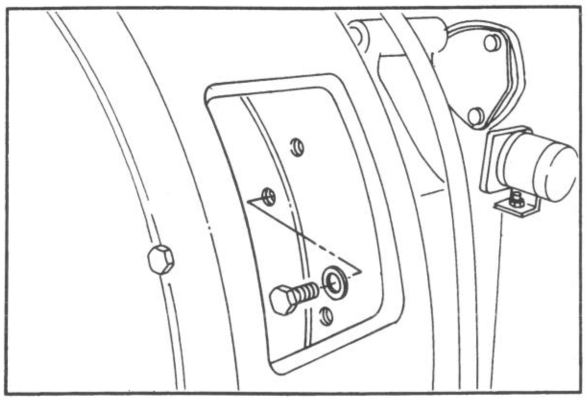


13. Install half of the flywheel housing capscrews and split lockwashers. Tighten the capscrews to bring the drive endbracket pilot into the flywheel housing recess.





14. On frame 7 and the larger frame 6 generators, remove the three rotor blocking screws and clips at the top, lower right and left sides of the end bracket. On the smaller frame 6, as well as frames 3, 4 and 5 generators, remove the wood blocks from under the generator fan.

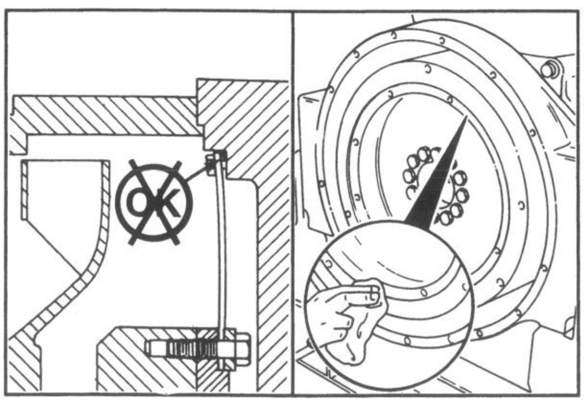


15. Install the grade 8 capscrews with flat washers through the generator drive discs into the flywheel.

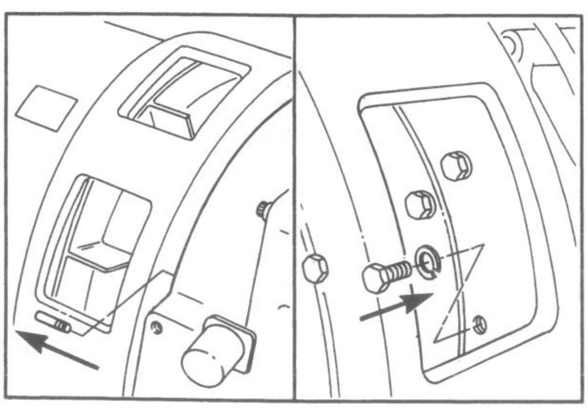
Caution: Do not use lock washers. Lock washers will bite into the flexplate causing high stress concentrations.

16. Tighten the bottom capscrews enough to draw the generator drive discs into the flywheel recess. Remove the flywheel guide studs and tighten the capscrews on each side to draw the discs into the flywheel recess. Tap discs lightly if necessary.

Note: The complete circumference of the drive discs must be seated in the flywheel recess.



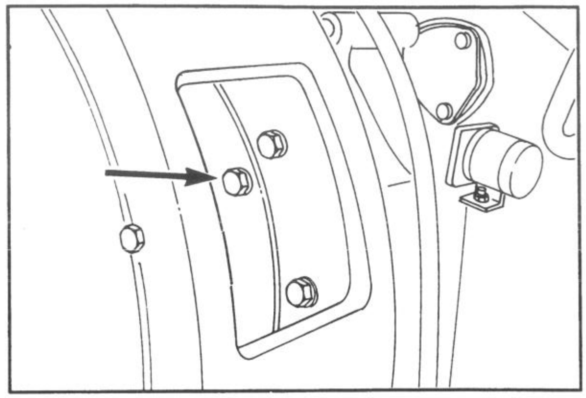
17. If a burr on the flywheel pilot prevents the drive discs from seating, remove the generator and polish the flywheel recess.



18. Remove the flywheel housing guide studs and install the remaining capscrews and split washers. Tighten the capscrews to the correct torque value as shown in Section 12-05.

19. Tighten the flywheel capscrews to the correct torque values, as shown for grade 8 capscrews in Section 12-05.

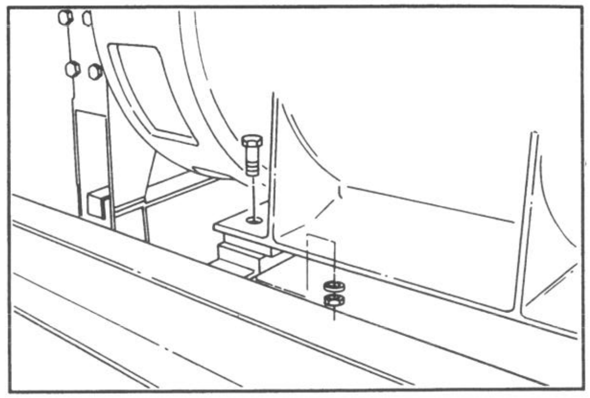
Note: On K-19 engines, the flywheel will turn before the specified torque can be attained. Engine rotation can be restrained by removing the 3/4-16 plug from the flywheel housing and inserting a (1/2 or 5/8 inch) screwdriver into the ring gear teeth. Install the plug after torquing is complete.



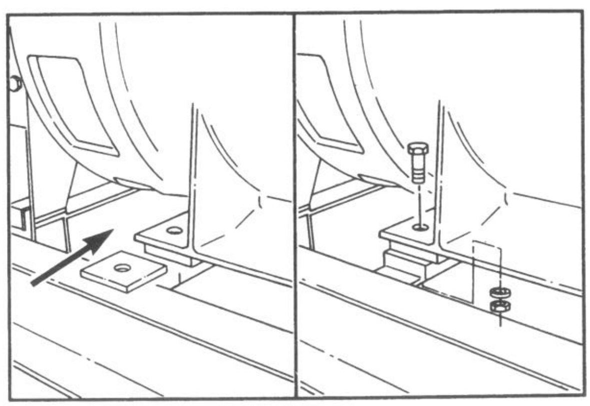
20. On NT-855 and KT-19 engines without flywheel housing supports, lower the generator to the crossmember. Install and tighten the crossmember capscrews.

Note: When the subbase is not on vibration isolators, it may be necessary to raise the subbase to access the crossmember mounting nuts.

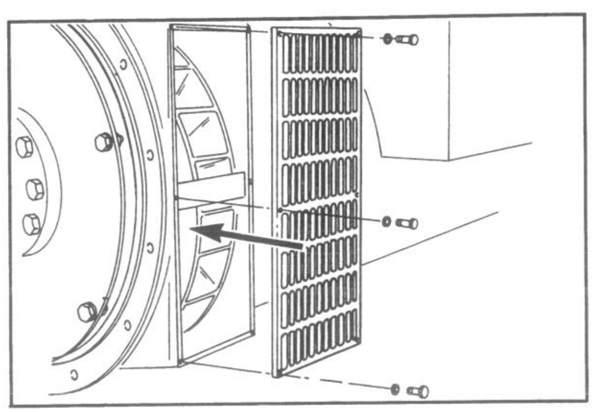
21. Remove the blocks from under the flywheel housing on NT-855 and KT-19 engines without flywheel housing supports.

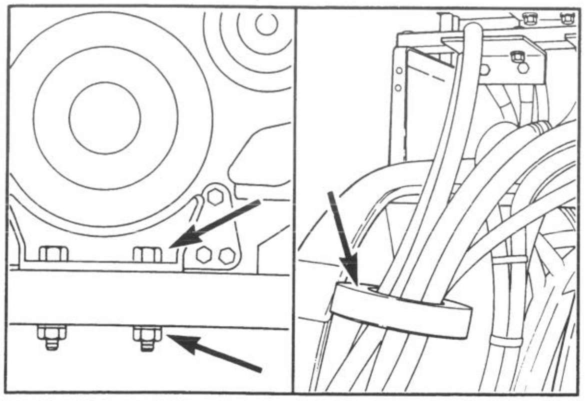


22. On engines with flywheel housing supports, install shims (as required) under each generator foot so each foot will support approximately the same weight.
23. Install the capscrews in the generator feet. Tighten the capscrews to the torque specified in Section 12-05.
24. Remove the lifting device from the generator.



25. Install the engine wiring harness if the unit has a generator mounted engine control panel.
26. Install the generator air outlet screens and access cover.

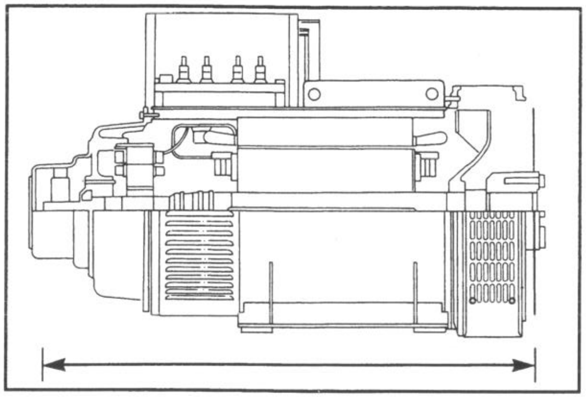




27. Tighten the two capscrews that hold the front engine support to the crossmember if they have been loosened.

28. Tighten the engine fan belts if they have been loosened.

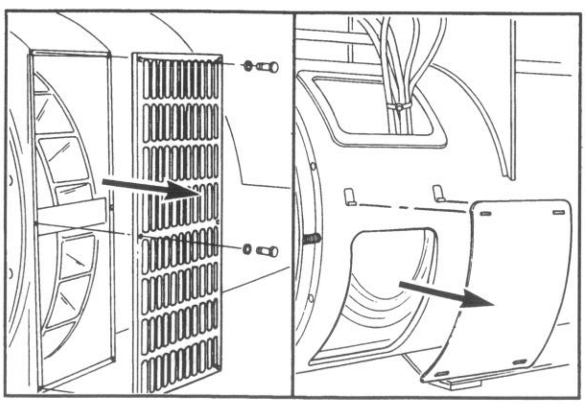
29. Install the load cables, current transformers, conduit and control wiring.



Main Rotor Assembly - Replace (6-09)

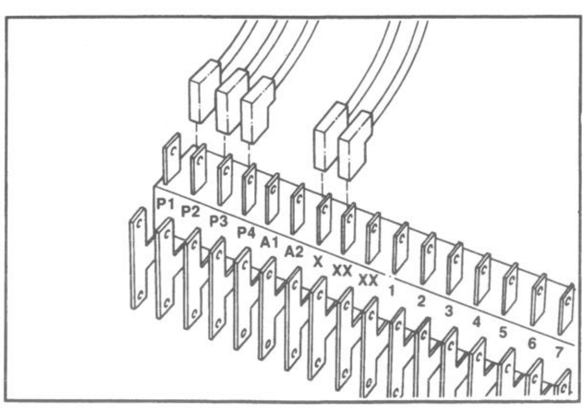
Remove

Note: The main rotor assembly is removed from the drive end of the generator. A minimum free area, the length of the generator, is required to remove the rotor. Refer to Procedure 6-05 for generator removal.



1. Remove the permanent magnetic exciter stator and rotor. Refer to Procedure 6-05.

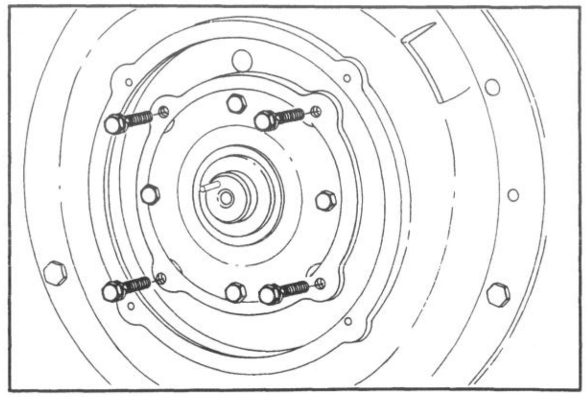
2. Remove the access cover, drive end screens, terminal box sides, lid and support brackets.



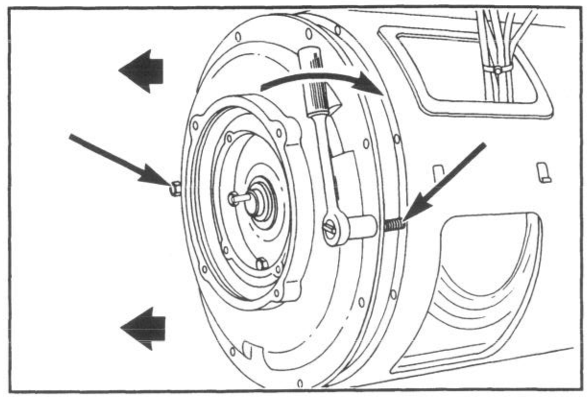
3. Disconnect exciter leads X and XX as well as P2, P3, and P4 from the auxiliary terminal block. Bring the leads back into the non-drive end bracket.

4. On generator frames 4 through 7, remove the outer 4 capscrews that hold the non-drive end bearing cartridge to the end bracket.

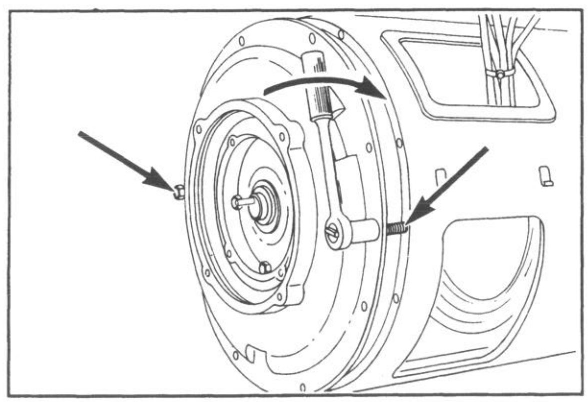
Note: Do not loosen the inner 4 capscrews unless the bearing is to be replaced. On generator frame 3, remove the 4 capscrews from the bearing cap.



5. Remove all of the capscrews that hold the non-drive end bracket to the frame.
6. Thread two of the capscrews into the jacking holes on the end bracket horizontal center line. Screw these capscrews in to pull the end bracket pilot from the locating recess in the main generator frame.

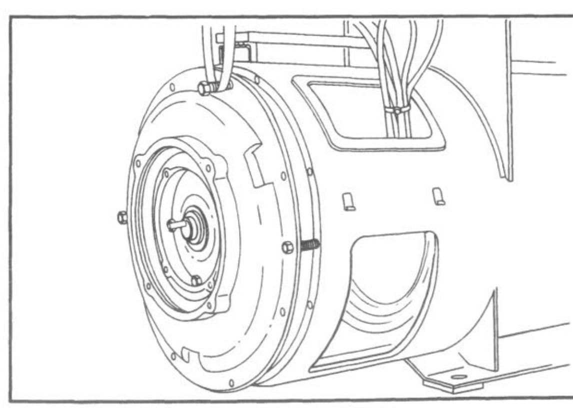


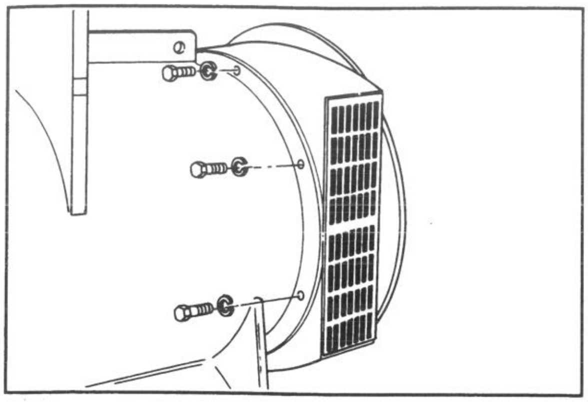
7. Tap the end bracket lightly while turning the jacking screws in. Check to make sure the bearing cartridge (frame 4 through 7) or bearing (frame 3) is not stuck in the end bracket.



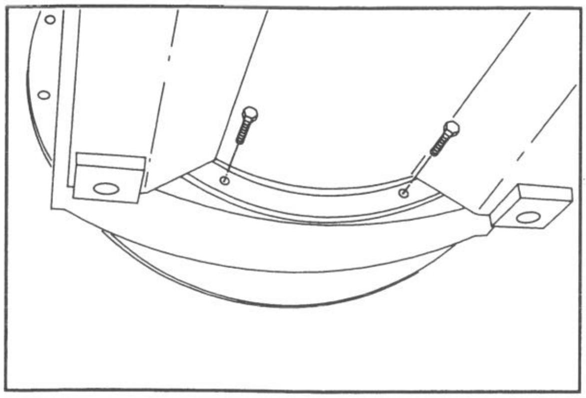
Caution: The main exciter stator is attached to the end bracket and comes out when the end bracket is removed. Use extreme care not to damage the main exciter as the end bracket is removed.

8. The end bracket (frame 6 or 7) should be supported as it is removed from the bearing cartridge.

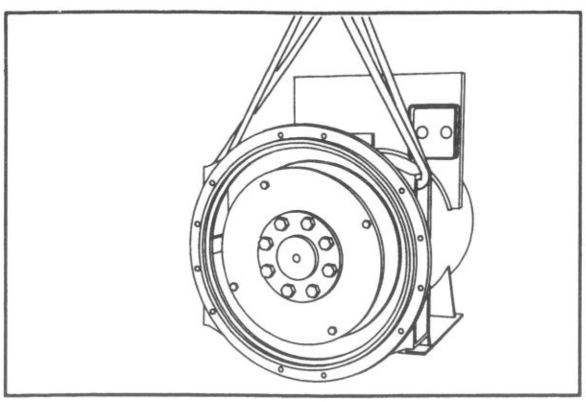




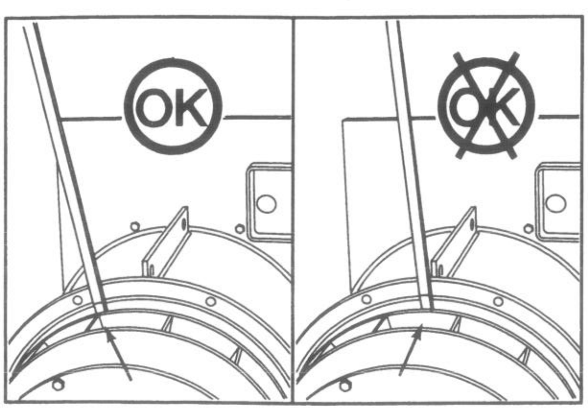
9. Remove the 8 capscrews holding the drive end bracket to the frame.



Note: Two of the capscrews are under the generator between the generator feet. It may be necessary to lift the generator to get access to these two capscrews.



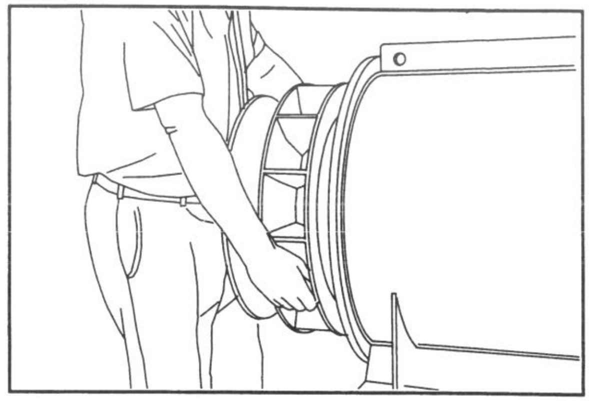
10. On generator frames 4 through 7, the drive end bracket should be supported while tapping the end bracket from the recess in the generator frame.



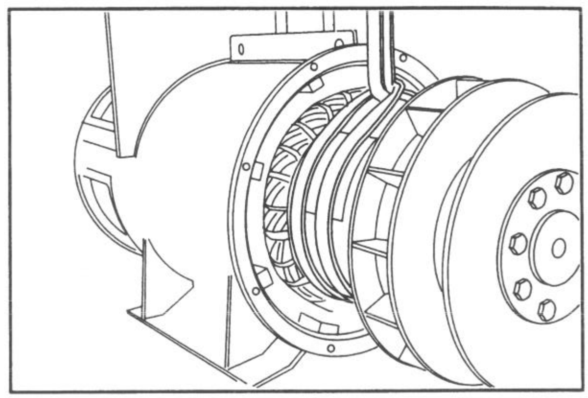
11. Move the rotor out from the stator by prying on the fan ring at a fan blade.

Caution: Do not pry on the fan ring between the fan blades. The fan blades can be easily bent or broken. The entire generator rotor must be disassembled (normally at the factory) to replace a generator fan.

12. Rotate the rotor while pulling it from the stator assembly. Pull the rotor out until the main rotor poles are exposed.

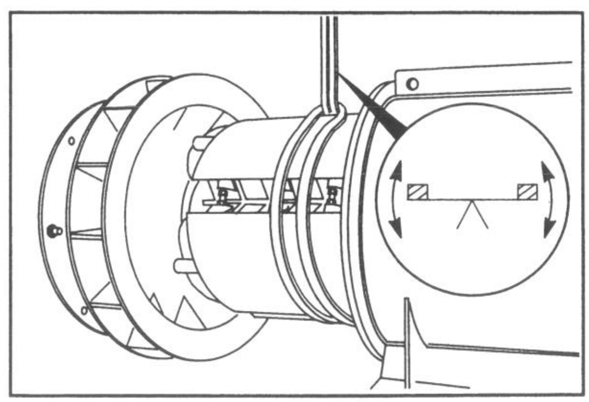


13. Support the rotor drive end with a sling around the main generator rotor poles.

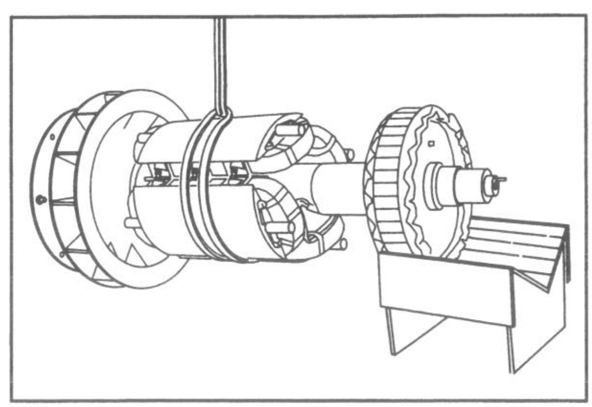


Note: This operation will be easier with a second person supporting and guiding the non-drive end of the shaft.

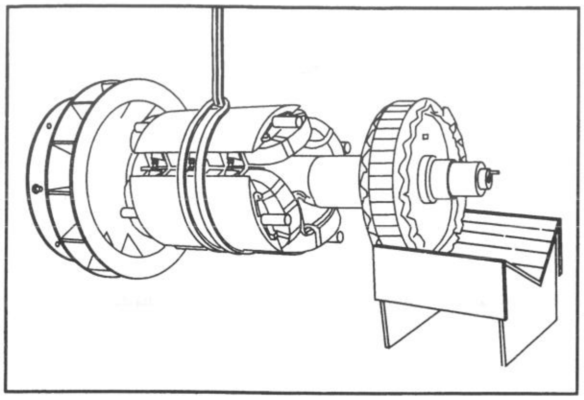
14. Continue to pull and rotate the rotor assembly as it is removed from the stator.
15. Move the sling closer to the center balance point of rotor as it is removed.



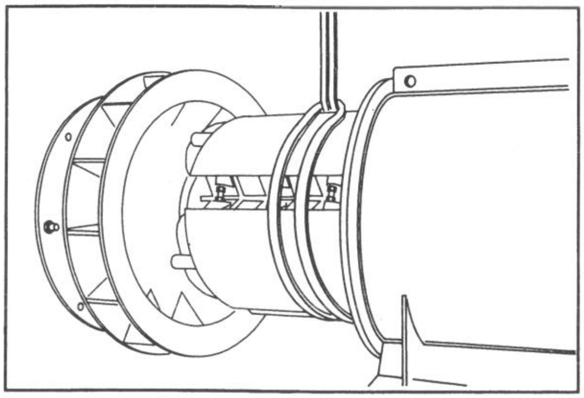
16. The best location for the sling is where only a slight downward force on the fan is required to balance the assembly.
17. Set the rotor in a formed support as shown to avoid damage to the main exciter rotor windings.



Install

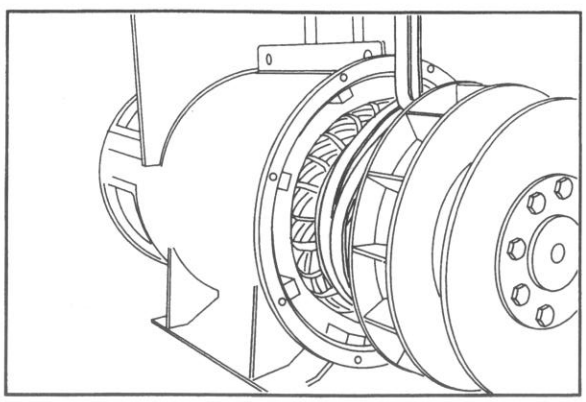


1. Put a sling around the main generator rotor at the approximate center balance point. The best location for the sling is where only a slight downward force on the fan is required to balance the assembly.



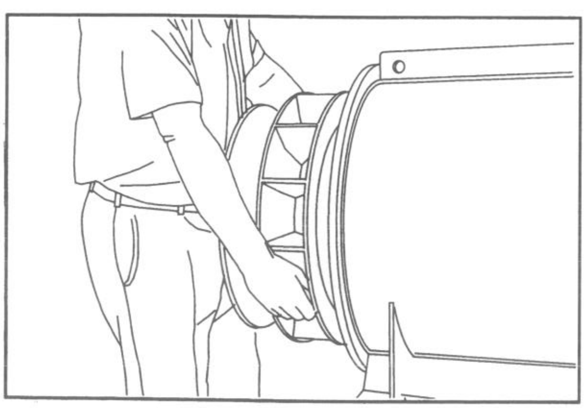
2. Position the rotor into the stator as far as the sling will allow. Use care to avoid bumping the main exciter rotor into the main generator stator.

Note: This operation will be easier with a second person supporting and guiding the non-drive end of the shaft.



3. Lower the support and re-position the sling closer to the fan. Lift the rotor and continue installation until the sling can no longer be used.

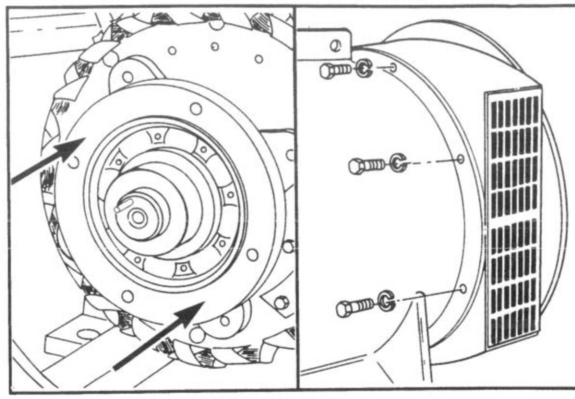
Caution: Do not wrap the sling around the rotor winding end turns. A sling can damage the rotor winding end turn insulation.



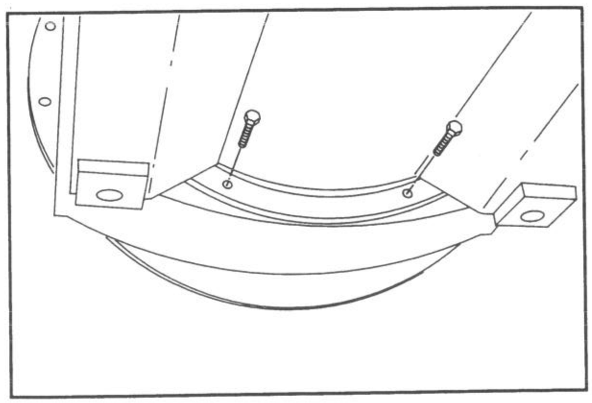
4. Finish installing the rotor in the generator stator by hand. Rock the rotor from side to side or twist it while pushing it into the stator. Continue until the main rotor poles are even with the main stator.

5. Install the bearing (frame 3) or bearing and cartridge (frame 4 through 7) if the bearing has been removed. Refer to Procedure 6-05.

6. Install the drive end bracket on the generator frame. A hoist should be used to lift the drive end bracket on frames 4 through 7. Tap the end bracket as the capscrews are tightened to make sure that the end bracket is seated in the main generator recess.

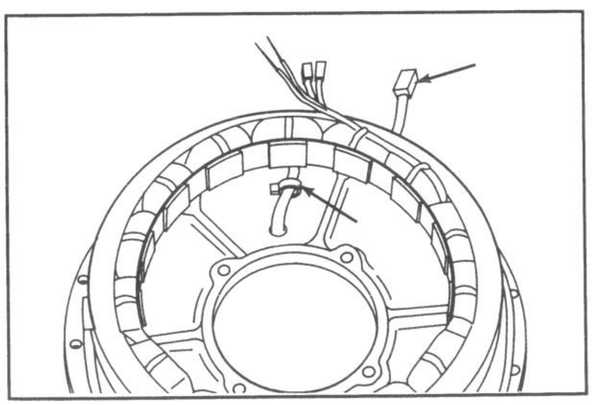


7. Install the two drive end bracket capscrews at the bottom of the generator. It may be necessary to lift the generator to access these capscrews.

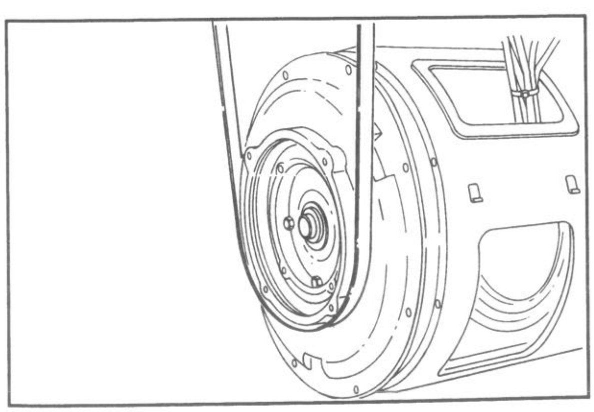


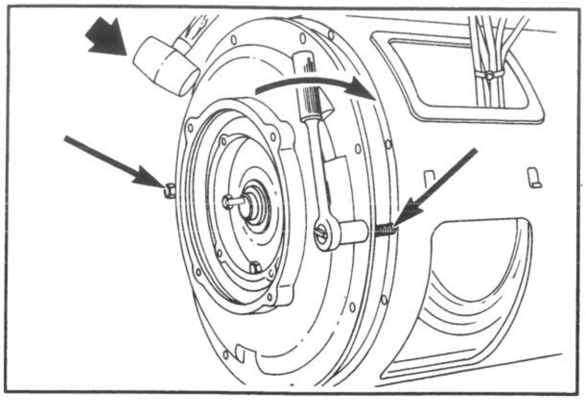
Note: Make sure that the permanent magnet exciter harness attached to the stator is through the end bracket and the harness is retained by the internal wire clamp. The harness is difficult to install when the end bracket is on the generator. Make sure that the main exciter stator leads will be at the top of the generator.

8. Install the end bracket on the bearing (frame 3), or on the bearing cartridge (frames 4 through 7).

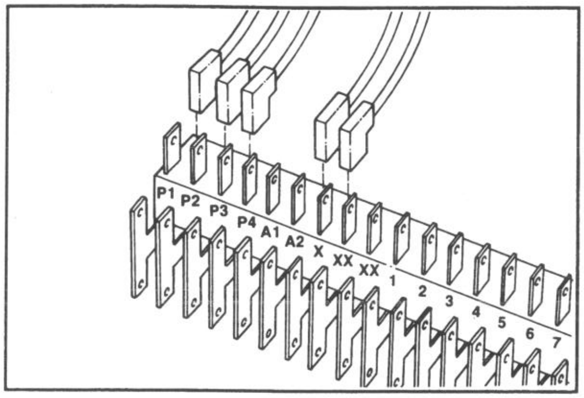


9. Lift the end bracket and rotor to pilot the end bracket into the generator frame recess. Frames 3 and 4 can normally be lifted by one person. Frames 5 through 7 will require a hoist and sling. Place the sling around the exciter mounting surface.



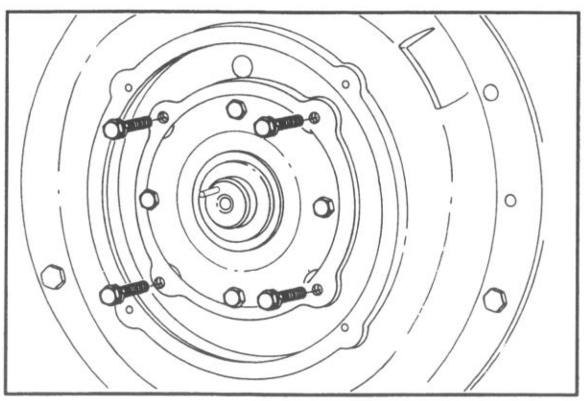


10. Install the capscrews which hold the end bracket to the generator frame. Tap the end bracket lightly- as the capscrews are tightened.



11. Pull the main exciter leads (X and XX) and the permanent magnetic exciter stator leads (P2, P3 and P4) through the hole in the frame terminal box.

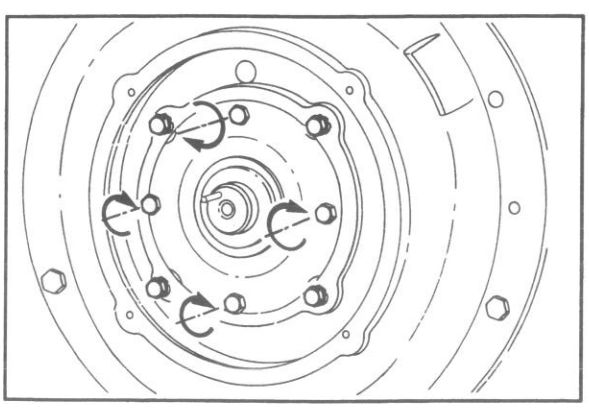
12. Connect the leads to the corresponding terminals on the auxiliary terminal block.



13. On generator frame 3, install the 4 capscrews through the outboard bearing cap and end bracket and into the inboard bearing cap.

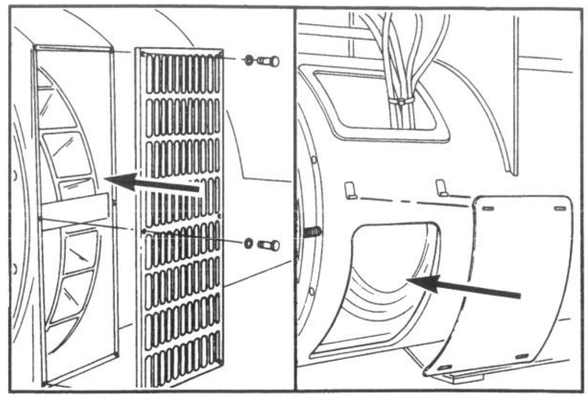
14. On generator frames 4 through 7, align the bearing cartridge threaded capscrew holes with the holes in the end bracket by turning the bearing end cap. The bearing cartridge will rotate in the end bracket.

15. Install the bearing cartridge capscrews.



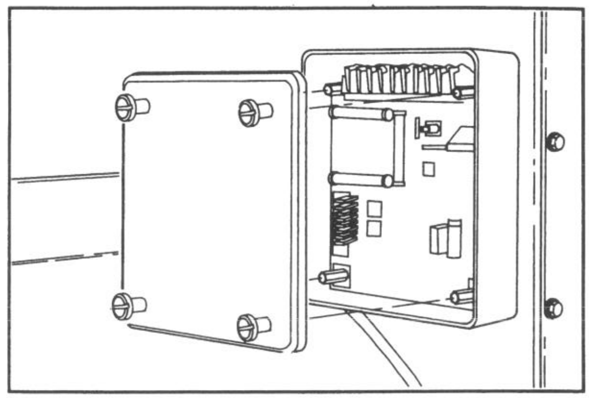
16. On generator frames 4 through 7, check the torque on the inner 4 capscrews that hold the bearing cap to the bearing cartridge. See Section (12-05).

17. Install the permanent magnet exciter. Refer to Procedure 6-05.
18. Install the non-drive end access cover, the terminal box sides, lid and support brackets.

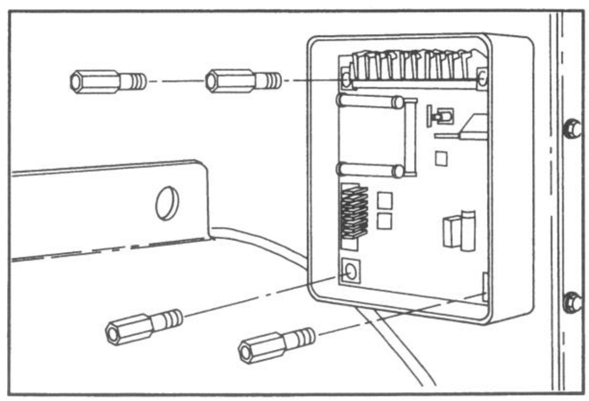


Permanent Magnet Exciter - Check (6-10)

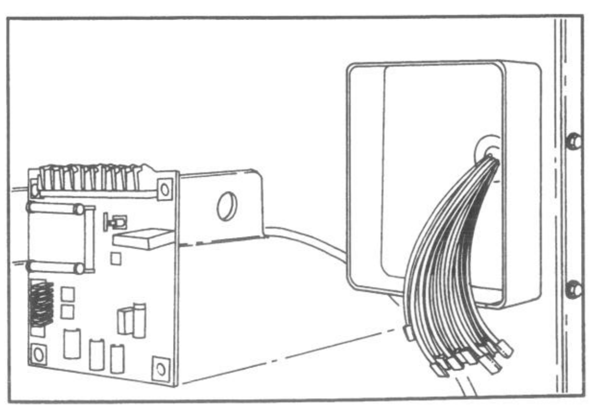
1. Remove the four captive screws and the cover from the AVR (Automatic Voltage Regulator) box.

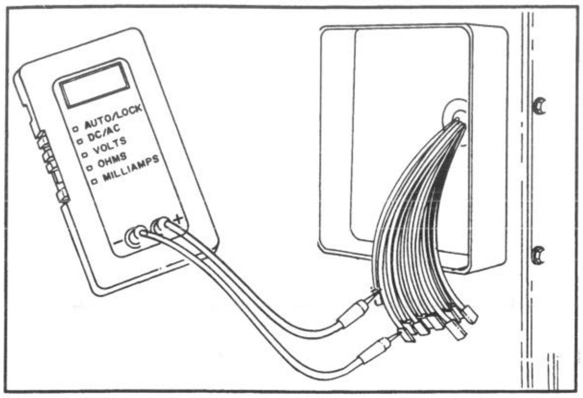


2. Remove the four threaded pillars holding the AVR in place.

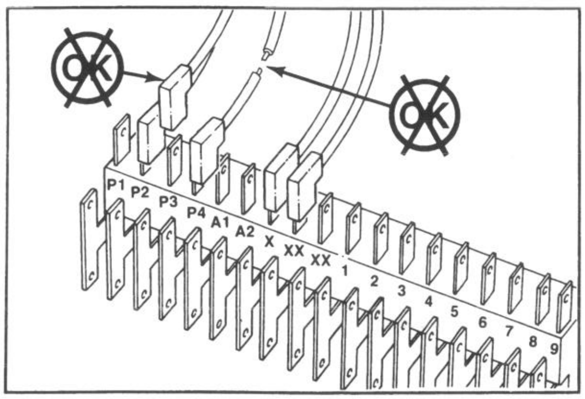


3. Pull the AVR from the box and remove all of the external leads.

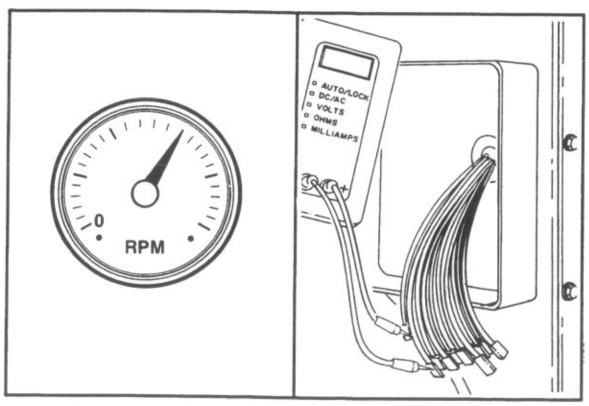




4. Use a multimeter and measure the resistance between exciter leads (P2 and P3), (P3 and P4) and (P2 and P4). The resistance for each pair should be 4 to 5 ohms at 20 to 40° C [68 to 104° F].



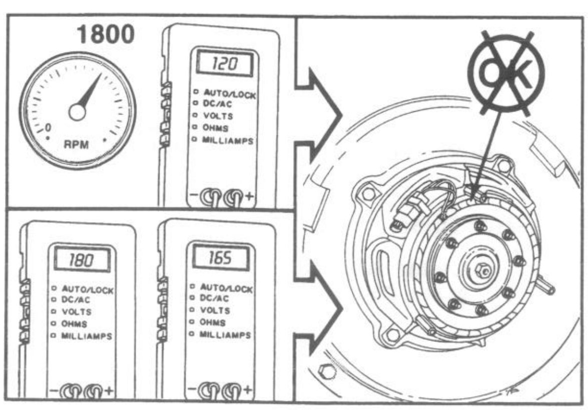
5. If the resistance is more than 10 ohms on any pair of leads, check for the following:
   1) Disconnected wire at the auxiliary terminal block.
   2) Broken or defective wire between the AVR and the auxiliary terminal block.
   3) Broken or defective wire between the auxiliary terminal block and the permanent magnetic exciter stator.
6. Repair or replace any broken leads.



7. Start the engine and bring the unit up to governed speed (1500 or 1800 RPM).

Warning: Use a multimeter and set it to measure A.C. voltage (the meter must be capable of measuring 200 to 250 volts). Measure and record the voltage from the following leads.

   1) P2 to P3
   2) P3 to P4
   3) P4 to P2

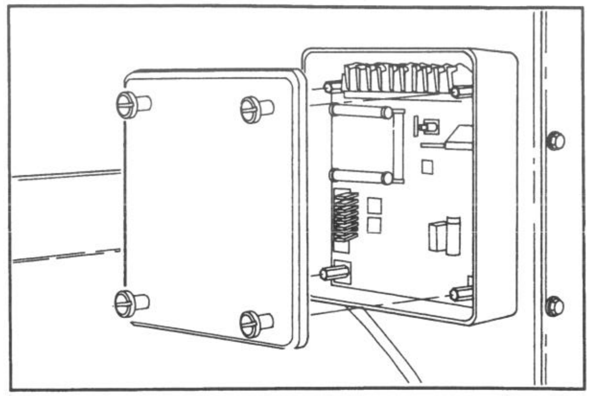


8. The voltage of each pair should be above 150 volts at 1500 RPM or above 180 volts at 1800 RPM.
9. If the voltages are equal but less than 150 or 180 volts, the permanent magnetic exciter rotor has been demagnetized and must be replaced.

Note: If the voltage is less than 150 or 180 volts, check to make sure the engine RPM is correct (1500 or 1800 RPM).

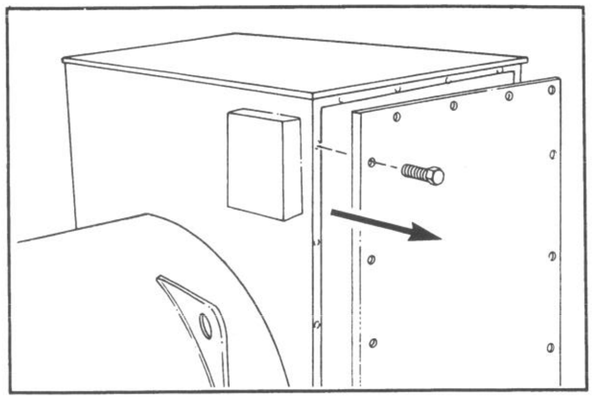
10. If the difference between the highest and lowest voltage is 10 volts or more, the permanent magnet exciter stator is defective and must be replaced.

11. If all measurements are satisfactory, stop the engine and install all 10 leads on the AVR and install the AVR.

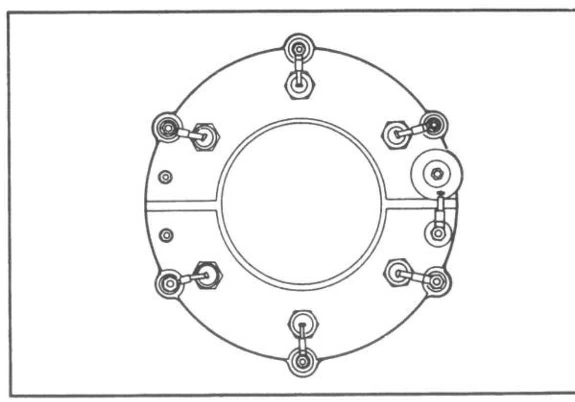


Rotating Diodes - Check (6-11)

1. Remove the non-drive end access cover and the two side covers from the terminal box.

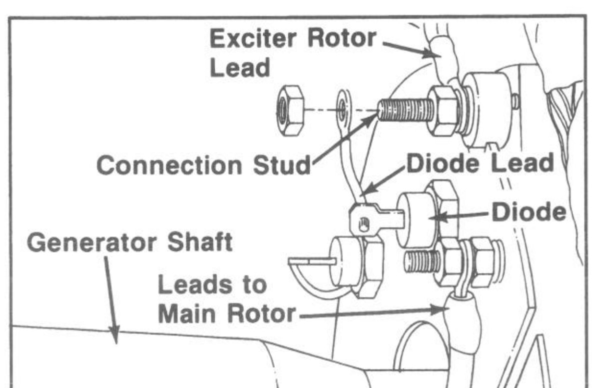


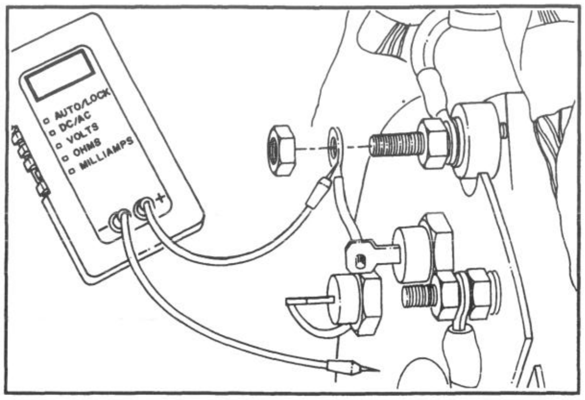
2. There are 3 diodes on each of the two plates attached to the hub. These plates are on the drive end side of the main exciter rotor. The diodes are easier to check if the crankshaft can be barred.



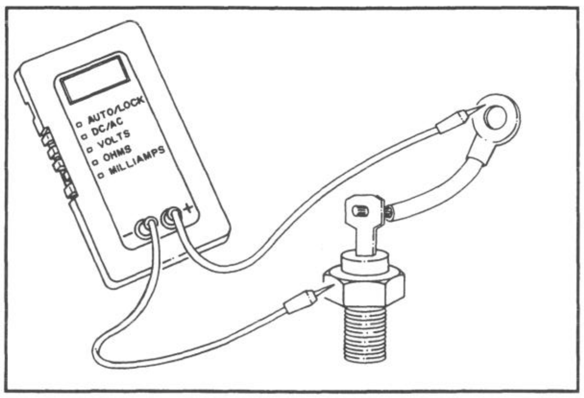
3. A lead from a diode and a lead from the main exciter rotor are both attached to an adjacent connector stud. Remove the diode lead from the connection stud.

Note: On generator frames 4 through 7, during assembly the diode lead is put at the bottom of the connection stud. To make later service easier, put the diode lead on the connector stud last (under the nut).



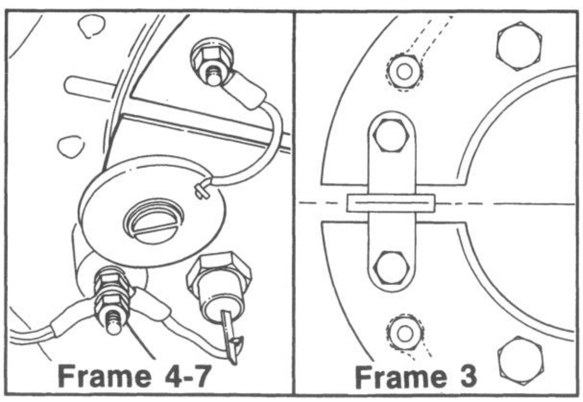


4. Use the multimeter, Part No. 3376898, and set it to read ohms. Connect one lead of the meter to the diode lead and the other meter lead to the diode plate. Record the reading. Reverse the meter leads and again record the reading.



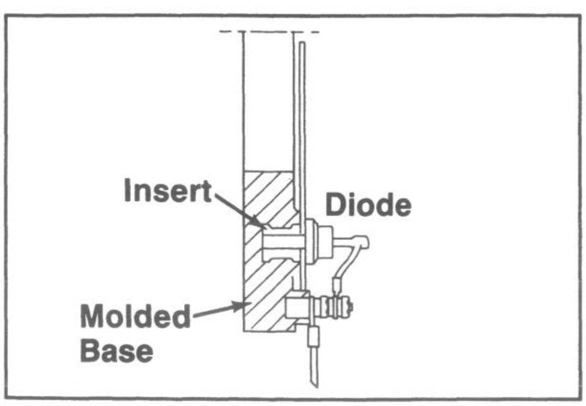
5. A good diode will give a high resistance reading in one direction and a lower resistance reading in the opposite direction. The high resistance reading should be at least 10 times the low reading.

6. A faulty diode will give a high resistance reading (open) in both directions or a low resistance reading (shorted) in both directions.



7. Before installing a new diode, check the appearance of the varistor (surge suppressor). On generator frame 3, the varistor is located between the two plates, and is held in place by the capscrews that attach the main generator rotor leads. On generator frames 4 through 7, the varistor is located on the opposite side of the shaft from the main generator rotor leads.

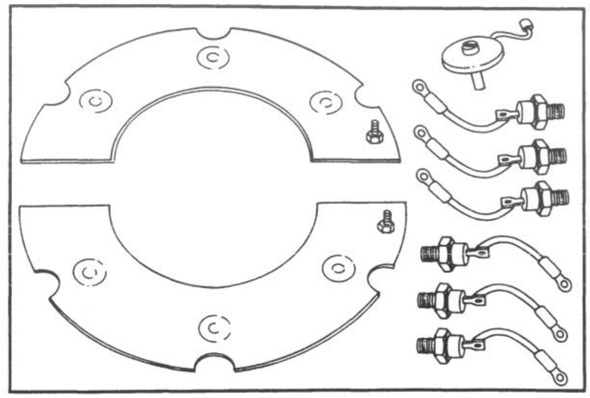
8. A faulty generator frame 3 varistor will be burned or missing. A faulty generator frame 4 through 7 varistor will be burned or have the lead wire burned off.



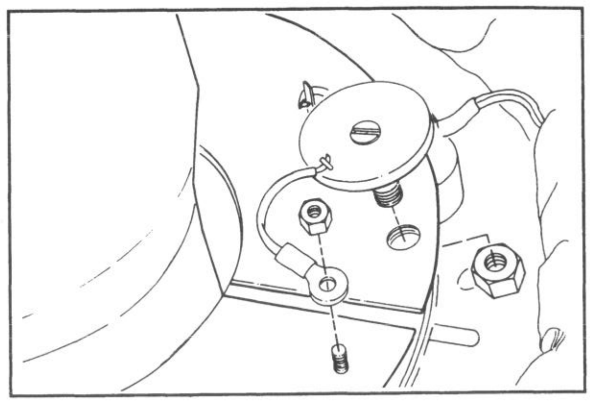
9. The diodes are held in place by captive inserts within the molded base. Remove the diode by turning it counter-clockwise.

10. To replace the varistor on frame 3 generators, remove the capscrews that hold the main generator rotor leads and varistor to the plate.

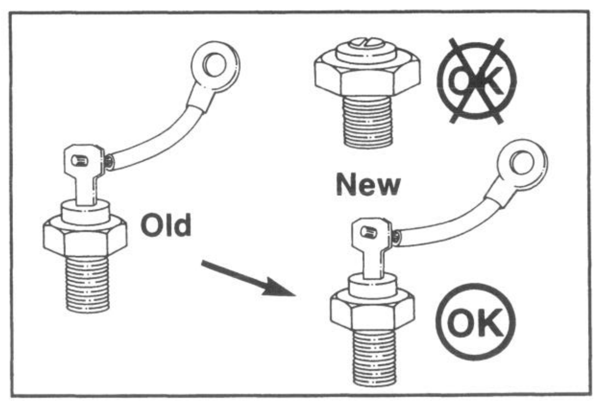
11. Install a new varistor and replace the rotor leads and capscrews.



12. To replace the varistor on frames 4 through 7:
    1) Disconnect the main generator rotor leads.
    2) Remove all 6 diodes.
    3) Move the ends of the two plates away from the main exciter rotor.
    4) Remove the nut from the varistor stud.
    5) Remove the varistor wire lead from the stud.
    6) Replace the varistor assembly.



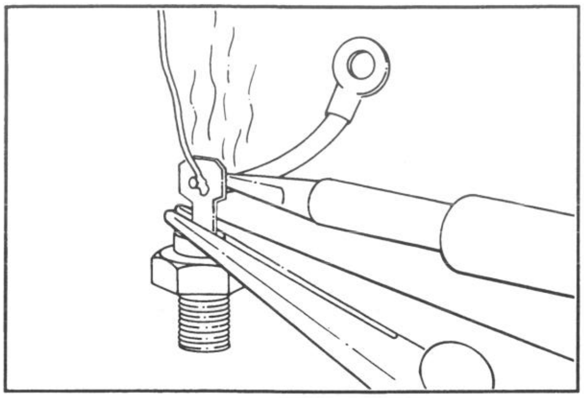
Note: When replacing a diode, the replacement must be from the same manufacturer and have the same model number. Diodes with black leads are reverse polarity and have the letter "R" in the model designation. The arrow on the diode will point towards the terminal. Always check the diode with a meter to be sure of its polarity.



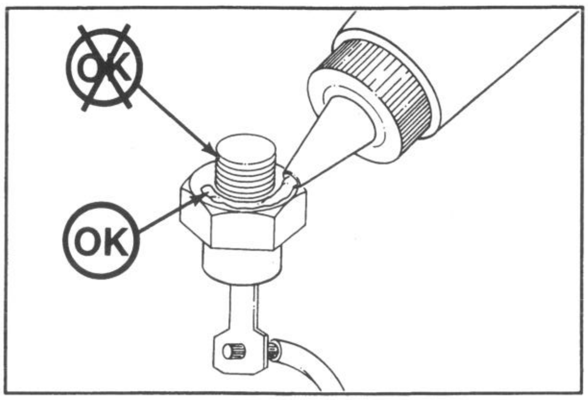
Example: I R 85 49 40HFR100 identifies a diode made by International Rectifier Co. The 85 49 is the date code. The 40 indicates a 40 ampere continuous rating. The HF is a designation for the size and shape. The R indicates reverse polarity. The 100 indicates that the diode is rated to withstand 1000 volts in the reverse direction.

Frames 2 and 3 Replacement Diodes		
	International Rectifier	Marconi
Red Lead	25F80	M25-800
Black Lead	25FR80	M25R800

Frames 4 through 7 Replacement Diodes		
	International Rectifier	Marconi
Red Lead	40HF100	M41-1000
Black Lead	40HFR100	M41R1000

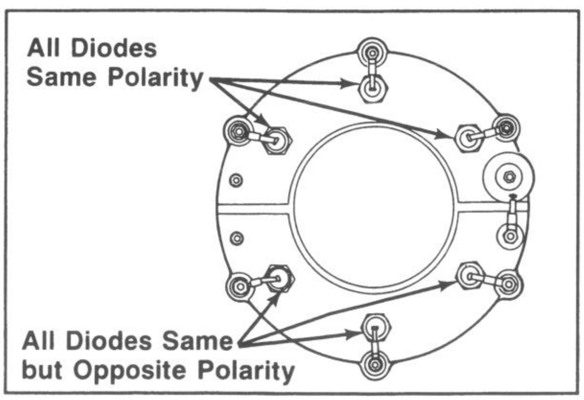


13. A diode obtained from an electrical supply company will not have a lead soldered to the terminal. If a lead must be soldered to the terminal, use 60-40 rosin core solder. Hold the diode terminal with long nose pliers during soldering to prevent excessive heat transfer through the terminal to the diode junction.



14. The area of the diode that will be in contact with the plate should be coated with Midland Silicone Heat Sink Compound Type MS 2623 or equivalent.

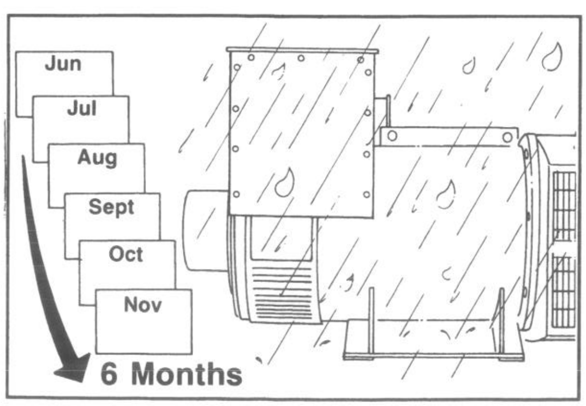
Caution: This compound must not be applied to the diode stud threads, since it will act as a lubricant and allow the diode to loosen.



15. Install the diodes on the plates.

Note: All of the diodes installed on one plate must have the same polarity, and all of the diodes installed on the other plate must have the opposite polarity. Do not mix the polarity of the diodes on a plate.

Note: On generators with permanent magnet exciter, it makes no difference which plate has the " R" polarity diodes.

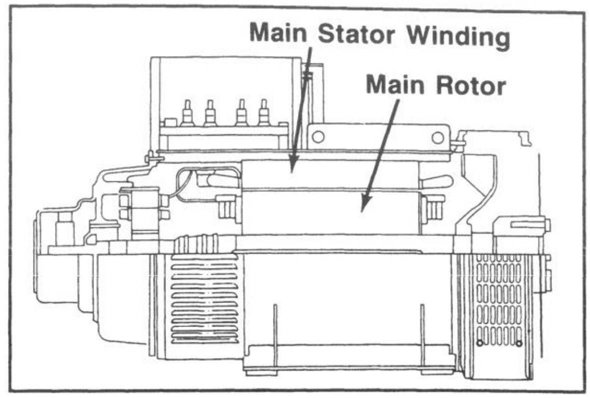


Insulation Resistance - Measurement (6-12)

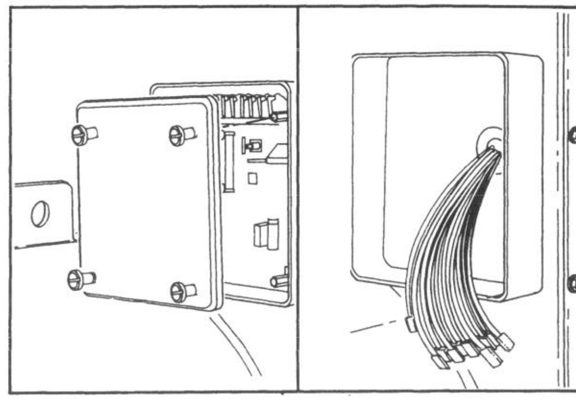
Note: If a generator has been in storage for over 6 months or has been exposed to high humidity or temperature changes that could cause condensation, check the insulation resistance before putting the unit into service.

Note: The insulation resistance of the main stator winding is the most important value. The insulation resistance of the main stator and the permanent magnet stator are easy to measure.

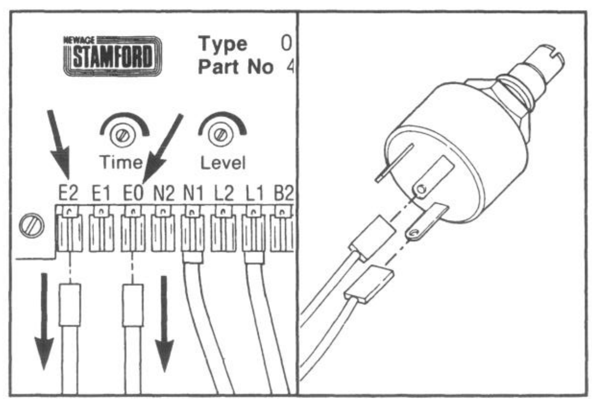
The insulation resistance of the main exciter rotor and main rotor are more difficult to measure and are less significant. It is recommended that these resistances be checked only when diagnosing a problem.



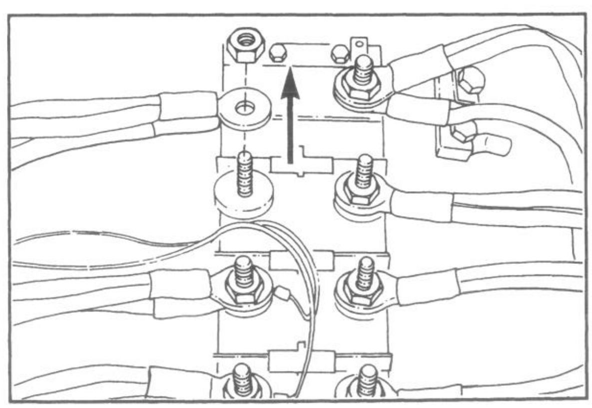
1. Remove the AVR from the AVR box and disconnect all of the external leads from the AVR. Refer to Procedure 6-04.
2. Separate the leads so that the terminals do not touch one another or the AVR box.

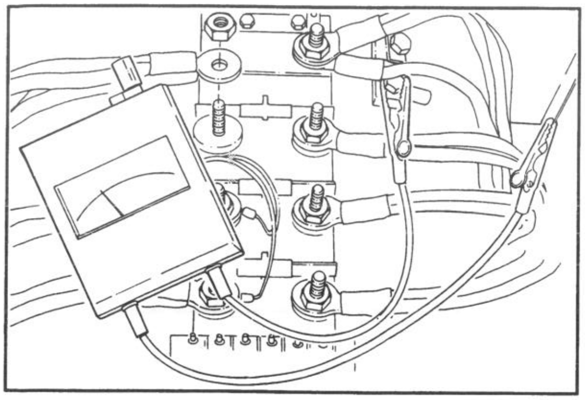


3. Remove both sides of the terminal box.
4. Remove the E0 and E2 leads from the overvoltage module. Separate the leads so they do not touch anything.
5. Remove the two leads from the voltage adjust rheostat. Separate the leads so they do not touch anything.



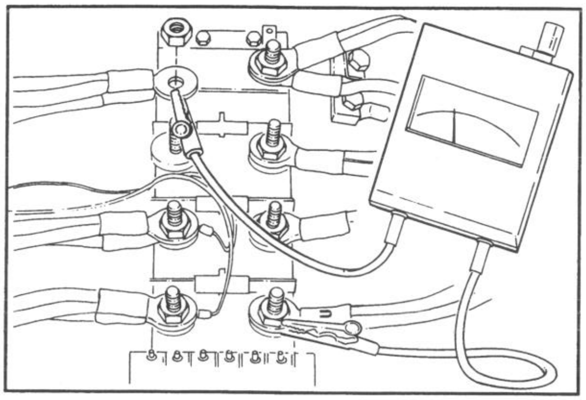
6. Remove the leads that connect the generator windings to the generator frame.
7. Open the generator main line circuit breaker (if there is one).
8. Disconnect any instrumentation and controls (voltmeter, wattmeter, load sensing governor, synchronizer, etc.) as well as any capacitors that may be connected to the main leads (U or U6, V or V6, W or W6 and N).



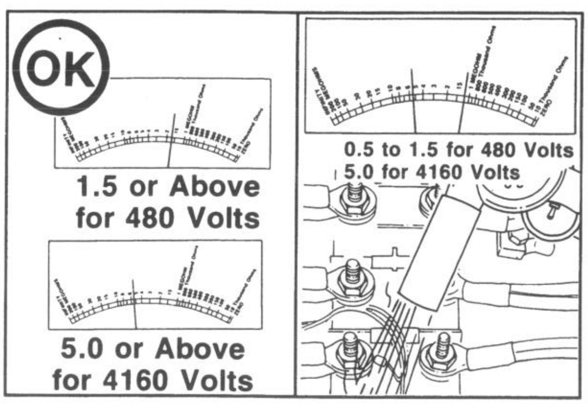


9. Use the megger, Part No. 3376304. Connect one lead of the megger to the ground connection point in the terminal box. Connect the other lead to the terminal box.

10. Crank or operate the megger 2 or 3 turns. The megger should indicate zero ohms. A zero reading shows that the ground is ok. If the megger does not read zero, move the clips to make better contact and keep checking until a zero reading is obtained.



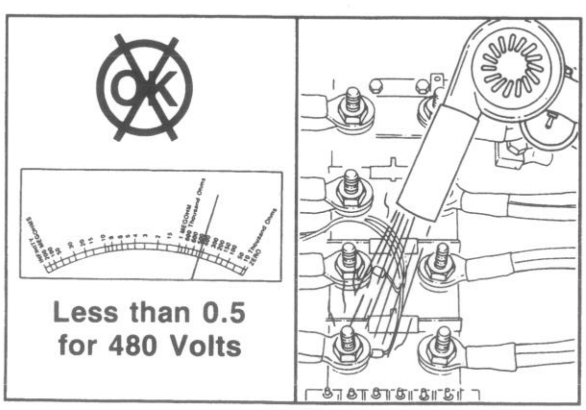
11. Remove the lead from the terminal box and connect it to generator lead U or terminal U. Crank the megger at approximately 120 RPM (2 turns per second) for 10 seconds and record the reading.



12. A reading of 1.5 megohms or above is satisfactory for generators that operate up to 480 volts.

13. A reading of 5 megohms or above is satisfactory for generators that operate up to 4160 volts.

14. A reading of 0.5 to 1.5 (or 5.0 megohms for 4160 volt generators) indicates that the main insulation is marginal. Dry the generator insulation and test again. Refer to Procedure 6-13.



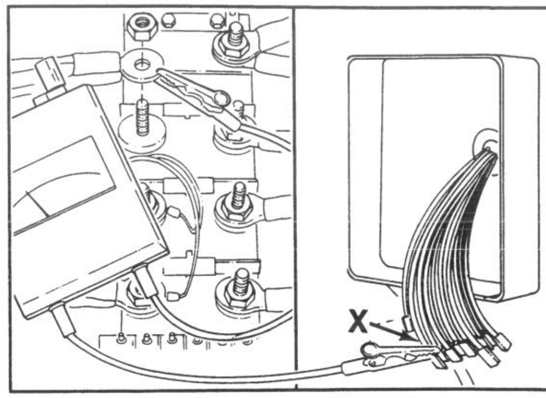
15. A reading of less than 0.5 megohms indicates an accidental grounding or a severe insulation problem. Recheck to make sure none of the terminals are touching the frame.

16. Check the main stator leads for worn insulation. Repair or replace as necessary.

17. Recheck to make sure that no control equipment or instrumentation is connected to terminals U, V, W or N.

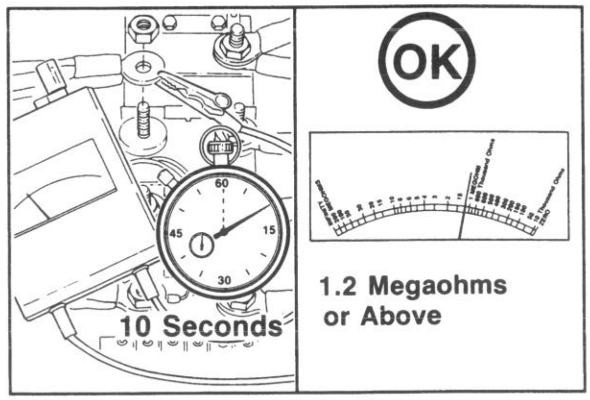
18. Dry the generator and test again. Refer to Procedure 6-13.

19. To measure the insulation resistance of the main exciter stator, remove the megger lead from terminal U and reconnect it to terminal X at the AVR box.



20. Crank the megger at approximately 120 RPM (2 turns per second) for 10 seconds and record the reading.

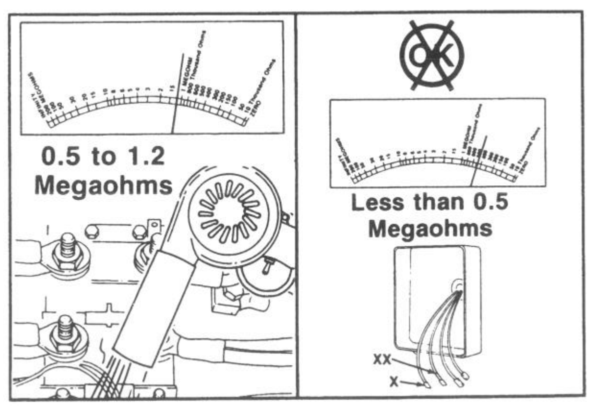
21. A reading of 1.2 megohms or above indicates the insulation resistance of the main exciter stator is satisfactory.



22. A reading of 0.5 to 1.2 megohms indicates the insulation resistance is marginal. Dry the generator and test again. Refer to Procedure 6-13.

23. A reading of less than 0.5 megohms indicates an accidental grounding or a severe insulation problem.

Check for worn or damaged lead insulation where the X and XX leads go through the terminal box. Also check where the leads go through the main generator frame. Dry the generator and test again. Refer to Procedure 6-13.



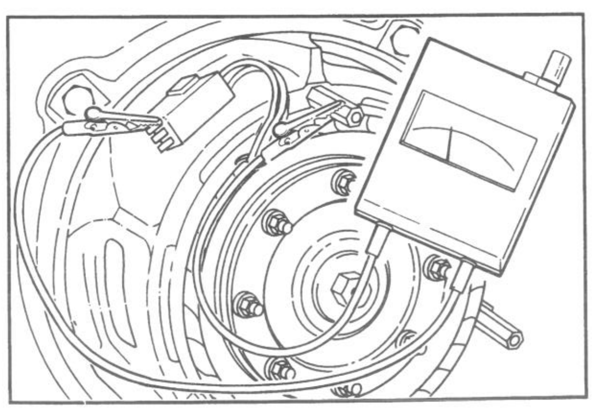
24. To measure the insulation resistance of the permanent magnet exciter windings:

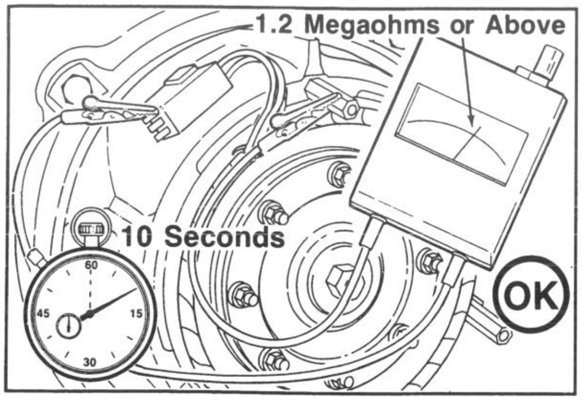
1) Remove the permanent magnet exciter end cover.

2) Disconnect the three wire permanent magnet exciter harness at the plug.

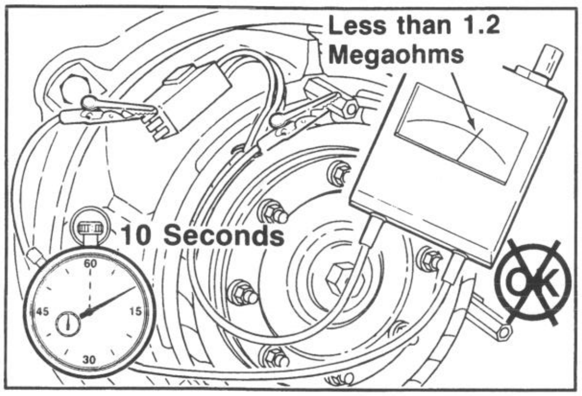
3) Connect one megger lead to any of the three prongs extending from the plug.

4) Connect the other megger lead to a convenient part of the frame.

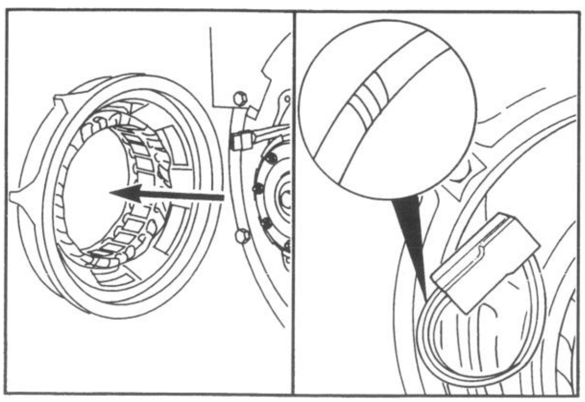




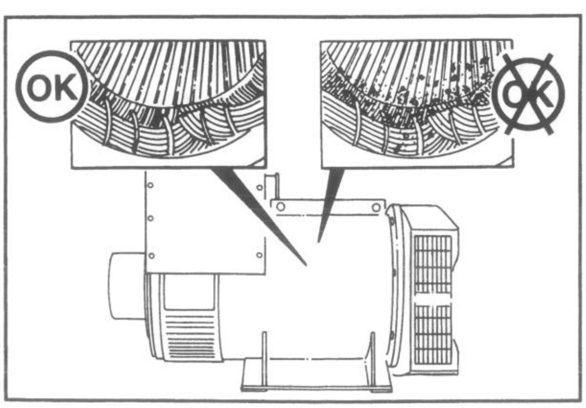
25. Crank the megger at approximately 120 RPM (2 turns per second) for 10 seconds and record the reading.
26. A reading of 1.2 megohms or above indicates that the insulation resistance of the permanent magnet exciter windings is satisfactory.



27. A reading of less than 1.2 megohms indicates that the permanent magnet exciter insulation is marginal or that there is an accidental grounding.



28. Remove the permanent magnet exciter stator. Check the exciter and the leads going to the plug for worn or damaged insulation.
29. Repair any damaged lead insulation with vinyl tape.
30. Dry the permanent magnet exciter stator and test again. Refer to Procedure 6-13.



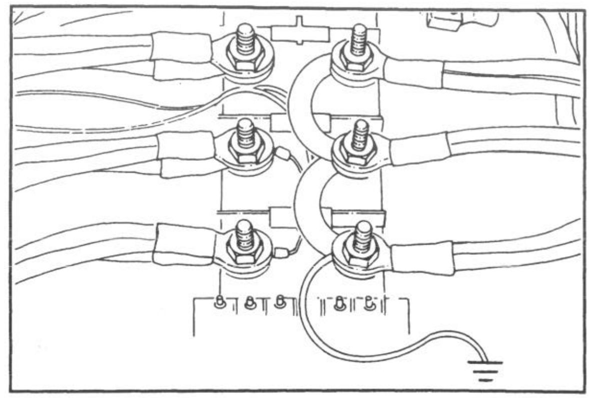
Generator Windings - Drying (6-13)

Note: Check the generator insulation before attempting to dry the insulation. Salt, carbon dust, oil and general dirt can all cause low insulation resistance. Contact a commercial electrical repair shop to correct these problems.

The generator insulation can be damp from sweating in high humidity condition or accidental exposure to water. Measure the insulation resistance with a megger Part No. 3376304 or equivalent. Refer to Procedure 6-12.

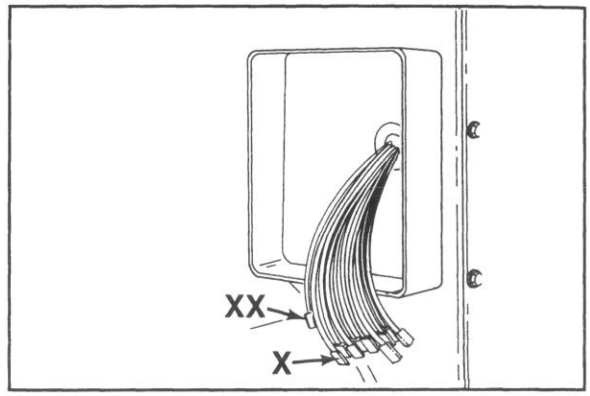
For generators connected to a runable engine:

1. Remove the terminal box sides. Connect the three generator output leads together and connect this junction to the frame ground. This is a grounded three phase short circuit connection.



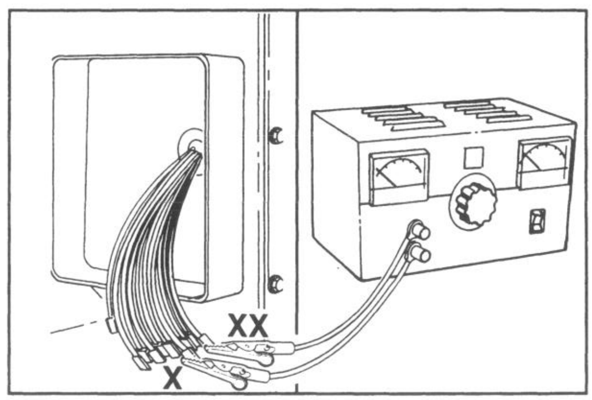
Note: Wires connecting the generator output leads together must be capable of carrying 3/4 of the rated generator output amps. The wire connecting the junction of the three output leads to the frame must be #10 or larger.

2. Remove the AVR from the AVR box. Remove the X and XX leads from the AVR.

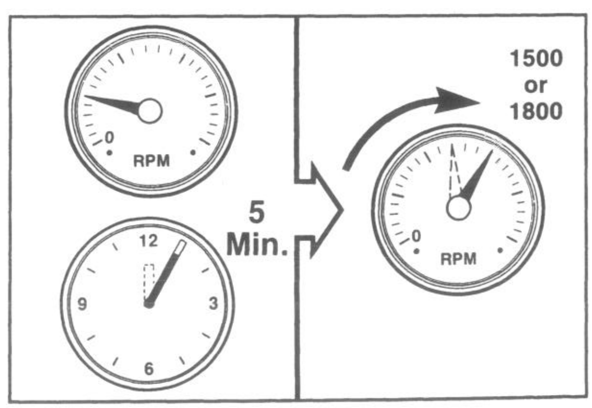


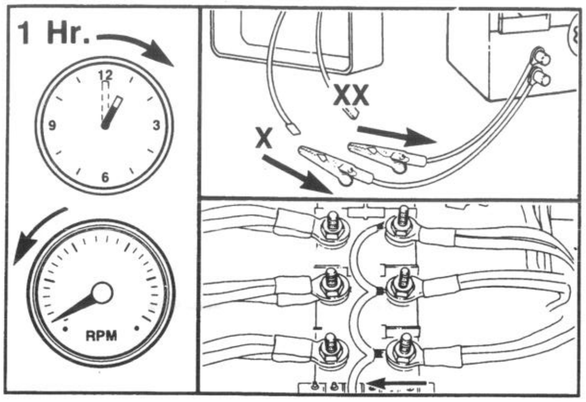
Note: Use a d.c. power source or storage battery, capable of producing 0.5 amps at 12 volts but not exceeding 13.2 volts to provide power to the generator X and XX leads.

3. Connect the positive (+) lead of power supply to the main exciter lead X at the AVR. Connect the negative (-) power supply lead to the D.C. exciter lead XX.

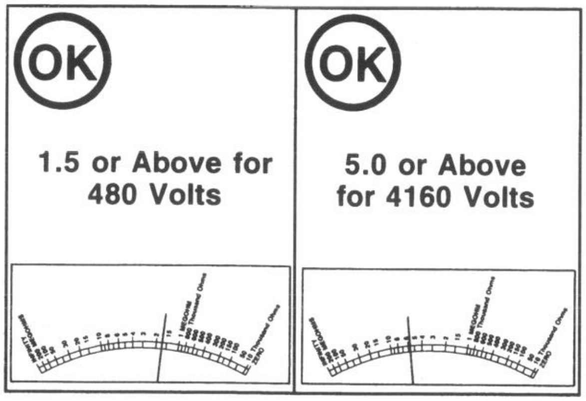


4. Start the engine. After five minutes at low idle, bring the engine up to rated speed.

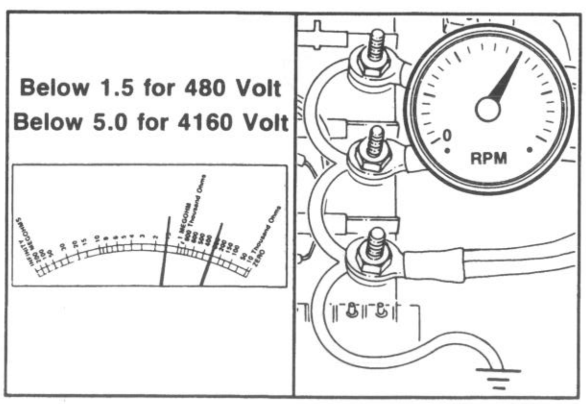




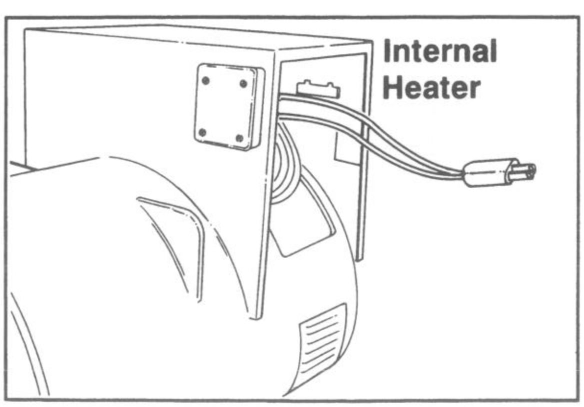
5. After one hour at rated speed:
   - Stop the engine.
   - Disconnect the voltage from the D.C. exciter.
   - Disconnect the shorted generator output leads from the generator frame.



6. Measure the main stator insulation resistance with the megger. Refer to Procedure 6-12.
7. Put the generator into service if:
   1) The reading is 1.5 or above for 480 volt generators.
   2) The reading is 5.0 or above for 4160 volt generators.



8. If the readings are below 1.5 megohms for 480 volt generators or below 5.0 for 4160 volt generators, continue drying.
9. Reconnect all three output terminals and repeat all previous drying steps.

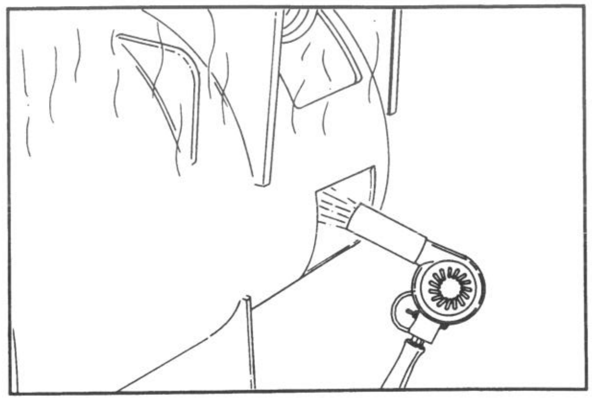


Note: For generators not connected to a runable engine, use forced warm air or if equipped, the internal heaters to dry the generator windings.

10. If the generator has internal heaters, connect the heaters to a suitable power source.

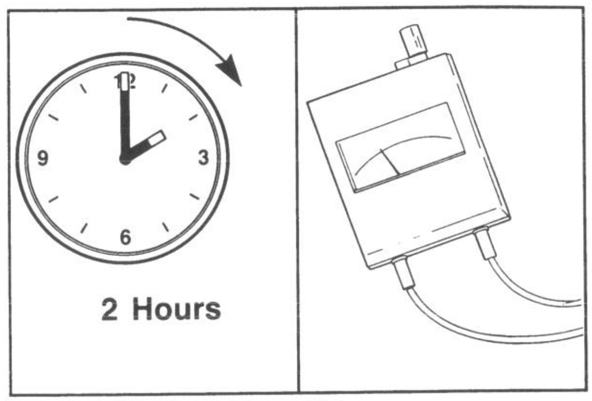
11. Direct the warm air from one or two fan heaters into the openings at either end of the generator. Make sure that the air flows over the windings through the generator.

Note: Do not exceed 80° C [176° F] air temperature when drying the generator.

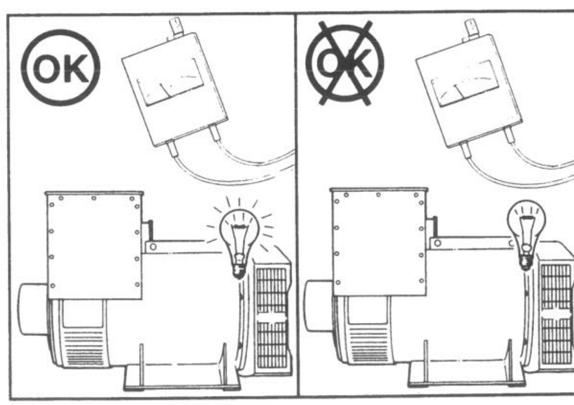


12. After two hours, measure the main stator insulation resistance. Refer to Procedure 6-13.

Note: If internal heaters are being used, disconnect the heaters before measuring the insulation resistance.

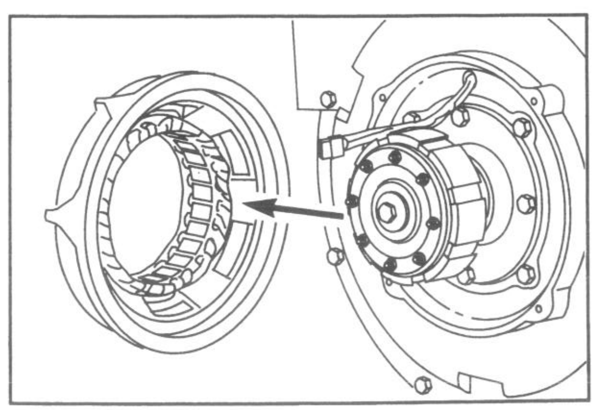


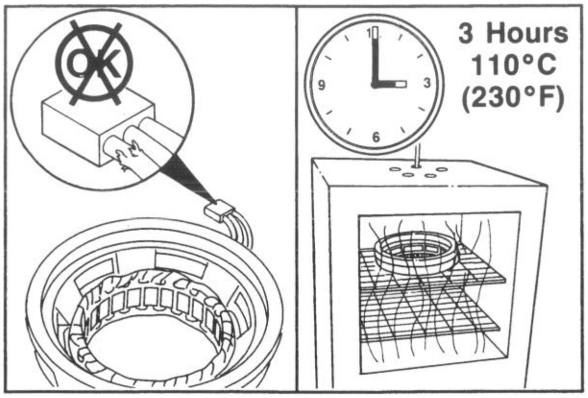
13. If the insulation resistance is satisfactory, put the unit into service.
14. If the insulation resistance is still too low, repeat all the previous drying steps.



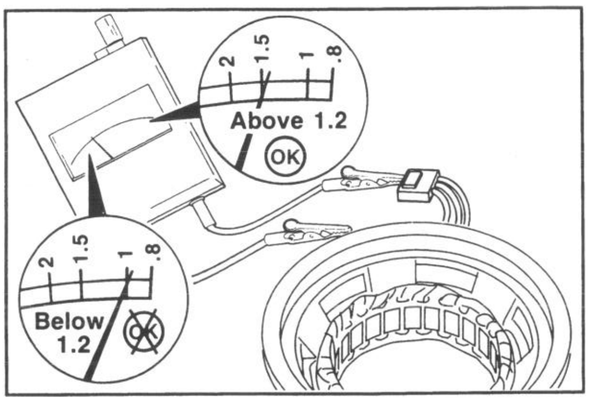
Note: The permanent magnet exciter stator can not be dried by the previous procedures.

15. To dry the permanent magnet exciter stator insulation, remove the permanent magnet stator from the generator. Refer to Procedure 6-03.



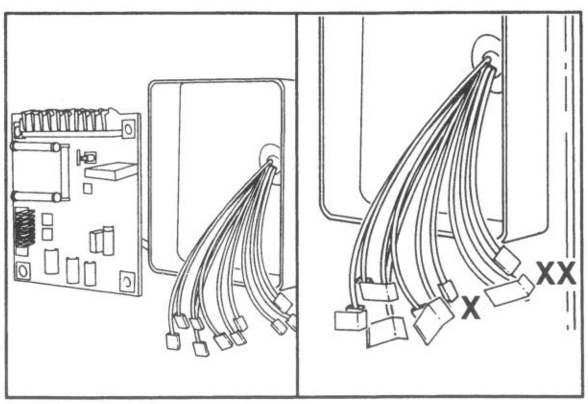


16. Inspect the stator. Check the leads going to the plug for worn or damaged insulation. Repair as required.
17. Recheck the insulation resistance. Refer to Procedure 6-13.
18. If the insulation resistance is still below 1.2 megohms, place the stator in an oven at 110° C [230° F] for 3 hours.



19. Remove the stator from the oven. Allow it to cool to room temperature. Measure the insulation resistance.
    1) If the reading is 1.2 megohms or above, reassemble the generator.
    2) If the reading is below 1.2 megohms, repeat the previous drying steps.

Note: Insulation resistance goes down rapidly as temperature rises. Measuring a hot (100° C [212° F]) stator can give a low reading.



No Load D.C. Excitation - Test (6-14)

Note: The no load D.C. Excitation test will indicate whether a generator problem is in the AVR or the generator.

1. Remove the AVR. Refer to Procedure 6-01.
2. Temporarily insulate (tape) all of the lead terminals except X and XX that were removed from the AVR.

3. Use a multimeter and set it to measure ohms. Measure the resistance between terminals X and XX at the AVR box. Acceptable resistance values are shown in table 6-1.
4. Resistance outside these values could be caused by damage to the exciter stator, possible during endbracket removal or installation.
5. Remove the non-drive end bracket. Refer to Procedure 6-07. Repair or replace the exciter stator.

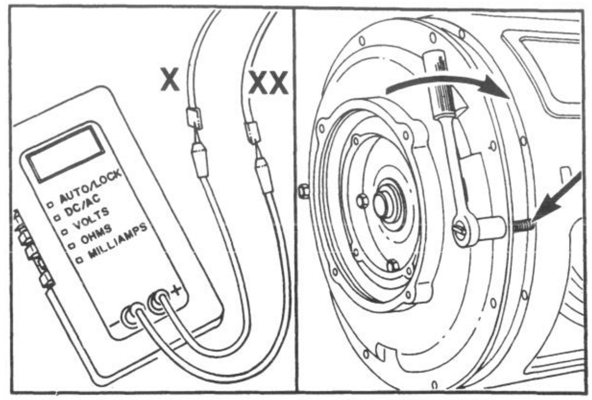
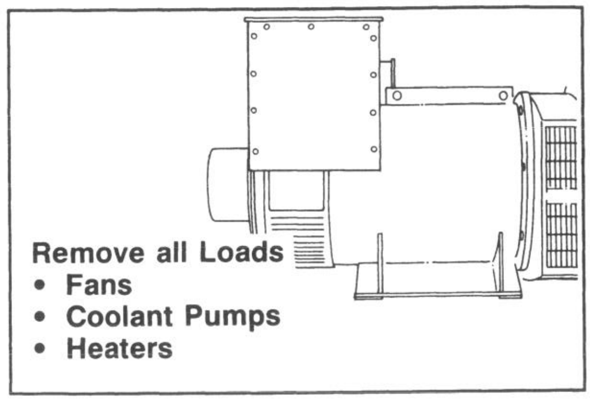


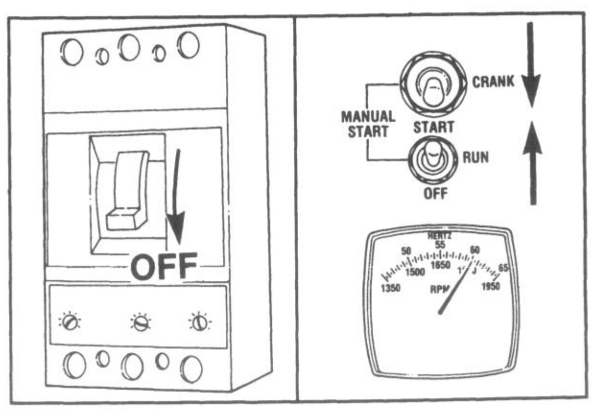
Table 6-1
D.C. Exciter (X to XX) Resistance

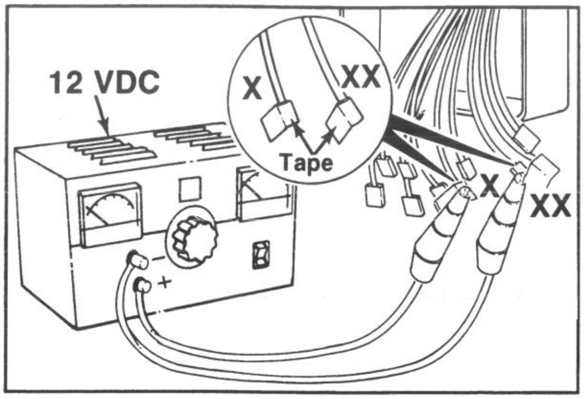
Frame	ohms
CC334	34.2 to 39.6
CC434	23.7 to 27.5
CC534	23.7 to 27.5
CC634	26.6 to 30.8
CC734	26.6 to 30.8

1. Remove all loads which may be connected to the generator. This includes fans, coolant pumps, heaters and any other equipment powered from the generator.



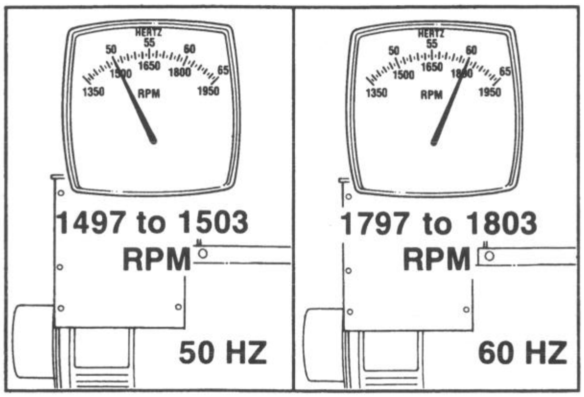
2. Open the main line circuit breaker, if the generator has one.
3. Start the engine and bring it up to rated speed.



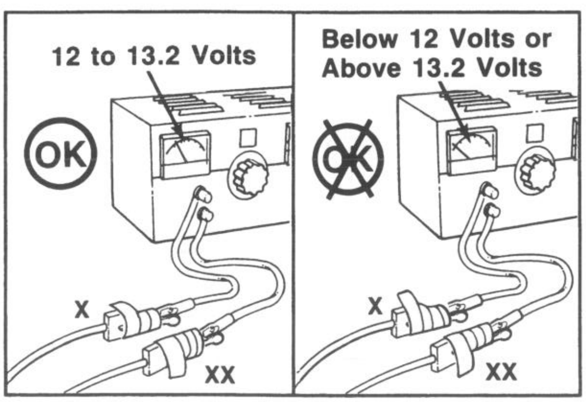


Note: Use a D.C. power source or storage battery, capable of producing 0.5 amps at 12 volts but not exceeding 13.2 volts to provide power to the generator X and XX leads.

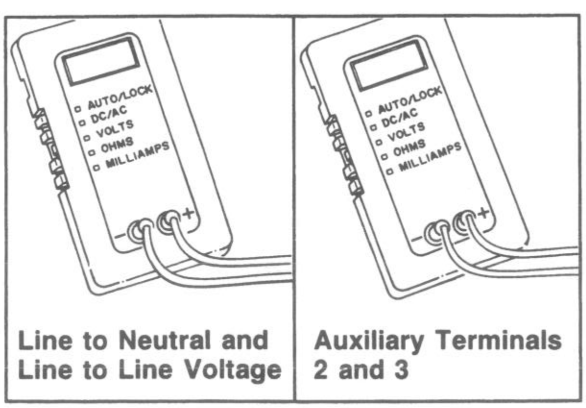
4. Connect the power source positive (+) lead to the X terminal at the AVR box. Connect the negative (-) lead to the XX terminal. Temporarily insulate (tape) the X and XX terminals to prevent accidental shorting.



5. Check the engine speed. Engine speed should be 1497 to 1503 RPM (49.9 to 50.1 Hz.) for 50 Hz. generators or 1797 to 1803 RPM (59.9 to 60.1 Hz.) for 60 Hz. generators. Adjust the engine speed as necessary.

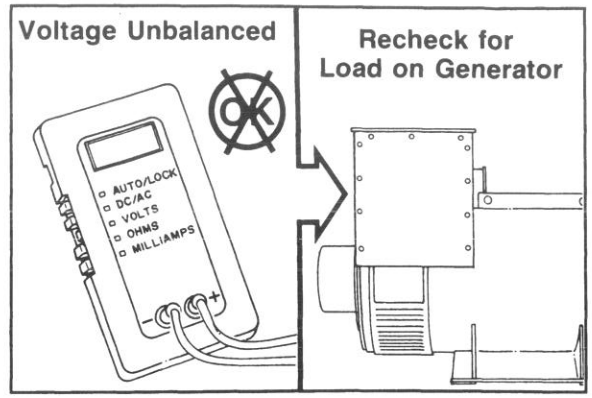


6. Measure the D.C. voltage at terminals X and XX. This voltage must be 12.0 to 13.2 volts. If it is not:
   - Adjust the D.C. power supply voltage.
   - Check the battery lead connections.
   - Connect a charger to the battery or replace the battery with a fresh one.

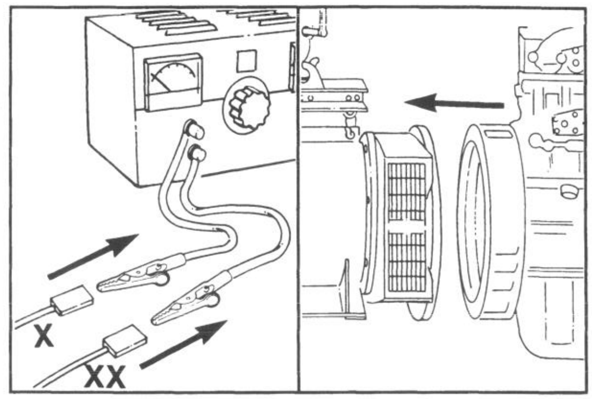


7. Measure and record the line to neutral voltage (for Wye or star connected generators) and the line to line voltage. Also record the voltage at the auxiliary terminals 2 and 3. Use the same meter to make all checks.

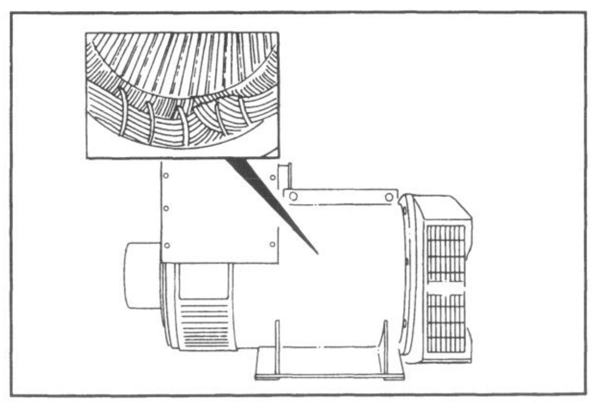
8. The line to neutral (line to line for delta connected generators) voltages must all be within 1 percent (1%) of the average voltage. If there is a voltage unbalance, recheck for any load on the generator. A load can cause a voltage unbalance condition.



9. If there is a voltage unbalance at no load:
   - Disconnect the power supply from X and XX.
   - Stop the engine.
   - Remove the generator from the engine and have it repaired or replaced. Refer to Procedure 6-08.

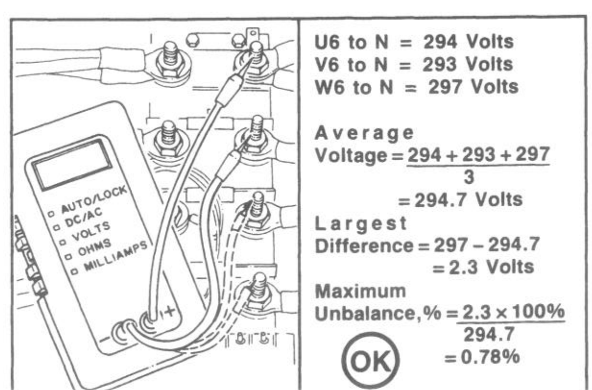


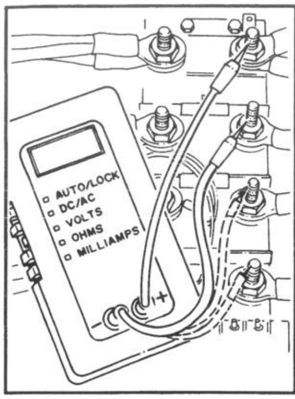
10. A voltage unbalance at no load indicates shorted turns in the main generator windings. Shorted turns will destroy the insulation and can damage the main stator laminations.



- Example: High Wye or Series Star connection. 60 Hz.

  In this example the main generator windings are ok.

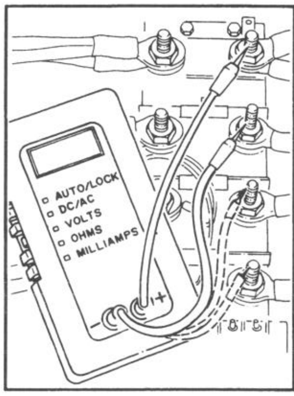




U6 to N = 244 Volts
V6 to N = 243 Volts
W6 to N = 225 Volts
Average
$$\text{Volts} = \frac{244 + 243 + 225}{3} = 237.3 \text{ Volts}$$
Greatest
$$\text{Difference} = 237.3 - 225 = 12.3 \text{ Volts}$$
Maximum
$$\text{Unbalance,\%} = \frac{12.3 \times 100\%}{237.3} = 5.18\%$$
~~OK~~

- Example: High Wye or Series Star connection. 50 Hz.

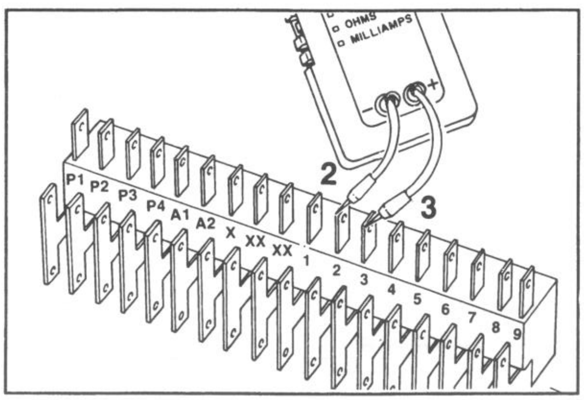
  In this example, W6 to neutral winding has a defect. Have the generator repaired or replaced.



U6 & U2 to N = 127 Volts
V6 & V2 to N = 126 Volts
W6 & W2 to N = 125 Volts
Average
$$\text{Volts} = \frac{127 + 126 + 125}{3} = \frac{378}{3} = 126 \text{ Volts}$$
Greatest
$$\text{Difference} = (127 - 126) \text{ or } (126 - 125) = 1 \text{ Volt}$$
Maximum
$$\text{Unbalance,\%} = \frac{1 \times 100\%}{126} = 0.79\%$$
OK

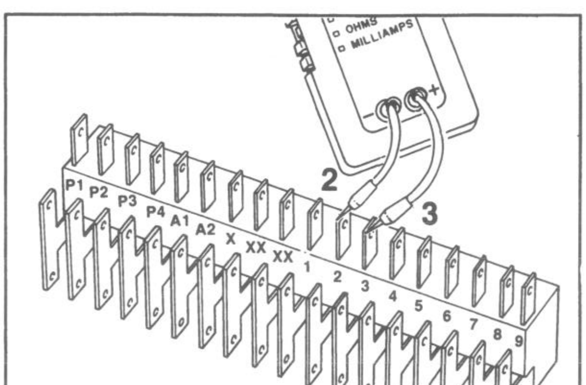
- Example: Low Wye or Parallel Star connection. 60 Hz.

  In this example the main generator windings are ok.



11. Use the multimeter and set it to measure a.c. voltage. On generators with a single phase sensing AVR and connected high Wye or series Star, the voltage at the auxiliary terminal block, terminals 2 and 3 must be one-half the line to line voltage.

    If the voltage is not one-half of line to line voltage, check the auxiliary terminal block and dropper transformer connections. See wiring diagrams 3052054 and 3052055 for wiring.

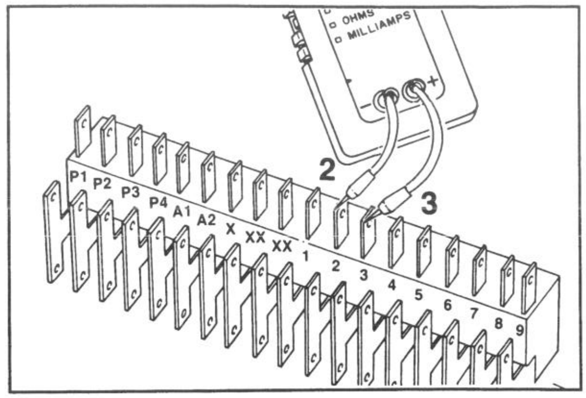


12. On generators with a single phase sensing AVR and connected low Wye, parallel star or delta, the voltage at the terminal block, terminals 2 and 3 must be the same as the line to line voltage.

    If the voltage is not the same, check the auxiliary terminal block connections. See wiring diagrams 3052054 and 3052055 for wiring.

13. Use the multimeter and set it to measure D.C. voltage. On PMG generators with a three phase sensing AVR, the voltage at the auxiliary terminal block, terminals 2 and 3 should be 10 to 19 volts D.C.

Check the dropper transformer (two transformers for three phase sensing) connections. Check the auxiliary terminal block connections. Check the three phase sensing module connections.

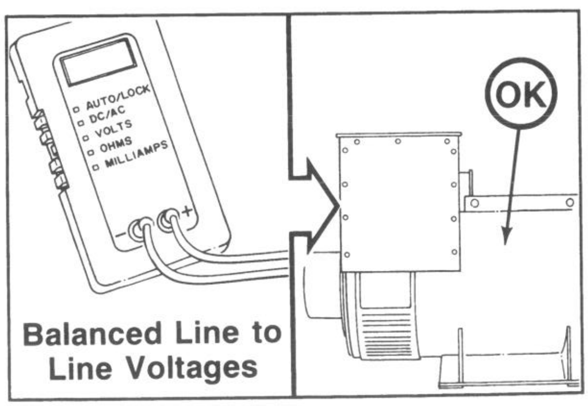


14. Table 6-2 shows the normal, no load line to line voltage range that should be obtained with 13.0 volts D.C. connected to exciter leads X and XX.

Table 6-2
Line to line voltage range with 13.0 volts at X and XX

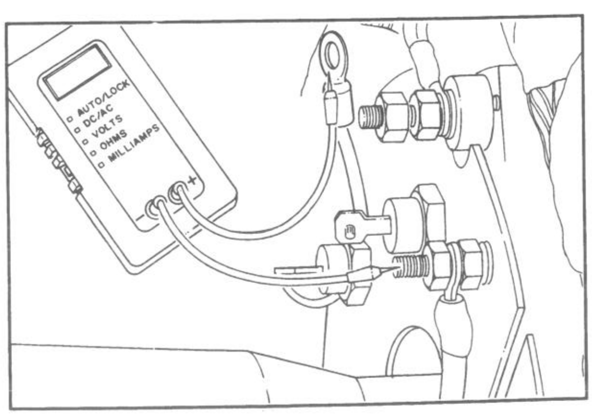
Generator Model	50 Hz. Hi Wye	60 Hz. Hi Wye	60 Hz. Lo Wye	60 Hz. Delta
CC3	405-455	495-545	247-272	286-315
CC4	440-490	530-580	265-290	305-335
CC5	390-440	475-525	237-262	274-303
CC6	400-450	490-540	245-270	283-312
CC7	360-410	440-490	220-245	254-283

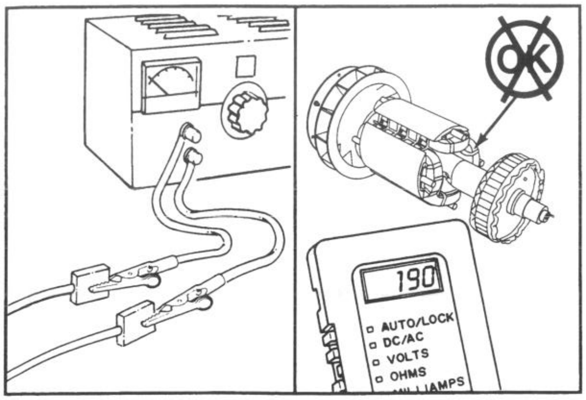
15. Balanced line to neutral and line to line voltages within the ranges shown in table 6-2 indicate that the generator windings and rotating rectifiers are all in good working order. The correct voltage at the auxiliary terminal block, terminals 2 and 3 indicate that the AVR is receiving the correct no load voltage. Omit the steps on checking the rotating diodes and checking the rotor windings. Any remaining electrical problems are in the voltage control system. See wiring diagrams 3052054, 5, and 6. Examine the wiring for loose, broken or corroded connections.



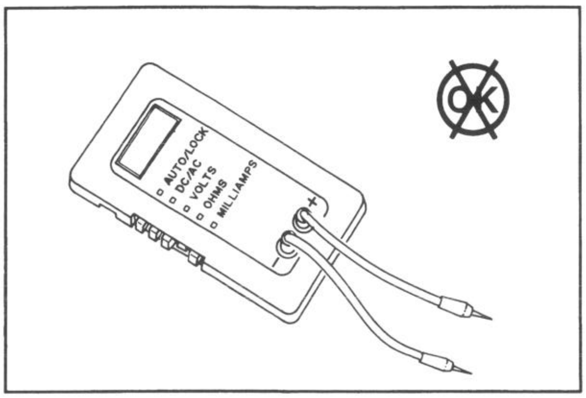
Balanced Line to Line Voltages

16. If the generator output voltage is not within the ranges shown in Table 6-2, check the rotating diodes. Refer to Procedure 6-11. Replace any defective diode or surge suppressor.





17. Repeat the 13 volt no load D.C. excitation test. Measure the line voltage and compare it with Table 6-2.
18. If the generator voltage is still NOT within the range shown in Table 6-2, there is probably a defect in a rotor winding.



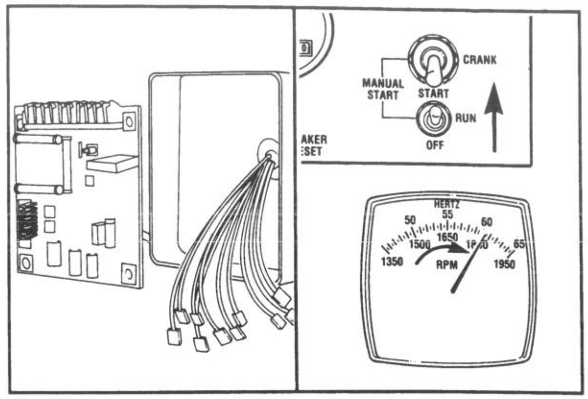
19. The resistances of the rotor windings are too low to determine if a winding is ok by using the Part No. 3376898 multimeter or most other hand held multimeters. See Table 6-3.

Table 6-3
Rotor Winding Resistances

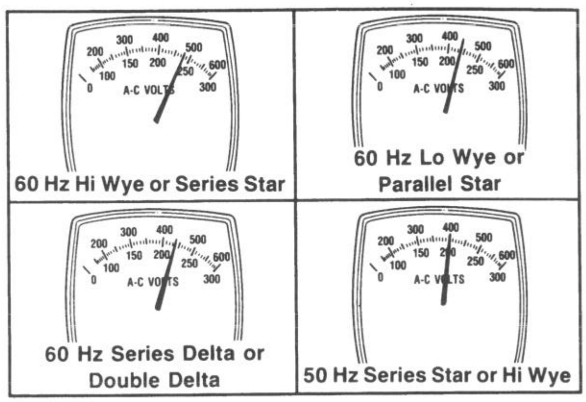
Generator Model	Exciter Rotor (ohms)	Main Rotor (ohms)
CC334A	0.16	1.34
CC334B	0.16	1.55
CC334C	0.16	1.71
CC334D	0.16	1.81
CC434C	0.17	0.93
CC434D	0.17	1.06
CC434E	0.17	1.20
CC434F	0.17	1.35
CC534C	0.16	1.55
CC534D	0.16	1.77
CC534E	0.16	1.96
CC534F	0.16	2.16
CC634AS	0.10	1.26
CC634A	0.10	1.37
CC634B	0.10	1.47
CC634C	0.10	1.66
CC634D	0.10	2.31
CC734A	0.13	2.05
CC734B	0.13	2.29
CC734C	0.13	2.71

Note: All resistances are approximate and at 20° C [68° F].

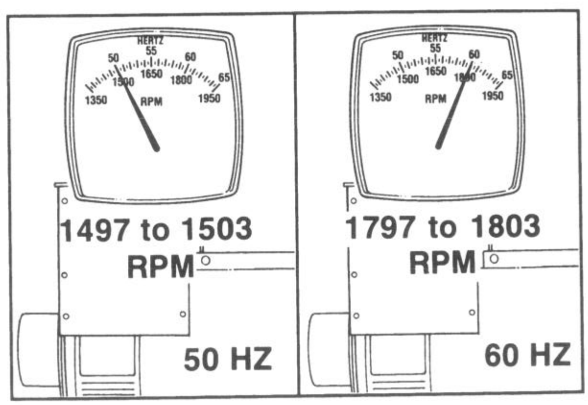
20. After determining that all rotating diodes and the surge suppressor is ok, check the rotor windings as follows:
    - Install the AVR. Refer to Procedure 6-04.
    - Remove all loads which may be connected to the generator.
    - Open the main line circuit breaker, if equipped with one.
    - Start the engine and bring it up to rated speed.



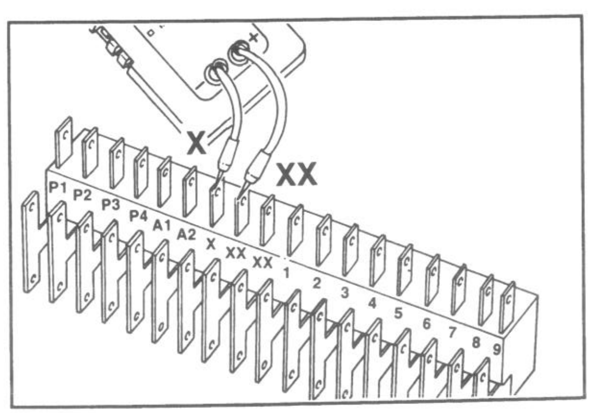
21. Adjust the line to line voltage to the following values:
    - 60 Hz. Hi Wye or Series Star connection: 480 volts.
    - 60 Hz. Lo Wye or Parallel Star connection: 240 volts.
    - 60 Hz. Series Delta or Single Phase Double Delta connection: 240 volts.
    - 50 Hz. Series Star or Hi Wye connection: 400 volts.



22. Check the engine speed. Engine speed should be 1497 to 1503 RPM (49.9 to 50.1 Hz.) for 50 Hz. generators or 1797 to 1803 RPM (59.9 to 60.1 Hz.) for 60 Hz. generators. Adjust the engine speed as necessary.



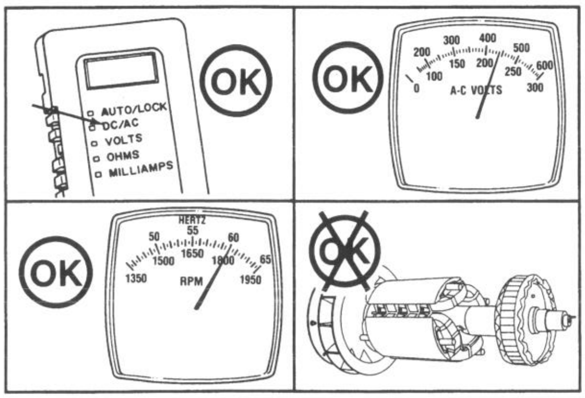
23. Use the multimeter, Part No. 3376898, and set it to measure D.C. voltage.
24. Measure and record the voltage at terminals X and XX on the auxiliary terminal block.



25. Compare the voltage readings with the values shown in Table 6-4.

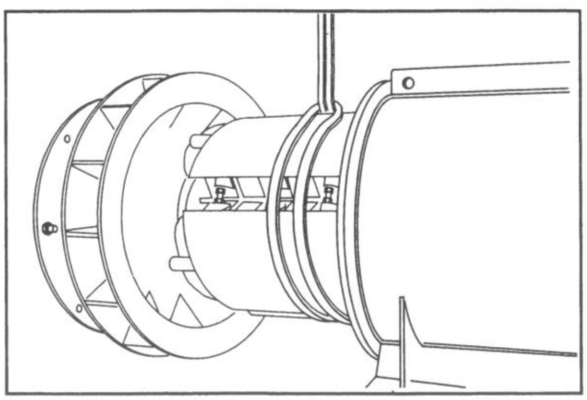
Table 6-4
No Load D.C. Voltage at X and XX

Generator Model	Wye (star) 240 or 480 volts, 60 Hz. 400 volts, 50 Hz.	Delta 240 volts, 60 Hz.
CC3	8 to 12	7 to 10
CC4	6 to 10	5 to 7
CC5	10 to 15	7.5 to 11
CC6	9 to 13	7 to 10
CC7	12 to 17	9.5 to 13

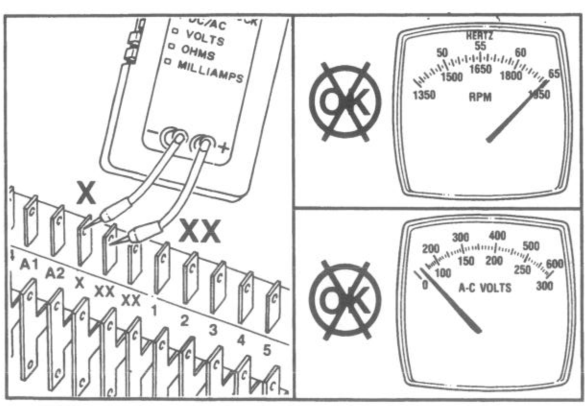


26. If the X to XX voltage is above the maximum values shown in Table 6-4:

- Check to make sure the meter is set to D.C. voltage.
- Check to make sure the generator voltage is at the specified value.
- Check to make sure the engine RPM or frequency is at the specified value.
- If all the above are correct, there is a defect in the generator rotor winding.



27. Stop the engine. Remove the generator from the engine. Refer to Procedure 6-08.
28. Remove the rotor from the generator. Refer to Procedure 6-09.
29. Repair or replace the rotor assembly.



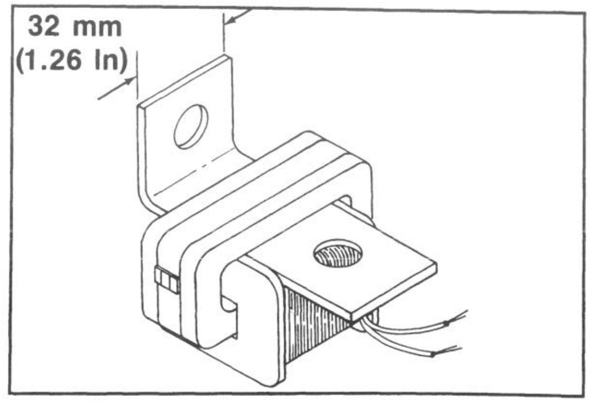
30. If the X to XX voltage is below the minimum values shown in Table 6-4:

- The frequency may be too high.
- The generator output voltage may be too low.
- The generator leads may be incorrectly connected (Example: 240 volt output when generator connected for 480 volt output).

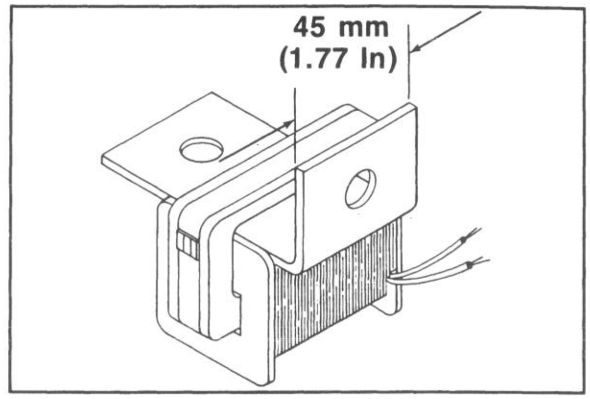
Paralleling Module - Installation and Adjustment (6-15)

Note: There are 2 different paralleling droop CT's (current transformers) used with generators that operate at up to 480 volts.

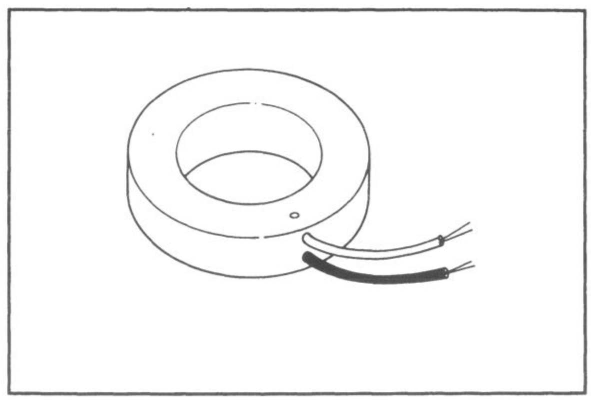
1. One droop CT is used for paralleling all frame 3 and 4 generators.



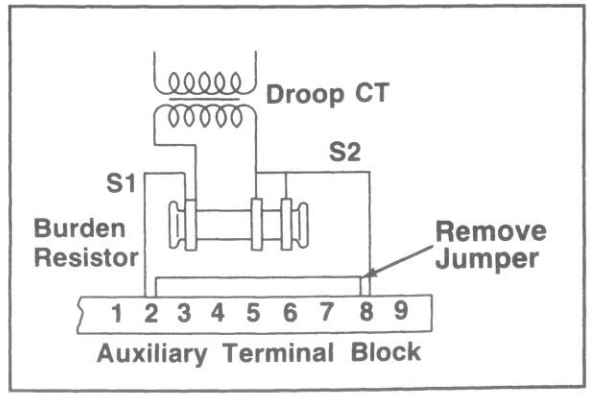
2. A different droop CT is used for paralleling frame 5, 6 and 7 generators..

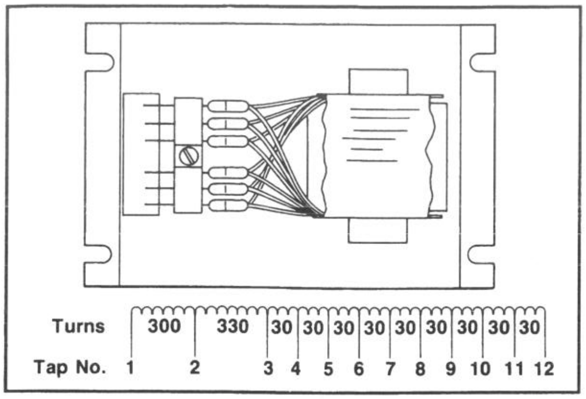


3. A ring (doughnut) type droop CT is used for medium voltage (2400 - 4160 volt, 60 Hz., or 1905 - 3300 volt, 50 Hz.) frame 7 generators.

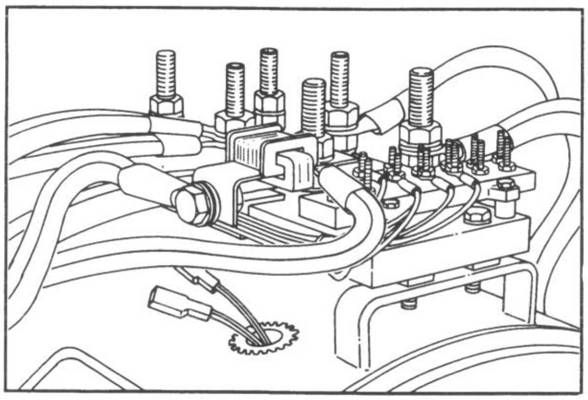


4. On Wye (Star) connected generators, the droop CT is in generator phase W. It is connected to an adjustable 215 ohm, 25 watt burden resistor and to auxiliary terminals 2 and 8. Recheck to make sure that the normal jumper wire between terminals 2 and 8 is removed. See Section 7 Electrical for wiring diagrams.





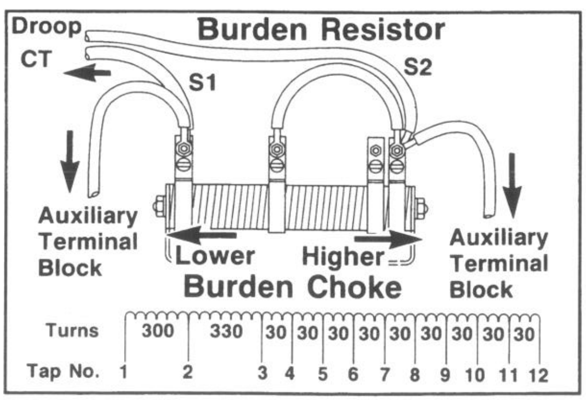
5. The droop CT is connected to a burden choke for delta or series delta or when a three phase sensing AVR and three phase sensing module are used. See Section 7 Electrical for wiring diagrams.



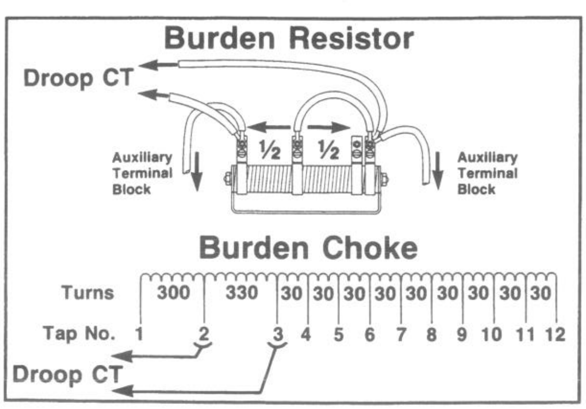
Note: Depending on the type (size) of the generator, one or more main rotor winding cables may be connected to each output terminal. Only one cable should be connected to the droop CT bar.

Note: Instructions for installations of paralleling kits on generators connected to provide single phase power are not included in this Manual. Twelve lead generators connected to provide single phase power can be paralleled using a doughnut type droop CT and a burden choke.

Contact the Electrical Application Engineering at Cummins for information on Paralleling Single Phase Generators.



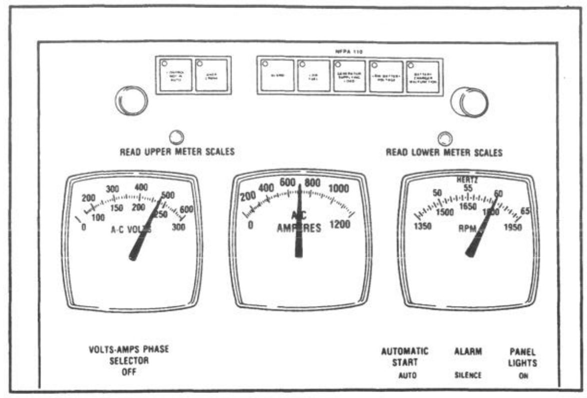
6. Set the percent of voltage droop for paralleling by adjusting the burden resistor or burden choke tap number. Set the percent voltage droop the same on all generators to be paralleled. This will allow the generators to share load current.
7. Identical generators with single phase sensing may later be connected for no voltage droop (also called Reactive Differential Compensation), but the burden resistor or chokes must be set correctly first.



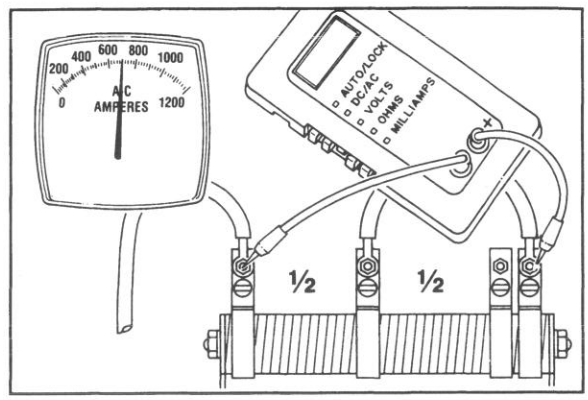
Set the burden resistor or burden choke as follows.

1. Initially set the burden resistor with 1/2 of the resistor shorted, or the burden choke connected to taps 2 and 3.
2. Start the engine and bring it up to speed.

3. Adjust the generator voltage to approximately rated voltage.
4. Close the circuit breaker.
5. Apply, in steps if necessary, any steady load that requires 25 to 80 percent of rated generator current.



6. Use a multimeter, Part No. 3376898, and set it to measure A.C. voltage. Measure and record the A.C. voltage between auxiliary terminal block terminals 2 and 8. On Wye (Star) connected generators, if the line currents are not the same, record the current from phase W (this is probably line 3).



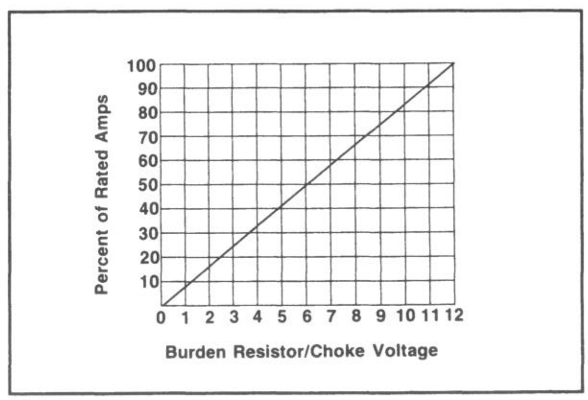
7. Compare the voltage measured at the auxiliary terminal block terminals 2 and 8 with the values shown.

Example:

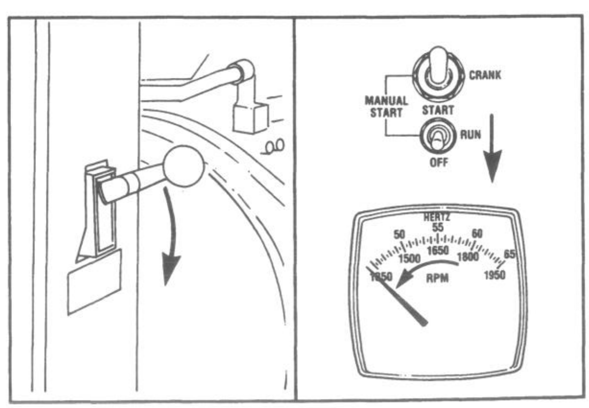
Generator Rated at 375 KVA (300 KW) 240 Volts, 902 amps.

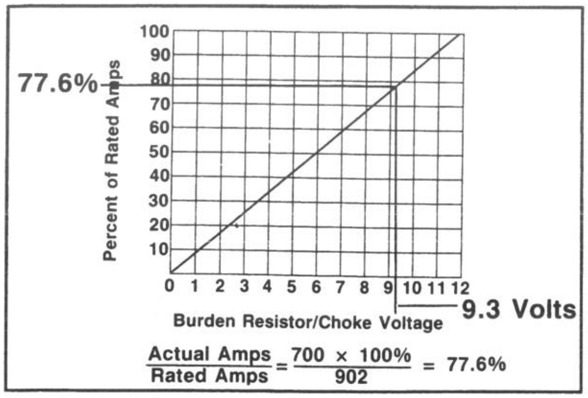
Test current = 700 amps

Voltage at 2 and 8 = 7.6 volts

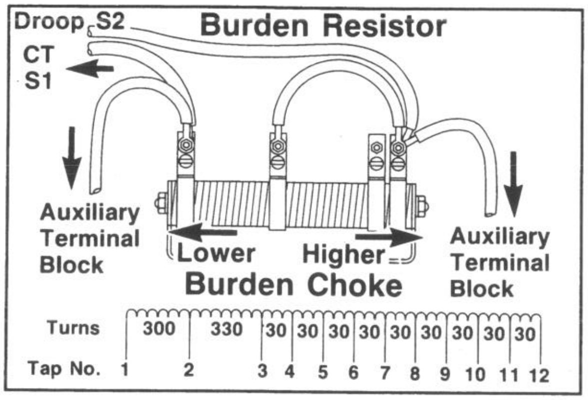


8. Remove the load from the generator. Allow any load bank fans to continue running for 5 minutes.
9. Open the generator line circuit breaker.
10. Stop the engine.





11. Example: At 77.6% of rated current, the desired voltage is 9.3 volts. 1



12. Move the resistor slide as shown to obtain the desired voltage. More resistance or different choke tap number will create more voltage at terminals 2 and 8.

    Move the burden resistor slider or burden choke tap connections to obtain the voltage indicated from Fig. 6-1.

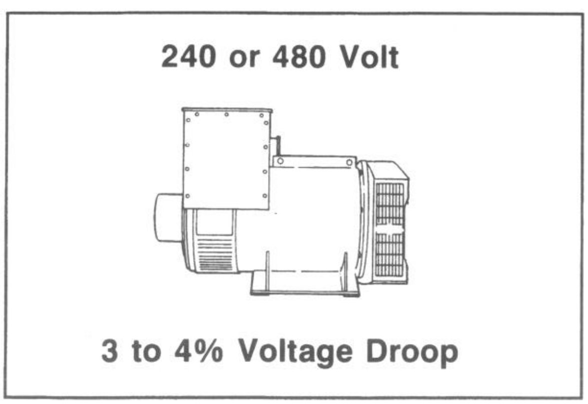
    a. MORE resistance will give MORE voltage.

    b. MORE burden choke turns will give MORE voltage. By selecting the burden choke tap connections, any multiple of 30 turns from 30 to 930 turns may be selected.

    Examples: Taps 5 and 12 = 210 turns
    Taps 3 and 12 = 270 turns
    Taps 1 and 2 = 300 turns
    Taps 2 and 3 = 330 turns
    Taps 2 and 4 = 360 turns
    Taps 1 and 3 = 630 turns

    c. Do NOT install a jumper to short choke turns.

Warning: Do not adjust the burden resistor or choke while the engine is running. The resistor or choke is normally 120 to 139 volts above ground.



Note: A 240 or 480 volt generator should have a 3 to 4 percent voltage droop at full load, 0.8 power factor.

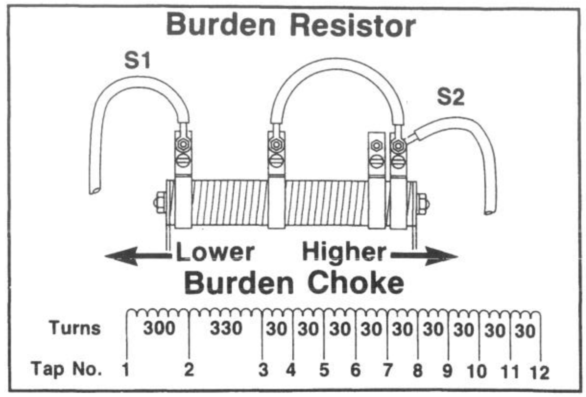
At a higher power factor, or less load, there will be less voltage droop. At 1.0 power, factor there is no measurable voltage droop (0.1% max).

This voltage droop essentially eliminates any circulating current or current imbalance between paralleling generators with matched individual no load voltage and frequencies. Since utility voltage variation is normally plus or minus 5 percent, the additional complexity of a reactive differential compensating system is seldom justified.

13. Recheck the burden resistor setting or burden choke tap connection.

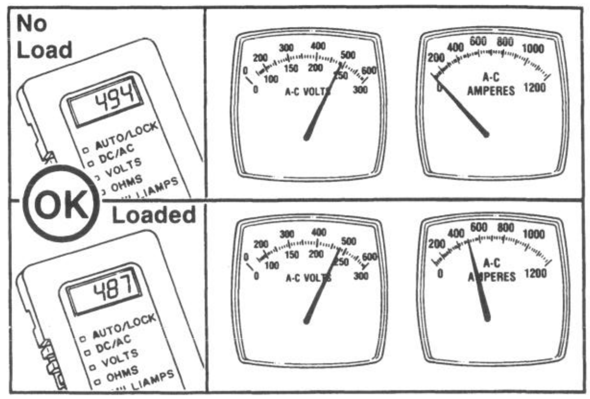
    Load the generator and record the line current and voltage at auxiliary terminal block terminals 2 and 8.

    Compare the readings with the previous example. Readjust the resistor or choke if necessary.

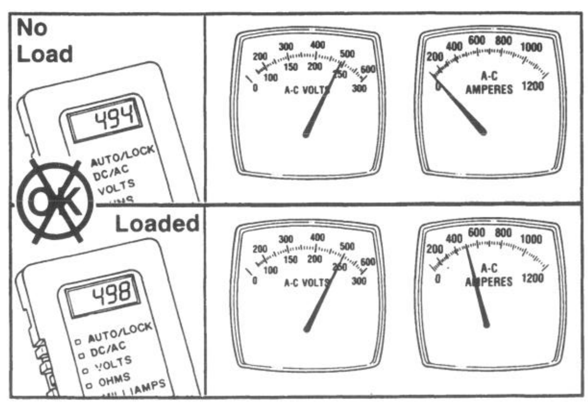


14. If the droop CT's are connected correctly, a lagging power factor load will cause the generator output voltage to decrease slightly when the generator is loaded.

Note: Motors running at light loads or no load, are usually the easiest way to obtain a lagging power factor load.



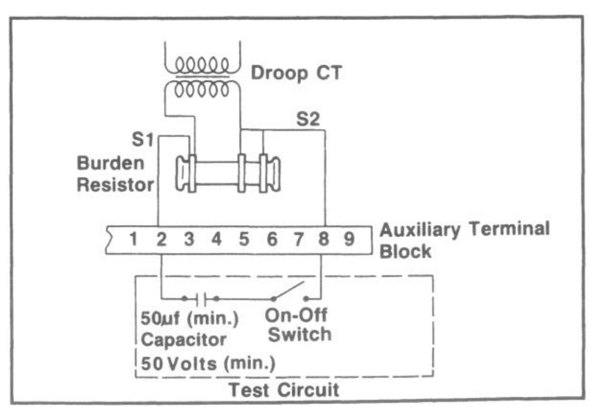
15. If the droop CT's are connected incorrectly, a lagging power factor load will cause the generator output voltage to increase slightly when the generator is loaded.

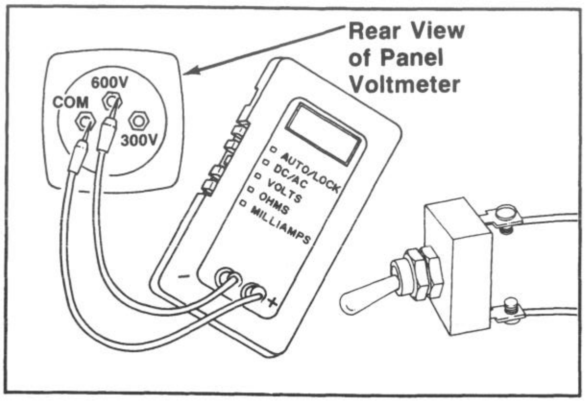


16. A droop CT and burden resistor or choke will cause no measurable change in generator output voltage with a Unity (1.0) power factor load such as heaters, incandescent lamps or a resistive load bank.

Note: The output voltage of a typical "PMG" generator, without a droop CT and burden resistor, will rise slightly (less than 1%) at rated KW 1.0 power factor load.

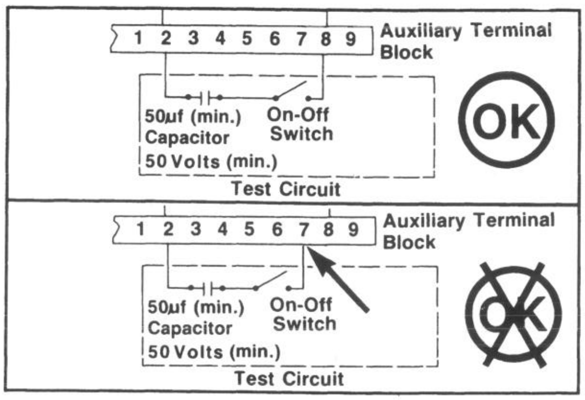
17. The circuit shown is a method of checking the polarity of the connections to the burden resistor used with single phase sensing, Wye (star) connected generators.





Caution: This test must be run on only one unit at a time.

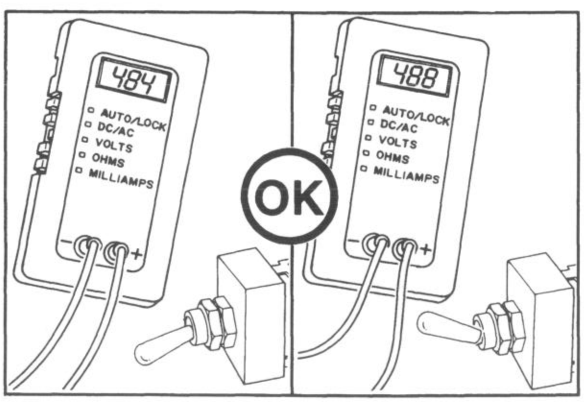
1. Connect a Serv. Pt. No. 3376898 multitester to read line to line output voltage.
2. Place the Test Circuit On-Off switch in the "Off" position.
3. Start the engine and bring it up to rated speed.
4. Close the generator main line circuit breaker.



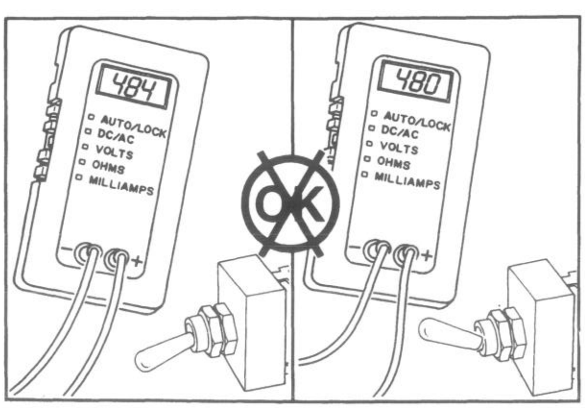
5. Adjust the generator voltage to approximately rated voltage.

Caution: Recheck to be sure that the Test Circuit is connected to auxiliary terminal board terminals 2 and 8. The capacitor may explode if connected to terminals 2 and 7.

6. Apply a minimum of 25 percent of rated KW, unity power factor load. (This is 20 percent of rated amps.)

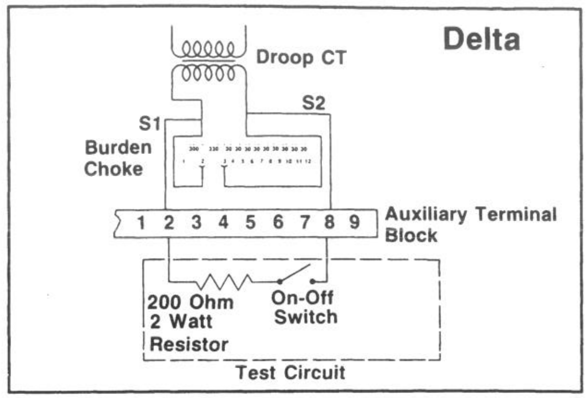


7. Read and record the reading of the Multitester.
8. Turn the Test Circuit Switch "On".
9. Read and record the reading of the multitester.
10. Remove the load, allow the load bank fans to run for a minimum of 5 minutes, open the generator main line circuit breaker and stop the engine.
11. If the reading in step 9 (switch ON) is HIGHER than the reading in step 7 (switch OFF) the CT connections are correct. Remove the Test Circuit.

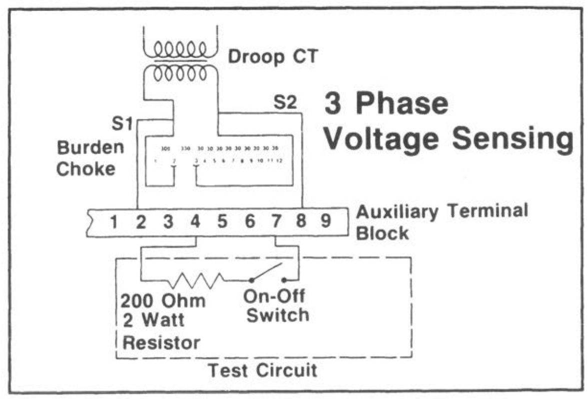


12. If the reading in step 9 (switch ON) is LOWER than the reading in step 7 (switch OFF) the CT connections are wrong. Reverse droop CT leads S1 and S2 and repeat steps 1 through 11.

Note: To check the polarity of the droop CT leads on a delta connected generator with single phase sensing (which uses a burden choke instead of a burden resistor), use the Test Circuit of Fig. 6-2 except substitute a 200 ohm, 2 watt resistor in place of the capacitor.

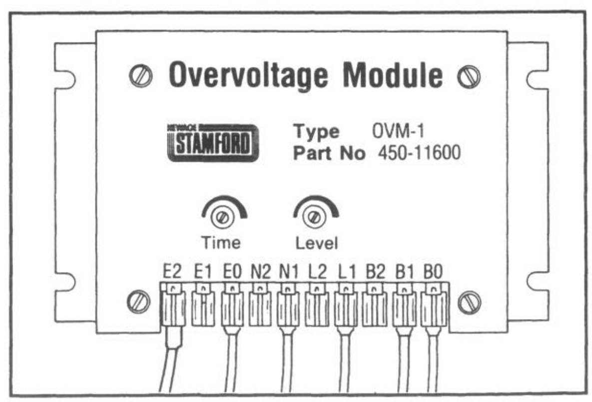


Note: To check the polarity of the droop CT leads on a unit with 3 phase voltage sensing (which also uses a burden choke instead of a burden resistor), use the Test Circuit of Fig. 6-2 except substiture a 200 ohm, 2 watt resistor in place of the capacitor AND connect the test circuit to auxiliary terminal block terminals 4 and 7 instead of 2 and 8.

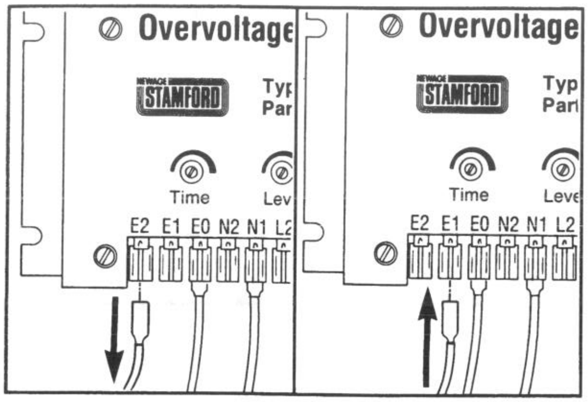


Overvoltage Module - Calibration (6-16)

Note: The OVM (overvoltage module) is a standard accessory on all Cummins "PMG" generators. It provides protection from relatively high voltages (750 volts plus, from a 480 volt, 60 Hz. generator) that can be produced if an AVR voltage sensing lead is broken or disconnected.

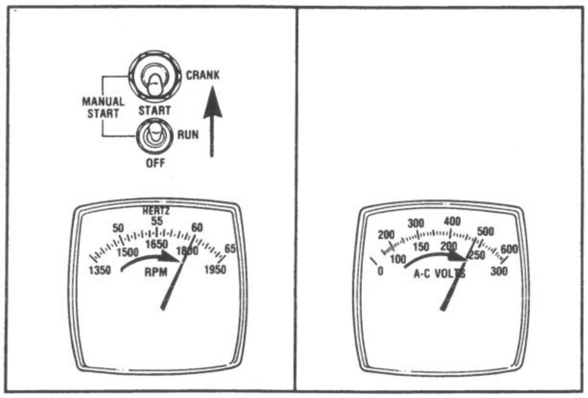


The voltage sensing circuit (terminals E0 and E2) of the OVM can be set to operate in the range of 240 to 350 volts. It is normally set to operate at 125 percent of rated voltage. See Section 7 for wiring connections to the OVM. The correct wiring diagram will show that the location of the OVM sensing leads changes when a 12 lead generator is reconnected for a different voltage. The OVM should be recalibrated whenever a generator is reconnected or if the normal output voltage is changed (Example: a 139/240 volt, 60 Hz. generator is changed to 120/208 volt, 60 Hz.).

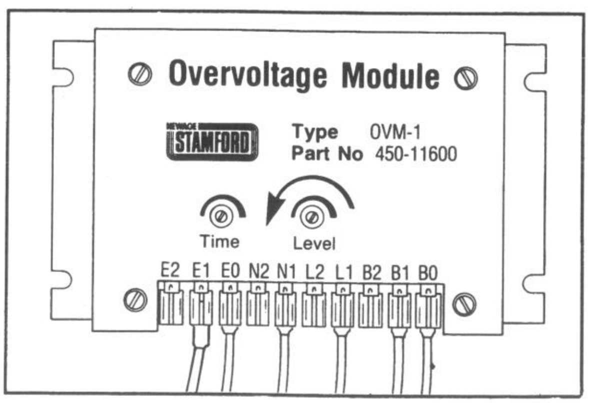


Calibrate the OVM as follows:

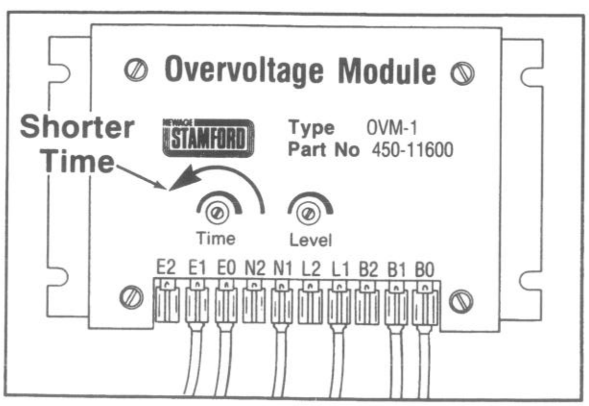
1. Stop the engine.
2. Remove the lead connected to the E2 terminal of the OVM and reconnect it to the adjacent E1 terminal.
3. Set the "Level" pot on the OVM fully clockwise.



4. Start the engine and bring it up to rated speed.
5. Adjust the no load generator output voltage to rated voltage.



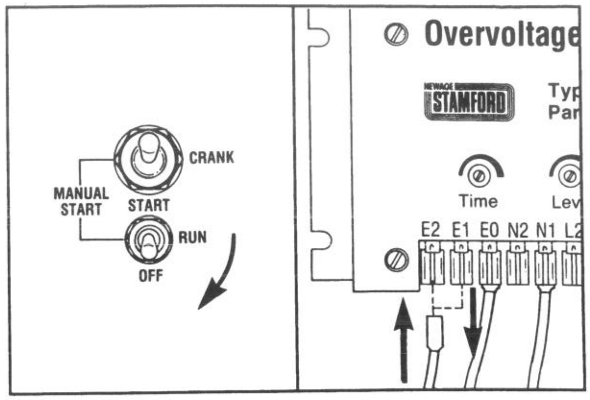
6. Slowly turn the "Level" pot on the OVM counter-clockwise until the voltage regulator switch trips.



7. The "Time" setting pot is normally set to trip in 1 to 1 1/2 seconds. Turn the "Time" setting pot counter-clockwise to reduce the tripping time.

8. Stop the engine.
9. Remove the load from terminal E1 and reconnect it to terminal E2.

   The OVM is now set to trip at 125 percent of the voltage connected to termianls E2 and E0.



Automatic Voltage Regulator (AVR) - Information (6-17)

1. All terminals (K1, K2, P2, P3, XX, P4, X, 3, 2 and 1) should be connected for the AVR to operate. The functions of the terminals are:
   - K2 and K1 - Disabling connection, must be connected for the AVR to produce an output.
   - P2, P3 and P4 - Three phase power input from permanent magnet exciter. No load range: 60 Hz. 180 - 210 volts a.c., 50 Hz. 150 - 175 volts a.c.
   - XX and X - Direct current output to main exciter stator. Varies with output voltage, load and power factor. Range: 5. to 50 volts d.c.
   - 3 and 2 - Sensing voltage. This will be 170 to 250 volts a.c. for a single phase AVR. This will be 11.5 to 15 volts d.c. for a three phase sensing AVR.
   - 1 - Connection point for one side of the remote voltage adjust rheostat. The other side of the remote voltage adjust rheostat is connected to terminal 2 at the auxiliary terminal block. If the lead to terminal 1 of the AVR is broken or disconnected, the AVR will still function, but the remote voltage adjust rheostat will have no control.
2. A quick test for operation of the AVR is:
   - Operate the engine at rated speed, 1500 or 1800 RPM.
   - Turn the voltage adjust rheostat on the AVR from maximum to minimum volts.
   - The AVR is operating if the generator output voltage changes.
3. If one of the K1, K2, XX or X leads are broken or disconnected, or if any two of the P2, P3 or P4 leads are broken or disconnected, the no load generator output voltage will fall to less than 30 percent of normal for a Wye (star) connected generator. Turning the voltage adjust rheostat will not change this voltage.
4. If either of leads 2 or 3, which sense generator output voltage, are broken or disconnected, the no load generator output voltage will immediately rise to 1 1/2 to 2 times the normal voltage for a Wye (star) connected generator (the voltage will rise even higher for a delta connected generator). The overvoltage module accessory is included as a standard item on all Cummins "PMG" generators to protect equipment from this high voltage.
5. The generator will sustain a short circuit current of 2.5 to 3 times rated current for approximately 10 seconds without damage to the generator. In order to prevent damage to the generator from short circuit current for longer periods, a protection circuit is included in the AVR. This circuit senses excess voltage across the d.c. exciter terminals X and XX. On the Cummins "PMG" generators, excess voltage is anything over 60 volts and is selected by the C terminal to 60 volts jumper on the AVR. When the voltage exceeds 60 volts, a timing circuit is activated. In approximately 10 seconds after it is activated, the protection circuit de-energizes the d.c. exciter, collapsing generator output. The protection circuit will not reset until after the engine has stopped (approximately 10 seconds).

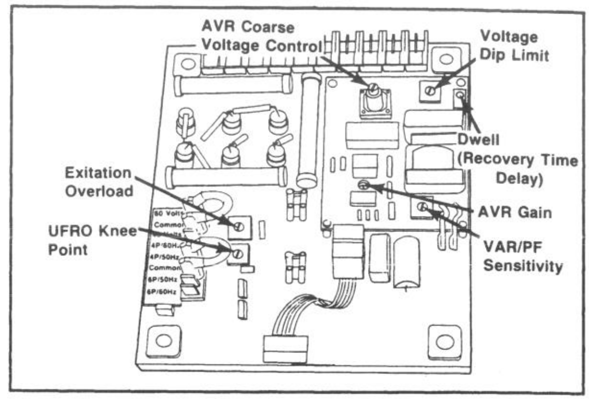
   The protection circuit will also operate under other abnormal conditions:
   - Severe overload at low power factor.
   - Operation at moderate (above 1/2) load with one or more rotating diodes open.
   - Short circuit in one of the generator windings.

   The protection circuit operates only when something is wrong. The problem may be in the load or within the generator, but it must be resolved before operation can continue.

Note: Nominal regulator dip limit and transient response — voltage 35 percent with a 5-second recovery, frequency 10 percent with a 6-second recovery.

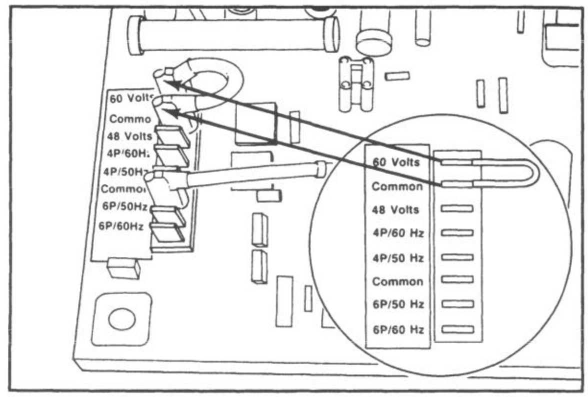
There are seven different adjustment potentiometers on the Cummins AVR. They are:

1. AVR Coarse Voltage Control
2. AVR Gain
3. Excitation Overload
4. UFRO Knee Point
5. Voltage Dip Limit
6. Dwell (Recovery Time Delay)
7. VAR/PF Sensitivity

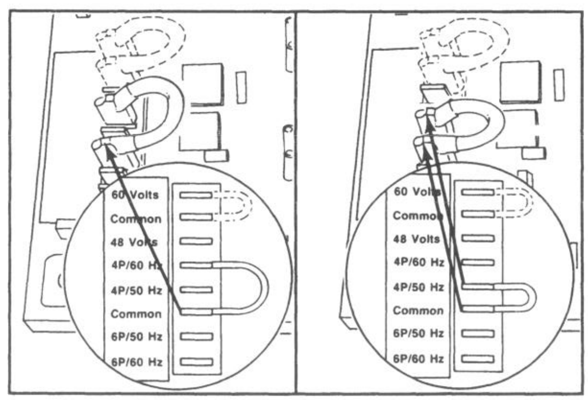


Automatic Voltage Regulator Adjustments (6-18)

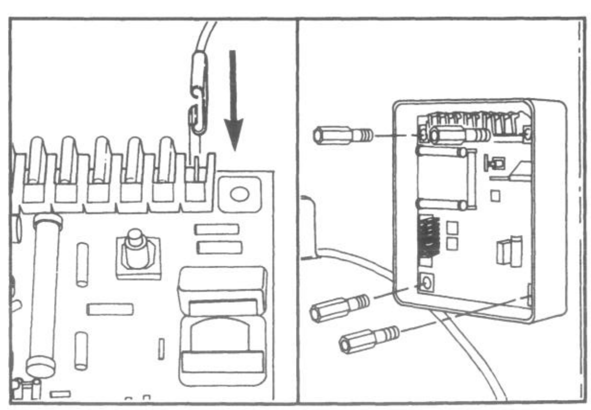
1. Before installing a new AVR, check to see that the top jumper is installed on the top "C" and "60 volt" terminals. This jumper sets the protective voltage level in the AVR and should be "60 volts" for all Cummins PMG generators.

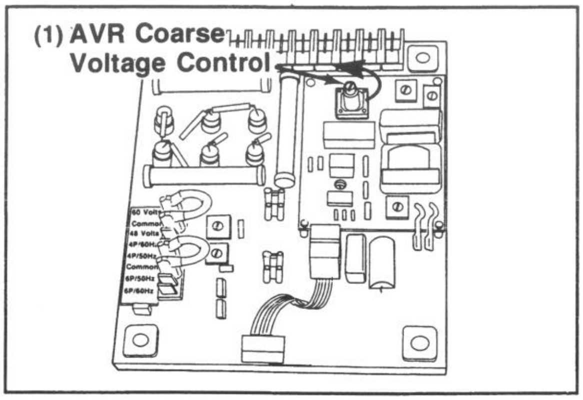


2. Check to see that the bottom jumper is installed between the bottom "C" and the appropriate "4P50" (4 pole, 50 Hz.) or "4P60" (4 pole, 60 Hz.) terminals. The placement of this jumper determines the speed range where underfrequency protection begins.

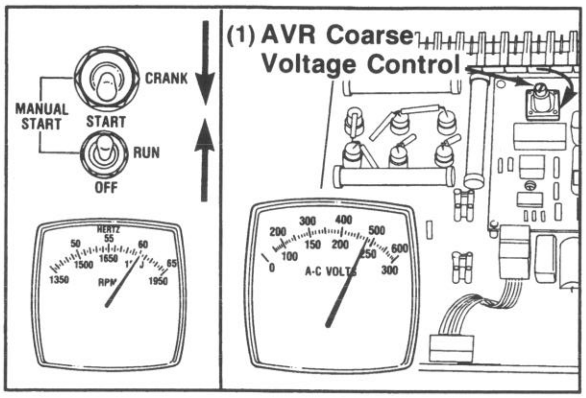


3. Connect all ten leads to the AVR. Mount the AVR in the AVR box.

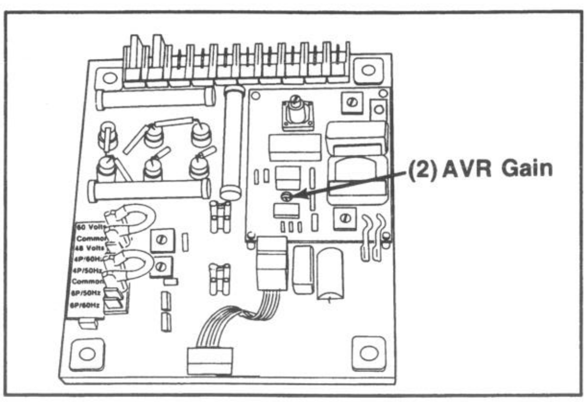




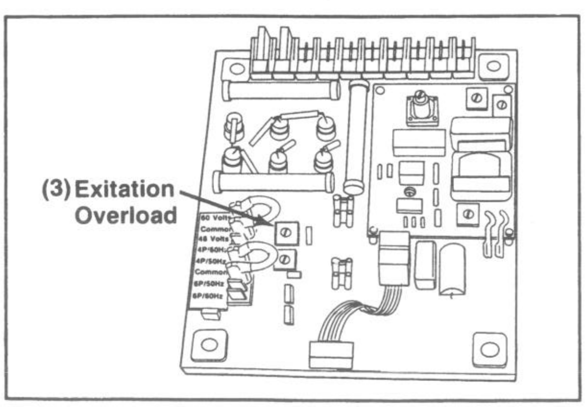
4. Turn the AVR coarse voltage control (1) all the way counterclockwise.



5. Start the engine. Bring the engine up to rated speed.
6. Turn the coarse voltage control (1) clockwise until the generator is producing approximately rated voltage. Turn the remote voltage trimmer control to obtain the precise voltage required. No additional adjustments are normally required.

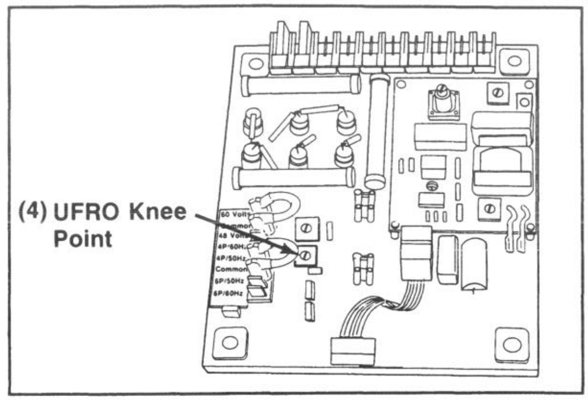


7. The AVR Gain control (2) is difficult to locate. It is on the main AVR control board and is accessible through a 4mm (0.160 in.) dia. hole in the approximate left center of the auxiliary board. The hole is below a rectangular red capacitor on the auxiliary board. The AVR Gain control is preset and sealed. Normally, the AVR Gain control should not be adjusted. If the voltage is unstable after a block load reduction, turn the AVR Gain control counterclockwise. Any gain adjustment affects the generator output voltage. Reset the output voltage after any AVR Gain adjustment. Turn the AVR Gain clockwise if rated voltage can not be obtained by means of the Coarse and Trimmer voltage controls.

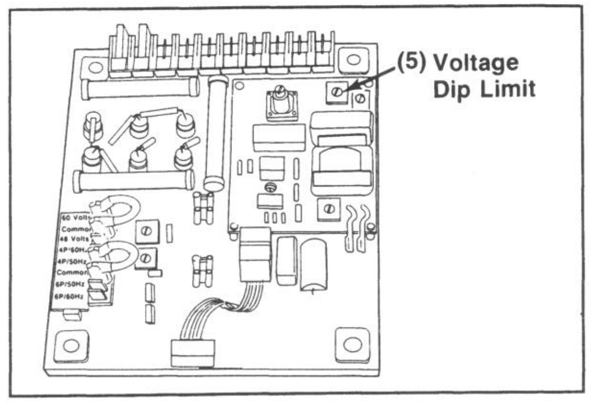


8. The Excitation Overload (3) is a manufacturing adjustment. It is factory calibrated and sealed. Normally the Excitation Overload control should not be adjusted. Turning the Excitation Overload control clockwise raises the "60 volt" protective circuit trip voltage.

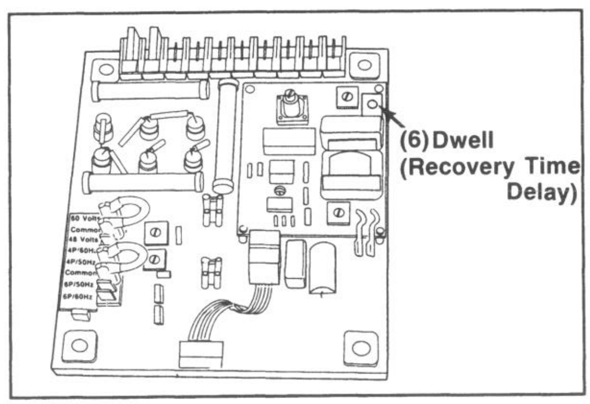
9. The UFRO (Under Frequency Roll Off) Knee Point (4) is preset and sealed at 97% (58.2 Hz. and 48.5 Hz.) of rated frequency. Normally, the UFRO Knee Point control should not be adjusted. Turning the UFRO Knee Point Control clockwise raises the frequency at which voltage becomes dependent on frequency. If the unit is operated on the UFRO slope, the generator output voltage will change with temperature as well as with frequency.



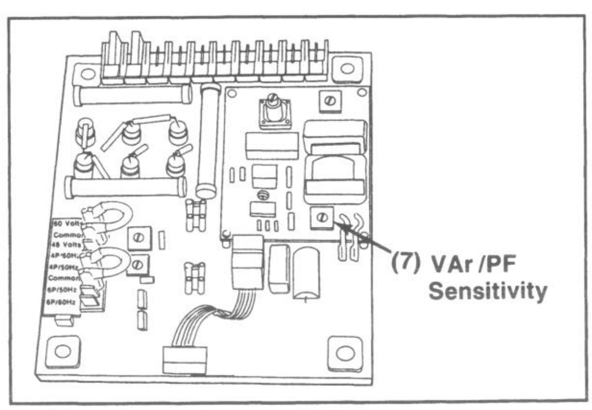
10. The Voltage Dip Limit (5) (top right square pot. on auxiliary board) is preset and sealed at approximately 30 percent of the operating voltage. Normally, the Voltage Dip Limit control should not be adjusted. Turning the Voltage Dip Limit control clockwise increases the voltage dip on large load pickup. This will make it easier for the engine to pick up load. Turning the control counter-clockwise reduces the voltage dip (makes the AVR "stiffer"). The engine may not be able to pick up the load if the Voltage Dip Limit is set too far counter-clockwise.



11. The Dwell (Recovery Time Delay) (6) (top, far right, rectangular, 20 turn pot.) is preset and sealed at the maximum (full clockwise) position. Normally, the Dwell control should not be adjusted. Turning the Dwell control counter-clockwise will reduce the dwell time and make the voltage return to rated value quicker.

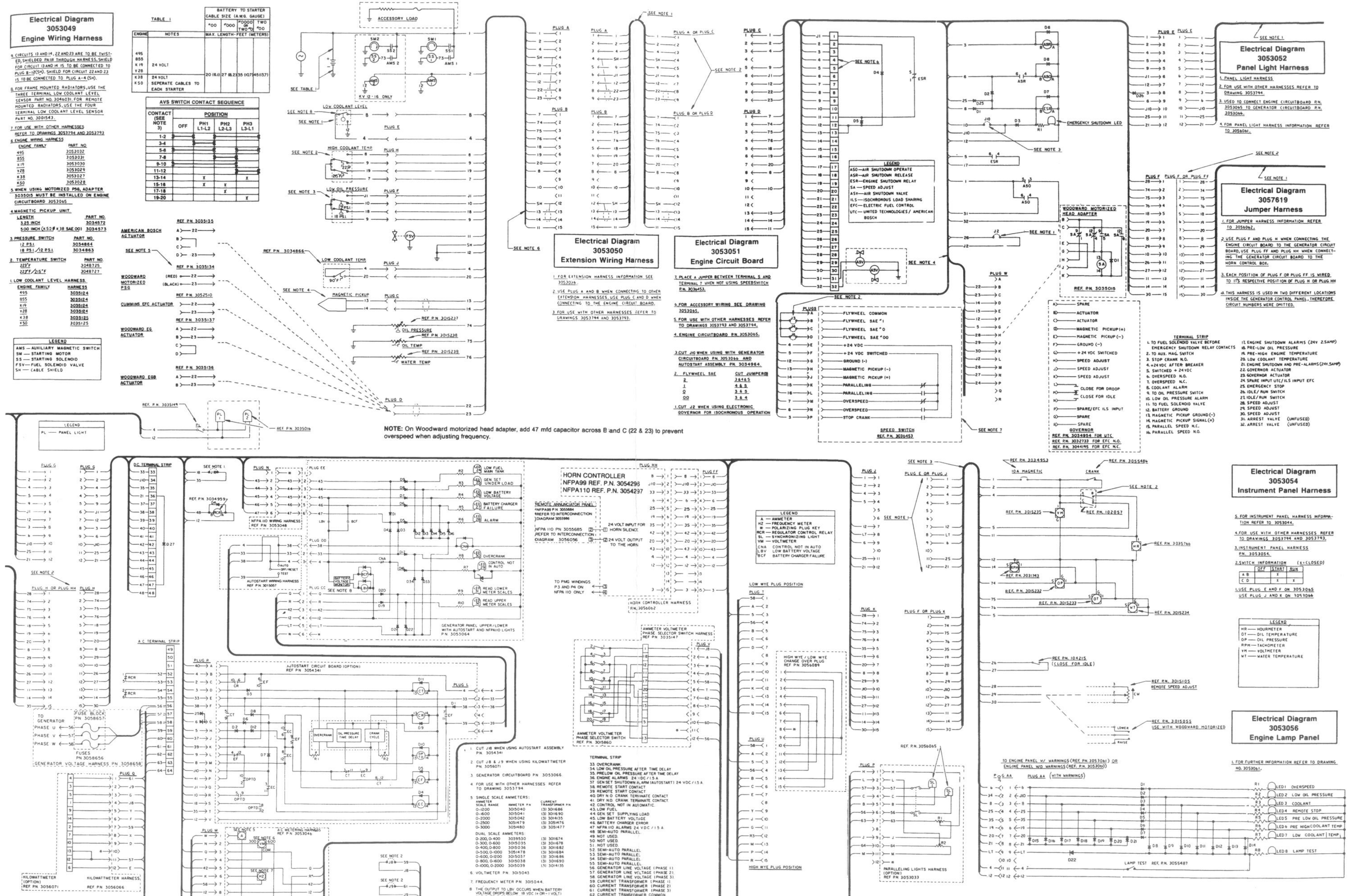


12. The VAr/P.F. Sensitivity (7) lower center square pot on the auxiliary board control, adjusts the response of the AVR to the signal from a VAr/P.F. controller. This control has no effect on the AVR unless a VAr/P.F. controller is used. The control is set at midrange.



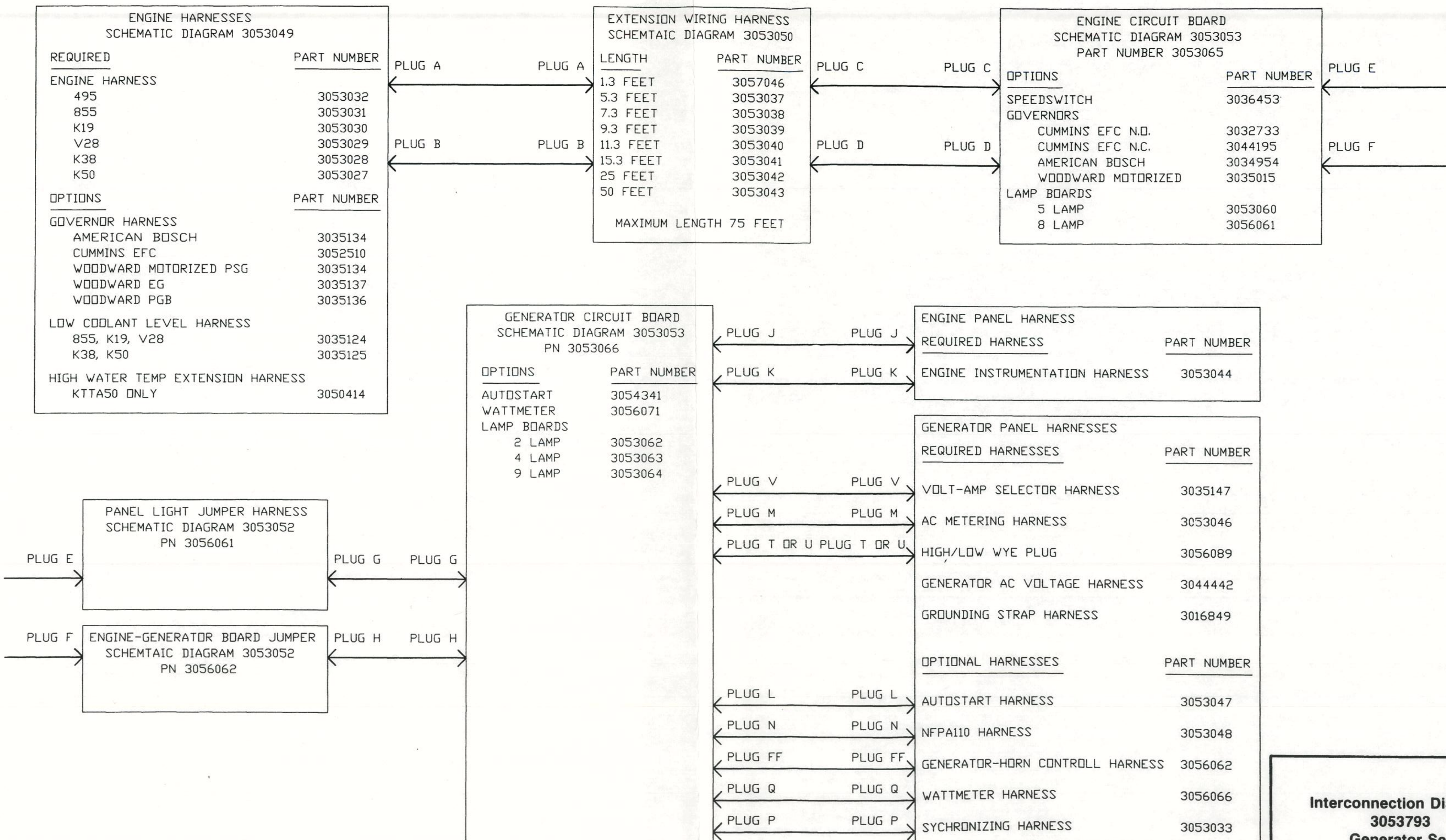
Section 7 - Wiring Diagrams

ge No.
30
31
32
33
34
35
36



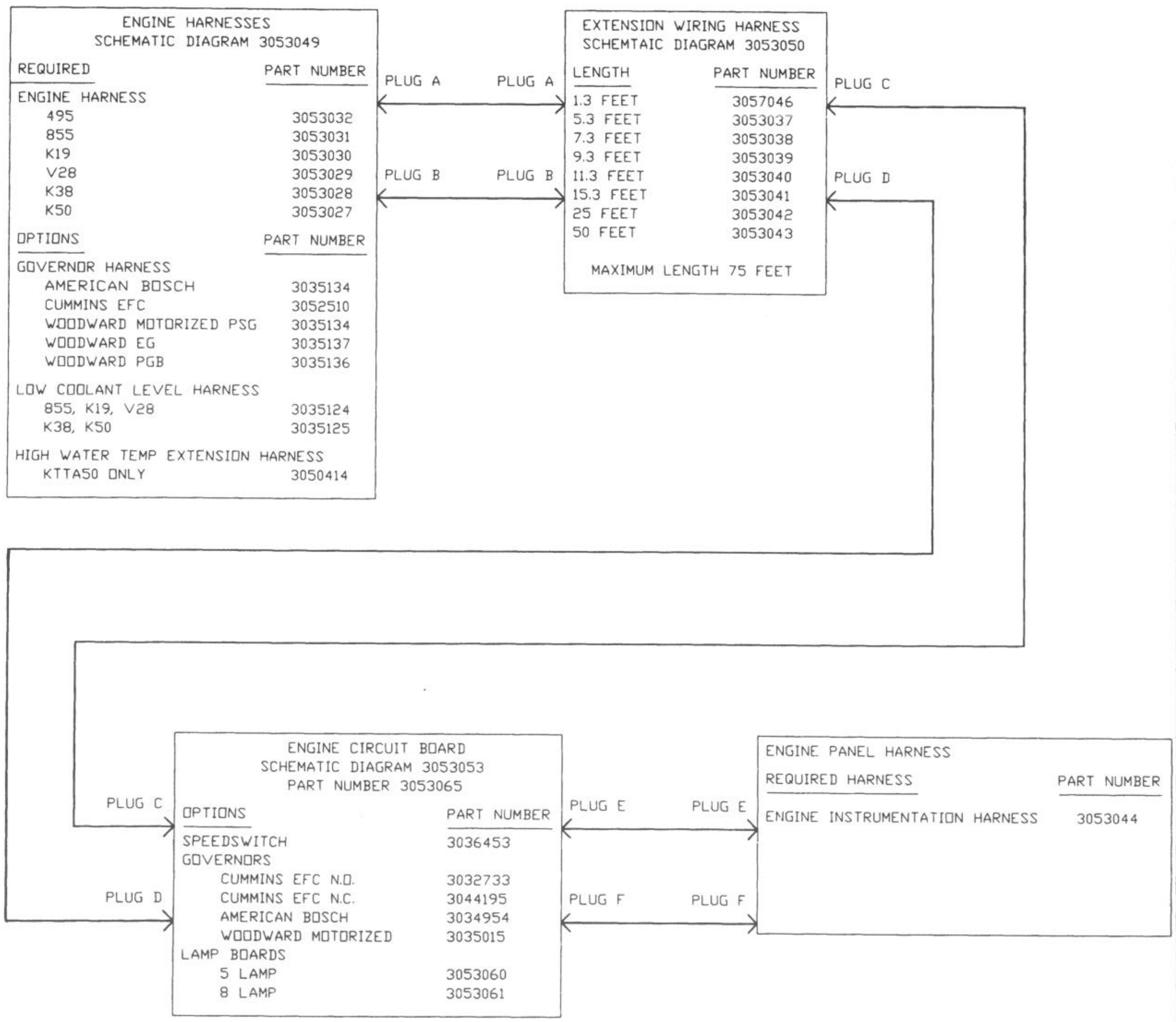
Bulletin No. 3810337
Composite Wiring Diagram for Gen Set Control Panel and Engine Electrics

GENERATOR SET WIRING INTERCONNECTION DIAGRAM



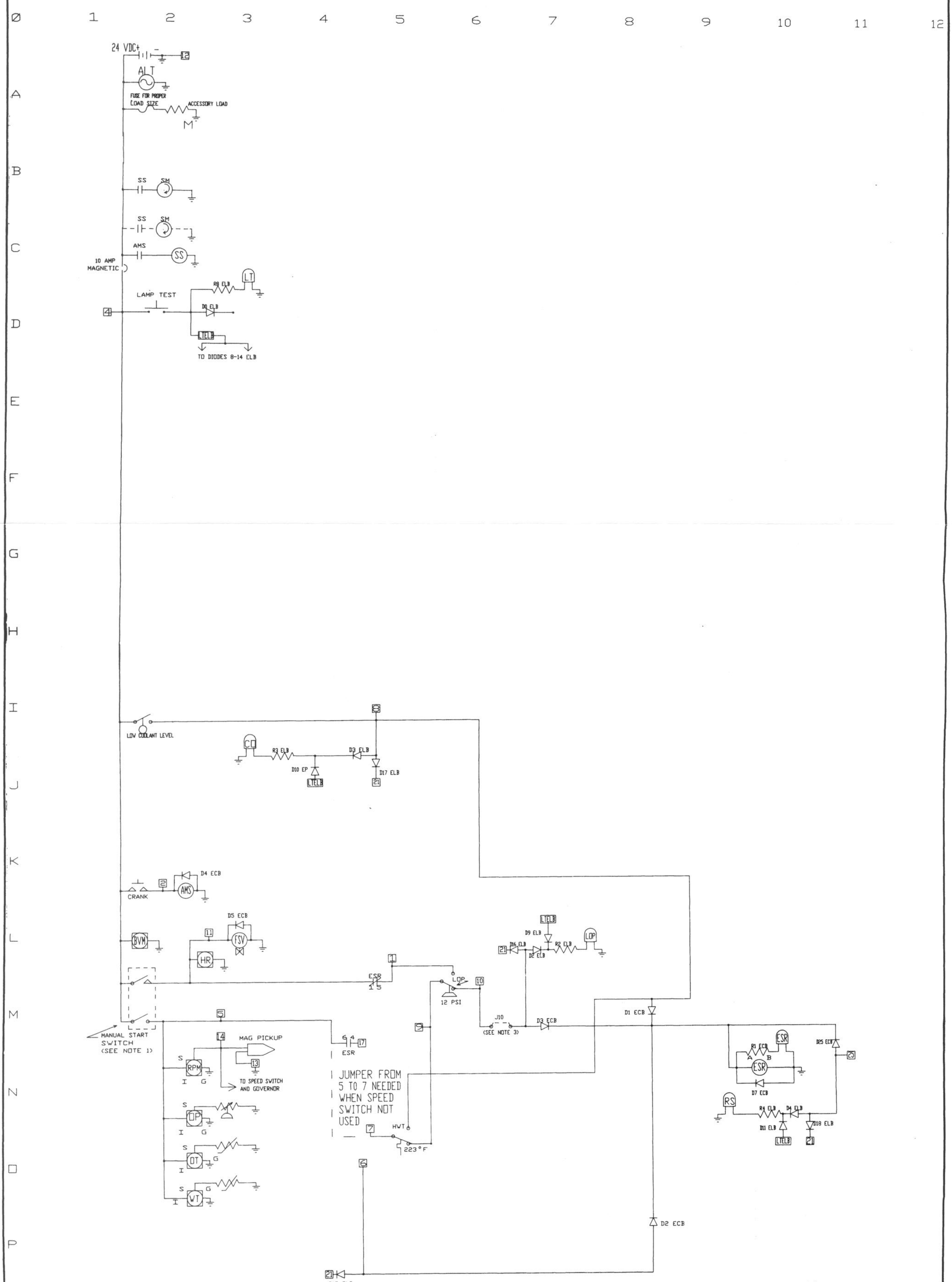
Interconnection Diagram
3053793
Generator Set

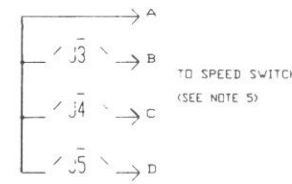
G-DRIVE, CONSTRUCTION WIRING INTERCONNECTION DIAGRAM



Interconnection Diagram
3053794
G-Drive, Construction

GEN SET CONTROL PANEL LOGIC DIAGRAM





LEGEND

AL	– Alarm
ALT	– Alternator
AMS	– Auxiliary Magnetic Switch
AS	– Alarm Silence
ASB	– Autostart Circuit Board
ASO	– Air Shutdown Operate
ASR	– Air Shutdown Release
ASV	– Air Shutdown Valve
AU	– Automatic
BCF	– Battery Charger Failure
BVM	– Battery Voltmeter
CC	– Crank Cycle
CNA	– Control Not In Automatic
CO	– Coolant
CR	– Crank Relay
CT	– Crank Termination Relay
EC	– Engine Coolant Relay
ECB	– Engine Circuit Board
EF	– Engine Failure Relay
ELB	– Engine Light Board
ESR	– Emergency Shutdown Relay
FSV	– Fuel Solenoid Valve
GCB	– Generator Circuit Board
GLB	– Generator Light Board
GSL	– Generator Supplying Load
HR	– Hourmeter
HWT	– High Water Temperature
LFMT	– Low Fuel Main Tank
LO	– Lower Scale
LOP	– Low Oil Pressure
LWT	– Low Water Temperature
LTELB	– Lamp Test Engine Light Board
LTGLB	– Lamp Test Generator Light Board
OC	– Overcrank
OP	– Oil Pressure
OPTD	– Oil Pressure Time Delay
OS	– Overspeed
OT	– Oil Temperature
PHWT	– Pre-High Water Temperature
PL	– Panel Light
PLOP	– Pre-Low Oil Pressure
RCR	– Regulator Control Relay
RPM	– Tachometer
RS	– Remote Stop
RSC	– Remote Start Contact
SC	– Stop Crank
SM	– Starting Motor
SS	– Starting Solenoid
UP	– Upper Scale
WT	– Water Temperature

TERMINAL STRIP

1	- Oil Pressure Switch
2	- To Auxiliary Magnetic Switch
3	- Stop Crank N.O.
4	- +24VDC After Circuit Breaker
5	- Switched + 24VDC
6	- Overspeed N.O.
7	- Overspeed N.C.
8	- Cooland Alarm
9	- To Oil Pressure Switch
10	- Low Oil Pressure Alarm
11	- To Fuel Solenoid Valve
12	- Ground
13	- Ground - Magnetic Pickup
14	- Magnetic Pickup
15	- Parallel Speed N.C.
16	- Parallel Speed N.O.
17	- Shutdown Alarm - 24V/.5A
18	- Pre-Low Oil Pressure
19	- Pre-High Water Temperature
20	- Low Water Temperature
21	- Engine Alarm Circuit
25	- Emergency Shut-Down
31	- Arrest Valve (Unfused)
32	- Arrest Valve (Unfused)
33	- Overcrank
34	- Low Oil Pressure After Time Delay
35	- Pre-Low Oil Pressure After Time Delay
36	- Engine Alarm Circuit
38	- Remote Start Contact
39	- Remote Start Contact
40	- Dry N.O. CT Contact
41	- Dry N.O. CT Contact
42	- Control Not In Auto
43	- Low Fuel Main Tank
44	- Generator Supplying Load
45	- Low Battery Voltage
46	- Battery Charger Failure
47	- Generator Alarm Circuit
48	- Regulator Control Relay
52	- Semi-Auto Parallel
53	- Semi-Auto Parallel
54	- Semi-Auto Parallel
55	- Semi-Auto Parallel

1. Switch Information (X = Closed)

	Off	Start	Run
AB		X	
CD		X	X

2. Insert jumper between terminals 5 and 7 when not using speed switch.

3. Cut J10 when using Generator Circuit Board (Part No.3053065) and Autostart Assembly (Part No.3054341).

4. Cut J18 when using Autostart Assembly (Part No.3054341).

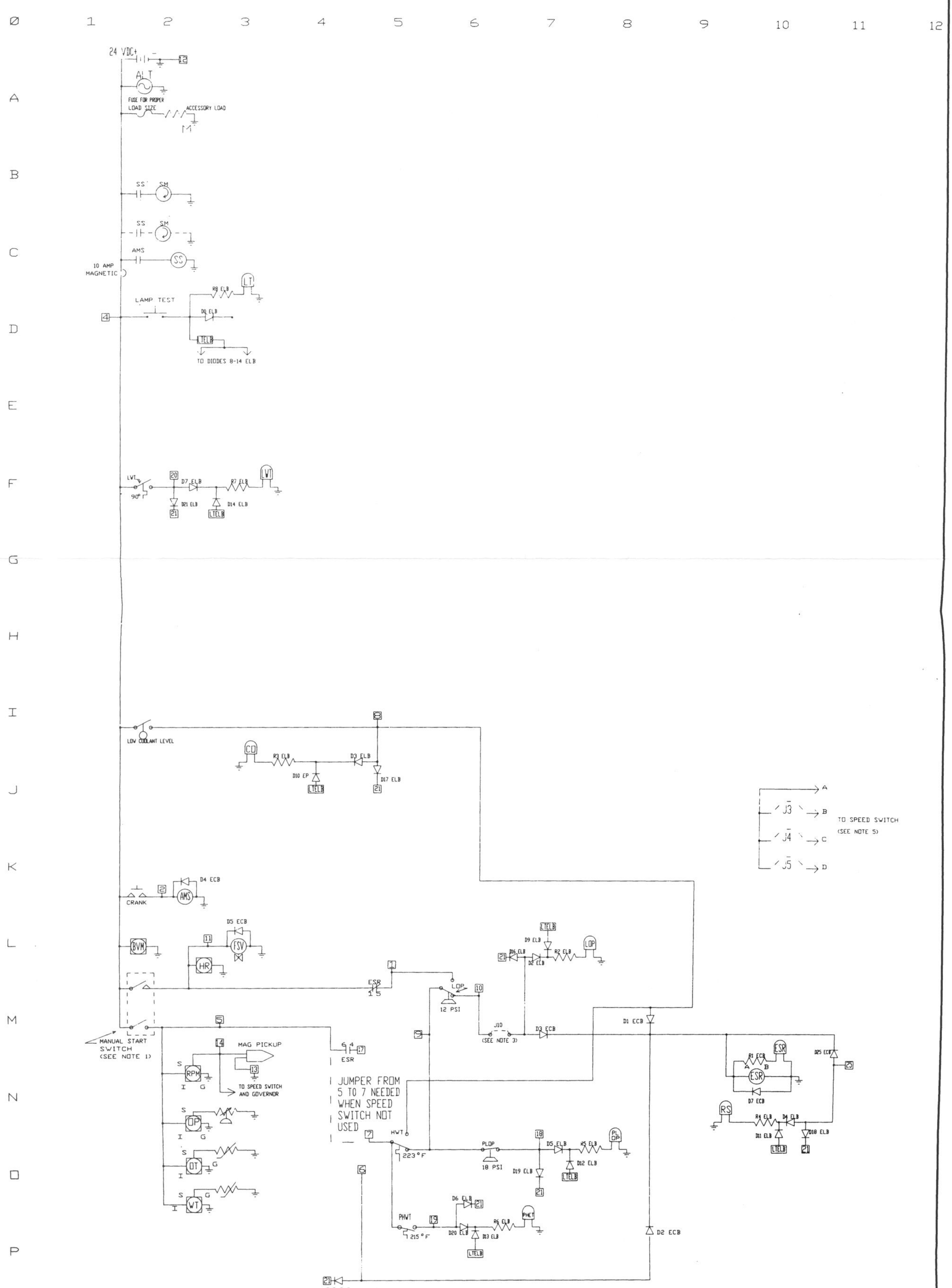
5.

Flywheel (SAE)	Cut Jumpers
2	3, 4 and 5
1	4 and 5
0	3 and 5
00	3 and 4

6. See Diagram 3053793, and 3053794 for Engine Wiring Systems.

RELAY	CONTACTS	LOCATION
ASO		P4
	3-5	A2
	4-6	A2
ASR		H2
	4-6	P4
CR		J9
	6-10	L2
CT		I6
	5-9	M12
	8-12	J5
	11-13	J5
EC		I6
	1-9	J6
	3-11	M6
	6-10	J5
	6-12	J5
EF		J10
	4-12	M5
	5-9	K5
	6-10	E2
	7-11	K4
ESR		N10
	1-5	M5
	4-6	M4
OPTD		H6
	2-10	M5
	5-9	M6
	8-12	O7
RCR		N12
	1-5	N12
	2-6	N12

GEN SET CONTROL PANEL LOGIC DIAGRAM WITH PRE-ALARMS



21 D15 ELB

Q

LEGEND

AL – Alarm
ALT – Alternator
AMS – Auxiliary Magnetic Switch
AS – Alarm Silence
ASB – Autostart Circuit Board
ASO – Air Shutdown Operate

ASR – Air Shutdown Release
ASV – Air Shutdown Valve
AU – Automatic
BCF – Battery Charger Failure
BVM – Battery Voltmeter
CC – Crank Cycle
CNA – Control Not In Automatic
CO – Coolant
CR – Crank Relay
CT – Crank Termination Relay
EC – Engine Coolant Relay
ECB – Engine Circuit Board
EF – Engine Failure Relay
ELB – Engine Light Board
ESR – Emergency Shutdown Relay

FSV – Fuel Solenoid Valve
GCB – Generator Circuit Board
GLB – Generator Light Board
GSL – Generator Supplying Load
HR – Hourmeter
HWT – High Water Temperature

LFMT – Low Fuel Main Tank
LO – Lower Scale
LOP – Low Oil Pressure
LWT – Low Water Temperature
LTELB – Lamp Test Engine Light Board
LTGLB – Lamp Test Generator Light Board
OC – Overcrank
OP – Oil Pressure

OPTD – Oil Pressure Time Delay
OS – Overspeed
OT – Oil Temperature
PHWT – Pre-High Water Temperature
PL – Panel Light

PLOP – Pre-Low Oil Pressure
RCR – Regulator Control Relay
RPM – Tachometer
RS – Remote Stop
RSC – Remote Start Contact
SC – Stop Crank

SM – Starting Motor
SS – Starting Solenoid
UP – Upper Scale

WT – Water Temperature

TERMINAL STRIP

1 - Oil Pressure Switch
2 - To Auxiliary Magnetic Switch
3 - Stop Crank N.O.
4 - +24VDC After Circuit Breaker
5 - Switched + 24VDC
6 - Overspeed N.O.
7 - Overspeed N.C.
8 - Cooland Alarm
9 - To Oil Pressure Switch
10 - Low Oil Pressure Alarm
11 - To Fuel Solenoid Valve
12 - Ground
13 - Ground - Magnetic Pickup
14 - Magnetic Pickup
15 - Parallel Speed N.C.
16 - Parallel Speed N.O.
17 - Shutdown Alarm - 24V/.5A
18 - Pre-Low Oil Pressure
19 - Pre-High Water Temperature
20 - Low Water Temperature
21 - Engine Alarm Circuit
25 - Emergency Shut-Down
31 - Arrest Valve (Unfused)
32 - Arrest Valve (Unfused)
33 - Overcrank
34 - Low Oil Pressure After Time Delay
35 - Pre-Low Oil Pressure After Time Delay
36 - Engine Alarm Circuit
38 - Remote Start Contact
39 - Remote Start Contact
40 - Dry N.O. CT Contact
41 - Dry N.O. CT Contact
42 - Control Not In Auto
43 - Low Fuel Main Tank
44 - Generator Supplying Load
45 - Low Battery Voltage
46 - Battery Charger Failure
47 - Generator Alarm Circuit
48 - Regulator Control Relay
52 - Semi-Auto Parallel
53 - Semi-Auto Parallel
54 - Semi-Auto Parallel
55 - Semi-Auto Parallel

1. Switch Information (X = Closed)

	Off	Start	Run
AB		X	
CD		X	X

2. Insert jumper between terminals 5 and 7 when not using speed switch.

3. Cut J10 when using Generator Circuit Board (Part No.3053065) and Autostart Assembly (Part No.3054341).

4. Cut J18 when using Autostart Assembly (Part No.3054341).

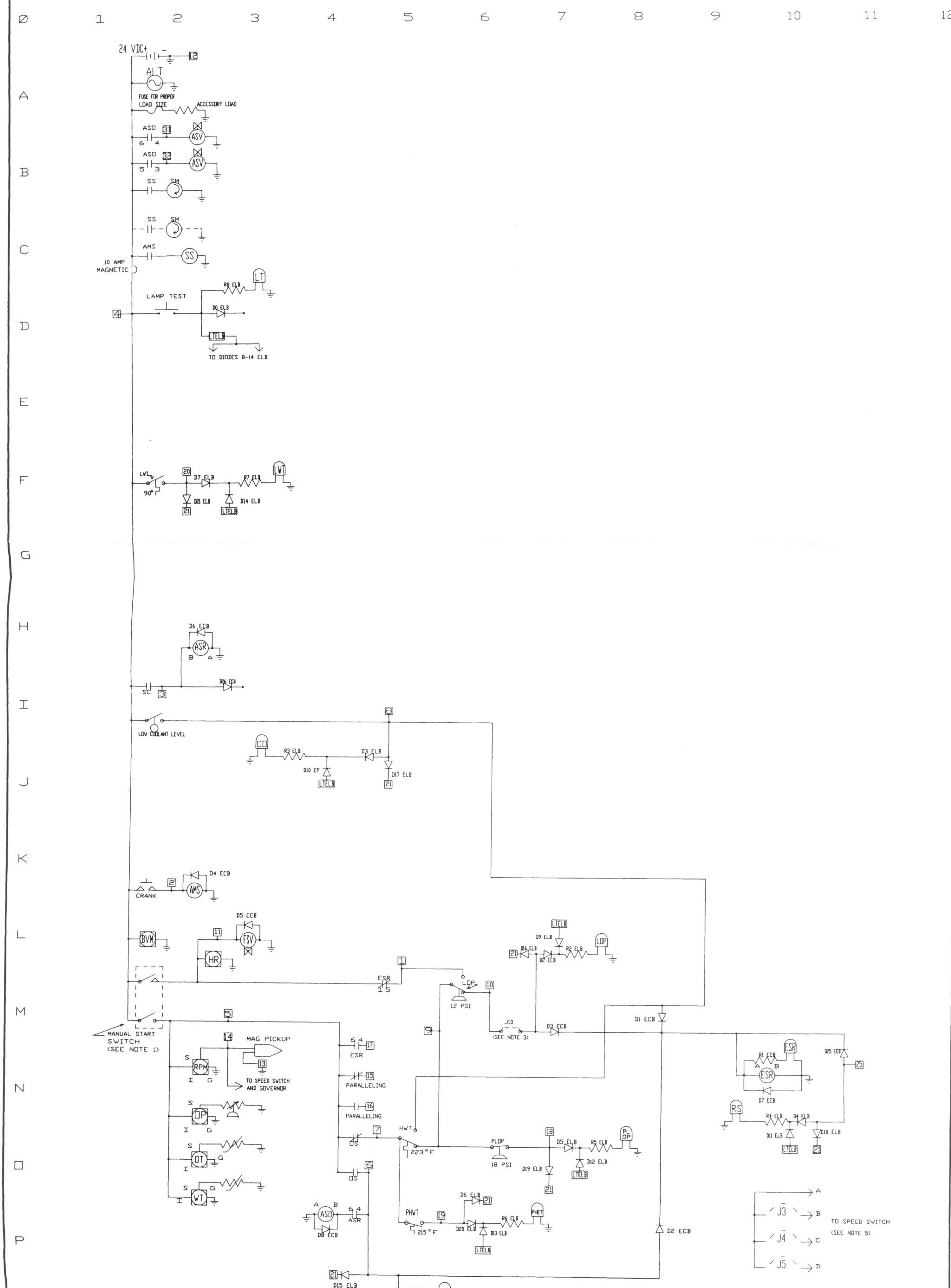
5.

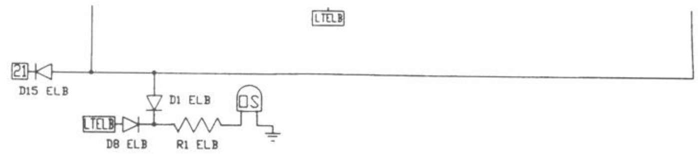
Flywheel (SAE)	Cut Jumpers
2	3, 4 and 5
1	4 and 5
0	3 and 5
00	3 and 4

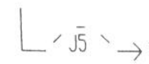
6. See Diagram 3053793, and 3053794 for Engine Wiring Systems.

RELAY	CONTACTS	LOCATION
ASO		P4
	3-5	A2
	4-6	A2
ASR		H2
	4-6	P4
CR		J9
	6-10	L2
CT		I6
	5-9	M12
	8-12	J5
	11-13	J5
EC		I6
	1-9	J6
	3-11	M6
	6-10	J5
	6-12	J5
EF		J10
	4-12	M5
	5-9	K5
	6-10	E2
	7-11	K4
ESR		N10
	1-5	M5
	4-6	M4
OPTD		H6
	2-10	M5
	5-9	M6
	8-12	O7
RCR		N12
	1-5	N12
	2-6	N12

GEN SET CONTROL PANEL LOGIC DIAGRAM WITH SPEED SWITCH AND PRE-ALARMS







Q

LEGEND

AL – Alarm
ALT – Alternator
AMS – Auxiliary Magnetic Switch
AS – Alarm Silence
ASB – Autostart Circuit Board
ASO – Air Shutdown Operate

ASR – Air Shutdown Release
ASV – Air Shutdown Valve
AU – Automatic
BCF – Battery Charger Failure
BVM – Battery Voltmeter
CC – Crank Cycle
CNA – Control Not In Automatic
CO – Coolant
CR – Crank Relay
CT – Crank Termination Relay
EC – Engine Coolant Relay
ECB – Engine Circuit Board
EF – Engine Failure Relay
ELB – Engine Light Board
ESR – Emergency Shutdown Relay

FSV – Fuel Solenoid Valve
GCB – Generator Circuit Board
GLB – Generator Light Board
GSL – Generator Supplying Load
HR – Hourmeter
HWT – High Water Temperature

LFMT – Low Fuel Main Tank
LO – Lower Scale
LOP – Low Oil Pressure
LWT – Low Water Temperature
LTELB – Lamp Test Engine Light Board
LTGLB – Lamp Test Generator Light Board
OC – Overcrank
OP – Oil Pressure

OPTD – OIl Pressure Time Delay
OS – Overspeed
OT – Oil Temperature
PHWT – Pre-High Water Temperature
PL – Panel Light

PLOP – Pre-Low Oil Pressure
RCR – Regulator Control Relay
RPM – Tachometer
RS – Remote Stop
RSC – Remote Start Contact
SC – Stop Crank

SM – Starting Motor
SS – Starting Solenoid
UP – Upper Scale

WT – Water Temperature

TERMINAL STRIP

1 - Oil Pressure Switch
2 - To Auxiliary Magnetic Switch
3 - Stop Crank N.O.
4 - +24VDC After Circuit Breaker
5 - Switched + 24VDC
6 - Overspeed N.O.
7 - Overspeed N.C.
8 - Cooland Alarm
9 - To Oil Pressure Switch
10 - Low Oil Pressure Alarm
11 - To Fuel Solenoid Valve
12 - Ground
13 - Ground - Magnetic Pickup
14 - Magnetic Pickup
15 - Parallel Speed N.C.
16 - Parallel Speed N.O.
17 - Shutdown Alarm - 24V/.5A
18 - Pre-Low Oil Pressure
19 - Pre-High Water Temperature
20 - Low Water Temperature
21 - Engine Alarm Circuit
25 - Emergency Shut-Down
31 - Arrest Valve (Unfused)
32 - Arrest Valve (Unfused)
33 - Overcrank
34 - Low Oil Pressure After Time Delay
35 - Pre-Low Oil Pressure After Time Delay
36 - Engine Alarm Circuit
38 - Remote Start Contact
39 - Remote Start Contact
40 - Dry N.O. CT Contact
41 - Dry N.O. CT Contact
42 - Control Not In Auto
43 - Low Fuel Main Tank
44 - Generator Supplying Load
45 - Low Battery Voltage
46 - Battery Charger Failure
47 - Generator Alarm Circuit
48 - Regulator Control Relay
52 - Semi-Auto Parallel
53 - Semi-Auto Parallel
54 - Semi-Auto Parallel
55 - Semi-Auto Parallel

1. Switch Information (X = Closed)

	Off	Start	Run
AB		X	
CD		X	X

2. Insert jumper between terminals 5 and 7 when not using speed switch.

3. Cut J10 when using Generator Circuit Board (Part No.3053065) and Autostart Assembly (Part No.3054341).

4. Cut J18 when using Autostart Assembly (Part No.3054341).

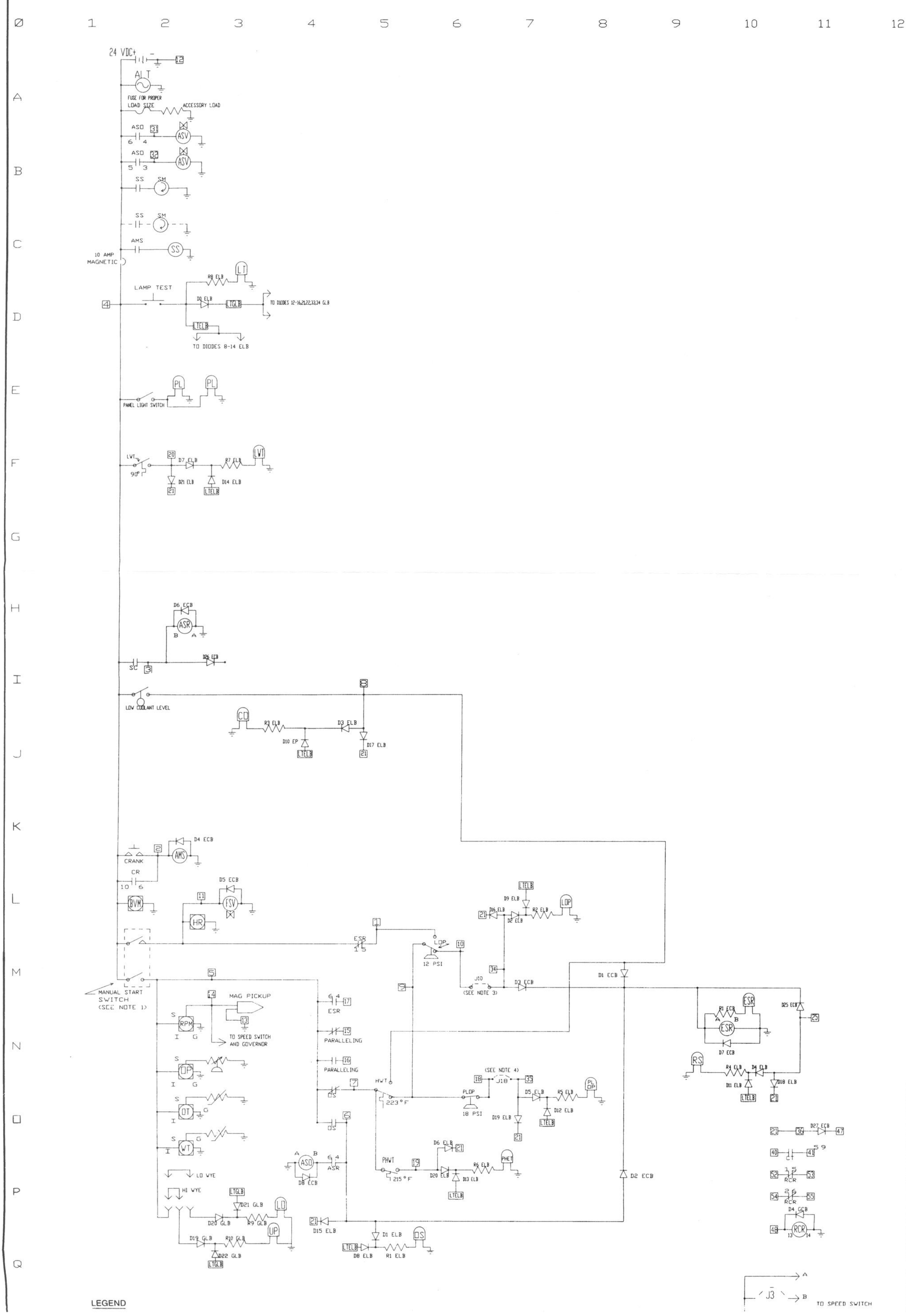
5.

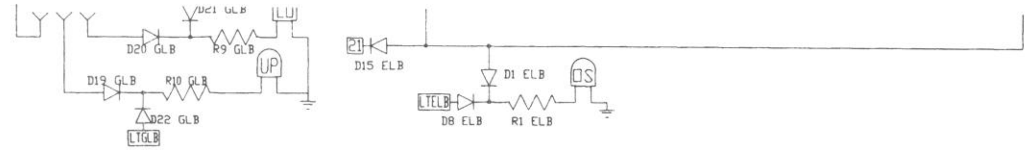
Flywheel (SAE)	Cut Jumpers
2	3, 4 and 5
1	4 and 5
0	3 and 5
00	3 and 4

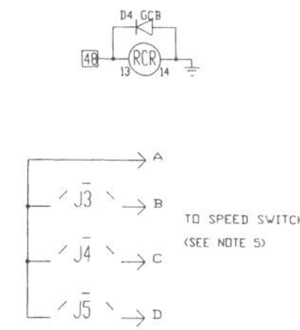
6. See Diagram 3053793, and 3053794 for Engine Wiring Systems.

RELAY	CONTACTS	LOCATION
ASO		P4
	3-5	A2
	4-6	A2
ASR		H2
	4-6	P4
CR		J9
	6-10	L2
CT		I6
	5-9	M12
	8-12	J5
	11-13	J5
EC		I6
	1-9	J6
	3-11	M6
	6-10	J5
	6-12	J5
EF		J10
	4-12	M5
	5-9	K5
	6-10	E2
	7-11	K4
ESR		N10
	1-5	M5
	4-6	M4
OPTD		H6
	2-10	M5
	5-9	M6
	8-12	O7
RCR		N12
	1-5	N12
	2-6	N12

GEN SET CONTROL PANEL LOGIC DIAGRAM WITH GENERATOR PANEL, SPEED SWITCH, AND PRE-ALARMS







Q

LEGEND

AL – Alarm
ALT – Alternator
AMS – Auxiliary Magnetic Switch
AS – Alarm Silence
ASB – Autostart Circuit Board
ASO – Air Shutdown Operate

ASR – Air Shutdown Release
ASV – Air Shutdown Valve
AU – Automatic
BCF – Battery Charger Failure
BVM – Battery Voltmeter
CC – Crank Cycle
CNA – Control Not In Automatic
CO – Coolant
CR – Crank Relay
CT – Crank Termination Relay
EC – Engine Coolant Relay
ECB – Engine Circuit Board
EF – Engine Failure Relay
ELB – Engine Light Board
ESR – Emergency Shutdown Relay

FSV – Fuel Solenoid Valve
GCB – Generator Circuit Board
GLB – Generator Light Board
GSL – Generator Supplying Load
HR – Hourmeter
HWT – High Water Temperature

LFMT – Low Fuel Main Tank
LO – Lower Scale
LOP – Low Oil Pressure
LWT – Low Water Temperature
LTELB – Lamp Test Engine Light Board
LTGLB – Lamp Test Generator Light Board
OC – Overcrank
OP – Oil Pressure

OPTD – Oil Pressure Time Delay
OS – Overspeed
OT – Oil Temperature
PHWT – Pre-High Water Temperature
PL – Panel Light

PLOP – Pre-Low Oil Pressure
RCR – Regulator Control Relay
RPM – Tachometer
RS – Remote Stop
RSC – Remote Start Contact
SC – Stop Crank

SM – Starting Motor
SS – Starting Solenoid
UP – Upper Scale

WT – Water Temperature

TERMINAL STRIP

1 - Oil Pressure Switch
2 - To Auxiliary Magnetic Switch
3 - Stop Crank N.O.
4 - +24VDC After Circuit Breaker
5 - Switched + 24VDC
6 - Overspeed N.O.
7 - Overspeed N.C.
8 - Cooland Alarm
9 - To Oil Pressure Switch
10 - Low Oil Pressure Alarm
11 - To Fuel Solenoid Valve
12 - Ground
13 - Ground - Magnetic Pickup
14 - Magnetic Pickup
15 - Parallel Speed N.C.
16 - Parallel Speed N.O.
17 - Shutdown Alarm - 24V/.5A
18 - Pre-Low Oil Pressure
19 - Pre-High Water Temperature
20 - Low Water Temperature
21 - Engine Alarm Circuit
25 - Emergency Shut-Down
31 - Arrest Valve (Unfused)
32 - Arrest Valve (Unfused)
33 - Overcrank
34 - Low Oil Pressure After Time Delay
35 - Pre-Low Oil Pressure After Time Delay
36 - Engine Alarm Circuit
38 - Remote Start Contact
39 - Remote Start Contact
40 - Dry N.O. CT Contact
41 - Dry N.O. CT Contact
42 - Control Not In Auto
43 - Low Fuel Main Tank
44 - Generator Supplying Load
45 - Low Battery Voltage
46 - Battery Charger Failure
47 - Generator Alarm Circuit
48 - Regulator Control Relay
52 - Semi-Auto Parallel
53 - Semi-Auto Parallel
54 - Semi-Auto Parallel
55 - Semi-Auto Parallel

1. Switch Information (X = Closed)

	Off	Start	Run
AB		X	
CD		X	X

2. Insert jumper between terminals 5 and 7 when not using speed switch.

3. Cut J10 when using Generator Circuit Board (Part No.3053065) and Autostart Assembly (Part No.3054341).

4. Cut J18 when using Autostart Assembly (Part No.3054341).

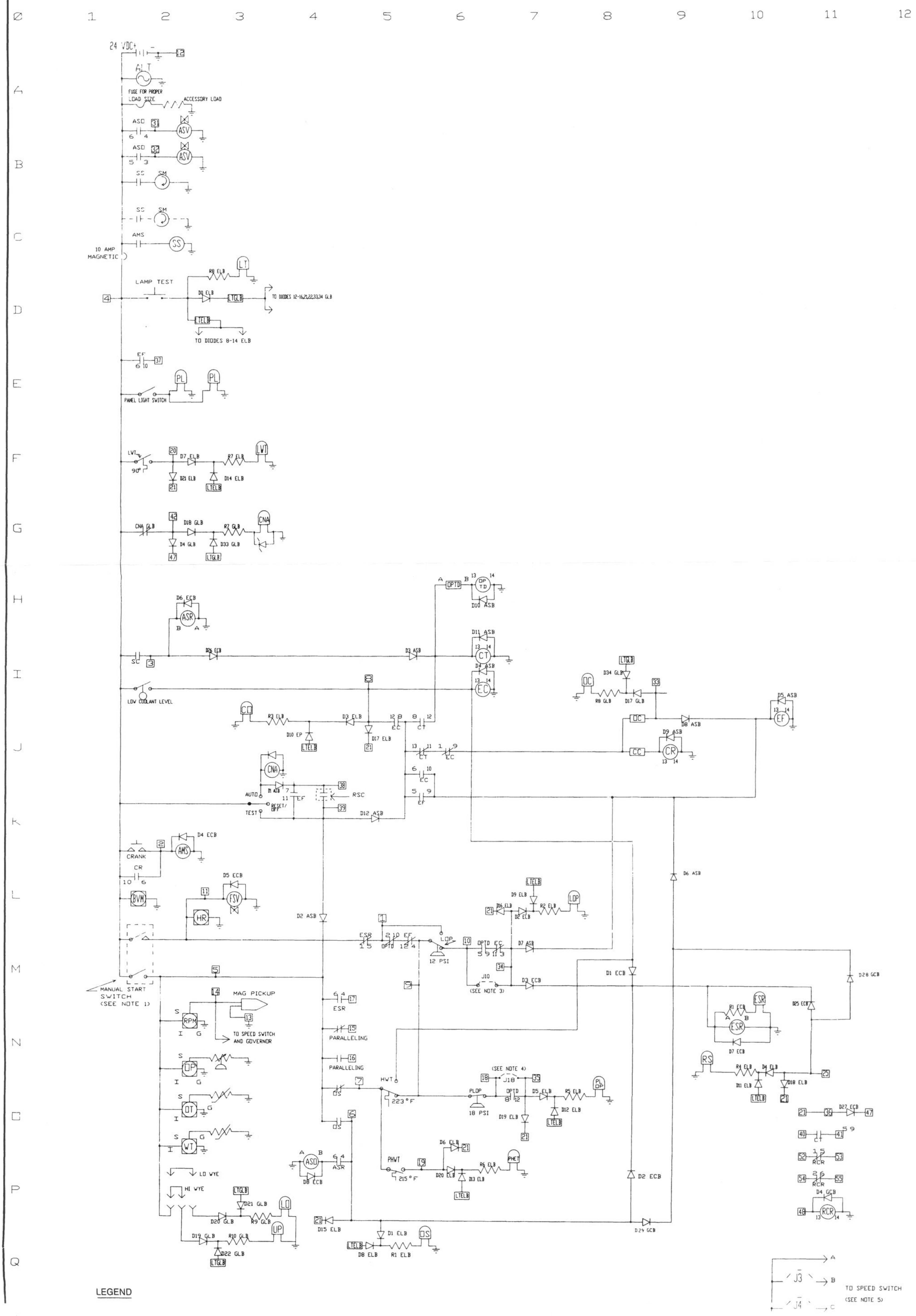
5.

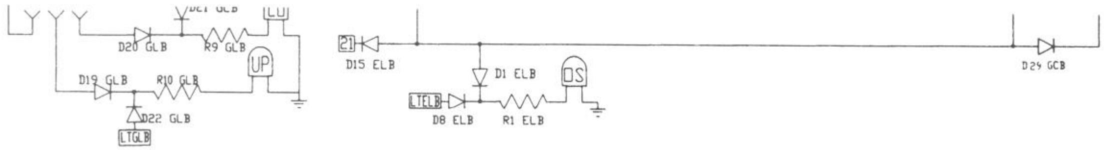
Flywheel (SAE)	Cut Jumpers
2	3, 4 and 5
1	4 and 5
0	3 and 5
00	3 and 4

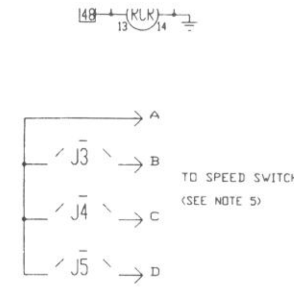
6. See Diagram 3053793, and 3053794 for Engine Wiring Systems.

RELAY	CONTACTS	LOCATION
ASO		P4
	3-5	A2
	4-6	A2
ASR		H2
	4-6	P4
CR		J9
	6-10	L2
CT		I6
	5-9	M12
	8-12	J5
	11-13	J5
EC		I6
	1-9	J6
	3-11	M6
	6-10	J5
	6-12	J5
EF		J10
	4-12	M5
	5-9	K5
	6-10	E2
	7-11	K4
ESR		N10
	1-5	M5
	4-6	M4
OPTD		H6
	2-10	M5
	5-9	M6
	8-12	O7
RCR		N12
	1-5	N12
	2-6	N12

GEN SET CONTROL PANEL LOGIC DIAGRAM WITH AUTO-START, GENERATOR PANEL, SPEED SWITCH, AND PRE-ALARMS







LEGEND

AL - Alarm
ALT - Alternator
AMS - Auxiliary Magnetic Switch
AS - Alarm Silence
ASB - Autostart Circuit Board
ASO - Air Shutdown Operate

ASR - Air Shutdown Release
ASV - Air Shutdown Valve
AU - Automatic
BCF - Battery Charger Failure
BVM - Battery Voltmeter
CC - Crank Cycle
CNA - Control Not In Automatic
CO - Coolant
CR - Crank Relay
CT - Crank Termination Relay
EC - Engine Coolant Relay
ECB - Engine Circuit Board
EF - Engine Failure Relay
ELB - Engine Light Board
ESR - Emergency Shutdown Relay

FSV - Fuel Solenoid Valve
GCB - Generator Circuit Board
GLB - Generator Light Board
GSL - Generator Supplying Load
HR - Hourmeter
HWT - High Water Temperature

LFMT - Low Fuel Main Tank
LO - Lower Scale
LOP - Low Oil Pressure
LWT - Low Water Temperature
LTELB - Lamp Test Engine Light Board
LTGLB - Lamp Test Generator Light Board
OC - Overcrank
OP - Oil Pressure

OPTD - Oil Pressure Time Delay
OS - Overspeed
OT - Oil Temperature
PHWT - Pre-High Water Temperature
PL - Panel Light

PLOP - Pre-Low Oil Pressure
RCR - Regulator Control Relay
RPM - Tachometer
RS - Remote Stop
RSC - Remote Start Contact
SC - Stop Crank

SM - Starting Motor
SS - Starting Solenoid
UP - Upper Scale

WT - Water Temperature

TERMINAL STRIP

1 - Oil Pressure Switch
2 - To Auxiliary Magnetic Switch
3 - Stop Crank N.O.
4 - +24VDC After Circuit Breaker
5 - Switched + 24VDC
6 - Overspeed N.O.
7 - Overspeed N.C.
8 - Cooland Alarm
9 - To Oil Pressure Switch
10 - Low Oil Pressure Alarm
11 - To Fuel Solenoid Valve
12 - Ground
13 - Ground - Magnetic Pickup
14 - Magnetic Pickup
15 - Parallel Speed N.C.
16 - Parallel Speed N.O.
17 - Shutdown Alarm - 24V/.5A
18 - Pre-Low Oil Pressure
19 - Pre-High Water Temperature
20 - Low Water Temperature
21 - Engine Alarm Circuit
25 - Emergency Shut-Down
31 - Arrest Valve (Unfused)
32 - Arrest Valve (Unfused)
33 - Overcrank
34 - Low Oil Pressure After Time Delay
35 - Pre-Low Oil Pressure After Time Delay
36 - Engine Alarm Circuit
38 - Remote Start Contact
39 - Remote Start Contact
40 - Dry N.O. CT Contact
41 - Dry N.O. CT Contact
42 - Control Not In Auto
43 - Low Fuel Main Tank
44 - Generator Supplying Load
45 - Low Battery Voltage
46 - Battery Charger Failure
47 - Generator Alarm Circuit
48 - Regulator Control Relay
52 - Semi-Auto Parallel
53 - Semi-Auto Parallel
54 - Semi-Auto Parallel
55 - Semi-Auto Parallel

1. Switch Information (X = Closed)

	Off	Start	Run
AB		X	
CD		X	X

2. Insert jumper between terminals 5 and 7 when not using speed switch.

3. Cut J10 when using Generator Circuit Board (Part No.3053065) and Autostart Assembly (Part No.3054341).

4. Cut J18 when using Autostart Assembly (Part No.3054341).

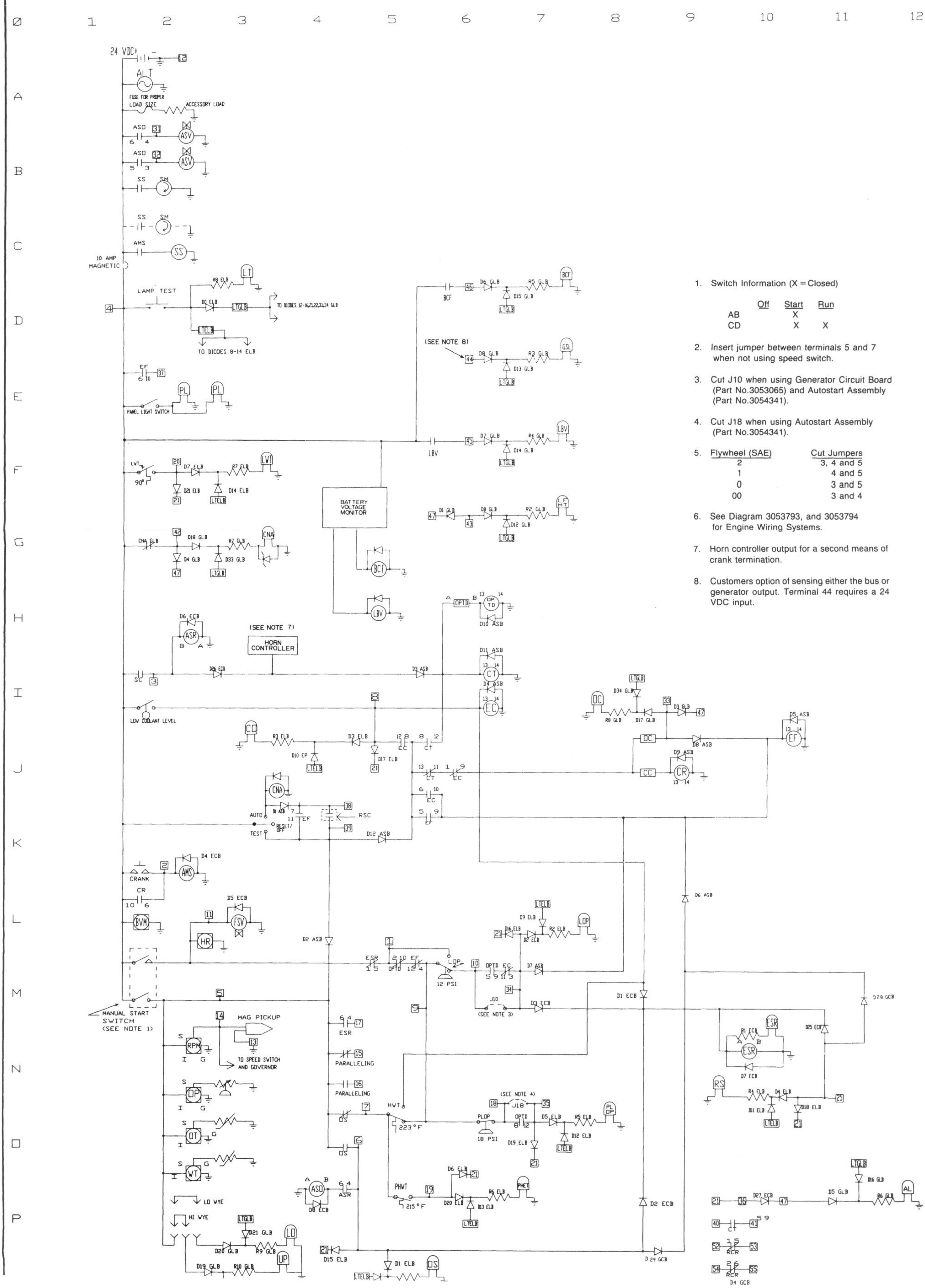
5.

Flywheel (SAE)	Cut Jumpers
2	3, 4 and 5
1	4 and 5
0	3 and 5
00	3 and 4

6. See Diagram 3053793, and 3053794 for Engine Wiring Systems.

RELAY	CONTACTS	LOCATION
ASO		P4
	3-5	A2
	4-6	A2
ASR		H2
	4-6	P4
CR		J9
	6-10	L2
CT		I6
	5-9	M12
	8-12	J5
	11-13	J5
EC		I6
	1-9	J6
	3-11	M6
	6-10	J5
	8-12	J5
EF		J10
	4-12	M5
	5-9	K5
	6-10	E2
	7-11	K4
ESR		N10
	1-5	M5
	4-6	M4
OPTD		H6
	2-10	M5
	5-9	M6
	8-12	O7
RCR		N12
	1-5	N12
	2-6	N12

GEN SET CONTROL PANEL LOGIC DIAGRAM
WITH NFPA 110, AUTO-START, GENERATOR PANEL, SPEED SWITCH, AND PRE-ALARMS



1. Switch Information (X = Closed)

	Off	Start	Run
AB		X	
CD		X	X

2. Insert jumper between terminals 5 and 7 when not using speed switch.

3. Cut J10 when using Generator Circuit Board (Part No.3053065) and Autostart Assembly (Part No.3054341).

4. Cut J18 when using Autostart Assembly (Part No.3054341).

5.

Flywheel (SAE)	Cut Jumpers
2	3, 4 and 5
1	4 and 5
0	3 and 5
00	3 and 4

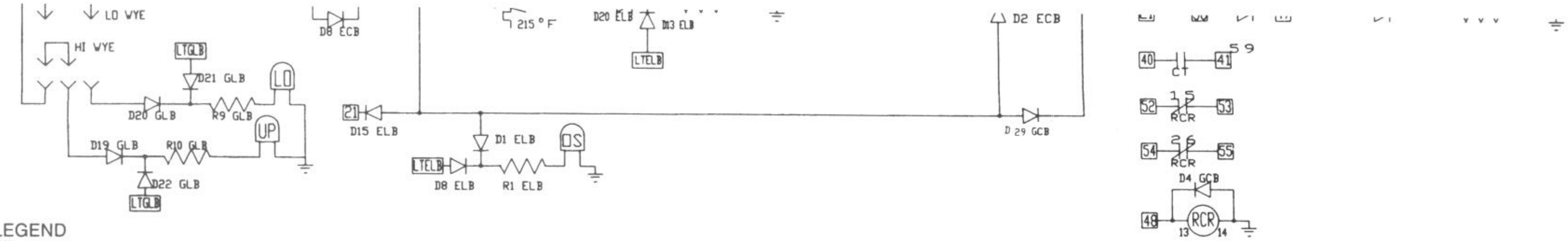
6. See Diagram 3053793, and 3053794 for Engine Wiring Systems.

7. Horn controller output for a second means of crank termination.

8. Customers option of sensing either the bus or generator output. Terminal 44 requires a 24 VDC input.

P

Q



LEGEND

AL – Alarm
ALT – Alternator
AMS – Auxiliary Magnetic Switch
AS – Alarm Silence
ASB – Autostart Circuit Board
ASO – Air Shutdown Operate

ASR – Air Shutdown Release
ASV – Air Shutdown Valve
AU – Automatic
BCF – Battery Charger Failure
BVM – Battery Voltmeter
CC – Crank Cycle
CNA – Control Not In Automatic
CO – Coolant
CR – Crank Relay
CT – Crank Termination Relay
EC – Engine Coolant Relay
ECB – Engine Circuit Board
EF – Engine Failure Relay
ELB – Engine Light Board
ESR – Emergency Shutdown Relay

FSV – Fuel Solenoid Valve
GCB – Generator Circuit Board
GLB – Generator Light Board
GSL – Generator Supplying Load
HR – Hourmeter
HWT – High Water Temperature
LBV – Low Battery Voltage
LFMT – Low Fuel Main Tank
LO – Lower Scale
LOP – Low Oil Pressure
LWT – Low Water Temperature
LTELB – Lamp Test Engine Light Board
LTGLB – Lamp Test Generator Light Board
OC – Overcrank
OP – Oil Pressure

OPTD – OIl Pressure Time Delay
OS – Overspeed
OT – Oil Temperature
PHWT – Pre-High Water Temperature
PL – Panel Light

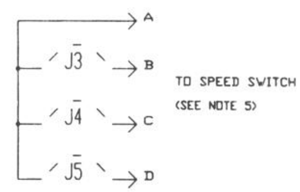
PLOP – Pre-Low Oil Pressure
RCR – Regulator Control Relay
RPM – Tachometer
RS – Remote Stop
RSC – Remote Start Contact
SC – Stop Crank

SM – Starting Motor
SS – Starting Solenoid
UP – Upper Scale

WT – Water Temperature

TERMINAL STRIP

1 - Oil Pressure Switch
2 - To Auxiliary Magnetic Switch
3 - Stop Crank N.O.
4 - +24VDC After Circuit Breaker
5 - Switched + 24VDC
6 - Overspeed N.O.
7 - Overspeed N.C.
8 - Cooland Alarm
9 - To Oil Pressure Switch
10 - Low Oil Pressure Alarm
11 - To Fuel Solenoid Valve
12 - Ground
13 - Ground - Magnetic Pickup
14 - Magnetic Pickup
15 - Parallel Speed N.C.
16 - Parallel Speed N.O.
17 - Shutdown Alarm - 24V/.5A
18 - Pre-Low Oil Pressure
19 - Pre-High Water Temperature
20 - Low Water Temperature
21 - Engine Alarm Circuit
25 - Emergency Shut-Down
31 - Arrest Valve (Unfused)
32 - Arrest Valve (Unfused)
33 - Overcrank
34 - Low Oil Pressure After Time Delay
35 - Pre-Low Oil Pressure After Time Delay
36 - Engine Alarm Circuit
38 - Remote Start Contact
39 - Remote Start Contact
40 - Dry N.O. CT Contact
41 - Dry N.O. CT Contact
42 - Control Not In Auto
43 - Low Fuel Main Tank
44 - Generator Supplying Load
45 - Low Battery Voltage
46 - Battery Charger Failure
47 - Generator Alarm Circuit
48 - Regulator Control Relay
52 - Semi-Auto Parallel
53 - Semi-Auto Parallel
54 - Semi-Auto Parallel
55 - Semi-Auto Parallel



RELAY	CONTACTS	LOCATION
ASO		P4
	3-5	A2
	4-6	A2
ASR		H2
	4-6	P4
CR		J9
	6-10	L2
CT		I6
	5-9	M12
	8-12	J5
	11-13	J5
EC		I6
	1-9	J6
	3-11	M6
	6-10	J5
	8-12	J5
EF		J10
	4-12	M5
	5-9	K5
	6-10	E2
	7-11	K4
ESR		N10
	1-5	M5
	4-6	M4
OPTD		H6
	2-10	M5
	5-9	M6
	8-12	O7
RCR		N12
	1-5	N12
	2-6	N12

GEN SET CONTROL PANEL AC LOGIC DIAGRAM

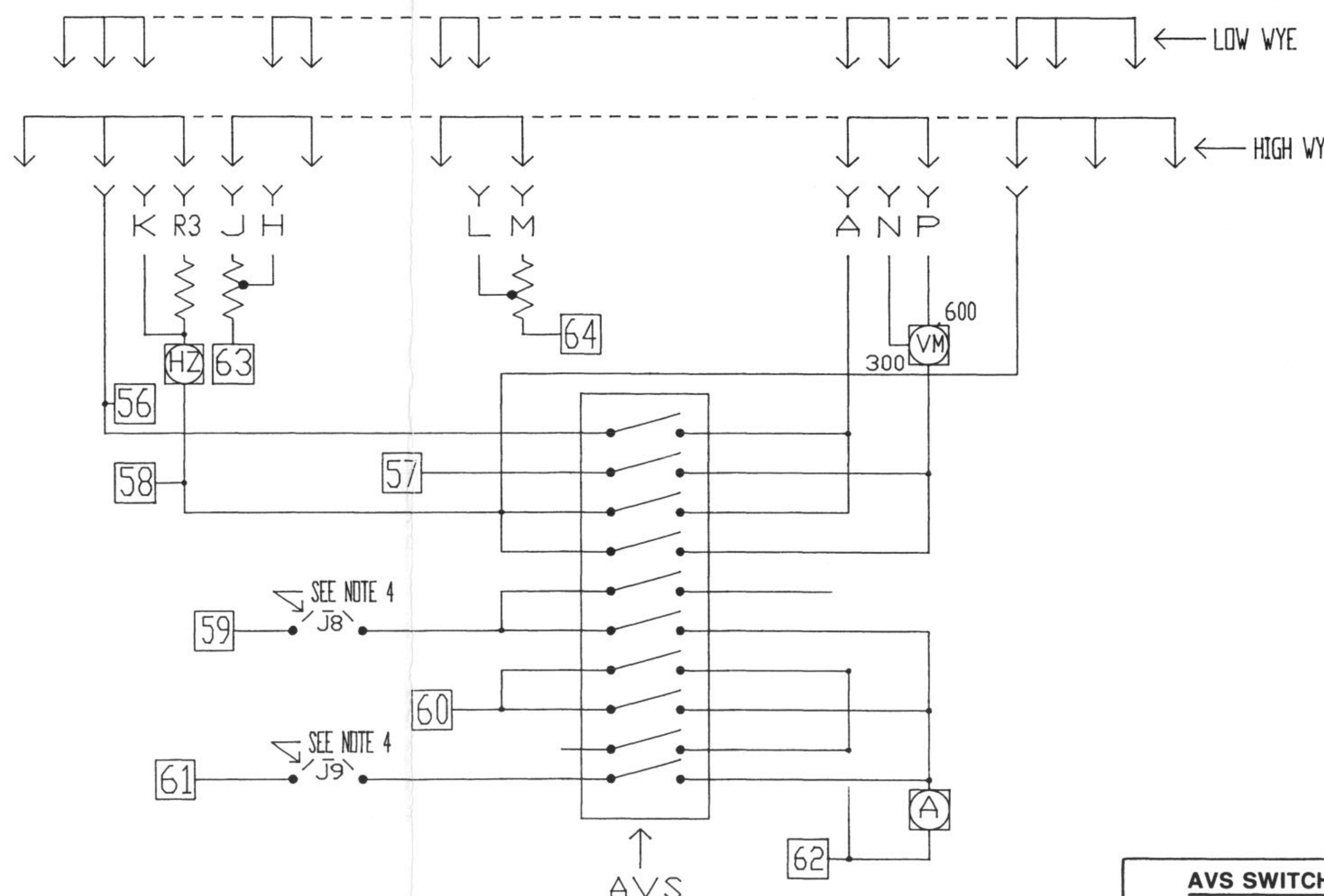
LEGEND

A - Ammeter
AVS - Amp/Volt Selector Switch
HZ - Frequency Meter
SA - Speed Adjust
SL - Synchronizing Light
VM - AC Voltmeter

TERMINAL STRIP

5 - Switched + 24 VDC
12 - Ground
13 - Ground Magnetic Pickup
14 - Magnetic Pickup +
22 - Governor Actuator
23 - Governor Actuator
24 - See Note 6
26 - Idle/Run Switch
27 - Idle/Run Switch
28 - Speed Adjust
29 - Speed Adjust
30 - Speed Adjust
56 - T1
57 - T2
58 - T3
59 - CT1
60 - CT2
61 - CT3
62 - CT Com.
63 - L1
64 - L2

1. Spare - Part No. 3034954
   ILS Input - Part No. 3032733
2. Cut J2 when using governor (Part No. 3034954) for isochronous operation
3. Contacts 1-2 through 11-12 are make before break
4. Cut J8 and J9 when using kilowattmeter (Part No. 3015017)
5. See diagrams 3037461, 3037462 and 3037463 for engine wiring systems
6. Terminal to be used for the ILS input when using the EFC governor (Part No. 3032733). When using other governors, terminal to be used for a spare and is not used



AVS SWITCH CONTACT SEQUENCE

CONTACT (SEE NOTE 3)	POSITION			
	OFF	PH1 L1-L2	PH2 L2-L3	PH3 L3-L1
1-2	X		X	X
3-4		X		
5-6	X	X		X
7-8			X	
9-10	X	X	X	
11-12				X
13-14		X		X
15-16		X	X	
17-18			X	
19-20				X

GEN SET CONTROL PANEL AC LOGIC DIAGRAM WITH KILOWATTMETER

LEGEND

A - Ammeter
AVS - Amp/Volt Selector Switch
HZ - Frequency Meter
SA - Speed Adjust
SL - Synchronizing Light
VM - AC Voltmeter

TERMINAL STRIP

5 - Switched + 24 VDC
12 - Ground
13 - Ground Magnetic Pickup
14 - Magnetic Pickup +
22 - Governor Actuator

23 - Governor Actuator
24 - See Note 6
26 - Idle/Run Switch
27 - Idle/Run Switch
28 - Speed Adjust

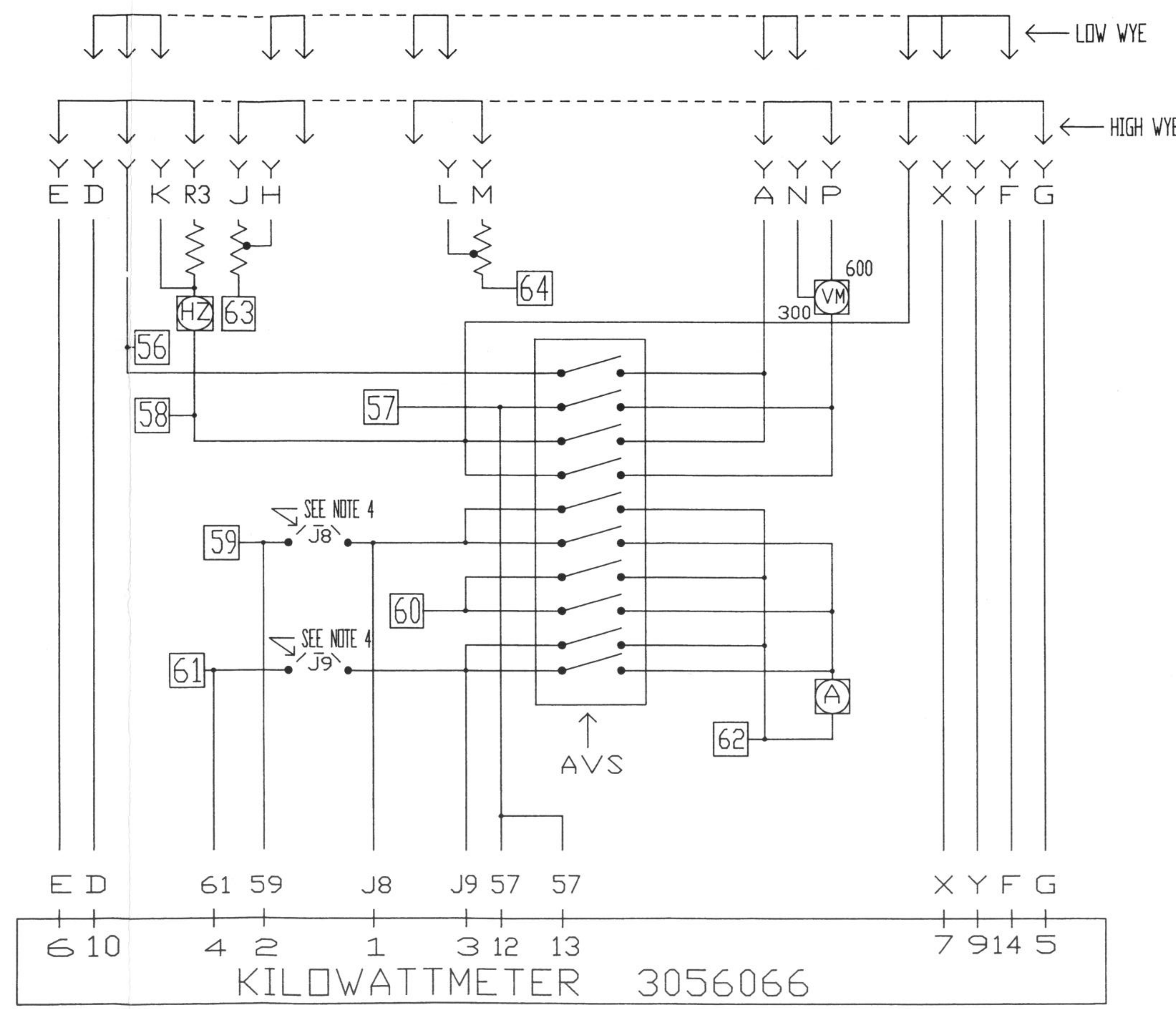
29 - Speed Adjust
30 - Speed Adjust
56 - T1
57 - T2
58 - T3

59 - CT1
60 - CT2
61 - CT3
62 - CT Com.
63 - L1
64 - L2

AVS SWITCH CONTACT SEQUENCE

CONTACT (SEE NOTE 3)	POSITION			
	OFF	PH1 L1-L2	PH2 L2-L3	PH3 L3-L1
1-2	X		X	X
3-4		X		
5-6	X	X		X
7-8			X	
9-10	X	X	X	
11-12				X
13-14		X		X
15-16		X	X	
17-18			X	
19-20				X

1. Spare - Part No. 3034954
   ILS Input - Part No. 3032733
2. Cut J2 when using governor (Part No. 3034954) for isochronous operation
3. Contacts 1-2 through 11-12 are make before break
4. Cut J8 and J9 when using kilowattmeter (Part No. 3015017)
5. See diagrams 3037461, 3037462 and 3037463 for engine wiring systems
6. Terminal to be used for the ILS input when using the EFC governor (Part No. 3032733). When using other governors, terminal to be used for a spare and is not used



LOGIC DIAGRAM WITH PARALLELING LIGHTS AND KILOWATTMETER

LEGEND

A - Ammeter
AVS - Amp/Volt Selector Switch
HZ - Frequency Meter
SA - Speed Adjust
SL - Synchronizing Light
VM - AC Voltmeter

TERMINAL STRIP

5 - Switched + 24 VDC
12 - Ground
13 - Ground Magnetic Pickup
14 - Magnetic Pickup +
22 - Governor Actuator

23 - Governor Actuator
24 - See Note 6
26 - Idle/Run Switch
27 - Idle/Run Switch
28 - Speed Adjust

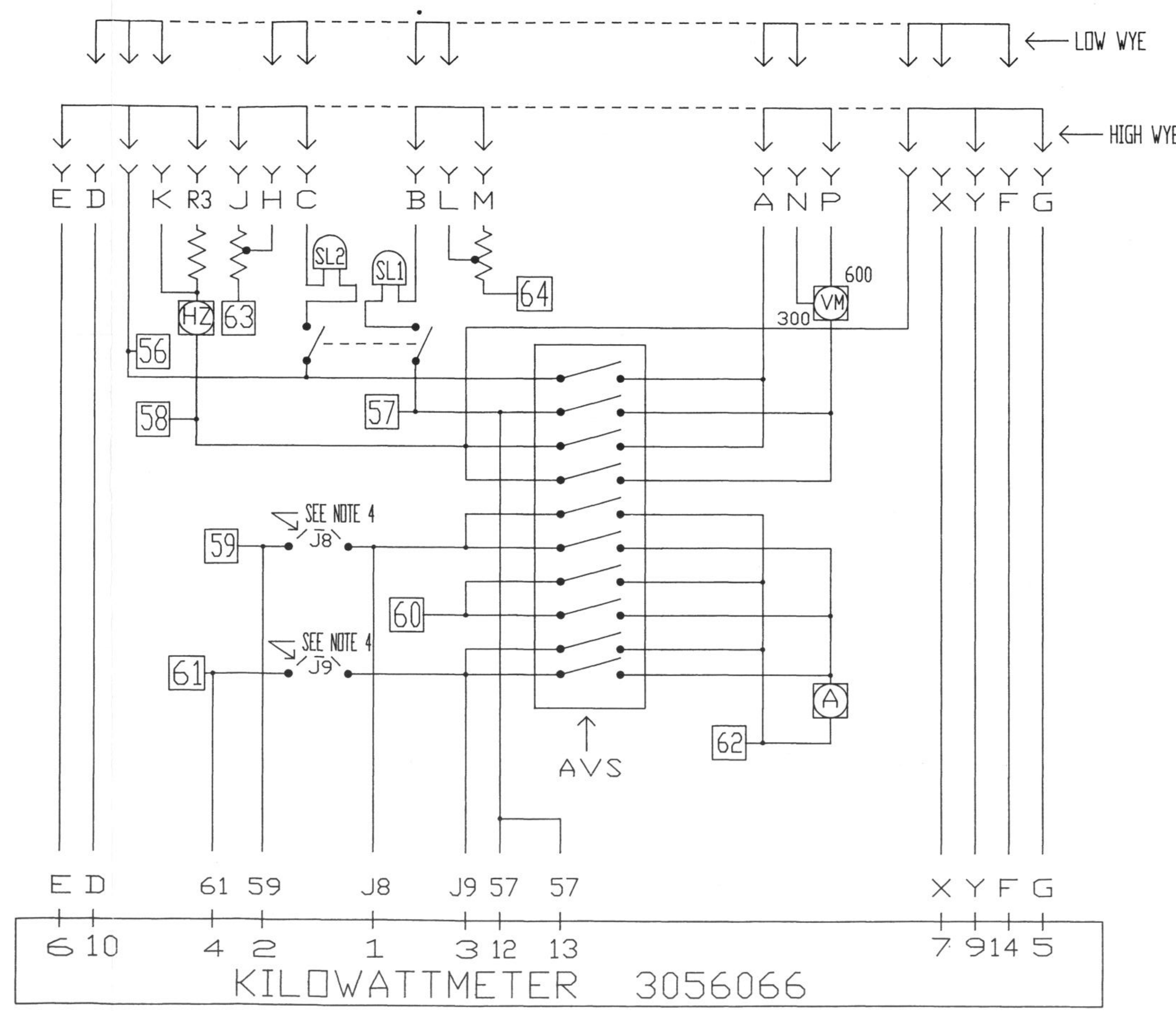
29 - Speed Adjust
30 - Speed Adjust
56 - T1
57 - T2
58 - T3

59 - CT1
60 - CT2
61 - CT3
62 - CT Com.
63 - L1
64 - L2

1. Spare - Part No. 3034954
   ILS Input - Part No. 3032733
2. Cut J2 when using governor (Part No. 3034954) for isochronous operation
3. Contacts 1-2 through 11-12 are make before break
4. Cut J8 and J9 when using kilowattmeter (Part No. 3015017)
5. See diagrams 3037461, 3037462 and 3037463 for engine wiring systems
6. Terminal to be used for the ILS input when using the EFC governor (Part No. 3032733). When using other governors, terminal to be used for a spare and is not used

AVS SWITCH CONTACT SEQUENCE

CONTACT (SEE NOTE 3)	POSITION			
	OFF	PH1 L1-L2	PH2 L2-L3	PH3 L3-L1
1-2				
3-4				
5-6				
7-8				
9-10				
11-12				
13-14		X		X
15-16		X	X	
17-18			X	
19-20				X



GEN SET GOVERNOR CONTROL LOGIC DIAGRAM

LEGEND

A - Ammeter
AVS - Amp/Volt Selector Switch
HZ - Frequency Meter
SA - Speed Adjust
SL - Synchronizing Light
VM - AC Voltmeter

TERMINAL STRIP

5 - Switched + 24 VDC
12 - Ground
13 - Ground Magnetic Pickup
14 - Magnetic Pickup +
22 - Governor Actuator

23 - Governor Actuator
24 - See Note 6
26 - Idle/Run Switch
27 - Idle/Run Switch
28 - Speed Adjust

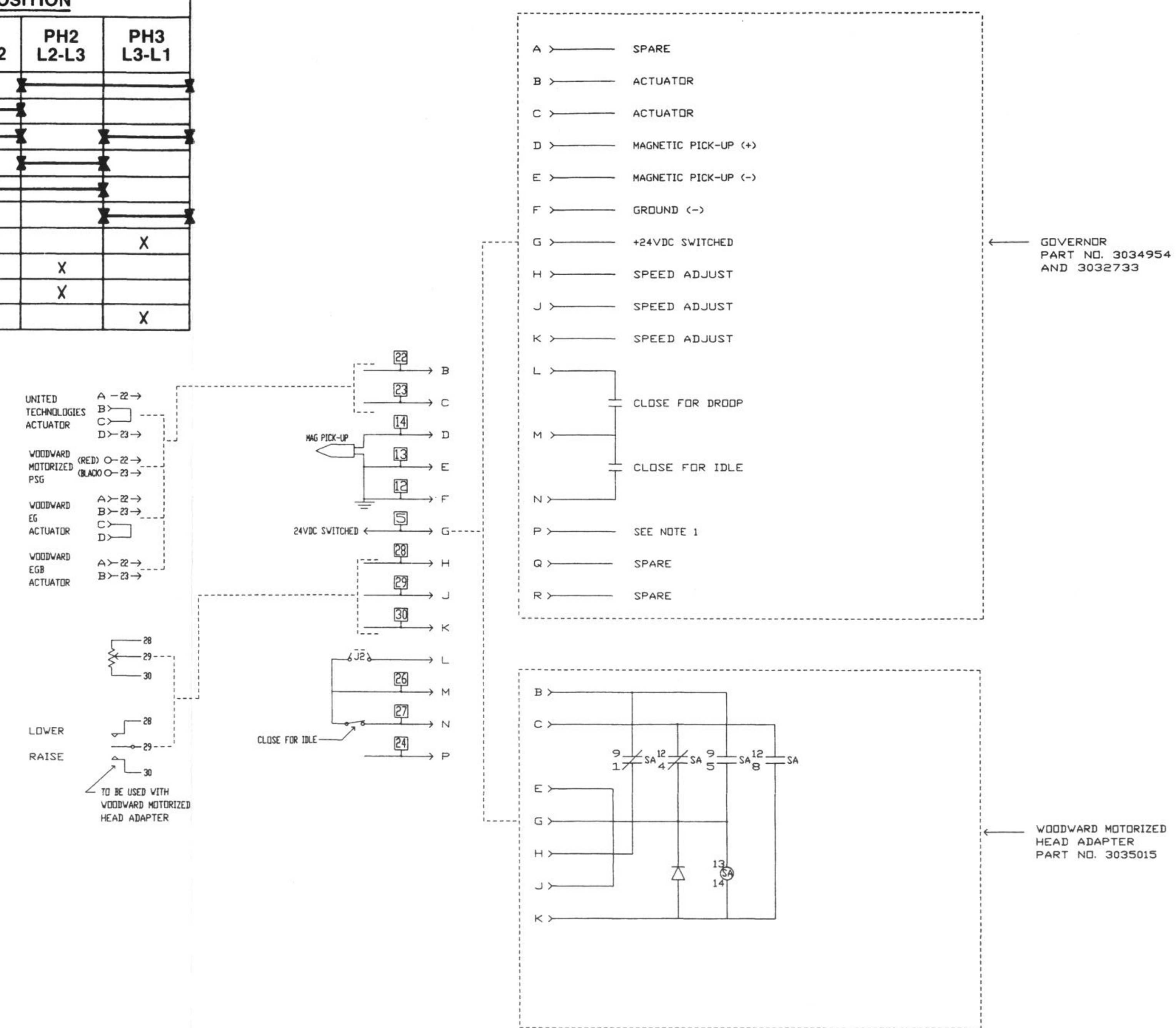
29 - Speed Adjust
30 - Speed Adjust
56 - T1
57 - T2
58 - T3

59 - CT1
60 - CT2
61 - CT3
62 - CT Com.
63 - L1
64 - L2

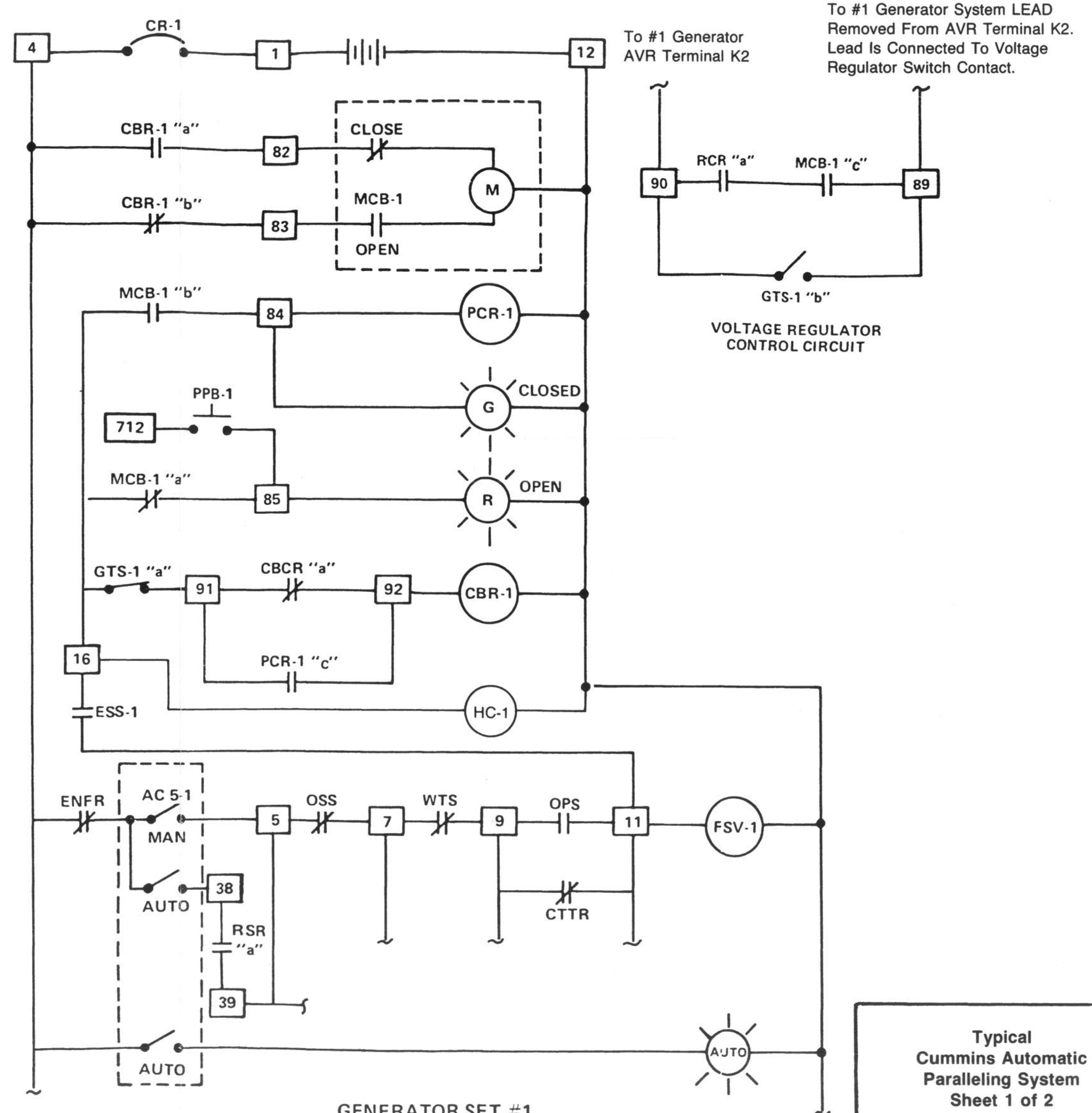
1. Spare - Part No. 3034954
   ILS Input - Part No. 3032733
2. Cut J2 when using governor (Part No. 3034954) for isochronous operation
3. Contacts 1-2 through 11-12 are make before break
4. Cut J8 and J9 when using kilowattmeter (Part No. 3015017)
5. See diagrams 3037461, 3037462 and 3037463 for engine wiring systems
6. Terminal to be used for the ILS input when using the EFC governor (Part No. 3032733). When using other governors, terminal to be used for a spare and is not used

AVS SWITCH CONTACT SEQUENCE

CONTACT (SEE NOTE 3)	POSITION			
	OFF	PH1 L1-L2	PH2 L2-L3	PH3 L3-L1
1-2	—		—	—
3-4		—		
5-6	—	—		—
7-8			—	
9-10	—	—	—	
11-12				—
13-14		X		X
15-16		X	X	
17-18			X	
19-20				X

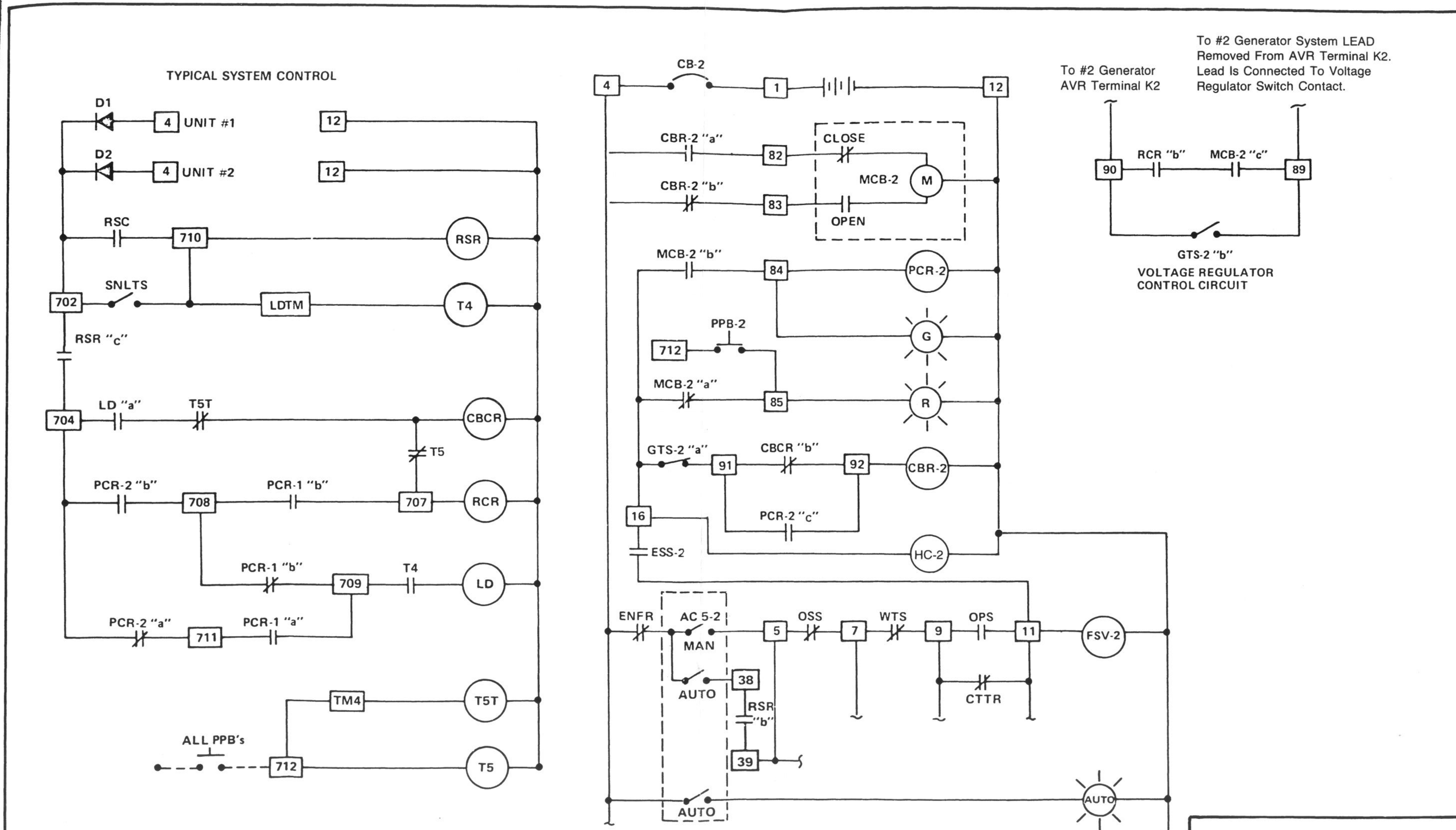


ACS - Automatic Cranking Panel Selector Switch
Auto - Indicator light, ACS in automatic position
CBCR - CBR Control Relay
CBR - Main Line Circuit Breaker Motor Control Relay
CTTR - Crank Termination Timed Relay (OPS By-Pass)
D - Diode
ENFR - Engine Failure Relay
ESS - Engine Speed Switch
FVS - Fuel Valve Solenoid
G - Green light, MCB in Closed Position
GTS - Generator Set Test Switch
HC - Main Line Circuit Breaker Holding Coil
LD - Load Dump Relay
LDTM - Load Dump Timing Module
M - MCB Motor Operator
MCB - Main Line Circuit Breaker
OPS - Low Lubricating Oil Pressure Switch
OSS - Overspeed Switch (Safety Control)
PCR - Paralleling Control Relay
PPB - Paralleling Push-Button
R - Red Light, MCB in Open Position
RCR - Generator Voltage Regulator Control Relay
RSC - Remote Start Contact - in automatic transfer switch
RSR - Master Crank Relay
SNLTS - System No-Load Test Switch
T4 - Timed LD Control Relay
TM4 - PPB Timing Module
T5 - PPB Relay
T5T - Re-Paralleling Relay
WTS - Engine Coolant Temperature Switch (Safety Control)



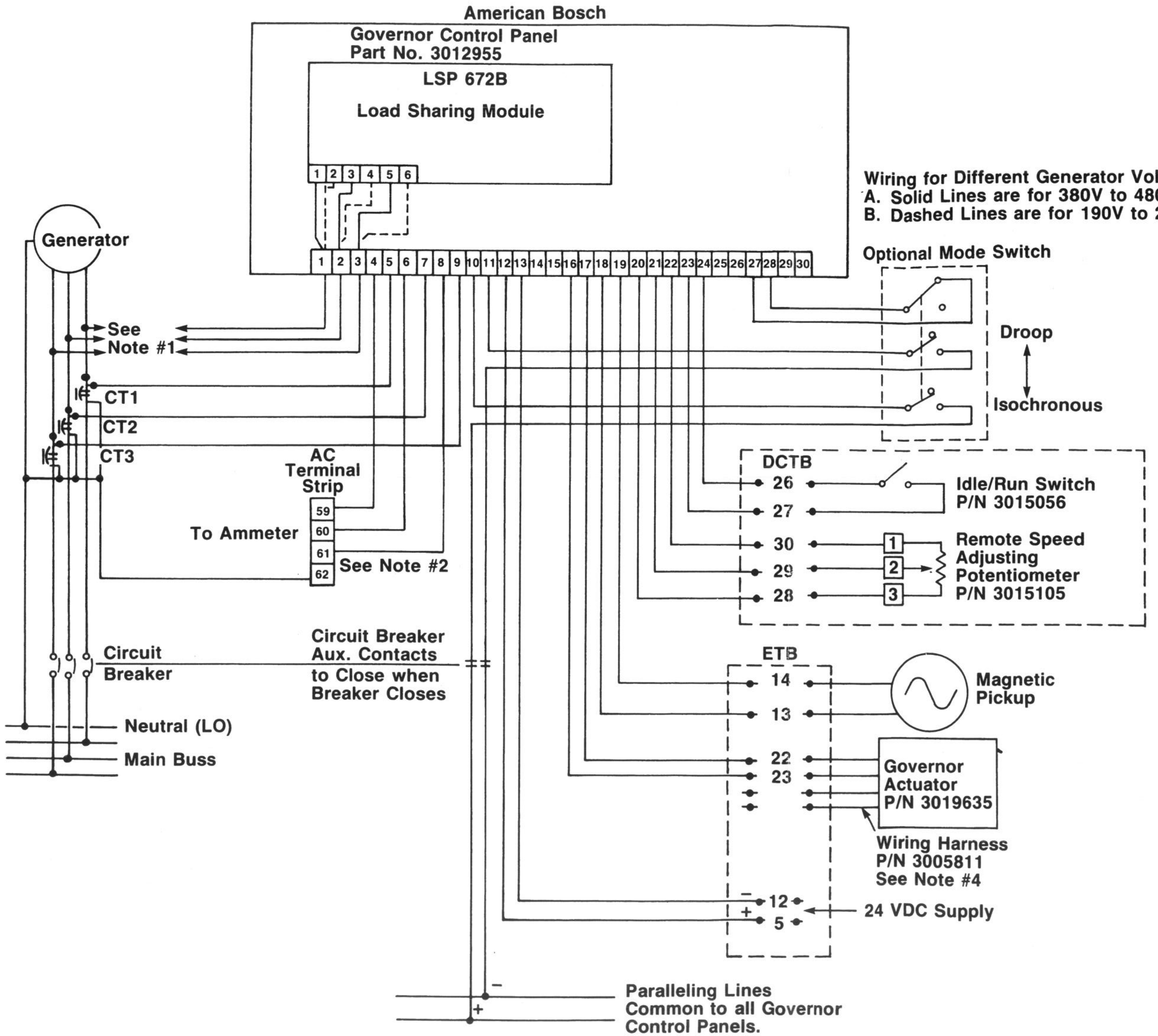
THIS DRAWING SHOWS ONLY THE PUSH-BUTTON METHOD OF REPARALLELING.

Typical Cummins Automatic Paralleling System Sheet 1 of 2



THIS DRAWING SHOWS ONLY THE PUSH-BUTTON METHOD OF REPARALLELING.

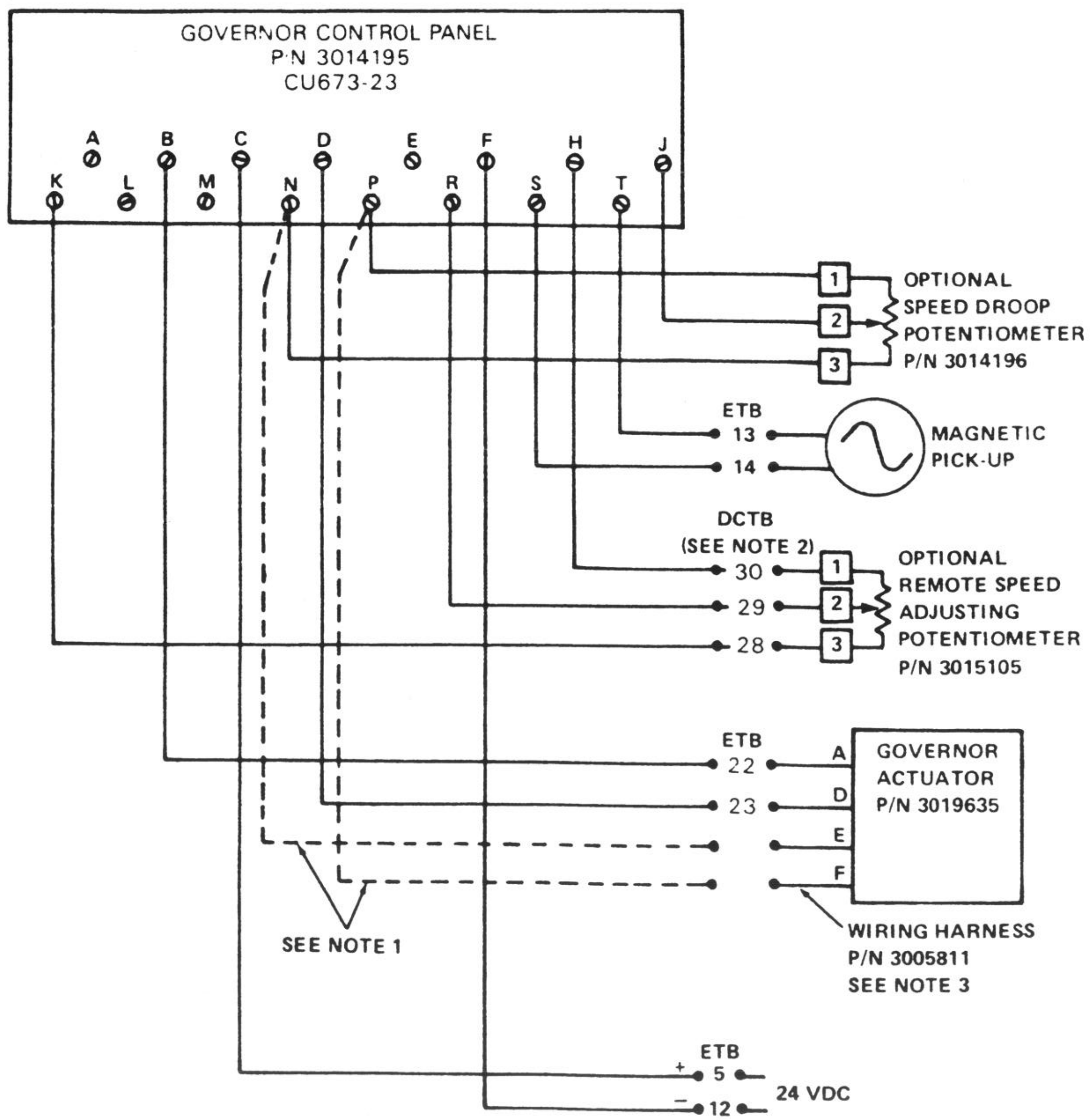
Typical Cummins Automatic Paralleling System Sheet 2 of 2

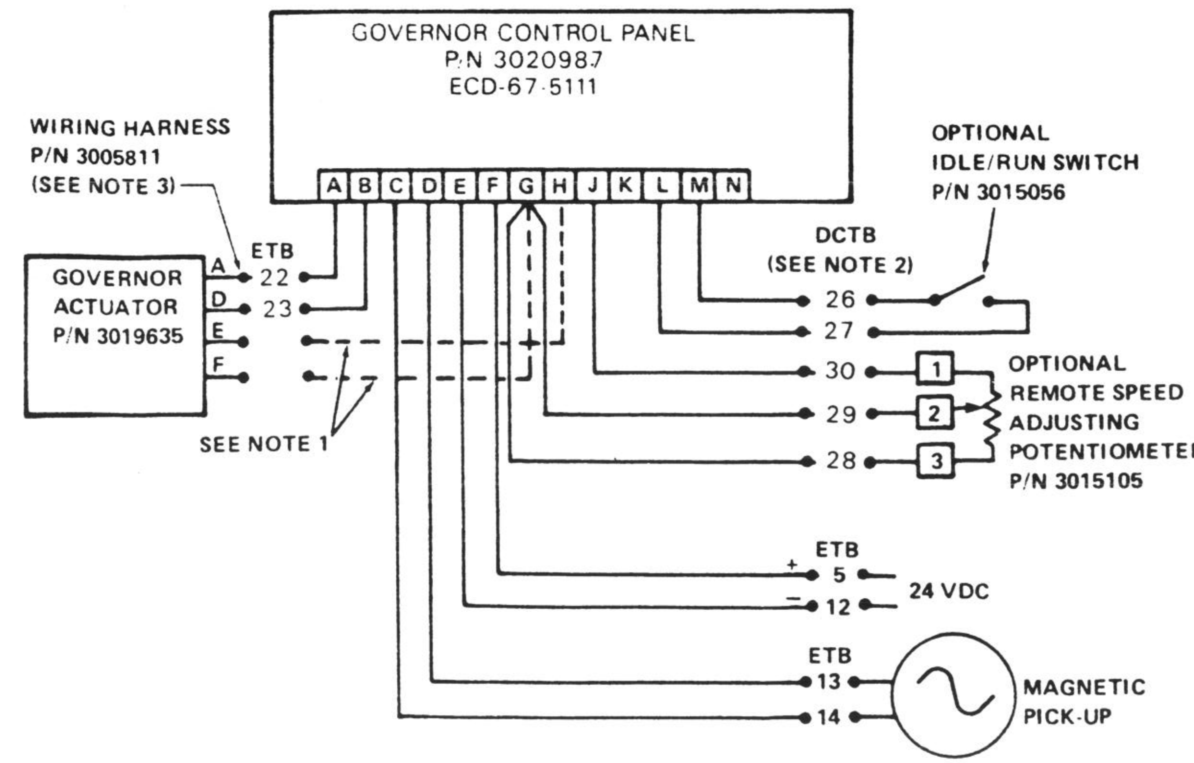


The Optional Idle/Run Switch and Remote Speed Adjusting Potentiometer are Wired through the DCTB when the Appropriate Generator Mounted Control Panel Option is Specified.

5. Reference Drawing Page 2.
4. Wiring harness 3005811 internally jumpers together actuator leads B and C.
3. Connect terminals 1, 2, & 3 on the governor control panel to either terminals 1, 3, & 5 or terminals 2, 4, & 6 on the load sensing module depending upon the generator output voltage.
2. Connections to ACTB terminals 59, 60, 61 & 62 are applicable for gen-sets with generator mounted control panel.
1. Phasing of the voltage and current sensing inputs to the governor control panel is critical for correct operation.

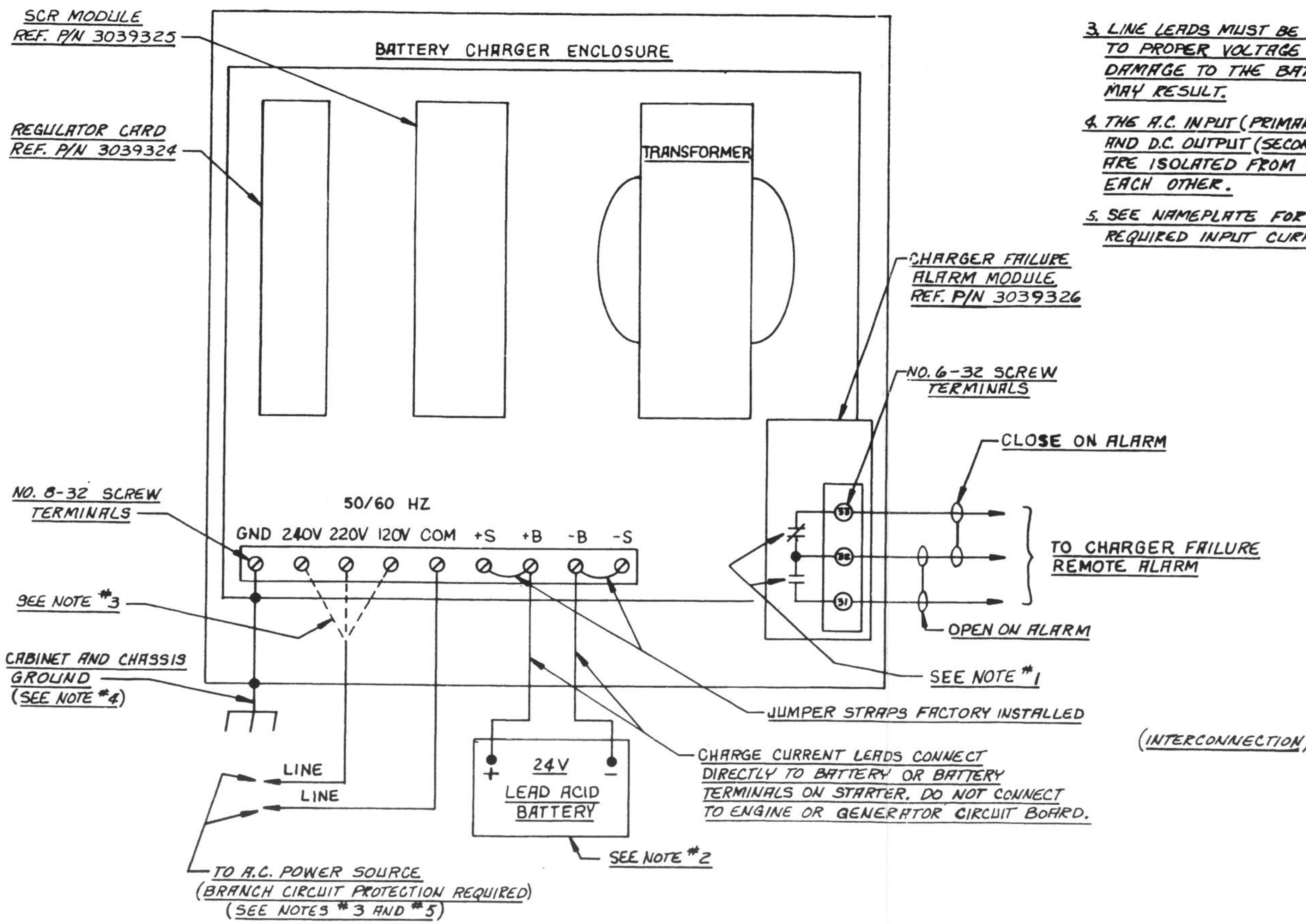
Wiring Diagram 212213
AMBAC Governor
(Sheet 1 of 2)





4. Reference Drawing Page 2.
3. Wiring harness 3005811 internally jumpers together actuator leads B & C.
2. The remote speed adjusting potentiometer and idle/run switch are wired through the DCTB when the correct generator mounted control panel option is specified.
1. For droop operation: (1) Connect actuator leads E and F to the appropriate terminals on the control panel; & (2) On panel 3020987 connect a jumper from terminal K to terminal L.

Wiring Diagram 212213
AMBAC Governor
(Sheet 2 of 2)



(INTERCONNECTION)

1. CONTACTS SHOWN IN THE ALARM STATE (RELAY DE-ENERGIZED). CONTACT RATING 10A AT 120 VAC OR 28 VDC. CONTACTS TRANSFER ON LOSS OF AC POWER, LOW BATTERY VOLTAGE, OR LOSS OF CHARGE CURRENT. CFA WILL NOT ALARM DURING CRANKING IN A PROPERLY OPERATING SYSTEM.

2. SPECIFICATIONS:
   CURRENT OUTPUT - SOLID STATE CURRENT LIMITING AT 5.0 A ±10%

   AUTOMATIC FLOAT (26.4 VDC) / EQUALIZE (28.08 VDC) DEPENDING ON STATE OF CHARGE OF BATTERY.

   VOLTAGE REGULATION - ±0.2% MAXIMUM FOR ± 10% LINE CHANGE.

   TEMPERATURE STABILITY - 0.08% / °C. MAXIMUM.

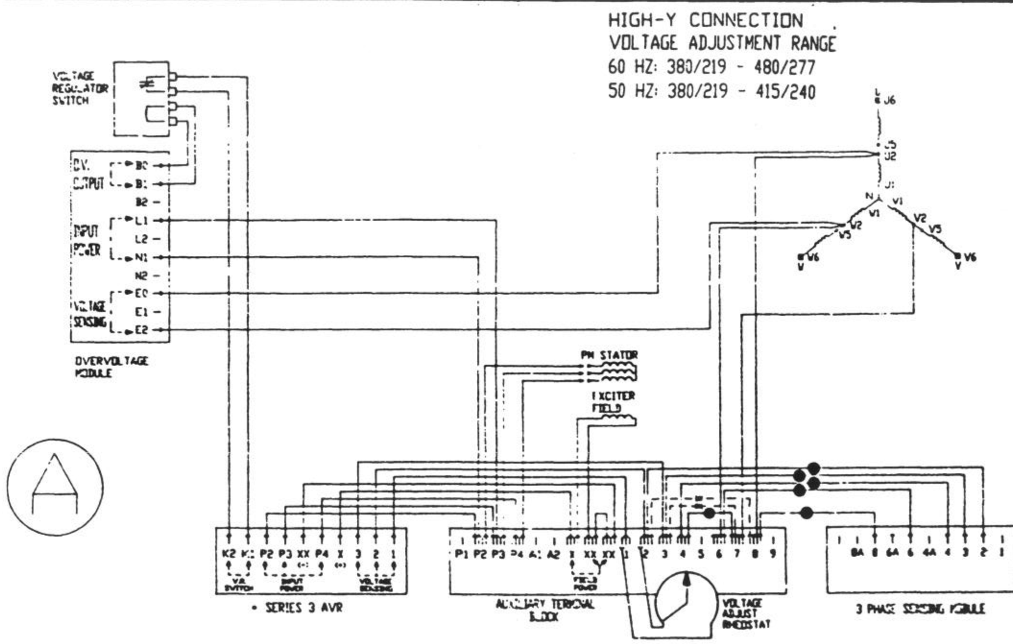
   FOR USE ON LEAD-ACID BATTERY SYSTEMS ONLY (TYPE SLI NOMINAL SP. GR. 1.275).

3. LINE LEADS MUST BE CONNECTED TO PROPER VOLTAGE TAP OR DAMAGE TO THE BATTERY CHARGER MAY RESULT.

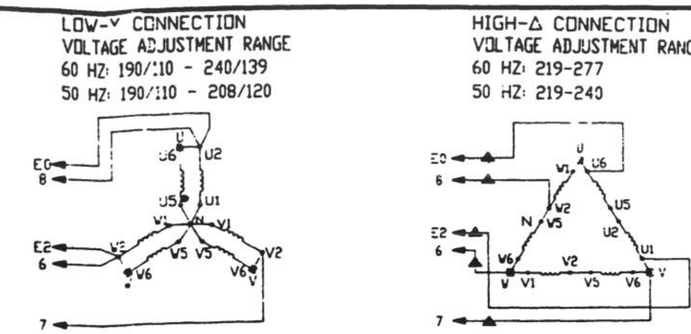
4. THE A.C. INPUT (PRIMARY) CIRCUITRY AND D.C. OUTPUT (SECONDARY) CIRCUITRY ARE ISOLATED FROM GROUND AND EACH OTHER.

5. SEE NAMEPLATE FOR MAXIMUM REQUIRED INPUT CURRENT.

Electrical Diagram 3039323
Charger, Battery



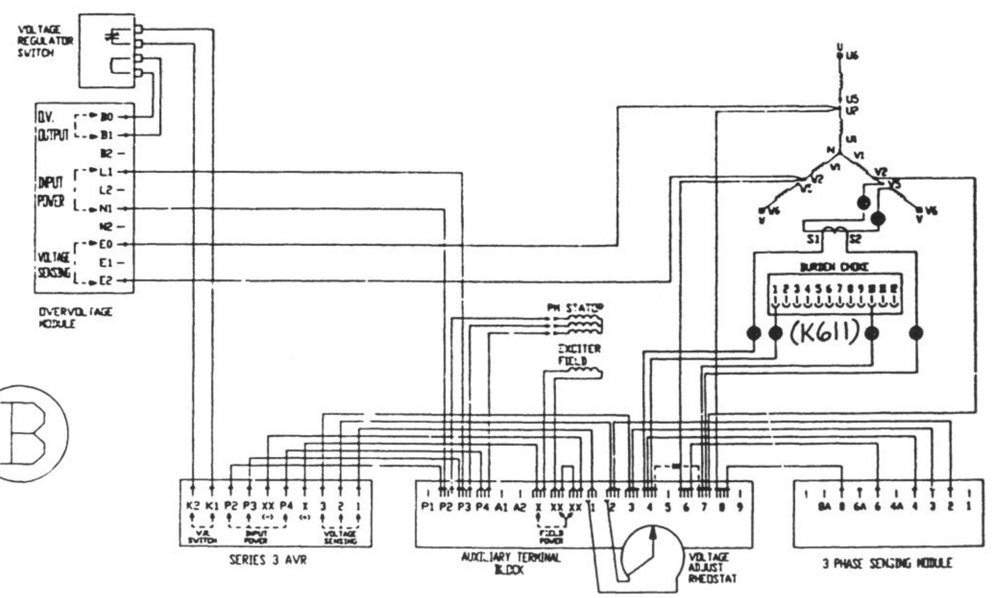
A



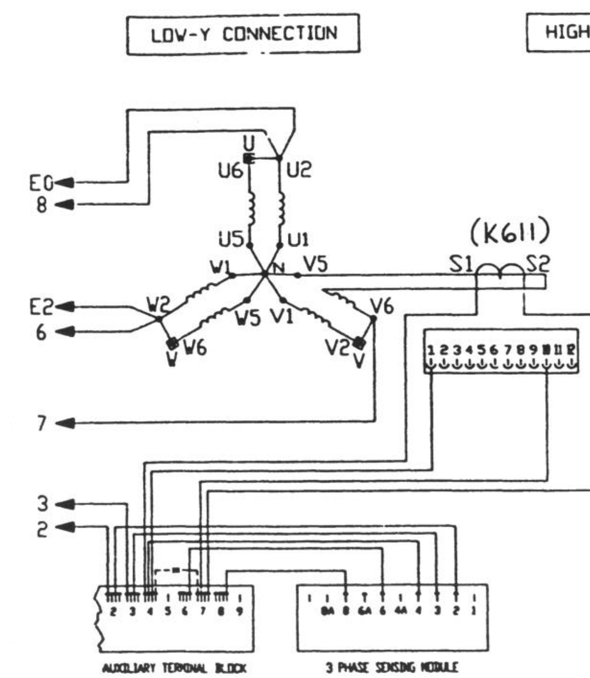
ER No.	Ltr	No.	Revision	Zone	Dr	Chkr	Approved	Date
32383	C	2	ADDED THIS SHEET (2)	—	VB	JC	RAA	8-3-88
34217	D	1	ADD ON TO NOTE 3: "AND REMOVE	-	-	-	-	-
			WIRE MARKED --*-- BETWEEN 4 AND 7 ON	-	-	-	-	-
			AUXILIARY TERMINAL BLOCK."	ZF	[illegible]	JK	PE	4-7-89

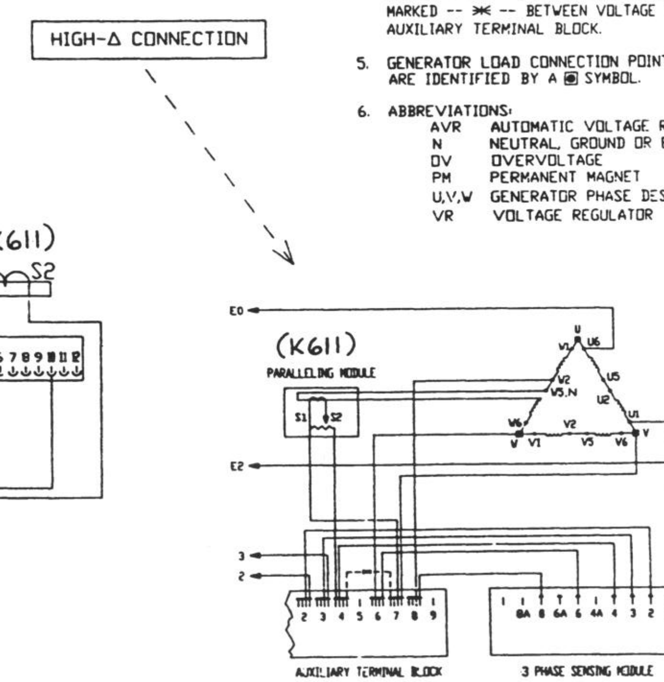
1. WHEN CONVERTING TO A 3-PHASE SENSING VOLTAGE REGULATOR
   a) ADD A 3-PHASE SENSING MODULE TO SECTION A. CONNECT WITH WIRES MARKED —●—. DISCONNECT AND REMOVE WIRES MARKED —✱-- BETWEEN 2 & 8 AND 3 & 7 ON THE AUXILIARY TERMINAL BLOCK.
   b) SECTIONS B AND C REFLECT ONLY ADDITIONAL CHANGES BEYOND THOSE SHOWN IN SECTION A.
2. WHEN RE-CONNECTING THE GENERATOR FROM HIGH-Y TO OTHER TYPE OF CONNECTIONS, A NUMBER OF CONTROL WIRES MUST BE RECONNECTED AT THE GENERATOR COIL LEAD STAND-OFFS OR BUS BARS, AS APPROPRIATE. THESE CONTROL WIRES ARE IDENTIFIED BY ▲ ON THE WIRING DIAGRAM.
3. D1 CONNECT PARALLELING MODULE WITH WIRES MARKED —●— AND REMOVE WIRE MK'D. -*- BETWEEN 4 & 7 ON AUX TERM. BLK.
   a) THE SLIDE WIRE RESISTOR IN THE PARALLELING MODULE IS ADJUSTED TO, AND THE BURDEN CHOKE IS CONNECTED FOR, A NOMINAL 4% VOLTAGE REGULATION THAT IS REQUIRED FOR PARALLEL OPERATION. IF THIS VOLTAGE REGULATION IS OBJECTIONABLE FOR SINGLE GENERATOR SET OPERATION, ADD A JUMPER ACROSS S1 AND S2 ON CURRENT TRANSFORMER.
   b) THE CURRENT TRANSFORMER IS CONNECTED TO ONLY ONE COIL LEAD OF THE GENERATOR. SEE PG. 4 FOR DETAILS.
4. CONNECT MANUAL VOLTAGE REGULATOR WITH WIRES MARKED —⊗—; DISCONNECT AND REMOVE 5 WIRES MARKED -- ✱ -- BETWEEN VOLTAGE REGULATOR AND AUXILIARY TERMINAL BLOCK.
5. GENERATOR LOAD CONNECTION POINTS U, V, AND W ARE IDENTIFIED BY A ⊞ SYMBOL.
6. ABBREVIATIONS:

AVR	AUTOMATIC VOLTAGE REGULATOR
N	NEUTRAL, GROUND OR EARTH
OV	OVERVOLTAGE
PM	PERMANENT MAGNET
U,V,W	GENERATOR PHASE DESIGNATIONS
VR	VOLTAGE REGULATOR

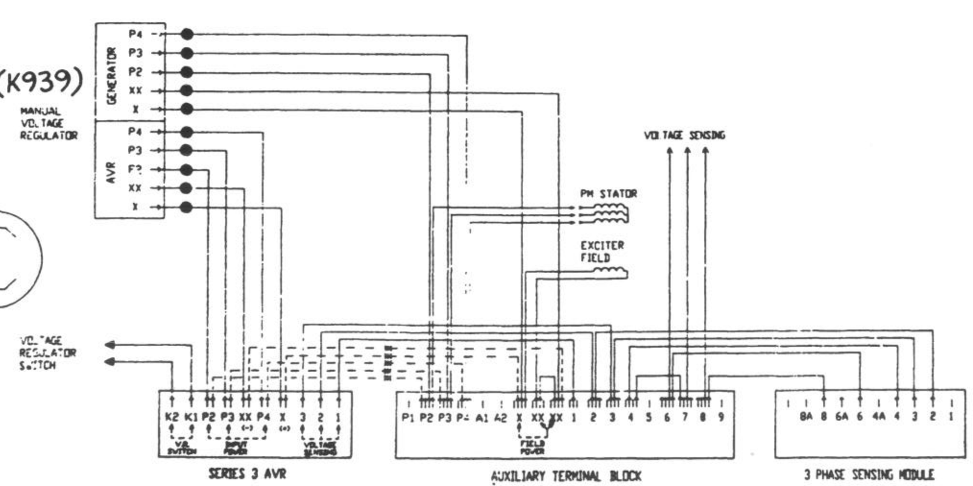


B





(K939)



C

(K922)

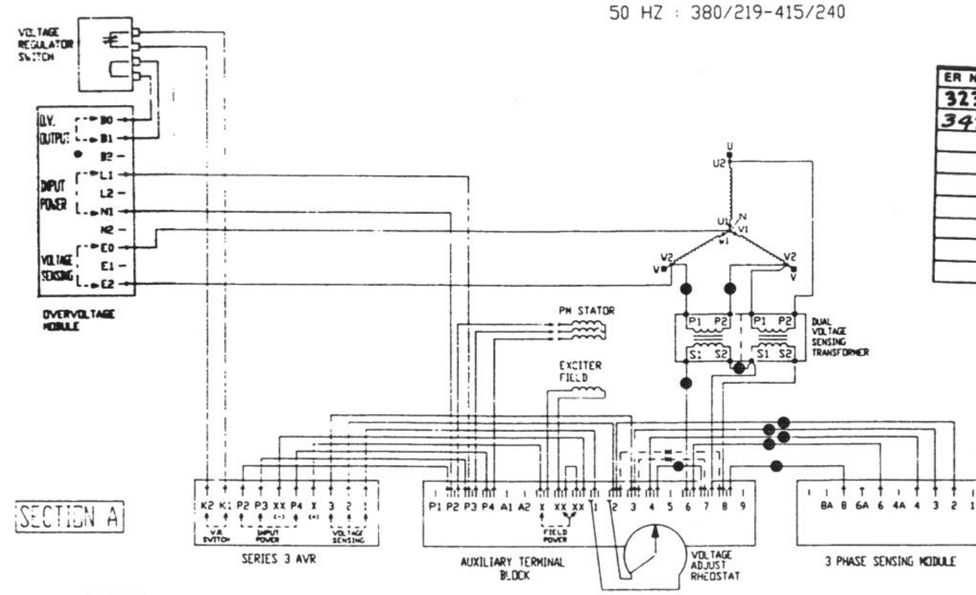
THREE PHASE SENSING VOLTAGE REGULATOR (12 LEAD GENERATOR)

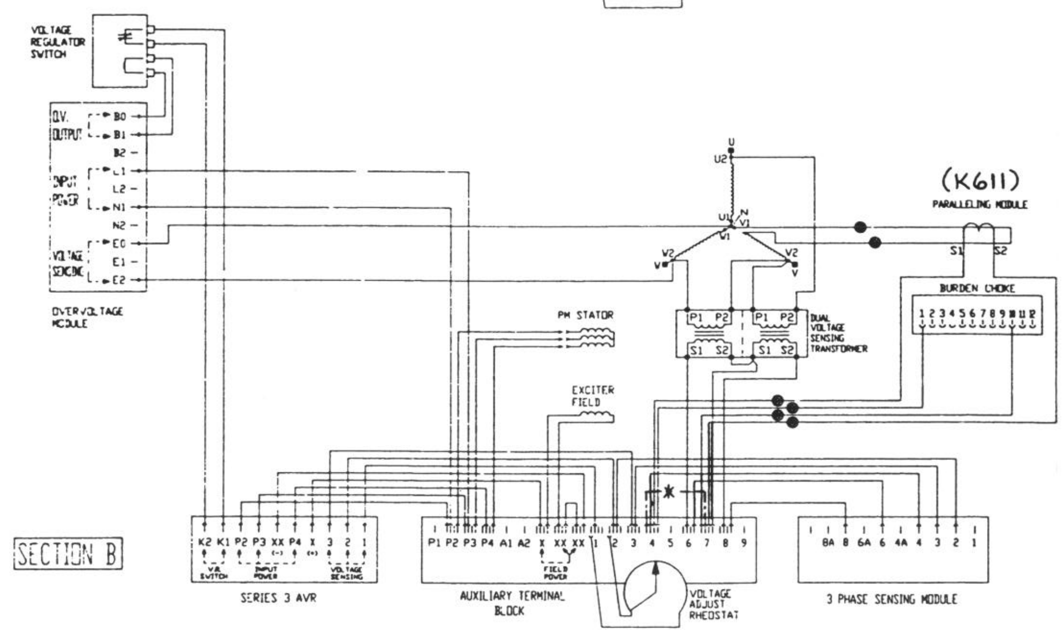
Electrical Diagram 3052054
Generator, Main

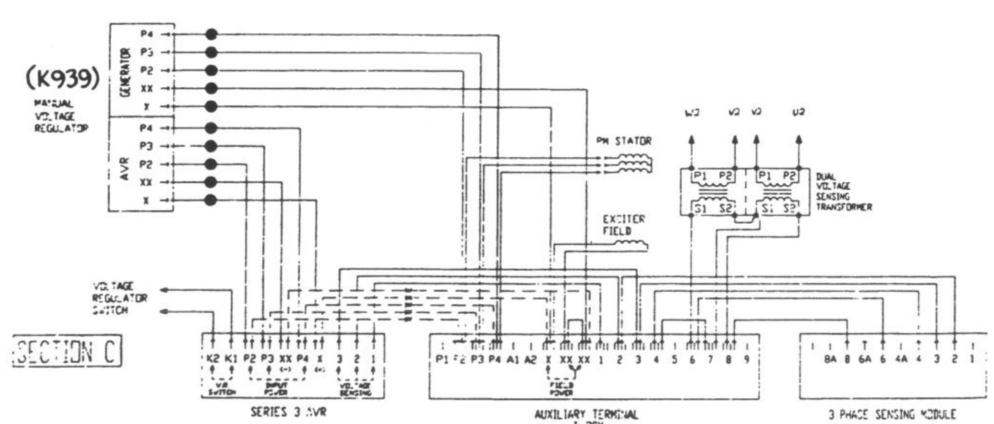
HIGH-Y CONNECTION
VOLTAGE ADJUSTMENT RANGE
60 HZ : 380/219-480/277
50 HZ : 380/219-415/240

HIGH-Δ CONNECTION
NOT AVAILABLE DUE TO
SIZE LIMITATIONS OF
THE BUS BARS.

ER No.	Ltr	No.	Revision	Zone	Dr	Chkr	Approved	Date
32383	C	2	ADDED THIS SHEET (2)	-	SG	CH	JAD	6-21-88
34217	D	1	ADDED TO NOTE 2: "AND REMOVE	-	-	-	-	-
			WIRE MARKED --*-- BETWEEN 4 & 7	-	-	-	-	-
			ON AUX. TERMINAL BLOCK."	2F	MM	JK		4-7-89







1. WHEN CONVERTING TO A 3-PHASE SENSING VOLTAGE REGULATOR
   a) ADD A 3-PHASE SENSING MODULE AND AN ADDITIONAL VOLTAGE SENSING TRANSFORMER TO SECTION A. CONNECT WITH WIRES MARKED —⊗— DISCONNECT AND REMOVE WIRES MARKED --⋈-- BETWEEN 2 & 8 AND 3 & 7 ON THE AUXILIARY TERMINAL BLOCK.
   b) SECTIONS B AND C REFLECT ONLY ADDITIONAL CHANGES BEYOND THOSE SHOWN IN SECTION A.

(D1) 2. CONNECT PARALLELING MODULE WITH WIRES MARKED —●— AND REMOVE WIRE MARKED --*-- BETWEEN 4 & 7 ON AUX. TERMINAL BLOCK.
   a) THE BURDEN CHOKE IS CONNECTED FOR A NOMINAL 4% VOLTAGE REGULATION THAT IS REQUIRED FOR PARALLEL OPERATION. IF THIS VOLTAGE REGULATION IS OBJECTIONABLE FOR SINGLE GENERATOR SET OPERATION, ADD A JUMPER ACROSS S1 AND S2 ON CURRENT TRANSFORMER.
   b) THE CURRENT TRANSFORMER IS CONNECTED TO ONLY ONE COIL LEAD IN THE V-PHASE OF THE GENERATOR. SEE PAGE 3 FOR DETAILS.

3. CONNECT MANUAL VOLTAGE REGULATOR WITH WIRES MARKED —⊗—; DISCONNECT AND REMOVE 5 WIRES MARKED -- ⋈ -- BETWEEN VOLTAGE REGULATOR AND AUXILIARY TERMINAL BLOCK.

4. GENERATOR LOAD CONNECTION POINTS U, V, AND W ARE IDENTIFIED BY A ⊡ SYMBOL.

5. ABBREVIATIONS:

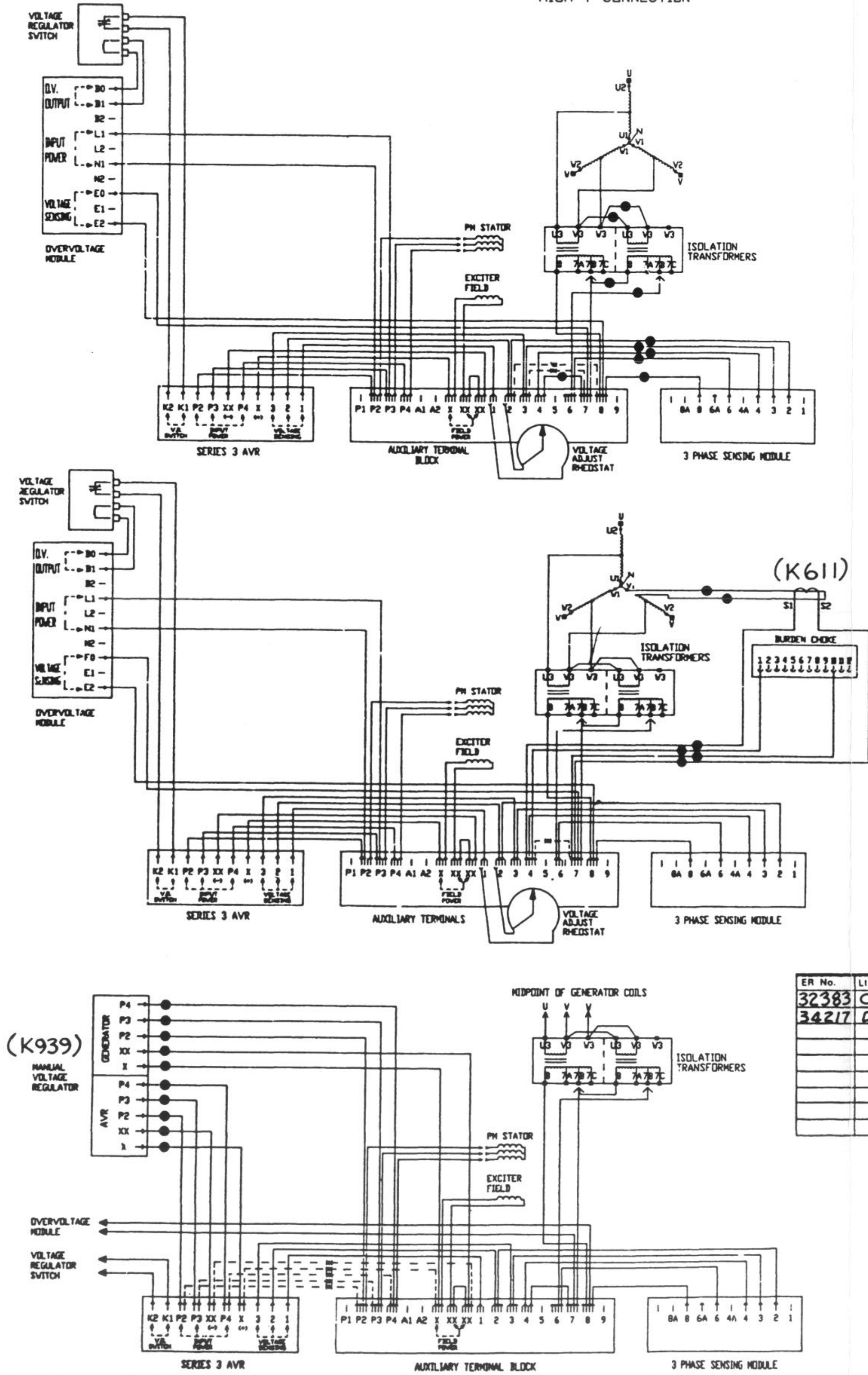
AVR	AUTOMATIC VOLTAGE REGULATOR
N	NEUTRAL, GROUND OR EARTH
OV	OVERVOLTAGE
PM	PERMANENT MAGNET
U,V,W	GENERATOR PHASE DESIGNATIONS
VR	VOLTAGE REGULATOR

(K922)

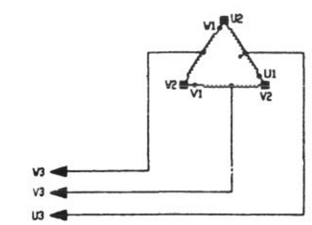
THREE PHASE SENSING VOLTAGE REGULATOR (6 LEAD GENERATOR)

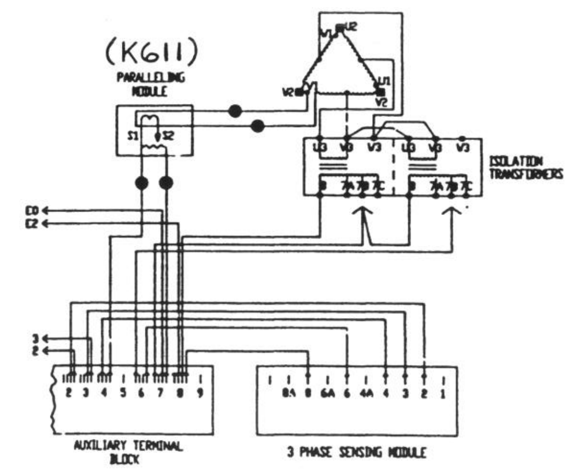
Electrical Diagram 3052055
Generator, Main

HIGH-Y CONNECTION



HIGH-Δ CONNECTION





1. WHEN CONVERTING TO A 3-PHASE SENSING VOLTAGE REGULATOR:
   a) ADD A 3-PHASE SENSING MODULE AND AN ADDITIONAL ISOLATION TRANSFORMER TO SECTION A. CONNECT WITH WIRES MARKED —⊛— DISCONNECT AND REMOVE WIRES MARKED --⋇-- BETWEEN 2 & 8 AND 3 & 7 ON THE AUXILIARY TERMINAL BLOCK.
   b) SECTIONS B AND C REFLECT ONLY ADDITIONAL CHANGES BEYOND THOSE SHOWN IN SECTION A.

(D1) 2. CONNECT PARALLELING MODULE WITH WIRES MARKED —⊛—, AND REMOVE WIRE MARKED --⋇-- BETWEEN 4 & 7 *ON AUX TERMINAL BLOCK.*
   a) THE BURDEN CHOKE OR SLIDE WIRE RESISTOR IS CONNECTED FOR OR ADJUSTED TO A NOMINAL 4% VOLTAGE REGULATION THAT IS REQUIRED FOR PARALLEL OPERATION. IF THIS VOLTAGE REGULATION IS OBJECTIONABLE FOR SINGLE GENERATOR SET OPERATION, ADD A JUMPER ACROSS S1 & S2 ON THE CURRENT TRANSFORMER.
   b) THE CURRENT TRANSFORMER IS CONNECTED TO ONLY ONE COIL LEAD IN THE V-PHASE OF THE GENERATOR.

3. HIGH VOLTAGE TRANSFORMER CONNECTIONS:
   HIGH-Y CONNECTION:
   FOR 4160 VOLT AT 60 HZ: 7 TO 7A
   FOR 3300 VOLT AT 50 HZ: 7 TO 7B
   HIGH-Δ CONNECTION:
   FOR 2400 VOLT AT 60 HZ: 7 TO 7C.

4. CONNECT MANUAL VOLTAGE REGULATOR WITH WIRES MARKED —⊛—; DISCONNECT AND REMOVE 5 WIRES MARKED -- ⋇ -- BETWEEN VOLTAGE REGULATOR AND AUXILIARY TERMINAL BLOCK.

5. GENERATOR LOAD CONNECTION POINTS U, V, AND W ARE IDENTIFIED BY A ◙ SYMBOL.

6. ABBREVIATIONS:
   AVR AUTOMATIC VOLTAGE REGULATOR
   N NEUTRAL, GROUND OR EARTH
   OV OVERVOLTAGE
   PM PERMANENT MAGNET
   U,V,W GENERATOR PHASE DESIGNATIONS
   VR VOLTAGE REGULATOR

ER No.	Ltr	No.	Revision	Zone	Dr	Chkr	Approved	Date
32383	C	2	ADDED THIS SHEET (2)	—	VB	JC	RAA	8-3-88
34217	D	1	ADDED ON TO NOTE 2 : "ON	–	–	–	–	–
			AUXILARY TERMINAL BLOCK"	2G	MM	JK	[illegible]	4-7-89

(K922)

THREE PHASE SENSING VOLTAGE REGULATOR (6 LEAD GENERATOR)

Electrical Diagram 3052056
Generator, Main

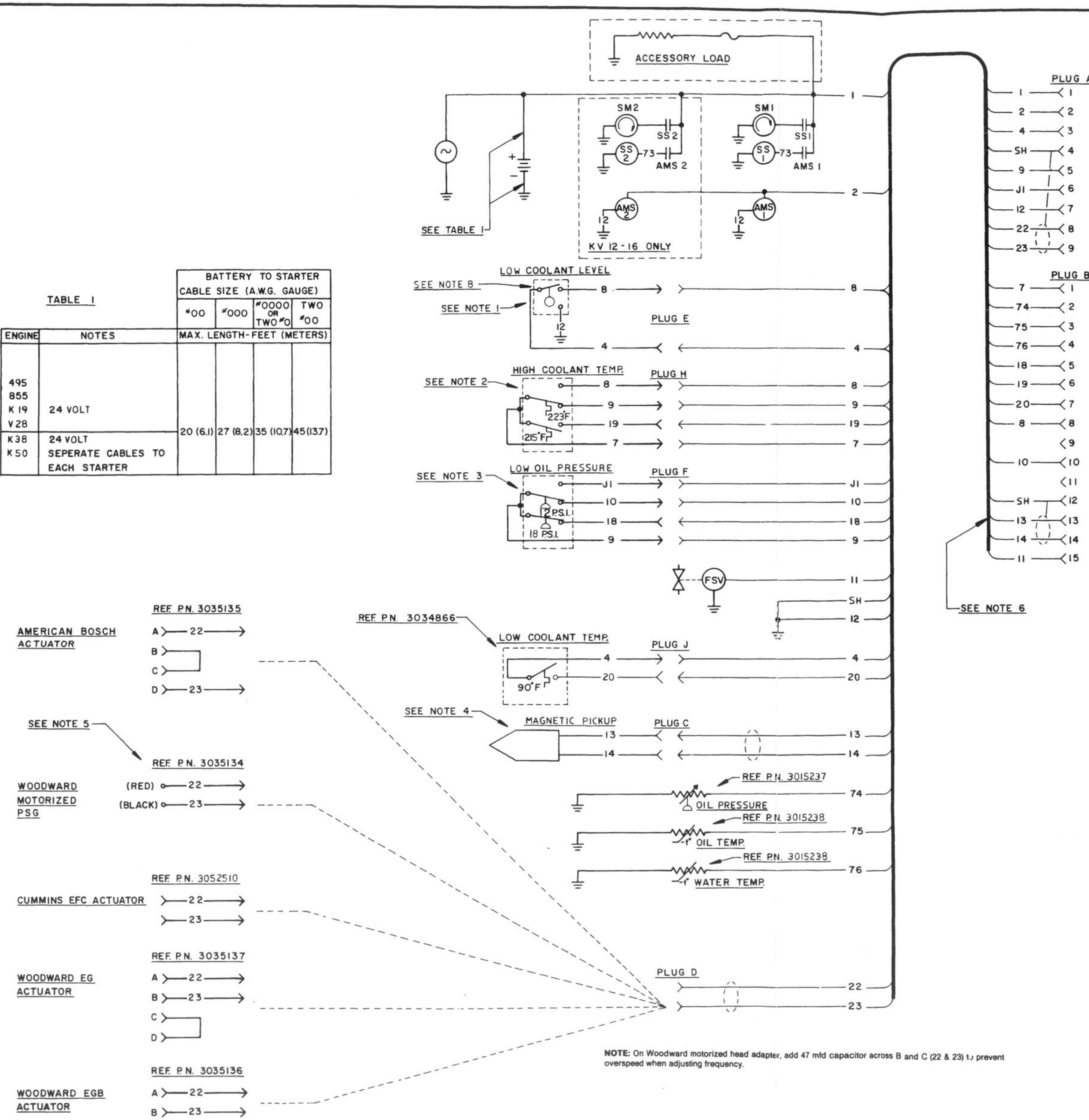


TABLE I

ENGINE	NOTES	BATTERY TO STARTER CABLE SIZE (A.W.G. GAUGE) #00	#000	#0000 OR TWO #0	TWO #00
		MAX. LENGTH-FEET (METERS)			
495 855 K19 V28	24 VOLT	20 (6.1)	27 (8.2)	35 (10.7)	45 (13.7)
K38 K50	24 VOLT SEPERATE CABLES TO EACH STARTER				

LEGEND

AMS — AUXILIARY MAGNETIC SWITCH
SM — STARTING MOTOR
SS — STARTING SOLENOID
FSV — FUEL SOLENOID VALVE
SH — CABLE SHIELD

9. CIRCUITS 13 AND 14, 22 AND 23 ARE TO BE TWISTED, SHIELDED PAIR THROUGH HARNESS. SHIELD FOR CIRCUIT 13 AND 14 IS TO BE CONNECTED TO PLUG B-12(SH). SHIELD FOR CIRCUIT 22 AND 23 IS TO BE CONNECTED TO PLUG A-4 (SH).

8. FOR FRAME MOUNTED RADIATORS, USE THE THREE TERMINAL LOW COOLANT LEVEL SENSOR PART NO. 3046031. FOR REMOTE MOUNTED RADIATORS, USE THE FOUR TERMINAL LOW COOLANT LEVEL SENSOR PART NO. 3001543.

7. FOR USE WITH OTHER HARNESSES REFER TO DRAWINGS 3053794 AND 3053793

6. ENGINE WIRING HARNESS

ENGINE FAMILY	PART NO.
495	3053032
855	3053031
K19	3053030
V28	3053029
K38	3053027
K50	3053028

5. WHEN USING MOTORIZED PSG, ADAPTER 3035015 MUST BE INSTALLED ON ENGINE CIRCUITBOARD 3053065

4. MAGNETIC PICKUP UNIT.

LENGTH	PART NO.
3.25 INCH	3034572
5.00 INCH (K50 & K38 SAE 00)	3034573

3. PRESSURE SWITCH	PART NO.
12 P.S.I.	3034864
18 P.S.I./12 P.S.I.	3034863

2. TEMPERATURE SWITCH	PART NO.
223°F	3048725
223°F/215°F	3048727

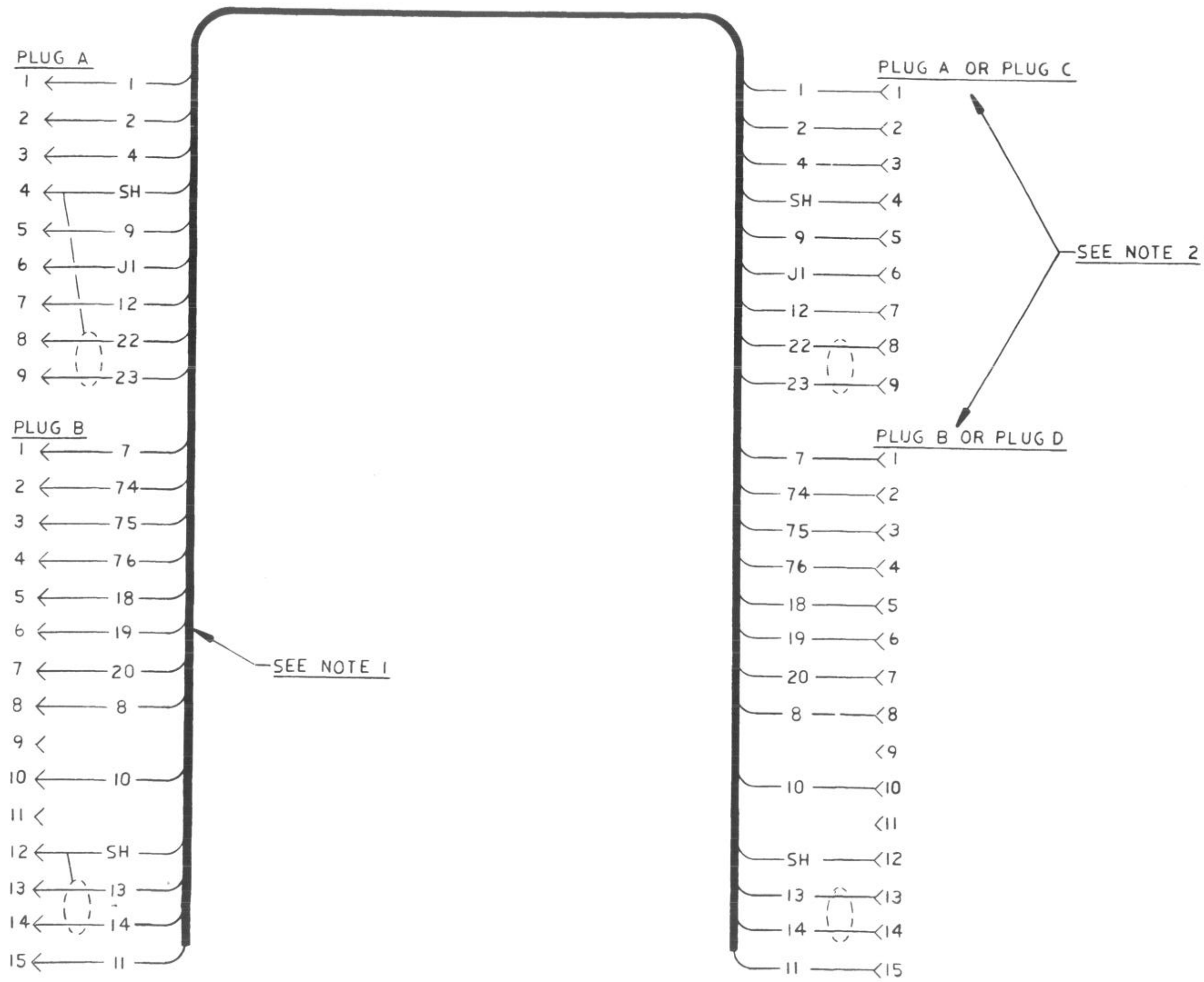
1. LOW COOLANT LEVEL HARNESS.

ENGINE FAMILY	HARNESS
495	3035124
855	3035124
K19	3035124
V28	3035124
K38	3035125
K50	3035125

NOTE: On Woodward motorized head adapter, add 47 mfd capacitor across B and C (22 & 23) to prevent overspeed when adjusting frequency.

(INTERCONNECTION)

Electrical Diagram
3053049
Engine Wiring Harness

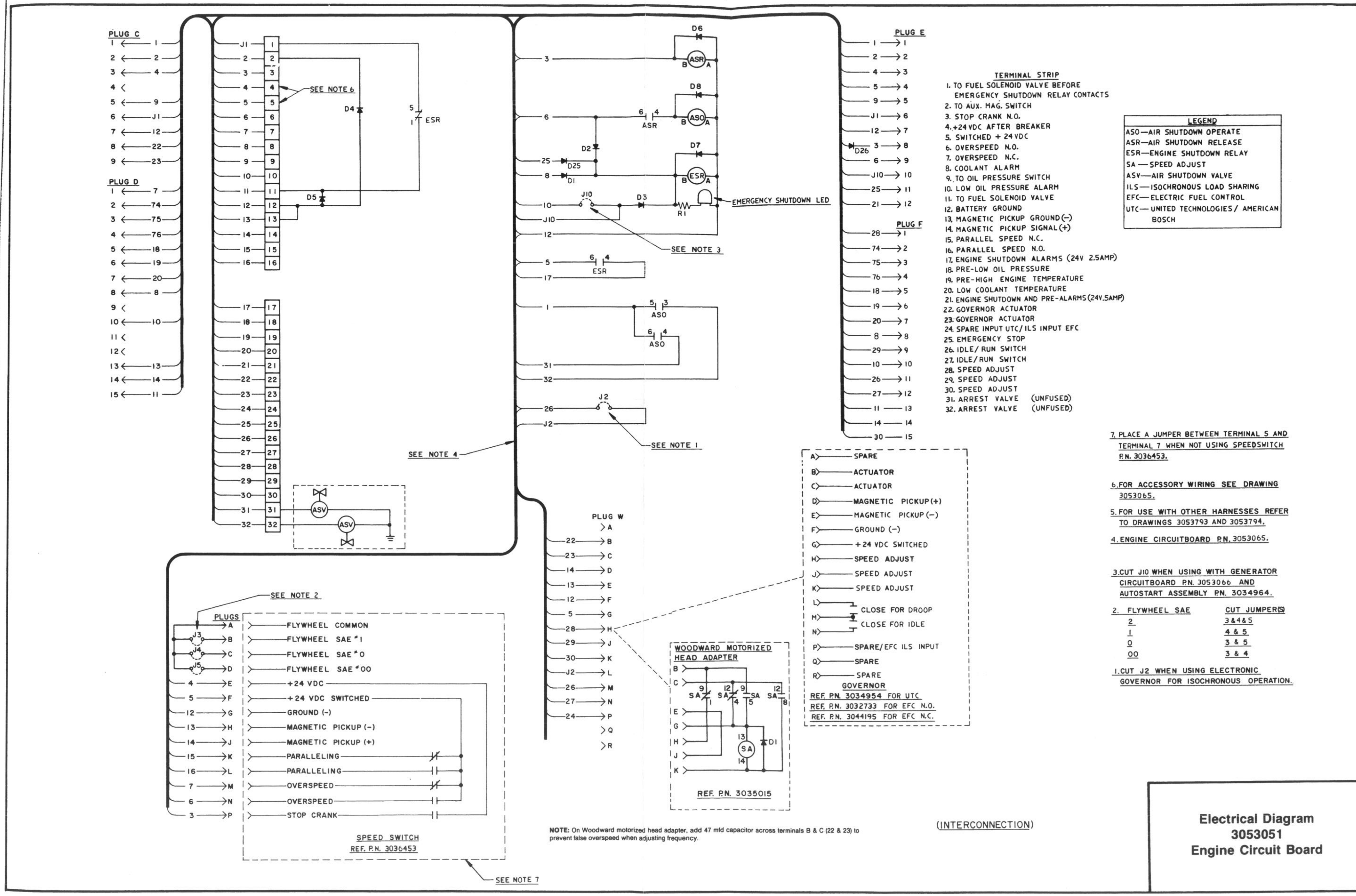


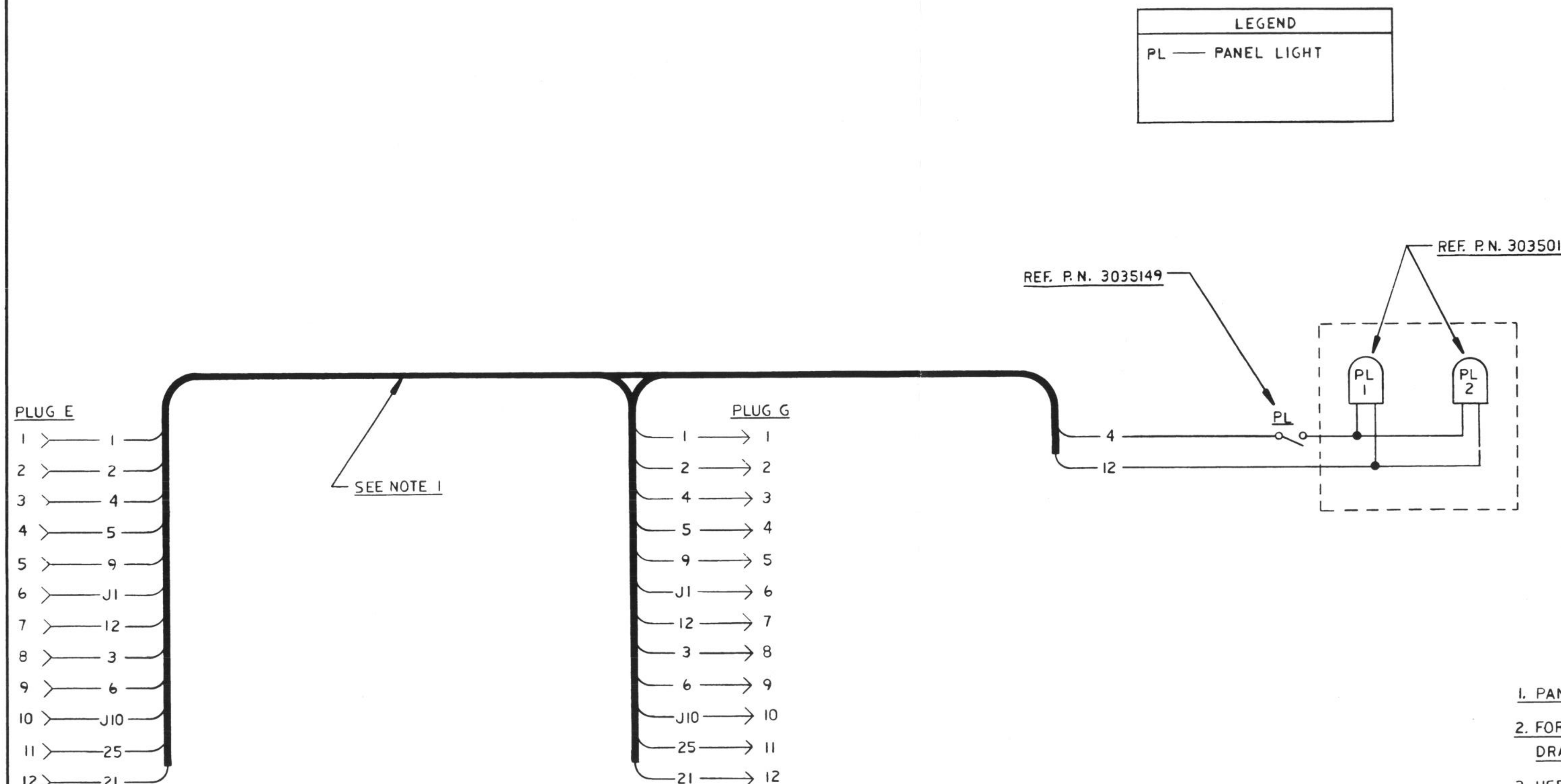
1. FOR EXTENSION HARNESS INFORMATION SEE 3053036.

2. USE PLUG A AND B WHEN CONNECTING TO OTHER EXTENSION HARNESSES. USE PLUG C AND D WHEN CONNECTING TO THE ENGINE CIRCUIT BOARD.

3. FOR USE WITH OTHER HARNESSES REFER TO DRAWINGS 3053794 AND 3053793.

Electrical Diagram
3053050
Extension Wiring Harness


PLUG C
PLUG D
PLUG E
PLUG F
PLUG W
PLUGS
SEE NOTE 1
SEE NOTE 2
SEE NOTE 3
SEE NOTE 4
SEE NOTE 6
SEE NOTE 7
EMERGENCY SHUTDOWN LED
TERMINAL STRIP
1. TO FUEL SOLENOID VALVE BEFORE EMERGENCY SHUTDOWN RELAY CONTACTS
2. TO AUX. MAG. SWITCH
3. STOP CRANK N.O.
4. +24VDC AFTER BREAKER
5. SWITCHED + 24VDC
6. OVERSPEED N.O.
7. OVERSPEED N.C.
8. COOLANT ALARM
9. TO OIL PRESSURE SWITCH
10. LOW OIL PRESSURE ALARM
11. TO FUEL SOLENOID VALVE
12. BATTERY GROUND
13. MAGNETIC PICKUP GROUND(−)
14. MAGNETIC PICKUP SIGNAL(+)
15. PARALLEL SPEED N.C.
16. PARALLEL SPEED N.O.
17. ENGINE SHUTDOWN ALARMS (24V 2.5AMP)
18. PRE-LOW OIL PRESSURE
19. PRE-HIGH ENGINE TEMPERATURE
20. LOW COOLANT TEMPERATURE
21. ENGINE SHUTDOWN AND PRE-ALARMS (24V.5AMP)
22. GOVERNOR ACTUATOR
23. GOVERNOR ACTUATOR
24. SPARE INPUT UTC/ILS INPUT EFC
25. EMERGENCY STOP
26. IDLE/RUN SWITCH
27. IDLE/RUN SWITCH
28. SPEED ADJUST
29. SPEED ADJUST
30. SPEED ADJUST
31. ARREST VALVE (UNFUSED)
32. ARREST VALVE (UNFUSED)
LEGEND
ASO—AIR SHUTDOWN OPERATE
ASR—AIR SHUTDOWN RELEASE
ESR—ENGINE SHUTDOWN RELAY
SA—SPEED ADJUST
ASV—AIR SHUTDOWN VALVE
ILS—ISOCHRONOUS LOAD SHARING
EFC—ELECTRIC FUEL CONTROL
UTC—UNITED TECHNOLOGIES/ AMERICAN BOSCH
7. PLACE A JUMPER BETWEEN TERMINAL 5 AND TERMINAL 7 WHEN NOT USING SPEEDSWITCH P.N. 3036453.
6. FOR ACCESSORY WIRING SEE DRAWING 3053065.
5. FOR USE WITH OTHER HARNESSES REFER TO DRAWINGS 3053793 AND 3053794.
4. ENGINE CIRCUITBOARD P.N. 3053065.
3. CUT J10 WHEN USING WITH GENERATOR CIRCUITBOARD P.N. 3053066 AND AUTOSTART ASSEMBLY P.N. 3034964.
2. FLYWHEEL SAE / CUT JUMPER(S)
2 / 3&4&5
1 / 4 & 5
0 / 3 & 5
00 / 3 & 4
1. CUT J2 WHEN USING ELECTRONIC GOVERNOR FOR ISOCHRONOUS OPERATION.
SPARE
ACTUATOR
ACTUATOR
MAGNETIC PICKUP(+)
MAGNETIC PICKUP (−)
GROUND (−)
+24 VDC SWITCHED
SPEED ADJUST
SPEED ADJUST
SPEED ADJUST
CLOSE FOR DROOP
CLOSE FOR IDLE
SPARE/EFC ILS INPUT
SPARE
SPARE
GOVERNOR
REF. P.N. 3034954 FOR UTC
REF. P.N. 3032733 FOR EFC N.O.
REF. P.N. 3044195 FOR EFC N.C.
WOODWARD MOTORIZED HEAD ADAPTER
REF. P.N. 3035015
FLYWHEEL COMMON
FLYWHEEL SAE #1
FLYWHEEL SAE #0
FLYWHEEL SAE #00
+24 VDC
+24 VDC SWITCHED
GROUND (−)
MAGNETIC PICKUP (−)
MAGNETIC PICKUP (+)
PARALLELING
PARALLELING
OVERSPEED
OVERSPEED
STOP CRANK
SPEED SWITCH
REF. P.N. 3036453
NOTE: On Woodward motorized head adapter, add 47 mfd capacitor across terminals B & C (22 & 23) to prevent false overspeed when adjusting frequency.
(INTERCONNECTION)
Electrical Diagram
3053051
Engine Circuit Board



1. PANEL LIGHT HARNESS
2. FOR USE WITH OTHER HARNESSES REFER TO DRAWING 3053794.
3. USED TO CONNECT ENGINE CIRCUITBOARD P.N. 3053065 TO GENERATOR CIRCUITBOARD P.N. 3053066.
4. FOR PANEL LIGHT HARNESS INFORMATION REFER TO 3056061.

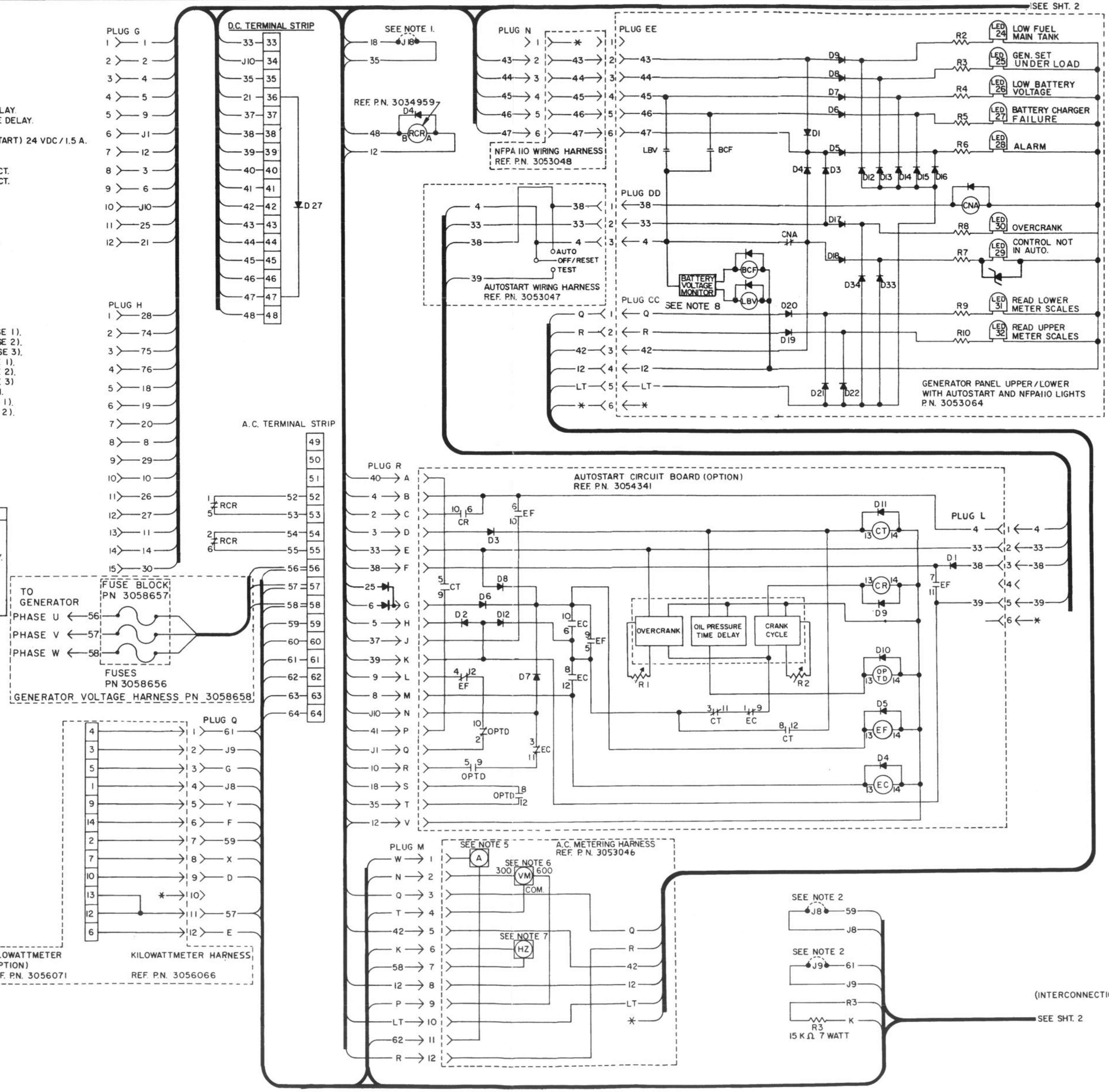
Electrical Diagram
3053052
Panel Light Harness

TERMINAL STRIP

33. OVERCRANK.
34. LOW OIL PRESSURE AFTER TIME DELAY.
35. PRELOW OIL PRESSURE AFTER TIME DELAY.
36. ENGINE ALARMS 24 VDC / 1.5 A.
37. GEN SET SHUTDOWN ALARM (AUTOSTART) 24 VDC / 1.5 A.
38. REMOTE START CONTACT.
39. REMOTE START CONTACT.
40. DRY N.O. CRANK TERMINATE CONTACT.
41. DRY N.O. CRANK TERMINATE CONTACT.
42. CONTROL NOT IN AUTOMATIC.
43. LOW FUEL.
44. GEN. SET SUPPLYING LOAD.
45. LOW BATTERY VOLTAGE.
46. BATTERY CHARGER ERROR.
47. NFPA 110 ALARMS 24 VDC / 1.5 A.
48. SEMI-AUTO PARALLEL.
49. NOT USED.
50. NOT USED.
51. NOT USED.
52. SEMI-AUTO PARALLEL.
53. SEMI-AUTO PARALLEL.
54. SEMI-AUTO PARALLEL.
55. SEMI-AUTO PARALLEL.
56. GENERATOR LINE VOLTAGE (PHASE 1).
57. GENERATOR LINE VOLTAGE (PHASE 2).
58. GENERATOR LINE VOLTAGE (PHASE 3).
59. CURRENT TRANSFORMER (PHASE 1).
60. CURRENT TRANSFORMER (PHASE 2).
61. CURRENT TRANSFORMER (PHASE 3).
62. CURRENT TRANSFORMER COMMON.
63. PARALLEL LINE VOLTAGE (PHASE 1).
64. PARALLEL LINE VOLTAGE (PHASE 2).

LEGEND

- A — AMMETER.
- HZ — FREQUENCY METER.
- * — POLARIZING PLUG KEY.
- RCR — REGULATOR CONTROL RELAY.
- SL — SYNCHRONIZING LIGHT.
- VM — VOLTMETER.
- CNA — CONTROL NOT IN AUTO
- LBV — LOW BATTERY VOLTAGE
- BCF — BATTERY CHARGER FAILURE

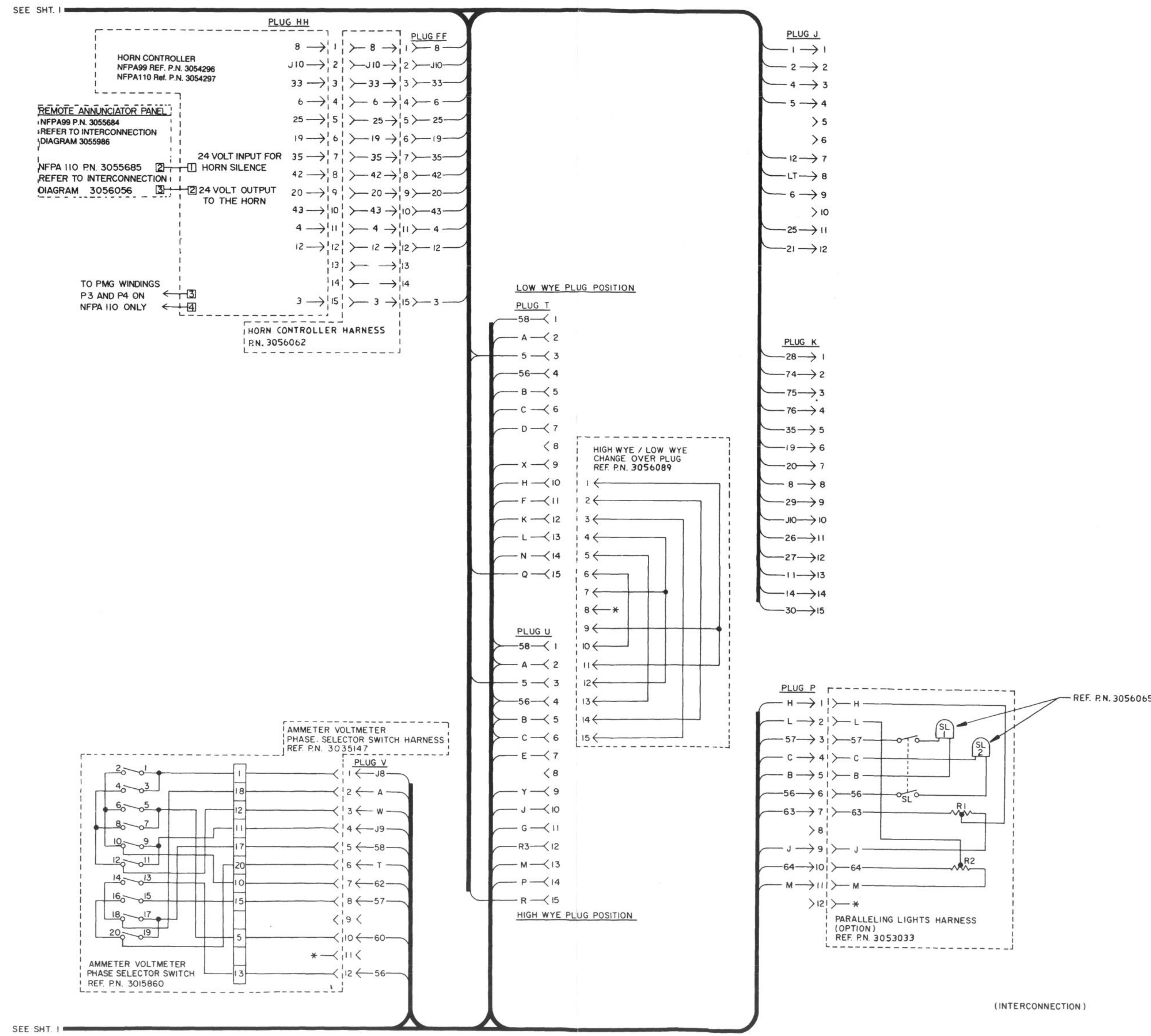


1. CUT J18 WHEN USING AUTOSTART ASSEMBLY P.N. 3054341
2. CUT J8 & J9 WHEN USING KILOWATTMETER P.N. 3056071
3. GENERATOR CIRCUITBOARD P.N. 3053066.
4. FOR USE WITH OTHER HARNESSES REFER TO DRAWING 3053794.
5. SINGLE SCALE AMMETERS:

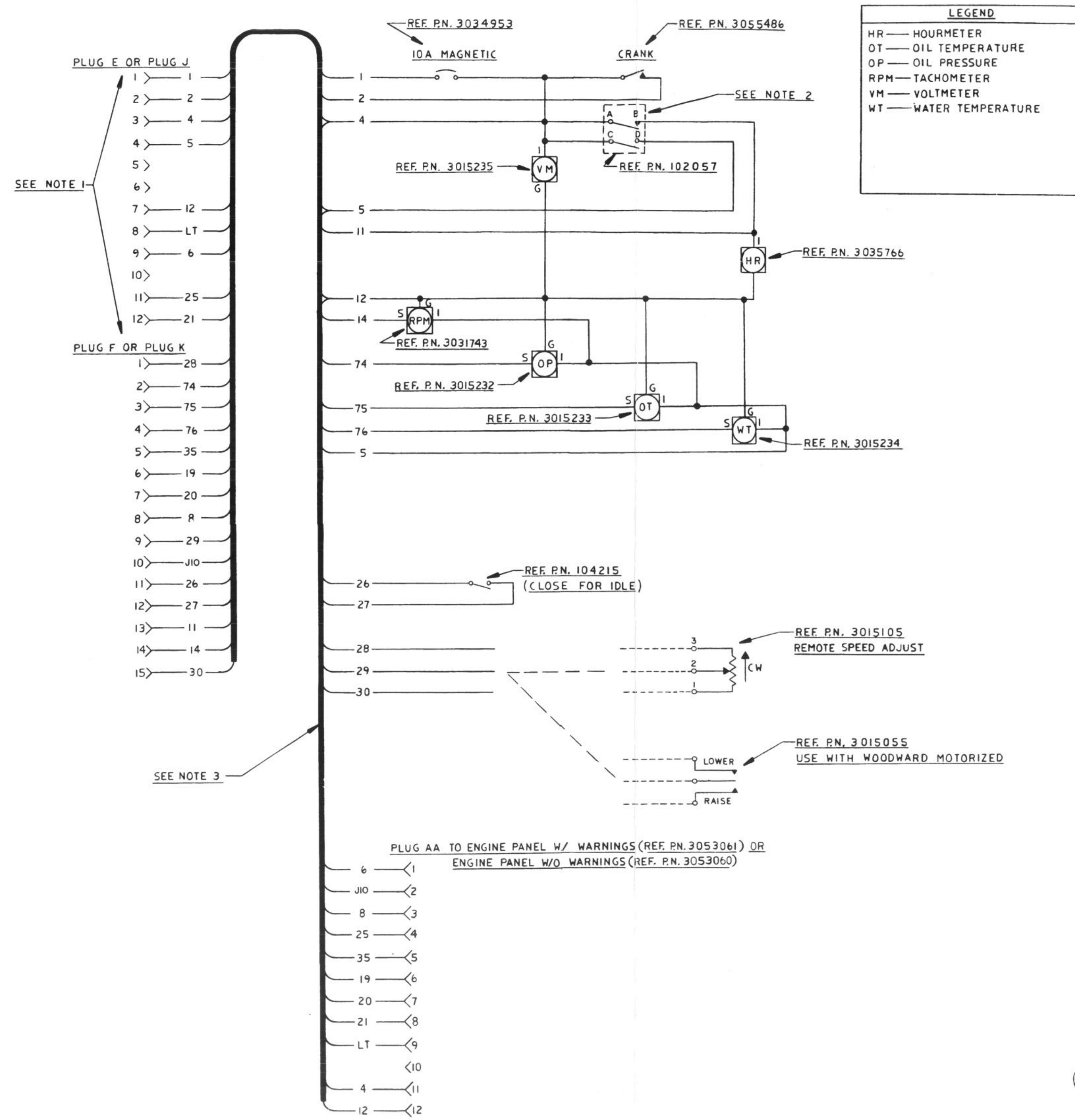
AMMETER SCALE RANGE	AMMETER P.N.	CURRENT TRANSFORMER P.N.
0-1200	3015040	(3) 3011686
0-1600	3015041	(3) 3011690
0-2000	3015042	(3) 3014135
0-2500	3051479	(3) 3051476
0-3000	3051480	(3) 3051477
DUAL SCALE AMMETERS:		
0-200, 0-400	3039530	(3) 3011674
0-300, 0-600	3015035	(3) 3011678
0-400, 0-800	3015036	(3) 3011682
0-500, 0-1000	3051478	(3) 3011684
0-600, 0-1200	3015037	(3) 3011686
0-800, 0-1600	3015038	(3) 3011690
0-1000, 0-2000	3015039	(3) 3014135

6. VOLTMETER P.N. 3015043.
7. FREQUENCY METER P.N. 3015044.
8. THE OUTPUT TO LBV OCCURS WHEN BATTERY VOLTAGE DROPS BELOW 18 VDC (+ OR - 1 VOLT) AND OUTPUT TO BFC OCCURS WHEN BATTERY VOLTAGE GOES ABOVE 32 VDC (+ OR - 1 VOLT)

Electrical Diagram 3053053 Generator Circuit Board Sheet 1 of 2



Electrical Diagram
3053053
Generator Circuit Board
Sheet 2 of 2



5. FOR INSTRUMENT PANEL HARNESS INFORMATION REFER TO 3053044.

4. FOR USE WITH OTHER HARNESSES REFER TO DRAWINGS 3053794 AND 3053793.

3. INSTRUMENT PANEL HARNESS P.N. 3053054.

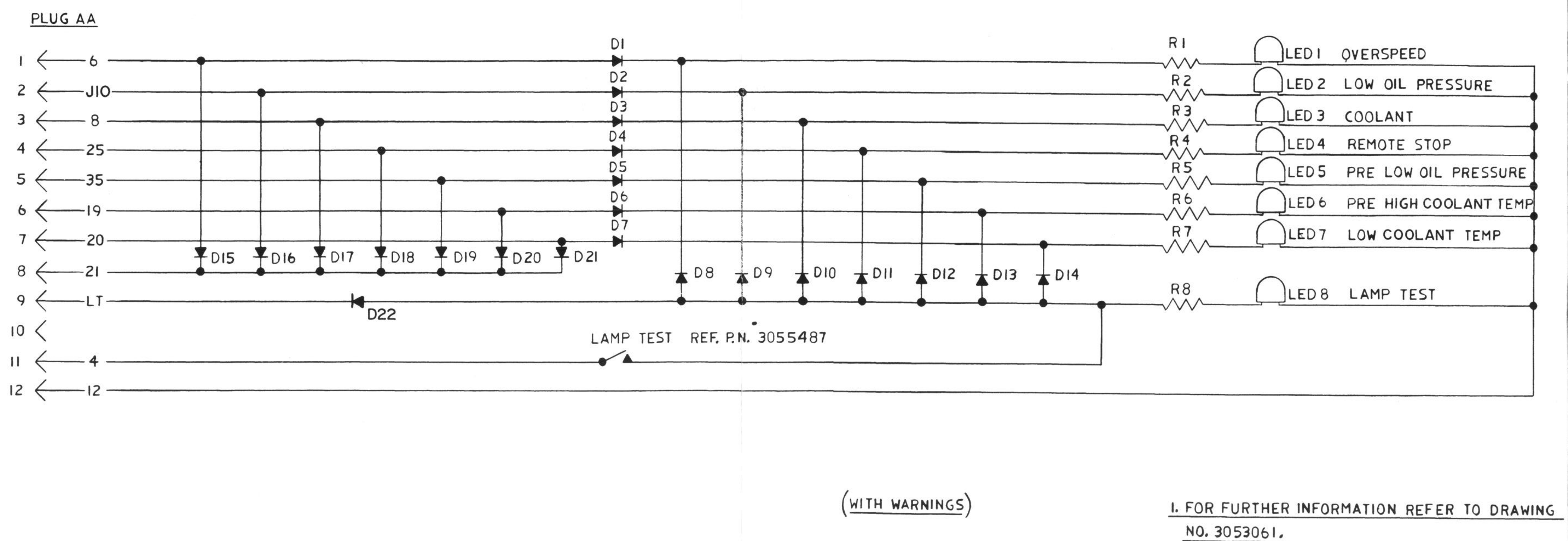
2. SWITCH INFORMATION (X=CLOSED)

	OFF	START	RUN
A B		X	
C D		X	X

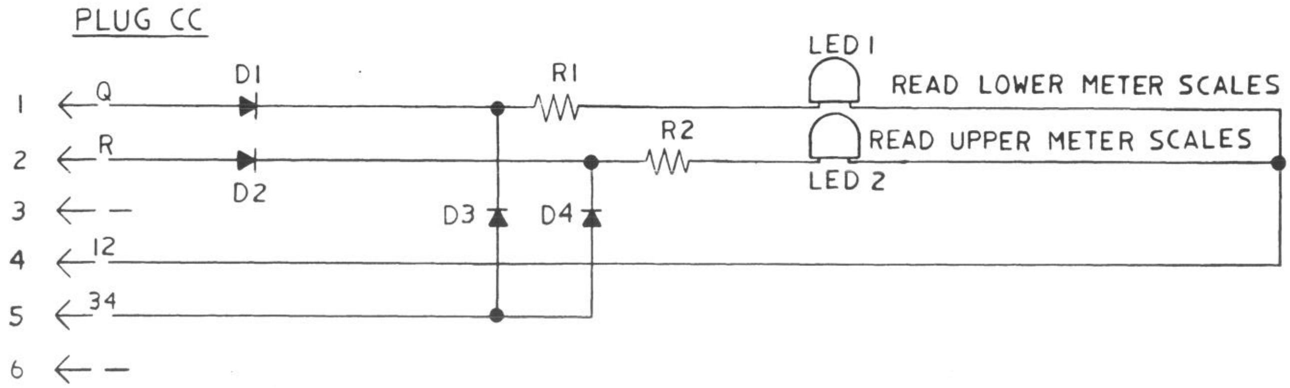
1. USE PLUG E AND F ON 3053065
USE PLUG J AND K ON 3053066

(INTERCONNECTION)

Electrical Diagram
3053054
Instrument Panel Harness



Electrical Diagram
3053056
Engine Lamp Panel

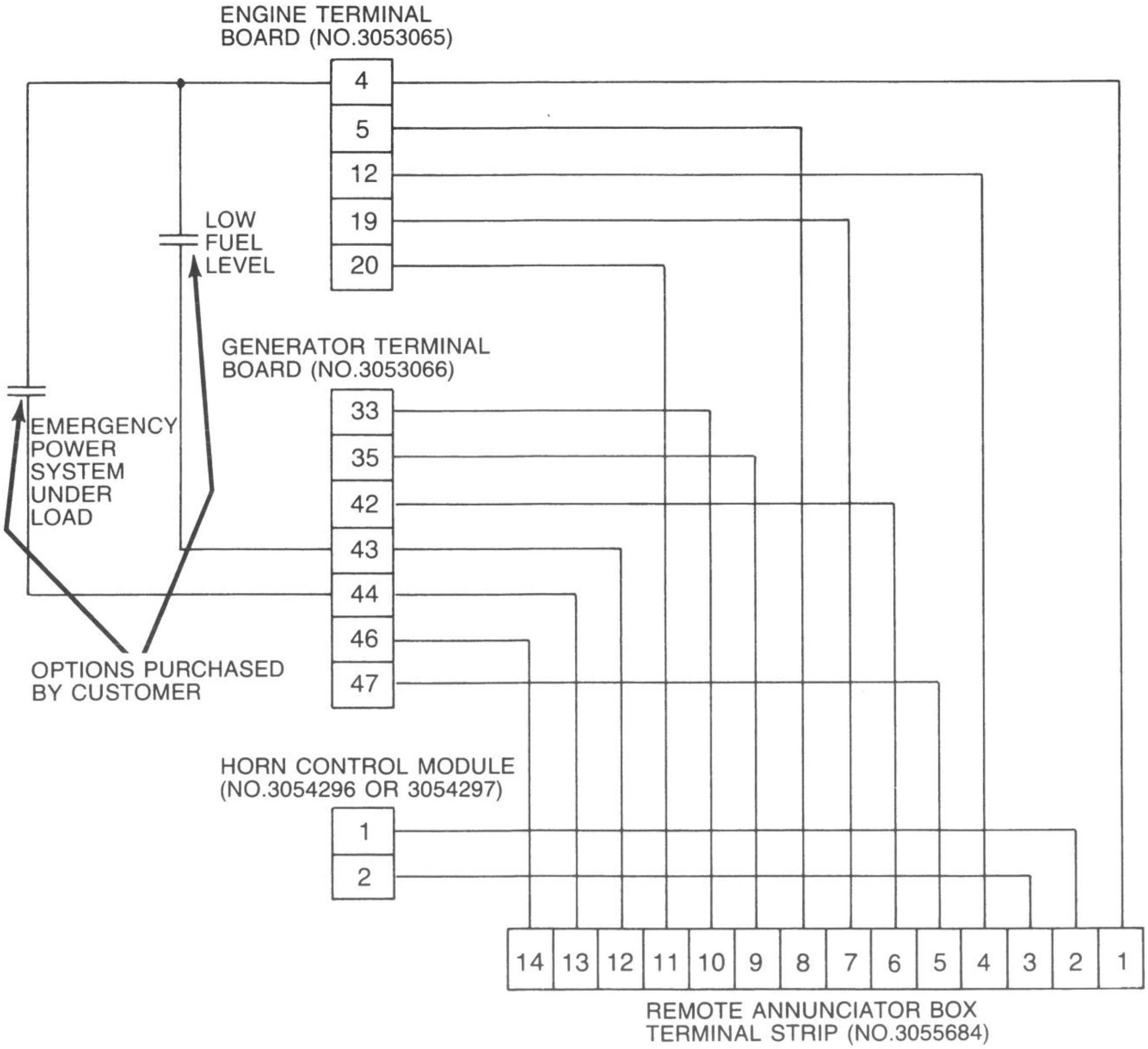


(UPPER/LOWER LIGHTS)

1. FOR FURTHER INFORMATION REFER TO DRAWING NO. 3053062.

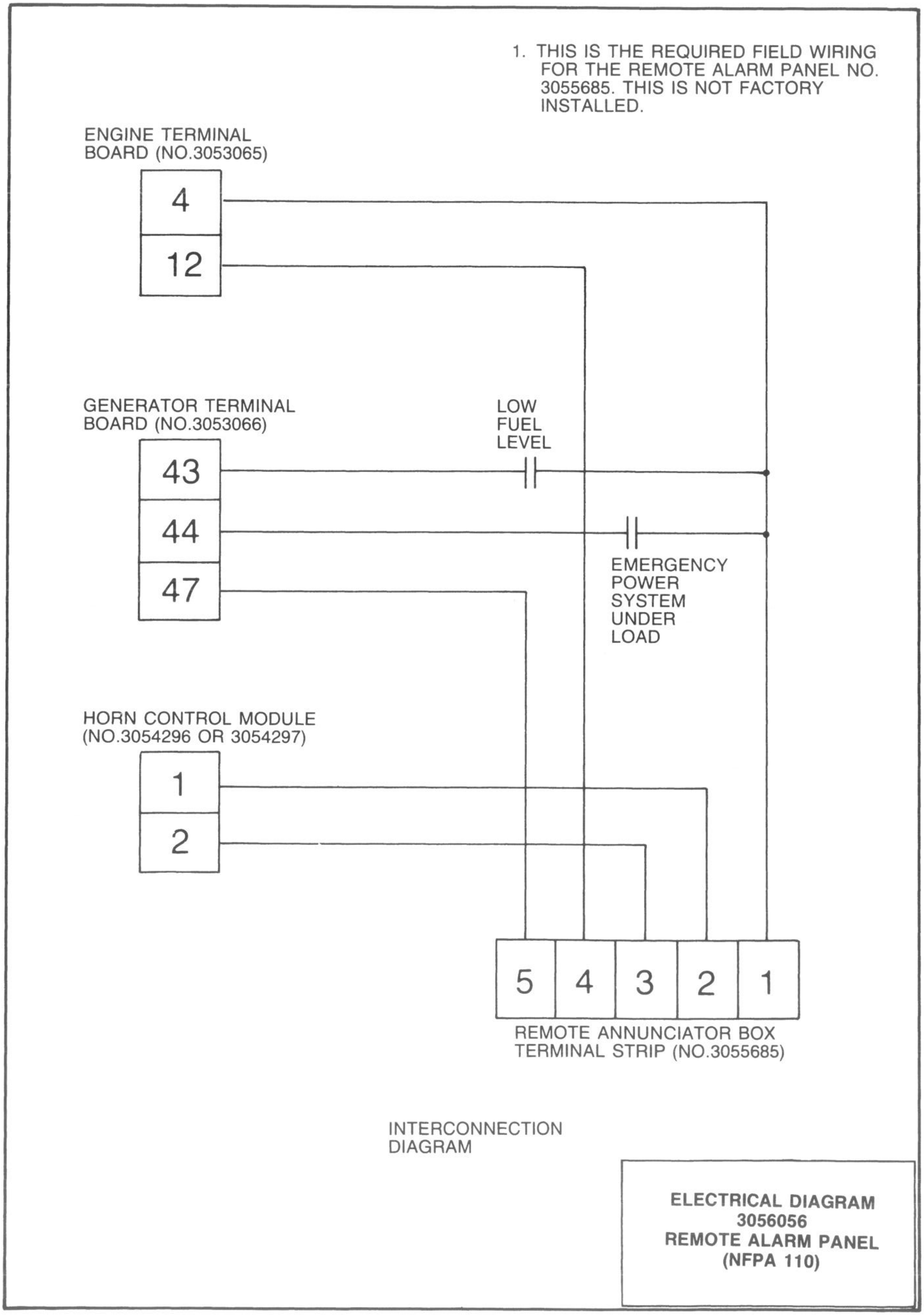
Electrical Diagram
3053057
Generator Lamp Board

1. THIS IS THE REQUIRED FIELD WIRING FOR THE REMOTE ALARM PANEL NO.3055684 THIS IS NOT FACTORY INSTALLED.



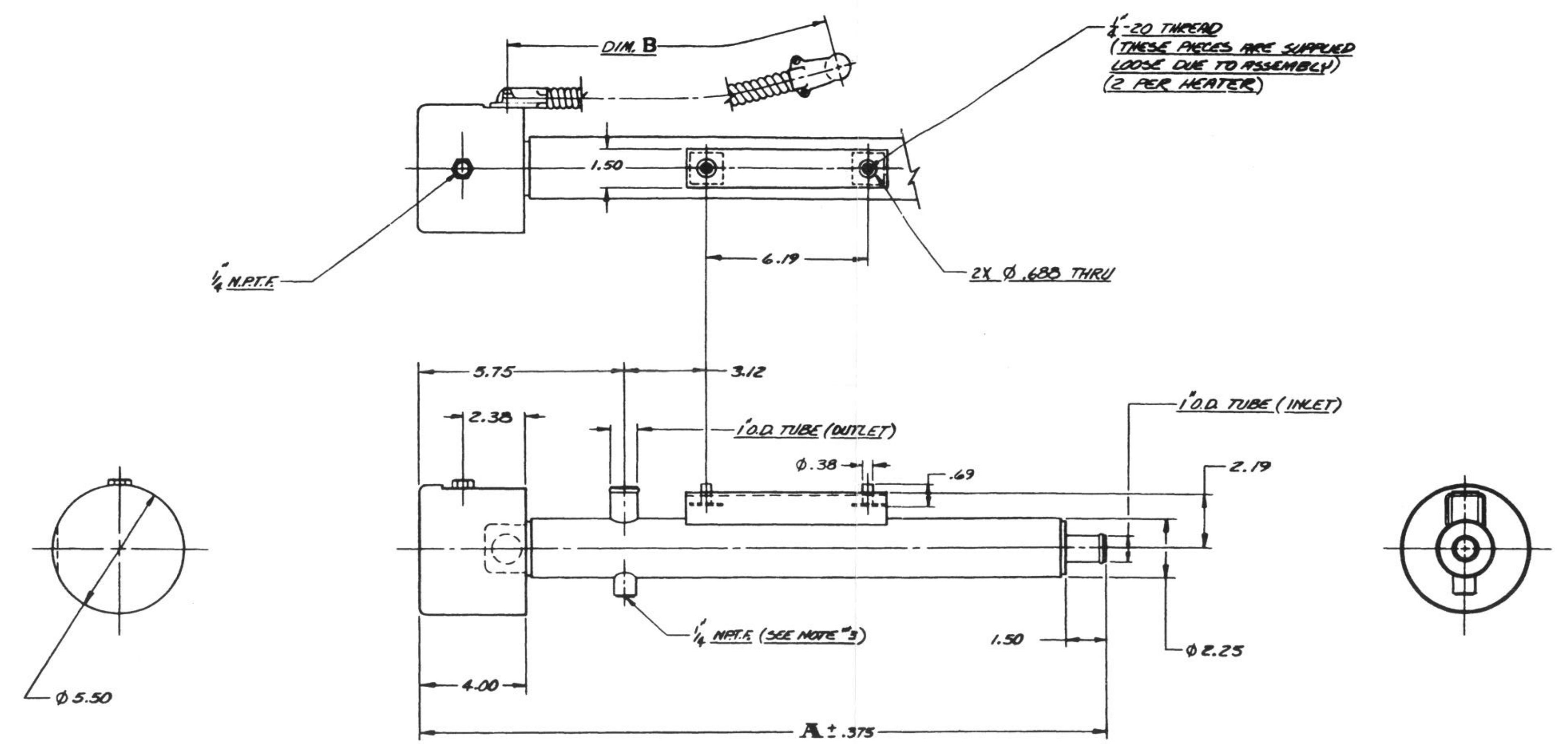
INTERCONNECTION DIAGRAM

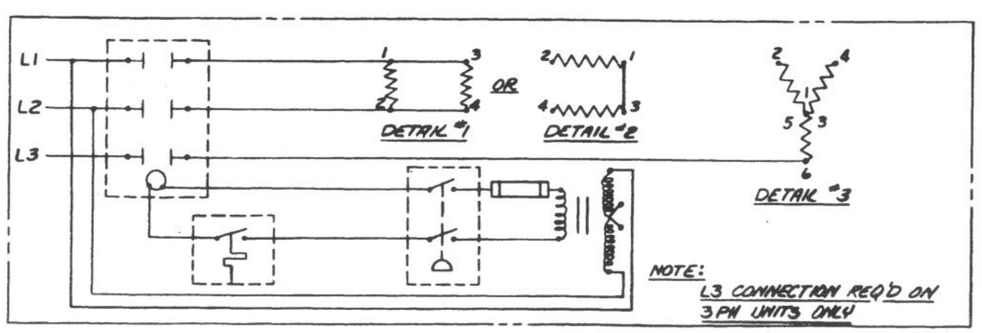
ELECTRICAL DIAGRAM
3055986
REMOTE ALARM PANEL
(NFPA 76A)


1. THIS IS THE REQUIRED FIELD WIRING FOR THE REMOTE ALARM PANEL NO. 3055685. THIS IS NOT FACTORY INSTALLED.
ENGINE TERMINAL BOARD (NO.3053065)
4
12
GENERATOR TERMINAL BOARD (NO.3053066)
43
44
47
LOW FUEL LEVEL
EMERGENCY POWER SYSTEM UNDER LOAD
HORN CONTROL MODULE (NO.3054296 OR 3054297)
1
2
5
4
3
2
1
REMOTE ANNUNCIATOR BOX TERMINAL STRIP (NO.3055685)
INTERCONNECTION DIAGRAM
ELECTRICAL DIAGRAM
3056056
REMOTE ALARM PANEL
(NFPA 110)

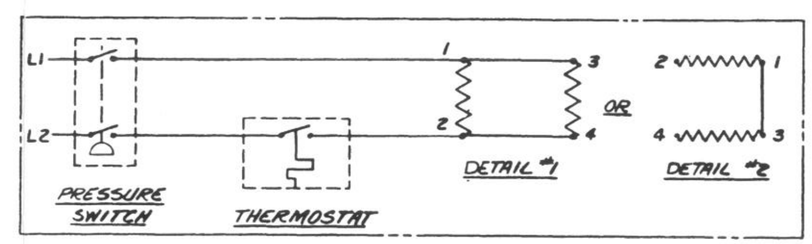
PART NO.	REV.	RELEASE NO.	SUPPLIER'S PART NO.	VOLTAGE	WATTS	PH	DIM. A	CONTROL PACKAGE	DETAIL #	DIM. B	REMARKS
3056181	00	862068	3-10-35-1	240	2500	1	20.25	OMIT	2	OMIT	
3056182	00	862068	3-10-35-2	240	4000	1	26.06	OMIT	1	OMIT	
3056183	00	862068	3-10-35-3	120	2500	1	20.25	OMIT	1	OMIT	
3056184	00	862068	3-10-35-4	480	4000	1	26.06	3056189	2	17.00	
3056185	00	862068	3-10-35-5	480	2500	1	20.25	3056189	2	17.00	
3053979	00	862068	3-10-35-7	120	4000	1	26.06	3056188	1	17.00	

1. TO BE PURCHASED FROM:
   WATLOW INDUSTRIES, INC.
   DIVISION OF WATLOW ELECTRIC CO.
   HANNIBAL, MO.
   FOR THEIR NO. (SEE TAB)
2. THERMOSTATS TO BE SET TO OPEN AT 120°F AND CLOSE AT 100°F.
3. HEATER TO HAVE DRAIN PLUG INSTALLED (DESIGN OPTIONAL WITH SUPPLIER)



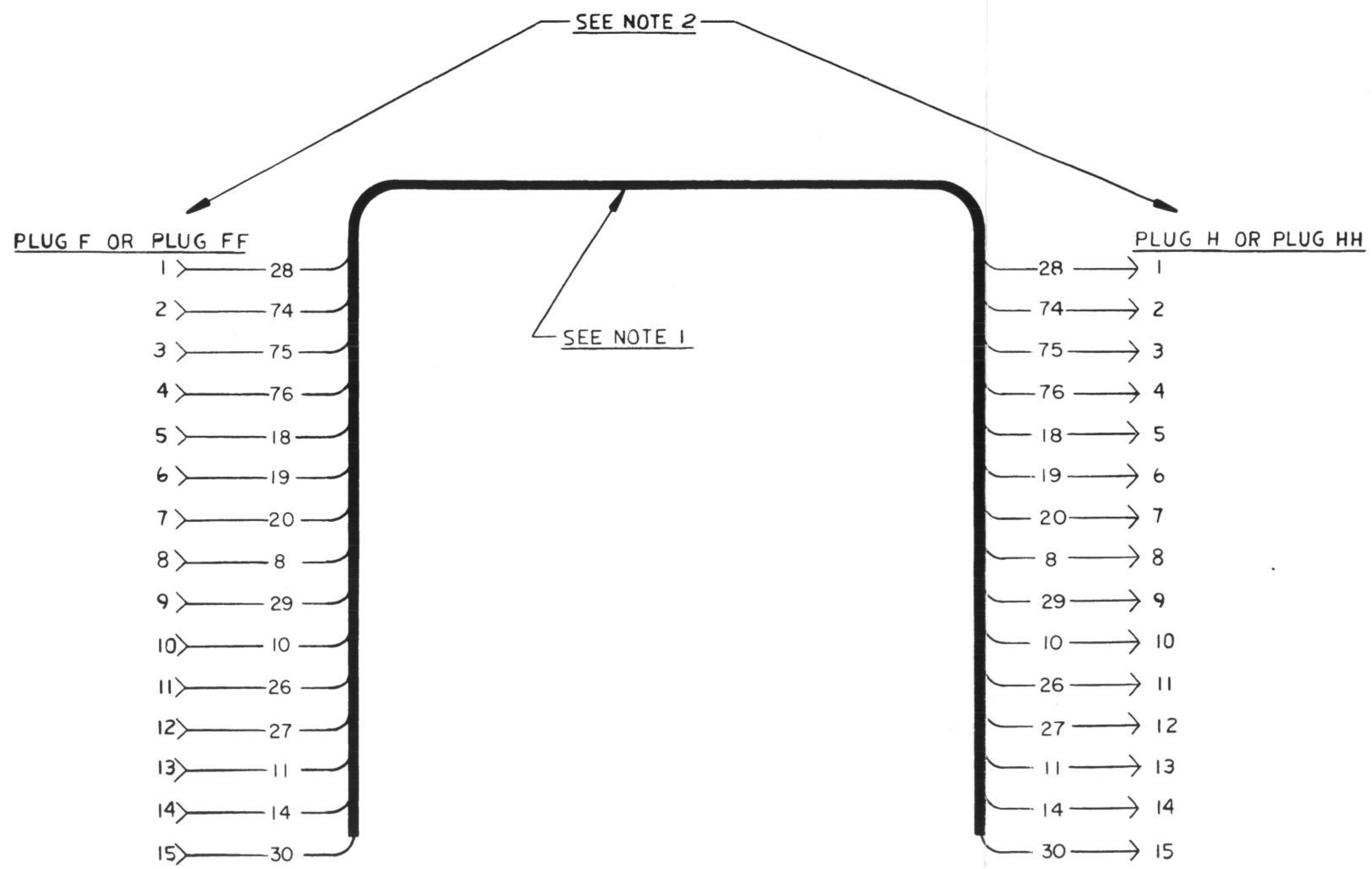


WIRING SCHEMATIC WITH CONTROL PACKAGE



WIRING SCHEMATIC WITHOUT CONTROL PACKAGE

Non-Cummins-TAB 3056187
Heater, Engine



1. FOR JUMPER HARNESS INFORMATION REFER TO 3056062.

2. USE PLUG F AND PLUG H WHEN CONNECTING THE ENGINE CIRCUIT BOARD TO THE GENERATOR CIRCUIT BOARD, USE PLUG FF AND PLUG HH WHEN CONNECTING THE GENERATOR CIRCUIT BOARD TO THE HORN CONTROL BOX.

3. EACH POSITION OF PLUG F OR PLUG FF IS WIRED TO IT'S RESPECTIVE POSITION OF PLUG H OR PLUG HH

4. THIS HARNESS IS USED IN TWO DIFFERENT LOCATIONS INSIDE THE GENERATOR CONTROL PANEL, THEREFORE CIRCUIT NUMBERS WERE OMITTED.

Electrical Diagram
3057619
Jumper Harness

Section 8 - Paralleling

Table of Contents

System Troubleshooting and Repair List

General Information (8-01)

Introduction to Paralleling

Warning: Make sure you read and understand all of the procedures in this manual before doing any work on the generator set.

Expansion of existing power generation systems, co-generation, peak shaving, and the need for multiple generator set flexibility is forcing increased use of more than one generator set to power common loads.

When two or more generators furnish power to a common load, they are said to be operating in parallel. For successful paralleling, all sets must have:

1. The same frequency. Generators of different speed can be paralleled providing the output frequency of the generators is identical.
2. The same voltage at the point of paralleling. Generators possessing unlike output voltages can be paralleled if proper use is made of voltage matching transformers to ensure like voltages at the point of paralleling.
3. Similar voltage regulation characteristics. This is normally ensured through the use of compatible voltage regulators. Some method of ensuring proportional sharing of reactive currents must also be incorporated.
4. Similar speed regulation characteristics. Speed control on paralleled sets governs the KW load on a unit and can affect system frequency.
5. Identical phase rotation. Phase sequence for Cummins PMG generator sets is U - V - W (1-2-3).
6. The same winding pitch - if the neutrals of wye (star) connected generators are connected together. All Cummins generators sold since approximately 1978 have been 2/3 pitch. A 2/3 pitch generator has essentially no line - to - neutral third harmonic voltage. Any six or twelve lead generators which can be connected in delta are wound with a 2/3 pitch.

When these conditions have been met, and the units are electrically in-phase, the generator sets can be paralleled.

Once paralleled, a unique set of conditions exist. Since the output three - phase voltage is the result of a rotating magnetic field, it is obvious that when this three - phase voltage is applied to a second generator, it will cause a rotating magnetic field in that generator's stator. Likewise, generator number one has a rotating magnetic field impressed upon it by the second generator.

The three - phase voltage impressed on the stator of each alternator creates current flow that results in a magnetic field which interacts with the main generator rotating field.

As long as frequency, voltage, phase rotation, and phase are identical, these magnetic fields are "lined up" and no torque exists. In fact, as long as these conditions persist, the engines do not know that paralleling has taken place. However, the dynamics of the system, which the governors must control, have altered drastically.

If unit one now attempts to decrease speed, it will no longer be able to act like a single generator set. As number one's magnetic field (impressed on generator two's stator), now lags two's rotor field, torque exists as the rotor field pulls unit one along.

Conversely, two's field (impressed on generator one's stator) is leading one's rotor field and torque exists as the rotor tries to pull unit two back. As a result, engine two must provide power to pull engine one to system speed and engine one "takes" power or is motorized. This produced torque is called synchronizing torque, and, as long as it is not exceeded, it will force the paralleled units to run at identical speeds. An exception to the identical speeds condition would be if the generators had differing numbers of poles; then, the speeds would be proportional since frequency is directly proportional to speed in synchronous generators according to the formula:

$$F = \frac{PS}{120} \quad \text{or} \quad S = \frac{120F}{P}$$

where F = frequency in hertz

P = number of poles (P = 4 in all Cummins generators)

S = speed in RPM

The extent of any resulting speed change will depend on the relative size and number of units. If the two units were of identical KW size, the decrease in system speed would be one-half the speed change of unit one if it were not paralleled. If the second unit were so large that unit one could not change the frequency, unit two would be defined as an infinite bus, and the system frequency would obviously not vary. Only the degree to which unit one was motorized would change.

Before discussing the various methods of putting the generator sets in parallel, some details will be given concerning the loads which must be proportionately shared by all paralleled generator sets. Basically, the kilowatt (KW) and volt - ampere reactive (KVAR) loads must be divided. The (KVAR) load is controlled by the voltage regulator and KW load - sharing is the governor's responsibility.

There are three KW loadsharing schemes: droop, isochronous, and combination droop - isochronous.

Droop Loadsharing

The key to successful droop loadsharing is setting each engine to the proper speed droop curve. Fig. 8-1 shows a typical droop curve. As the figure shows, a droop governed unit is characterized by a change in speed for a change in load. The amount of speed change from on-load to full-load is usually expressed as a percent of the full-load speed according to the equation:

$$\text{Speed Droop}(\%) = \frac{\text{No Load speed} - \text{Full Load speed} \times 100}{\text{Full Load Speed}}$$

Cummins generator sets using droop governing are to be adjusted for a minimum of 3% speed droop. A 3% droop setting would result in the following frequencies and engine speeds:

	No Load	Full Load
60 Hz System	61.8 Hz	60.0 Hz
	1854 RPM	1800 RPM
50 Hz System	51.5 Hz	50.0 Hz
	1545 RPM	1500 RPM

Since all units have the same droop curve, a given percentage of rated load will cause all units to decrease speed by the same amount and ensure proportional loadsharing.

Fig. 8-2 shows two units with dissimilar droop curves. In this example, the no load speeds are equal and the units therefore parallel properly at no load. However, when load is applied to the system, speed decreases, for example, to 60.5 Hz (line C). As pointed out earlier, all units must run the same speed and line C therefore represents the speed of both units.

The percentage of rated load carried by each unit can be found by locating the point of intersection of the system speed line (line C) and each unit's individual speed droop curve. Unit one will carry proportionately less load than unit two. Obviously, there are many ways in which the speed droop curves of paralleled units could be unequal. The result of such discrepancies, however, will always be failure to properly loadshare.

Isochronous Loadsharing

Isochronous governed generator sets are characterized by constant speed regardless of load (excluding transients and loads in excess of generator set ratings). Fig. 8-3 shows the speed curve for an isochronously governed system. On such a "zero droop" system, successful parallel operation can only be accomplished by using electronic sensing circuitry to measure each unit's KW load and then adjusting the fuel of all units to ensure proportional loadsharing with no system frequency change.

Each unit in the paralleling system must have its own KW load-measuring circuits, and, for proper operation, these circuits must be adjusted so that a given output voltage (load gain signal) represents the same percentage of rated load on all units. Furthermore, it is necessary for each measuring circuit to communicate with every other measuring circuit via a set of communication wires (paralleling lines).

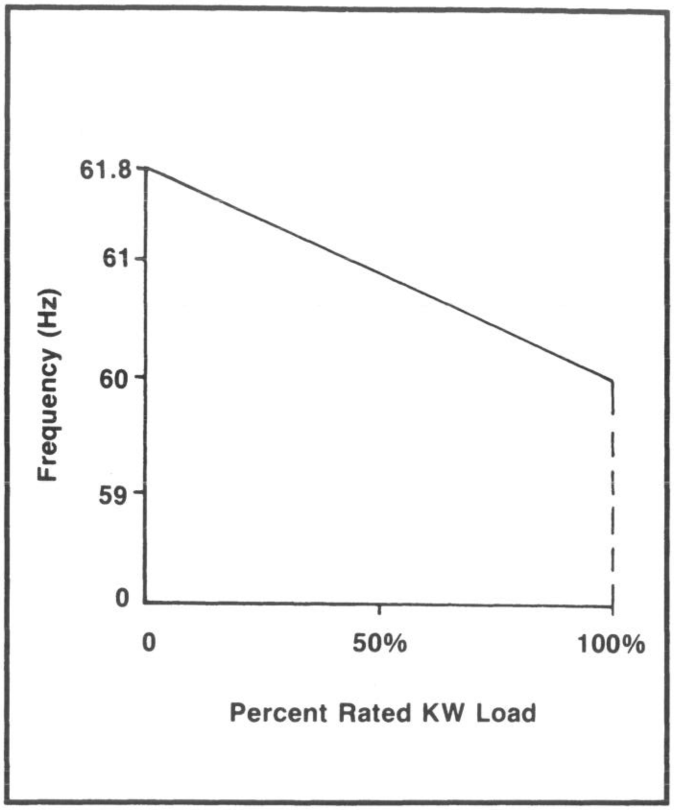


Fig. 8-1, (CGS326). Typical droop curve

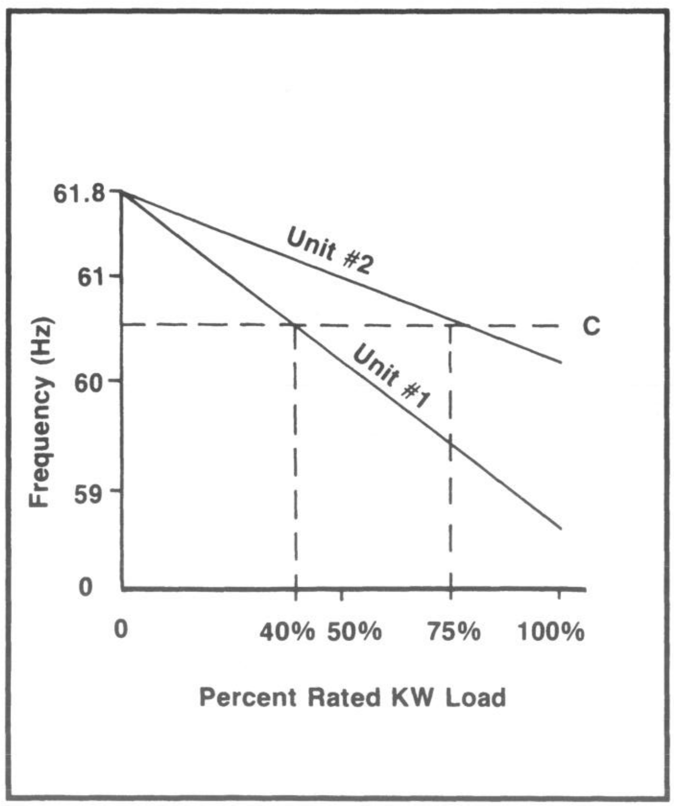


Fig. 8-2, (CGS327). Two units with dissimilar droop curves

Proper isochronous-parallel operation is dependent on the correct configuration of, and intercommunicationbetween, each unit's load-measuring circuit. The governor section of this manual contains the adjustment and testing procedures for the various KW load-measuring circuits.

Combination Droop-Isochronous Loadsharing

In a limited number of cases, combination or droop-isochronous paralleling will be desirable. Under certain load conditions, combination paralleling allows unlike-governed units to act similar to an isochronously governed system. Fig. 8-4 shows the speed droop curve for such a system.

Here, droop governed unit one carries the fixed portion of the system load (base load). Load variations above the base load level are handled by isochronously governed unit two. As long as the system load remains above the base load level and below the system capability, the output frequency will remain constant.

For example, assume generator set one is rated at 100 KW and generator set two at 200 KW. The base load is 70 KW.

As shown in Figure 8-4 , the droop curve of unit one has been adjusted so that 60 hertz will be attained with a load of 70 KW. Once unit one is carrying the 70 KW base load, its speed will have drooped to match the speed of isochronously governed unit two.

Generator set two can now be successfully paralleled to generator set one. All load variations between 70 KW and 270 KW will then be carried by unit two.

If, at any time, the total system load drops below the set base load value (system load = 50 KW for example) unit two will motor unit one.

Obviously, base loads up to the rated KW of unit one can be accommodated as long as the droop curve of unit one is adjusted accordingly. Further, the system load must not be allowed to drop below the set base load value while unit two is paralleled with unit one.

As can be seen from the proceeding discussion, this system does not result in proportional loadsharing. This means that unit one will see greater usage; and unless the governors are reconfigured, must always be the lead unit.

Volt-Ampere Reactive Loadsharing

Control of the rotor field current is used to maintain a specified output voltage on a Cummins PMG Generator.

The excitation required depends not only on the KW load applied, but the power factor of that load as well. In fact, the power factor of a load has a much greater effect on the required excitation than its KW.

It is rather easy to control the output voltage of a single generator. It is only necessary to sense the output voltage and adjust the excitation current accordingly.

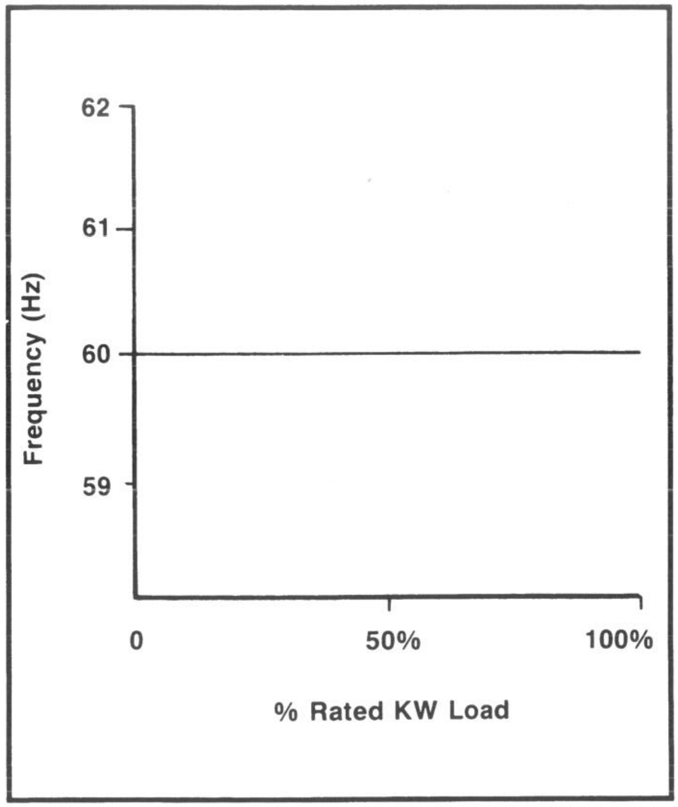


Fig. 8-3, (CGS328). Speed curve for isochronously governed system

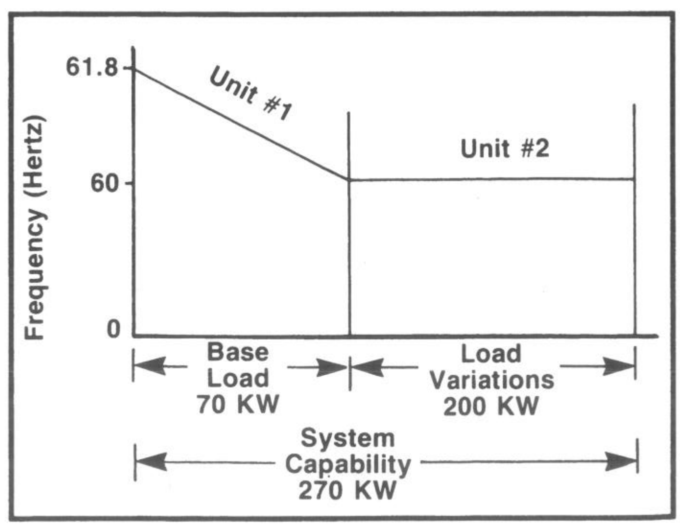


Fig. 8-4, (CGS329). Speed droop curve for droop-isochronous system

When two or more generator sets are paralleled, the situation becomes much more complex. Great care must now be taken to ensure that all generators have the same relative level of excitation. If, for example, generator one (See Fig. 8-5) is over excited compared to generator two, unit one will appear as a leading power factor load to number two, and two will act as a lagging power factor load to generator one.

Since there can be no difference in voltage between the units in a paralleled system, this excitation imbalance will cause current to circulate between the generators. Large circulating currents will result from very small differences in power factor and, therefore, the relative power factor of the paralleled generators must be taken into consideration along with the system output voltage.

What is required is a circuit which will recognize and adjust the power factor of a generator with respect to the power factor of the other paralleled units. Since the currents which result from excitation error are virtually totally reactive, this corrective circuit is commonly called a reactive volt-ampere compensation circuit.

Essentially, there are two types of compensation circuits: droop and reactive differential. Droop compensation is by far the more common, and is the only type normally used on Cummins Generator Sets.

Fig. 8-6 shows a typical generator equipped with the necessary droop compensation circuitry. Each generator in the paralleled system must have the indicated paralleling module. When correctly installed, this modification will effectively eliminate circulating current between paralleled generators.

The term "droop compensation" comes from the fact that lagging power factor loads applied to the system will cause the system to decrease its output voltage slightly. Leading power factor loads will result in a nominal system voltage increase, while unity power factor loads will have a negligible effect on the system output voltage.

In each case, the amount of system voltage change will depend on the extent and power factor of the load. At 0.8 power factor and rated KW, a 4 percent voltage change is typical. Procedures for setting and testing the droop compensation circuits are contained in the Single and Three Phase Paralleling Module, Installation and Adjustment Sections of this manual.

Paralleling With a Public Utility

Specific arrangements must be made with the public utility company involved before a generator is paralleled with the utility. For their own protection, a public utility company will always insist on at least a circuit breaker capable of interrupting any fault current within the generator that can be produced by the utility. Depending on the circumstances and the utility, other protection devices may be required.

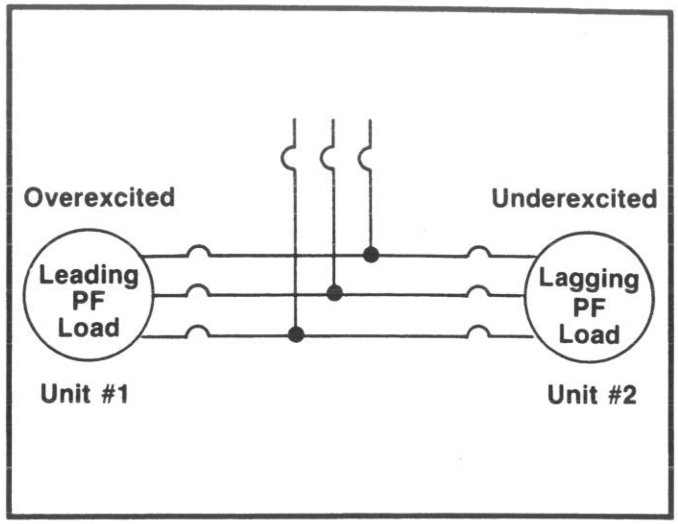


Fig. 8-5, (CGS330). Leading and lagging power factor loads

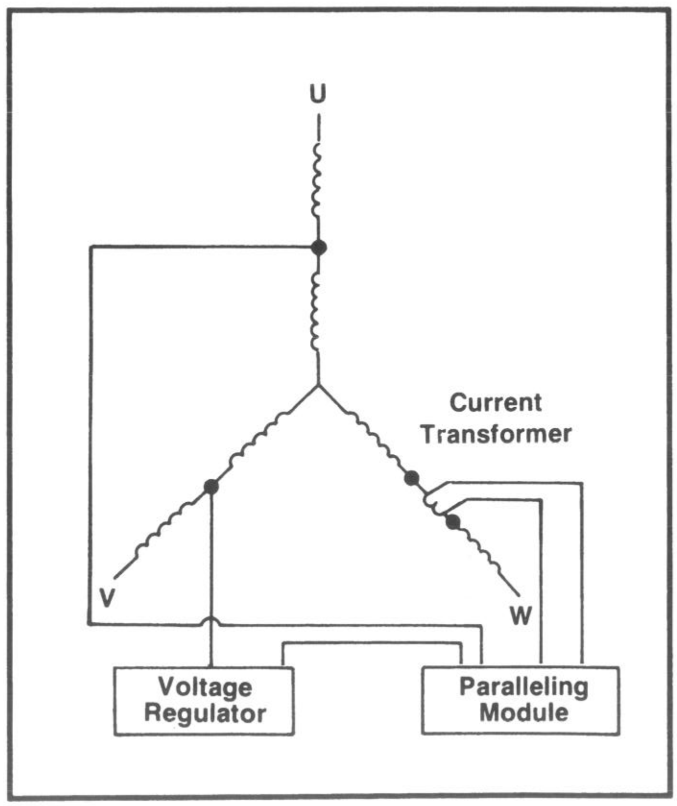


Fig. 8-6, (CGS331). Droop compensation circuit

Voltage Control

In order to protect the generator from producing excessive current caused by utility voltage variations, each generator that may be paralleled with a public utility MUST have a VAR/PF (Volt-Ampere Reactive/Power Factor) controller. It usually will also require a paralleling kit. Cummins generators with a voltage droop type paralleling kit have approximately a four percent decrease in voltage from no load to rated load at 0.8 power factor. The voltage from a public utility at the using facility is usually a nominal value (frequently 480 volts) plus or minus five percent under normal loading conditions. The voltage variations in facilities at some distance from the utility substation or under abnormal conditions may be much greater. This voltage variation will cause the generator current to vary widely. The VAR/PF controller senses voltage and generator current. It provides a signal to the generator AVR to maintain either a constant reactive volt-ampere load on the generator or a constant power factor load on the generator. The VAR/PF controller is disabled when the generator is not paralleled with the utility.

Governing

The governor on a generator set that is paralleled with a public utility may be either a speed droop type or an isochronous (same speed, no load and full load), load sharing governor. Each isochronous governor MUST have a load sensing module in order to control generator set KW load when a unit is operated in parallel with a public utility. In Canada and in the U.S.A., public utility system frequency is normally maintained between 59.9 and 60.1 Hz. Isochronous load sharing governors are usually used in these areas since the generator set load is readily controlled by a low (less than 10 volts) DC voltage applied to the governor paralleling lines. A common problem in such installations is incorrect phasing of the load sensing governor voltage and current lines. See Sec. 4.

The frequency variations in isolated utility systems may be much more than plus or minus 0.1 Hz. A speed droop type governor may be used in such installations. The operation of the system is then essentially the same as described in the Combination Droop-Isochronous Loadsharing section. The utility is the isochronous unit and supplies the variations in load. The paralleled droop governed unit(s) carry a fixed portion of the load.

Cummins Auto-Synchronizer (8-02)

General

The synchronizer provides automatic synchronization of an incoming generator to a bus in a minimum of time, by controlling the speed and phase of the generator to match it to the bus. As the generator comes up to speed, the synchronizer compares its frequency, phase and voltage to the bus. Any difference in frequency or phase results in a proportional signal to the governor control circuit. As the difference is reduced, so is the amplitude of the signal until the generator output is phase matched to the bus. When the generator output has reached the preset levels of synchronization, a relay inside is energized to provide an isolated single-pole double-throw contact for the circuit breaker control.

Standard Features

- Automatic Frequency and Phase Matching
- Solid State Circuity
- Visual Indication of Frequency, Phase and Voltage Differentials
- Built-in Synch Check Relay
- Adjustable Phase Angle Differential
- Remote Reset
- Electric Governor Compatibility

The Cummins Auto-Synchronizer will function with Cummins EFC.

Safety

The Auto-Synchronizer eliminates the risk of human error that might occur with manual paralleling. Operating personnel need not be present.

Proportional Plus Integral Output

The Auto-Synchronizer has a proportional plus integral output which allows it to be used with a wide variety of engine-generator sets.

Capture Range

±3.0 Hz - Synchronizes equally well from both directions.

High Reliability

The Auto-Synchronizer employs integrated circuits and digital components for high reliability. Each unit is subjected to thorough functional testing under operating conditions.

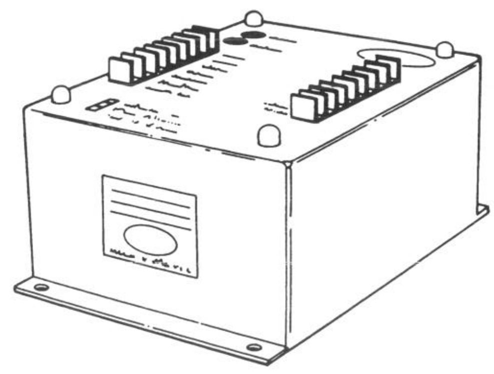
Chassis Design

The chassis is sturdily constructed of steel and is intended for behind-the-panel mounting.

Operational Modes

Automatic

The synchronizer performs as a speed matching automatic synchronizer. The speed and phase of the incoming generator are controlled and an isolated contact is closed when the voltage, frequency and phase are within limits.



Permissive

It performs as a synchronizing check relay only, with circuit breaker contacts output but no control in the incoming generator.

Off

It is still sensing but provides no contact output and no control signal.

It has three LED lights in the front of the unit to help the technician when first starting a control panel or when troubleshooting the control panel after it has been started. The LED lights indicate whether the synchronizing limits have been met by the incoming generator.

Typical Applications

- Automatic Synchronization with generators operated isochronously.
- Automatic Synchronization with generators operated in droop.
- Automatic Synchronization with an infinite bus.
- Automatic Synchronization with another AC 50/60 Hz power source to allow bumpless transfer.

Specifications

Input Power	Oncoming Generator	Bus
Voltage*	115 VAC	115 VAC
Frequency	50/60 Hertz	50/60 Hertz
Phase	1	1
Burden (VA)	10	7

*Stepdown potential transformers may be necessary to reduce other generator/bus voltages to the 115 VAC inputs.

- Breaker Closing Angle

Potentiometer adjustable, ±5° to ±20°

Output Signal

-4 volts to +4 volts DC

Contact Ratings

SPDT-makes and breaks 10A at 120 VAC, resistive, make and break 1A at 120 VDC, resistive

Synchronizing Time (typical)

Less than 6 seconds based on an engine-generator acceleration rate of 55% per second

Operating Temperature

-40° C to +70° C [-40° F to 158° F]

Environment

Printed circuit is tropicalized with conformal coating

Vibration

Withstands the following vibration without failure or degraded performance: 0.06 inch double amplitude at 5 to 18 Hz. 1G at 18 - 30 Hz. 0.02 inch double amplitude at 30 to 48 Hz. 2.5 Gs at 48 - 70 Hz.

Finish

Tan baked enamel

Weigh

1.37 Kg. [3 lbs.]

Sample Specifications

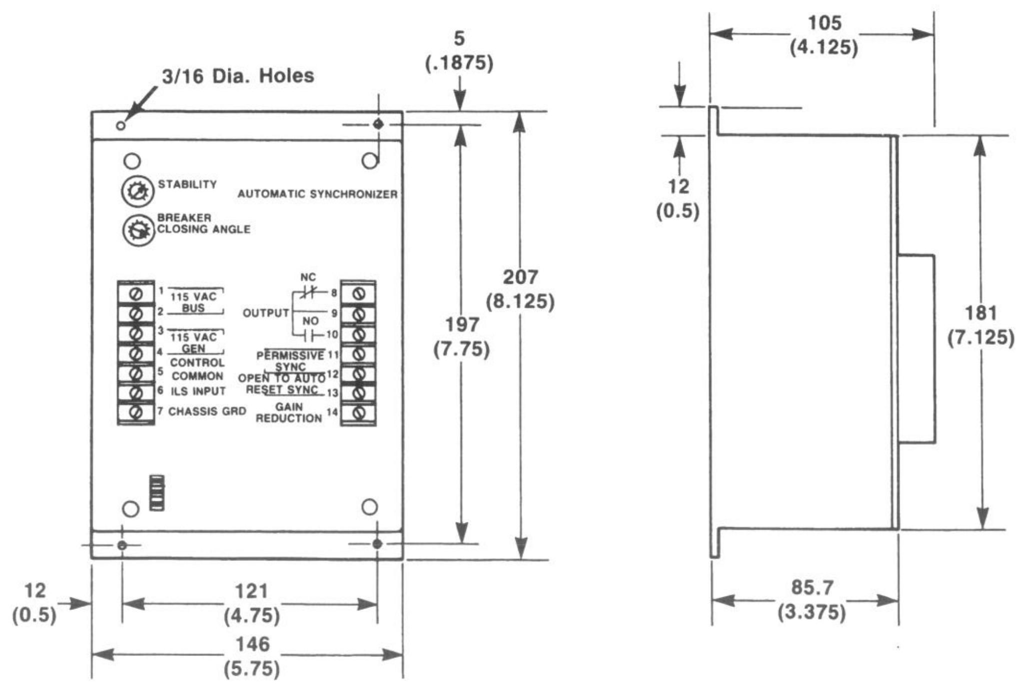
The synchronizing function shall be accomplished by means of an auto-synchronizer that can operate with an electric governor. It shall employ a phase locking method of synchronization. The unit shall employ single phase sensing. Phase angle shall be adjustable between ±5° and 20°.

The unit shall be designed for behind-the-panel mounting. Environmentally, the unit shall be capable of operations in an ambient environment of -40° C to +70° C [-40° F to 158° F]. It shall withstand vibration up to 2.5 Gs at 48 to 70 Hertz in any plane and withstand shock of up to 15 Gs in any plane.

The synchronizer shall be Cummins Auto-Synchronizer.

Auto-Synchronizer Outline

Dimensions in Millimeters
[inches in brackets]



Auto-Synchronizer Module

Table of Contents

Introduction

The Cummins Automatic Synchronizer is used to match the frequency and phase of an incoming generator to the frequency and phase of either the bus, the utility or another generator. The Synchronizer compares incoming generator to the frequency and phase to be matched and controls its speed and phase to assure synchronization within a minimum of time. Except for the circuit breaker control relay, the circuitry is completely solid-state.

Application

The Cummins Automatic Synchronizer is used in prime power installations, standby power installations and other situations where it is desirable to parallel an engine-generator to a stable power bus.

Since the Synchronizer is part of a closed-loop feed-back control system (see figure below), it has to be

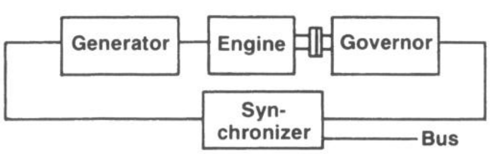


Fig. 1. Synchronizer closed-loop feed-back control system

adjusted to match the various responses of the other components of that loop. For that reason, it is recommended that one unit be used per generator. Using only one Synchronizer per system and switching all the various connections to each incoming generator, as needed, can possibly lead to complications and malfunctions of the total engine-generator system. Such malfunctions can take the form of erratic operation of the electronic governor or even, in extreme cases, internal damage to the synchronizer.

Specifications

- Input Voltages

Generator Terminal Voltage:

115 VAC ±15 Volts, 50 to 60 Hz

Bus Terminal Voltage:

115 VAC nominal, 140 Volts AC maximum, 50 to 60 Hz

Note: The part no. 3058501 auto-synchronizer can be operated on 115 VAC or 230 VAC by changing jumpers internal to the unit. The standard unit is set up to operate on 115 VAC. To obtain a 230 volt unit, cut the jumpers on the posts near the transformer printed circuit board in accordance with Figure 1A. Solder new jumper wires as shown in Fig. 1A. This figure is also silk-screened on the transformer printed circuit board for easy identification. The voltage shown on the cover for terminals 1-2 and 3-4 should be changed if the jumpers are changed.

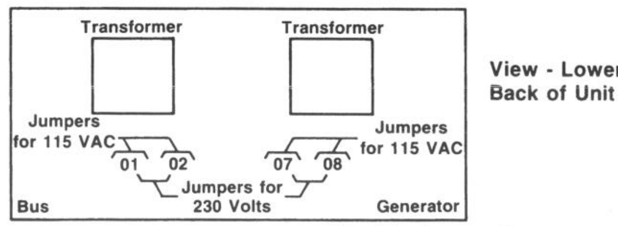


Fig. 1A. Jumper Arrangement

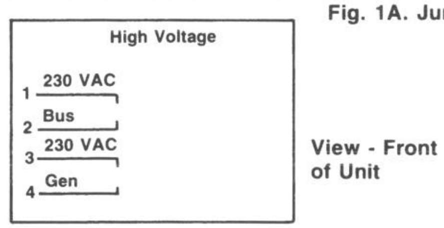


Fig. 1B. Decal

Power Consumption, Generator Terminals:

Maximum of 10 VA

The synchronizer draws its operation power from the generator voltage terminals.

Power Consumption, Bus Terminals:

Maximum of 7 VA

The input voltage on the bus terminals is for sensing only

Ambient Temperature:

-40° to +70° C [-40° to +158° F]

Output: Electronic signal

Circuit Breaker Contact Rating:

Isolated from "C" contacts. Rated at 10 AMP at 120 VAC

Environment:

PC board tropicalized with conformal coating

Operation

The synchronizer has three different modes of operation.

Automatic

It performs as a speed matching automatic synchronizer. The speed and phase of the incoming generator are controlled and an isolated contact is closed when the voltage, frequency and phase are within limits.

Permissive

It performs as a synchronizer check relay only, with circuit breaker contact output but no control on the incoming generator.

Off

It is still sensing but provides no contact output and no control signal.

In the "Automatic" mode, the synchronizer operates as follows: As soon as the incoming generator voltage reaches approximately 50% of output voltage, it compares its frequency to the bus. Because there is a difference, it sends a signal to the governor to bring the generator to the bus frequency. When the frequency difference is approximately ±0.2 Hz, the phase of the generator is also compared to the bus. The synchronizer then produces a governor control signal to bring the signal within the phase differential limit. It energizes the output contacts (terminals 8, 9 and 10) only after the following conditions are met:

1. Frequency difference is within ±0.1 Hz.
2. Phase difference is within the preset value (range is ±5° to ±20°).
3. Voltage difference is within ±10%.

These synchronizing differential limits are preset at the factory.

The synchronizer compares voltages only and does not adjust the generator voltage to the bus voltage.

In the "Permissive" mode, the synchronizer performs as above except that it does not control the speed and phase. The synchronizer is thus Permissive. The output contacts (terminals 8, 9 and 10) are switched when the synchronizing limits for voltage, frequency and phase are met. In the "Off" mode, the synchronizer senses the frequency, voltage and phase but generates no governor control signal and does not energize the output contacts. It is standing by, ready to operate in the "Automatic" or "Permissive" mode.

LED Indicating Lights

Three LED lights, in the front of the unit, help the technician when first starting a control panel or when troubleshooting the control panel after it has been started. The LED lights serve no functional purpose other than to indicate whether the synchronizing limits have been met by the incoming generator.

Normally during tests a technician removes the leads from terminals 8, 9 and 10 so that the incoming generator circuit breaker is not allowed to close onto the live bus. Then, the technician can start the incoming generator and look at the LED lights to verify the operation of the synchronizer.

The red lights indicate the voltage differential, the green light the frequency differential, and the yellow light the phase angle differential. If the incoming generator voltage differs from the live bus by a margin of more than 10%, then the red LED comes on. Similarly, if the frequency of the incoming generator differs from the live bus by a margin of more than 0.1 Hz, then the green light comes on. Finally, if the phase angle between the incoming generator frequency and the live bus frequency is more than 10 electrical degrees, then the yellow light comes on. When all the synchronizer limits have been met, then all three LED lights are off.

During tests, assuming the circuit breaker is not allowed to close as indicated above, and assuming that the incoming generator frequency is within limits, then the green light is off.

However, every time the phase angle between the incoming generator and the bus is 180 electrical degrees apart, the green light flashes on for a very brief period of time. This is a peculiarity of the circuit and is normal. During the rest of the time, the green light stays off, again assuming that the frequency differential is not more than ±0.1 Hz. Of course, the frequencies being different, the yellow LED turns off each time the two frequencies are in phase, so it appears that the yellow light is flashing.

These lights are provided strictly to help the technician in starting up or troubleshooting a generator system.

Dead Bus

If the bus is dead, the synchronizer waits until a voltage and frequency appear on the bus. Then it will attempt to match the incoming generator to the bus.

Installation

Mechanical

It is not dependent on any orientation for its operation, therefor, it can be mounted in any position.

Electrical

For proper operation, connections should be made in accordance with the wiring diagram in this manual and the following instructions.

The connections from the incoming generator and from the bus must be matched with respect to phase and rotation. Be sure that the voltage to terminals 1, 2, 3 and 4 are 115 VAC ±10 Volts.

A shielded cable is required for the control signal from terminals 5 and 6 to the governor. This prevents stray pick-up and hum in the control circuitry. The shielded cable should be connected as shown in the drawing at the end of this section.

The chassis ground on terminal 7 is for the convenience of the customer only and is to be connected at the customer's discretion.

Terminals 8, 9 and 10 provide an isolated single-pole double-throw contact for the circuit breaker control. The normally open side (terminals 9 and 10) is generally used to close an electrically operated circuit breaker when the voltage, frequency and phase are within limits.

Terminals 11, 12 and 13 determine under which operating mode the unit functions. Closing a contact between terminals 12 and 13 initiates the "Automatic" mode. Shorting out terminals 11 and 12 places the unit in the "Permissive" mode. If both 11, 12, and 12, 13 are left open, then the unit is in the "Off" mode and is standing by to operate in either of the other two modes.

For proper operation, the signal to go into the "Automatic" mode (e.g., closing a contact between terminals 12 and 13) should be given at the same time as the signal to start the incoming generator. As soon as the incoming generator is paralleled to the bus, the signal to the unit (the contact between terminals 12 and 13) should be opened to prevent interaction between the governor control signal.

The logic necessary to provide the timely and proper signal to the Automatic Synchronizer is the responsibility of the engine-generator control system.

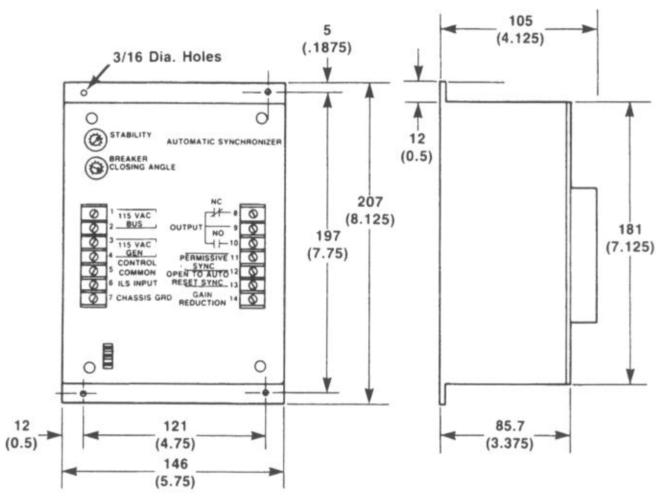


Fig. 2. Synchronizer outline

Calibration and Adjustments

The governor control signal is adjusted for ± 3.0 Hz of gain. This means that should the unloaded frequency of the engine-generator happen to be preset (by means of the speed potentiometer) at 57.0 or 63.0 Hz, The synchronizer is still able to control the frequency of the engine-generator such as to synchronize it to a 60 Hz bus. However, had the frequency been preset outside of that range (± 3.0 Hz), the Auto-Synchronizer would be restricted in its capacity to control the speed of the engine and thus would not achieve synchronization.

The auto-Synchronizer is pre-adjusted to provide stable operation. However, there will be times when, for example, potentiometers of the electronic governor are misaligned or the engine response is different than normal. These items can cause unstable operation of the Auto-Synchronizer. If this occurs, it can be detected as an oscillation or hunting of frequency and phase (this is best observed on a synchroscope) when the Auto-Synchronizer is controlling the governor of the incoming engine-generator.

Gain Range - (Response)

The "response" can be changed by jumping terminal 14 to terminal 6 or terminal 7. Adding jumper from 14 to 6 reduces the lead or derivative action right at zero phase angle and adding the jumper from 14 to 7 increases the lead or derivative action at zero phase angle. This can be used to modify the response near zero phase angle to provide more or less slowing or "breaking" right at the control point.

If a system requires and can tolerate faster auto-synchronizing, one can add a jumper inside the unit on the printed circuit board. There are three terminals, one each marked A, B and C. If a jumper is added to terminals A and B, the response will be faster.

For a system that is difficult to synchronize, the response of the auto-synchronizer can be slowed down by adding a resistor across terminals B and C on the printed circuit board. If a 15K ohm resistor is added from B to C, the response is reduced by approximately 40 percent. Further reductions in response can be made by reducing the resistor size. A practical low limit of resistance is probably 1K ohm.

It should be noted that adding a jumper or resistor to terminals A, B and C as mentioned does not alter the capture range. Adding external resistors for reducing the response of the auto-synchronizer should be avoided because that does reduce the capture range.

Stability

This adjustment is located on the front of the unit, at the top left corner. Stability should be adjusted in conjunction with the "Gain Range". First, determine whether the Auto-Synchronizer is controlling a fast or slow engine. If this cannot be determined, then an assumption has to be made. Once a "Gain Range" has been selected, observe operation of the system on a synchroscope while the Auto-Synchronizer is controlling the incoming generator. If the needle on the synchroscope has wide overshoots around the "noon" position while being synchronized, reduce the overshoots. ON the other hand, if the needle hesitates on the way to the "noon" position, there is too much stability and the potentiometer should be turned counterclockwise to reduce stability and reduce the time required to synchronize. Should a synchroscope not be available, the operator can listen closely to the incoming engine to determine whether it is overstabilized or understabilized. If satisfactory operation cannot be achieved, the alternate "Gain Range" should be tried and the "Stability" readjusted as described above. The two Gain Ranges have an overlap and it is possible that better operation can be achieved in the alternate range.

Making the adjustments described above may not remove the oscillations completely. The goal is, to achieve as stable an operation as possible.

Remember that closure of the contact at terminals 9 and 10 indicates that the generator is synchronized with the bus and the circuit breaker can be closed.

Phase Angle

This adjustment is located in the front of the unit, top left corner below the stability adjustment. The potentiometer adjusts the phase angle differential and its range is from $\pm 5°$ to $\pm 20°$ (Turning the potentiometer clockwise increases the differential). This adjustment determines the premissible phase angle differential between the incoming generator and the bus. For example, if the pot is adjusted for $\pm 10°$ differential, the Auto-Synchronizer will close its contact as soon as the generator frequency is within 10° of being in phase with the bus (Provided, of course, that the frequency and voltage are within the synchronizing limits.

Time Delay

The Auto-Synchronizer has a built-in option to provide a one second time delay prior to energizing the circuit breaker contacts on terminals 8, 9 and 10. The synchronizer is shipped with the time delay in the circuit. To remove the time delay in the circuit, it is necessary to cut the red jumper on the printed circuit board. Turn the Auto-Synchronizer over so that the printed circuit board is visible. The red jumper is in the right center of the board. Simply cut the jumper.

When the jumper is NOT cut, the synchronizer will wait one second after achieving synchronization, before energizing the output relay.

Maintenance and Troubleshooting

The synchronizer requires no maintenance or upkeep to provide years of trouble-free operation.

For self-protection, the synchronizer has two fuses. Both fuses are of the slow-blow type and have a rating of 1/2 AMP. They protect the synchronizer relay from surges that may occur in the input from the bus and incoming generator voltages.

The Automatic Synchronizer is a solid-state device and it is recommended that the PC board not be tested or repaired in the field.

Visual Inspection

Before starting the test, perform the following inspection:

1. Check both fuses to be sure they are not open.
2. Visually inspect the printed circuit board for burned, loose or broken components.
3. Visually inspect the relay contacts. Look for burned contacts or contacts welded together.

Simple Synchronizing Test

1. Connect proper AC (can be either 50 or 60 Hz) voltage to terminals 1 and 2. Connect a jumper from 1 to 3 and a jumper from 2 to 4.
2. Connect a jumper from 12 to 13.
3. The contact between terminals 9 and 10 should close. All LED lights should be "Off".
4. Remove jumper between 12 and 13. Contact between terminals 9 and 19 should open.
5. Connect a jumper between 11 and 12. The contact between terminals 9 and 10 should close. All LED lights should be "Off".
6. Remove jumper between 11 and 12. Contacts between terminals 9 and 10 should open.

The above test indicates that the synchronizer comparison level circuits are functioning properly.

Troubleshooting Procedures

Problem	Probable Cause	Corrective Action
Synchronizer does not correct frequency.	Generator or bus voltage not present.	Check voltage on synchronizer at bus and generator terminals.
	Wrong bus and/or generator voltage level.	Check wiring.
	Generator free running frequency too far from bus frequency, ±3 Hz.	Adjust governor to correct generator's frequency.
Frequency correction unstable.	Summing point connected to wrong terminal on synchronizer.	Check wiring.
	Shield of twisted pair shielded wire is ungrounded or not used.	Check wiring.
	Gain range jumper not correct.	Adjust gain range per instruction manual.
	Governor unstable.	Consult governor manual.
Synchronizer gives sync command, but no breaker closure occurs.	Improperly wired sync contacts.	Check wiring.
Synchronizer won't give sync command.	Generator and bus voltage are not the same.	Check voltages and correct.
Synchronizer phase locks generator 180° out of phase.	Either bus voltage or generator voltage polarity is reversed.	Correct wiring.
Generator frequency runs away high or low.	Summing point connections are backwards.	Check wiring.
	Connections of bus and on-coming generator inputs to synchronizer are reversed.	Check wiring.
Synchronizer gives breaker closure too far away from 0° phase angle.	Phase angle adjustment out of calibration.	Check phase angle adjustment.

Cummins Digital Isochronous Load Sharing Module (8-03)

The Cummins digital isochronous load sharing module has Reverse Power and Forward Power relay outputs and an analog Forward Power Monitoring output. It is compatible with NO & NC EFC governors. The unit provides proportional division of a common load between multiple engine generator sets while maintaining a fixed frequency on an isolated bus. The unit also has the capability of providing electrical load droop and the load pulse features if required on an application.

Features

- Isochronous load sharing
- Reverse Power relay output
- Forward Power relay output
- Forward Power Monitoring analog signal
- Internal paralleling line relay
- Load pulse
- Droop operation capability

Typical Applications

which requires any of the following:

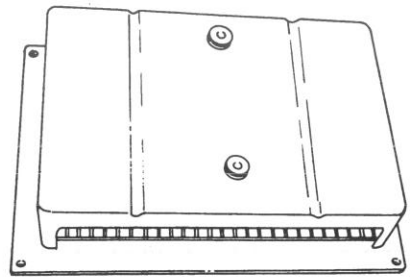
- Isochronous load sharing between two or more generator sets.
- Single or multiple unit peak shaving applications.
- Droop load sharing when paralleling with an infinite bus.
- Reverse or Forward power output contact signals.
- Analog signal for forward power monitoring of a system.
- Improvement of off-speed transient response by using the load pulse feature.

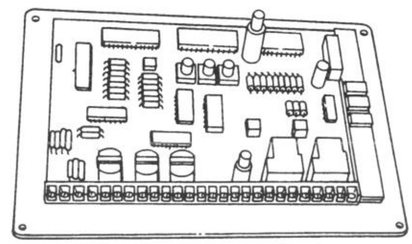
Multi-gen Set Capability

The ILS Control will enable a common load to be proportionately shared among any number of engine generators in a system. The generators need not have the same kilowatt ratings. All generators in the system will assume equal percentages of the load capacity.

Operation

The ILS Control compares the load on its generator to that on other generators in the same system and signals the governor to increase or decrease engine fuel to maintain its proportional share of the total system load. Current input signals from each of the three generator phases are summed to determine the actual kilowatt load for each generator. Each generator set's load is compared to all other loads and any difference from desired load sharing commands the EFC governor to change fuel so that load is proportionately shared.





Models Available

240 to 480 VAC ±20%

Specifications

- Voltage input: 3 Phase, 115 to 230 VAC or 240 to 480 VAC ±20% line-to-line. 50 to 60 Hz. (See available models)
- Current input: 3 Phase, 2.5 to 5.0 Amperes per phase at maximum generator load.

0.32 Va burden per phase on each current transformer at 2.5 Amperes.

1.25 Va burden per phase on each current transformer at 5.0 Amperes.

Load sharing setability (Accuracy)

Adjustable to ±0.5% between sets of equal size at full load.

Output (Dependent on load gain adjustment)

1. Test jacks: 6.0 Vdc typical at full load.
2. Paralleling line: 3.0 Vdc typical at full load.
3. Speed correcting signal: Compatible with standard EFC controllers.
4. Reverse power relay contacts - Normally closed.

   10 Amperes resistive @115 Vac (U.L. Approved)

   5 Amperes resistive @ 230 Vac
5. Forward power relay controls - Normally open.

   10 Amperes resistive @ 115 Vac (U.L. Approved)

   5 Amperes resistive @ 230 Vac
6. Forward power monitor: 0-2 VDC or 0-2 ma DC analog signal with full scale accuracy of 1%. Minumum meter movement of 1,000 ohms.

Adjustments

1. Current transformer calibration: Calibration to correct for variation in current obtained from the current transformers. Clockwise increases the output signal obtained at the test points.
2. Load sharing gain: Test point signal. Clockwise increases signal voltage at test points. Clockwise will decrease percentage of load carried by the generator.
3. Droop: 0 to 10% - clockwise increases droop setting.
4. Load pulse: Clockwise increases load pulse output.
5. Reverse power relay trip piont: Clockwise increases trip point. Trip point is adjustable with a range of 0% to 40% of full load. The trip point has an inverse time constant which decreases relay trip time on larger reverse power levels.

   Examples:

   - Trip time with a reverse power of 5% over setpoint, is approximately 20 seconds.
   - Trip time with a reverse power of 40% over setpiont, is approximately 5 seconds.
6. Forward power relay trip points:

   On point, Clockwise to increase, independent of "Off" point, adjustable with a range of 20 to 120% of full load.

   Off Point, Clockwise to increase, independent of "On" point, adjustable with a range of 10 to 100% of full load.
7. Forward power monitor gain: Clockwise to increase analog output signal, adjustable range of 0-2 VDC or 0-2 ma DC minimum at full load.

Environmental

Ambient operating temperature: -40° C [-40° F] to 85° C [185° F].

Enclosure: The ILS module is one compact assembly. The module cover is a sturdy non-conductive plastic that is secured to the module by two knurled nuts. The module is designed for behind-the-panel mounting.

Mounting: Attitude at any position.

Vibration: Withstands the following vibration without failure or degraded performance. 0.06 inch double amplitude at 5 to 18 Hz; 1G at 18 to 30Hz; 0.02 inch double amplitude at 30 to 38 Hz; 2.5 G's at 48 to 70 Hz.

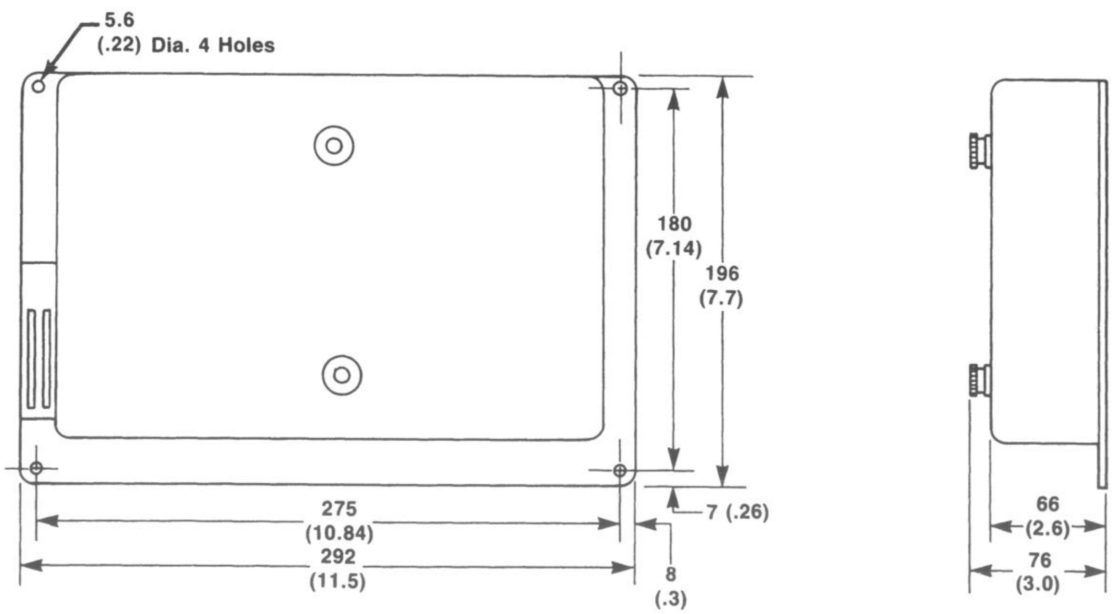
Shock: Withstands 15 G's in each of three mutually perpendicular axes.

Humidity: Will operate properly through condensing conditions.

Manual:

Typical wiring diagram:

Weight: 1.25 Kg [2.75 lbs].



Application Information

Cummins Auto-Synchronizer

The Cummins Auto-Synchronizer (P.N. 3058501) can be used with the Cummins governor and Cummins Digital Isochronous Load Sharing Control to automatically synchronize one generator with another or with a bus. The Auto-Synchronizer eliminates the risk of operator error inherent with manual synchronizing.

Figure 2 illustrates the wiring of two engine generator sets having Cummins governors, and Cummins Digital Isochronous Loading Sharing Controls and Cummins Auto-Synchronizers. Additional engine generator sets can be paralleled by wiring them at the point designated, PARALLELING LINES TO OTHER SYSTEMS.

It is recommended that an independent overspeed shutdown device be incorporated in every engine control system.

NOTES

1. Systems battery supply. If more than one engine is started using the same battery supply, use separate battery supply for each System. Twist power leads as shown. Use shielded leads as shown.
2. Select current transformers to provide 2.5 to 5.0 amps at full rated load. Current transformers require nominal 0.32 VA/PHASE at 2.5 amps, 1.25 VA/PHASE at 5.0 amps.
3. Observe current transformer polarity markings when connecting.
4. Power switch current rating: 10 amps.
5. Phasing of potential to Terminals 1, 2 and 3 is necessary to keep each signal in its correct phase relationship. If the generator voltage is not the same as the voltage range on Terminals 1, 2 and 3 of the Isochronous Load Sharing Control, a step-down transformer is required. Correct phasing of the transformer leads is necessary. Step-down transformers require nominal 1 VA/PHASE.
6. Droop/Isochronous switch is not required if units are always operated in Isochronous mode.
7. Cummins ILS: 230/480 Vac input-50/60 Hz.
8. Controller: 3037359 N.O., 3044196 N.C.
9. Actuator: EFC Fuel Valve.
10. If "Load Pulse" function is not being used, the "Load Pulse" Potentiometer must be set fully counterclockwise.
11. The Gain Range-(Response) Adjustment. See Paragraph 4.1 and 4.1.1 in Manual (F-19300-2).

    No Jumper 6 to 14: Auto-Synchronizer is set for fast responding engines.

    With Jumper 6 to 14: Auto-Synchronizer is set for slow responding engines.
12. a. Closing a contact or jumpering 11 to 12 allows the Auto-Synchronizer to perform as a sync check relay only, with circuit breaker contact output but no control on the incoming generator.

    b. Closing a contact between 12 to 13 allows the Auto-Synchronizer to perform as a speed matching unit. The speed and phase of the incoming generator are controlled and contact is closed to drive circuit breaker. Once the circuit breaker is closed the contact between 12 and 13 should be opened.

    c. Open contacts or no jumper 11 to 12 or 12 to 13 allows the Auto-Synchronizer to still sense any error but it does not provide any control or contact closures.
13. Step-down transformers require nominal 10 VA/PHASE.

Typical Wiring Diagram When Using a Cummins Digital ILS Unit and a Cummins Controller and EFC Fuel Valve and Cummins Auto-Synchronizer Cummins Engine Company's Controller Part Number 3037359 Normally Open or 3044196 Normally Closed

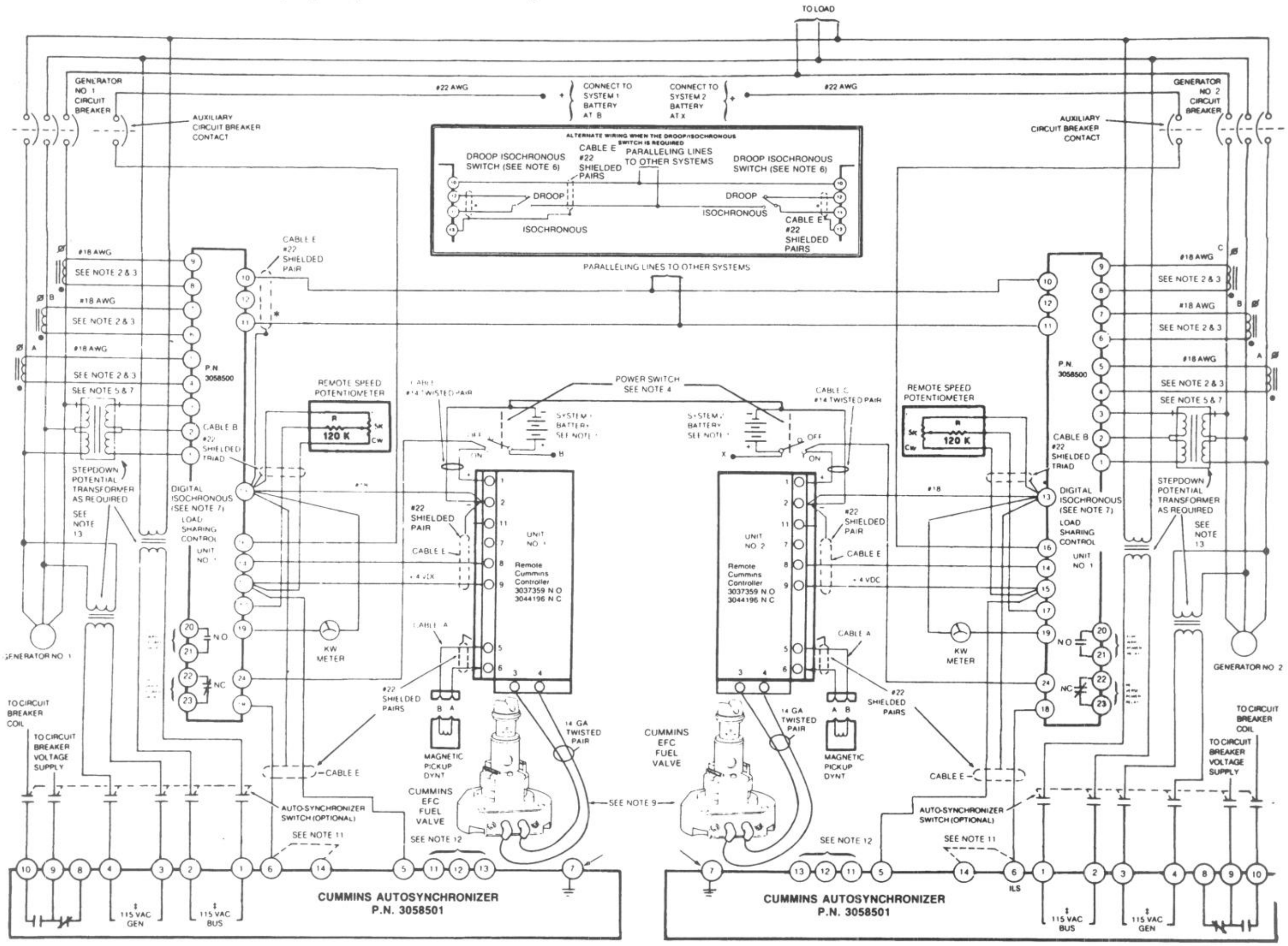


Figure 2.

Application Information

Cummins Digital Isochronous Load Sharing Control

The Cummins Digital Isochronous Load Sharing Control can be used with the Cummins EFC governor to provide control of an engine generator set by maintaining preset engine speed or proportional sharing of load between similar or dissimilar generators. Both droop and isochronous modes can be selected.

Figure 1 illustrates the wiring of two engine generator sets having Cummins governors and Digital Isochronous Load Sharing Controls. Additional engine generator sets can be paralleled by wiring them at the point designated, PARALLELING LINES TO OTHER SYSTEMS.

It is recommended that an independent overspeed shutdown device be incorporated in every engine control system.

NOTES

1. Systems battery supply. If more than one engine is started using the same battery supply, use separate battery supply for each System. Twist power leads as shown. Use shielded leads as shown.
2. Select current transformers to provide 2.5 to 5.0 amps at full rated load. Current transformers require nominal 0.32 VA/PHASE at 2.5 amps 1.25 VA/PHASE at 5.0 amps.
3. Observe current transformer polarity markings when connecting.
4. Power switch current rating: 10 amps.
5. Phasing of potential to Terminals 1, 2 and 3 is necessary to keep each signal in its correct phase relationship. If the generator voltage is not the same as the voltage range on Terminals 1, 2 and 3 of the Isochronous Load Sharing Control, a step-down transformer is required. Correct phasing of the transformer leads is necessary. Step-down transformers require nominal 1 VA/PHASE.
6. Droop/Isochronous switch is not required if units are always operated in the Isochronous mode.

Typical Wiring Diagram When Using a Cummins Digital ILS Unit and a Cummins Controller and EFC Fuel Valve

Cummins Engine Company's Remote Controller Number 3044196 Normally Closed or 3037359 Normally Open

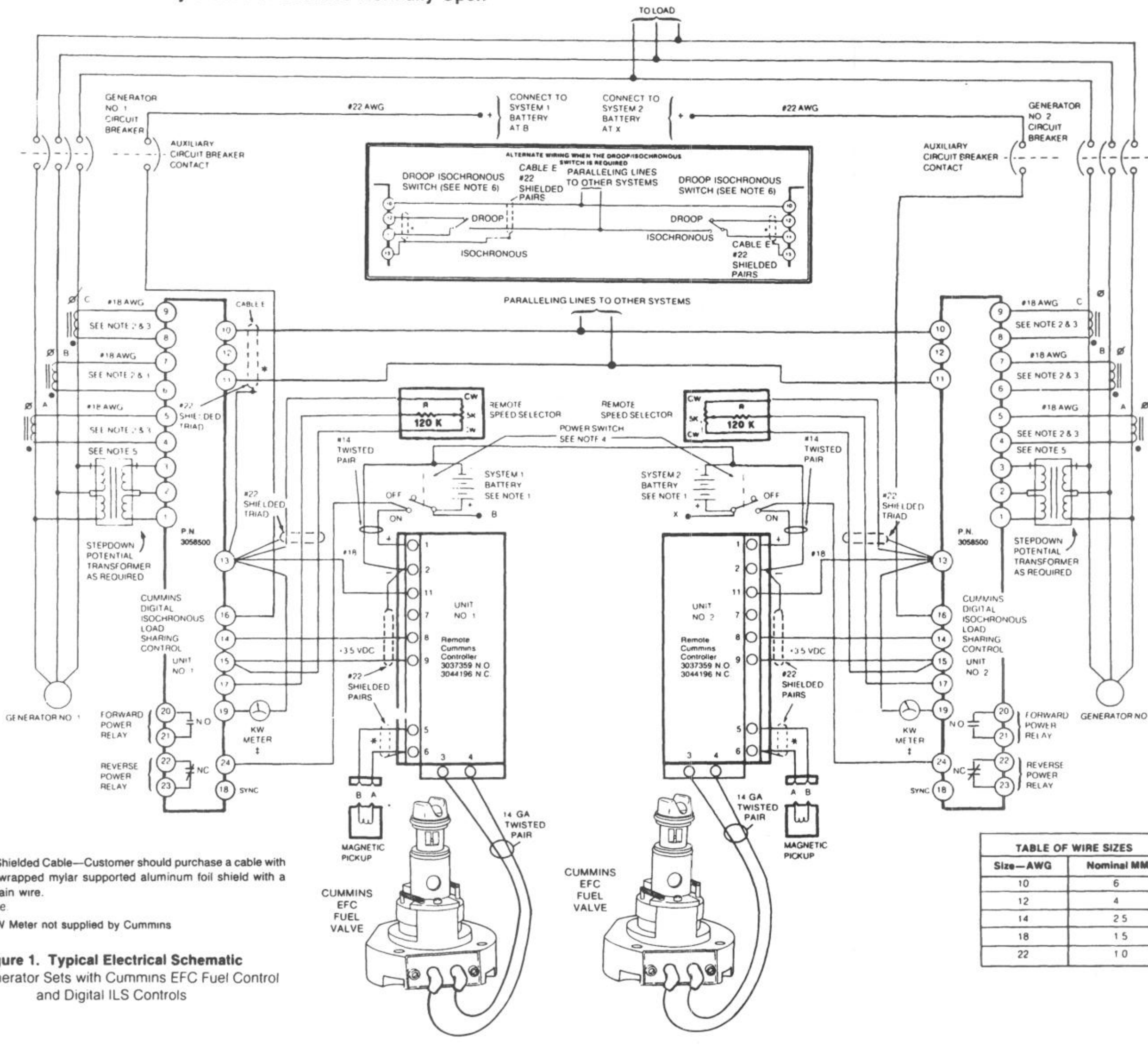


TABLE OF WIRE SIZES	
Size—AWG	Nominal MM²
10	6
12	4
14	2.5
18	1.5
22	1.0

*Shielded Cable—Customer should purchase a cable with a wrapped mylar supported aluminum foil shield with a drain wire.
wire.

‡ KW Meter not supplied by Cummins

Figure 1. Typical Electrical Schematic
Two Generator Sets with Cummins EFC Fuel Control and Digital ILS Controls

Installation Checkout

Following completion of system wiring and before starting the engine/generator, perform the checkout procedure to assist in verifying that the ILS unit is operational. These checks provide an indication of the unit's operating capability.

1. Remove the ILS module cover
2. Visual inspection
   a. Check all wiring for loose connections or broken wires.
   b. Check wiring to verify it agrees with the system wiring diagram.
   c. Repair or correct wiring before starting engine/generator.
3. ILS initial potentiometer settings
   a. Set "L. S. Gain" potentiometer fully clockwise.
   b. Set "Droop" potentiometer fully counterclockwise.
   c. Set forward power on, potentiometer fully clockwise.
   d. Set forward power off, potentiometer fully clockwise.
   e. Set reverse power potentiometer fully clockwise.
   f. Set "load pulse" potentiometer fully counterclockwise. Note: Balance potentiometer is factory set.
4. If remote speed potentiometer is used, set it to mid-range.

   (the 3015105 potentiometer is a 10-turn unit.)

   *If the unit nust be set up against an infinite bus, then set "the droop" potentiometer at mid-range for a starting point.
5. Check the EFC controller and if necessary, set potentiometers as called out on the calibration and adjustments for the EFC controller.

   CAUTION: Current transformers must be connected to burden resistors. Do not operate engine/generator when any leads are removed from terminals 4, 5, 6, 7, 8 or 9 of the ILS module. Current transformers can develop dangerously high voltages when they are operated into an open circuit.
6. Start the engine.
   a. The idle/run switch should be in the run position.
   b. If the actuator does not allow the fuel system to open far enough to allow engine to start, the "Speed" potentiometer will have to be adjusted clockwise to increase the speed setting.
   c. Adjust the EFC controller's internal "Speed" potentiometer until the engine/generator is operating at the correct RPM for generating the desired generator output frequency.
   d. Calibrate the EFC controller per the calibration and adjustment sheet for the controller.
   e. Once engine/generator is running stable, proceed to Step 7, ILS Voltage and Current Phasing Check.
7. ILS Voltage and Current Phasing Check
   a. Start engine/generator and load unit to as near full load as possible with a unity power factor load. Keep load constant and balanced.
   b. Connect DC voltmeter to TP1 and TP2 test jacks. See Figure 2 in the Installation Section. The red jack is plus and the black jack is minus. The positive lead of the voltmeter goes into the red jack.

      Adjust the C.T. CAL potentiometer to achieve 7.5 VDC at the test points. Clockwise increases test point voltage; counterclockwise decreases test point voltage.

      CAUTION: Current transformers must be connected to burden resistors. Do not operate engine/generator when any leads are removed from terminals 4, 5, 6, 7, 8 or 9 of the ILS module. Current transformers can develop dangerously high voltages when they are operated into an open circuit.
   c. Stop the engine. Check for correct phasing of the voltage and current inputs to the ILS module by placing a jumper between terminals 4 and 5 (Phase A). Restart the engine and apply the load. The voltage at test jacks TP1 and TP2 should drop by 1/3. Stop the engine. Remove jumper from between terminals 4 and 5.

      Repeat procedure for terminals 6 and 7 (Phase B) and terminals 8 and 9 (Phase C). Each time the voltage should drop by 1/3. If the above conditions are not obtained, proceed with the next step to establish the correct phase relationship for the potential and current transformer connections. If the phase wiring is correct proceed to Step H.

      Note: Improper wiring of the three-phase current and voltage inputs causes most parallel load sharing difficulties. The voltage of one phase is often wired with the current signal of another phase or transformers are wired in backwards so that the two signals oppose rather than add to each other.
   d. Stop the engine. Recheck the wiring. Make certain all CTs are phased identically and that the voltage at terminal 1 comes from the same phase as the CT connected to terminals 4 and 5. Terminal 2's voltage connection should be from the same phase as the CT connected to terminals 6 and 7, and terminal 3's voltage should be from the same phase as the CT connected to terminals 8 and 9. Correct any mistakes and repeat steps A through C, recording the voltage at the test points for each step.

e. Stop the engine. If the test point voltage is negative, but still drops by one-third when the jumper is applied to each CT connection, then all CTs are phased backwards. Terminals 4 and 5, 6 and 7, 8 and 9 should be reversed. If the jumper causes any test point voltage to increase then it is likely that phase is backwards.

f. To determine if all CTs are functioning, the voltage across the ILS's burden resistors can be read. This voltage should be .05 ohms x secondary current. Check that the CT ratio is correct for your generator.

g. When proper power measurement is achieved, proceed to Step h.

h. Start the engine and load the generator to 100% load. Then adjust the ILS module "C.T. CAL" potentiometer for 7.5 VDC at TP1 and TP2. The following table can be used for setting TP1 and TP2 if 100% load cannot be obtained.

% Load	TP1 to TP2 DC Voltage
80	6.00
50	3.75
20	1.50

i. Do not adjust the C.T. CAL potentiometer again. It may be desirable to apply an adhesive such as RTV to make further adjustment more difficult. .

j. Next, with the same load applied, turn the L. S. GAIN potentiometer CCW until the test point voltage drops to 8/10 of its previous value.

k. At unity power factor measure the generator KW output or calculate it based on voltage and current readings.

The ILS current transformer burden resistors are .05 ohms. Phase currents can be determined by measuring the voltage across the burden resistors and calculating the current transformer current,

$$\frac{V_{burden}}{.05} = \text{C.T. current}$$

and scaling upward by the current transformer step down ratio.

With a 1.0 power factor load, KW can be calculated with the following equation:

$$KW = \frac{1.732 \times V_{LL} \times (I_A + I_B + I_C)}{3 \times 1000}$$

The power monitor output has a range of 0-5 volts D.C. or 0-5 ma for 100% load and the test points at 7.5 volts. Adjust the "P.M. Gain" potentiometer to provide the correct KW reading on your meter. Lock the "P.M. Gain" potentiometer with adhesive.

l. Continue with the other adjustment as necessary in Steps 8, 9, 10 and 11.

8. ILS "Droop" Potentiometer Adjustment

a. Turning the "Droop" potentiometer clockwise increases the percentage of droop. The "Droop" potentiometer sets the amount of speed regulation for the prime mover. The "Droop" potentiometer biases the wheatstone bridge in a direction to cause the speed to decrease with an increase in load. Percent of droop is the difference in engine speed at no load with respect to engine speed at full load expressed as a percentage. The ratio of full load capacity to actual load must be taken into consideration when the load does not have a unity power factor. To set droop, proceed with the following steps.

b. Set Droop/Isochronous switch to droop position. If switch is not used, make sure ILS terminal 11 is connected to terminal 12.

c. Set ILS "L. S. GAIN" potentiometer to obtain 6V at TP1 and TP2 at full load. This voltage TP1 and TP2 must be set to the same value on all engines in the same system.

Note: If stability problems are evident during paralleling, reduce the voltage at the TP1 and TP2 by turning the L.S. GAIN CCW. This reduction MUST be done on all ILS modules. All test point voltages MUST be equal at full load.

d. Set "Droop" potentiometer to provide desired percentage of droop.

e. Operate engine/generator at correct frequency of 51.5 or 61.8 Hz no load and record Hz reading. This is frequency F1.

f. Load engine/generator to full load and record Hz reading. This is frequency F2.

g. Calculate droop as shown below:

$$\%\ \text{Droop} = \frac{F1 - F2}{F2} \times 100$$

h. The above procedure may have to be repeated several times to obtain the desired percentage of droop.

9. ILS "Load Pulse" Potentiometer Adjustment

Note: If "Load Pulse" function is not being used, the "Load Pulse" Potentiometer must be set fully counterclockwise.

a. Turning the "Load Pulse" potentiometer clockwise increases the amplitude of the load pulse signal. The load pulse sensor provides a pulse output to the amplifier when a step change in load on the generator occurs.

b. The "Load Pulse" adjustment should be set to provide the minimum pulse necessary to meet the required transient response of the system.

c. Set "Load Pulse" potentiometer fully counterclockwise.

d. If a recording of transient response is necessary, connect recorder to engine/generator under test.

e. Apply and reject load per requirement.

f. Increase the "Load Pulse" potentiometer and repeat step "E" until the offspeed transients meet the limits specified.

10. Forward power On and Off point adjustment

a. The forward power On and Off points can be approximately set without starting the engine. The Off point must be lower than the On point, and if having Off and On points close together is desirable, proceed to step b.

FP ON		FP OFF	
Full CCW	Full CW	Full CCW	Full CW
20%	120%	10%	100%

If no relay closure is desired, set both adjustments fully CW.

b. Turn the forward power On potentiometer fully CW.

c. Turn the forward power Off potentiometer fully CCW.

d. Start the engine and load it to the desired forward power On point. Slowly turn the forward On potentoimeter CCW until the forward power relay closes. The forward power On potentiometer is now set.

e. Reduce generator loading to the desired forward power Off point. Slowly turn the forward power Off potentiometer CW until the forward power relay opens again. The forward power Off potentiometer is set. It may be desirable to lock both settings with an adhesive to prevent further adjustment.

Stop the engine.

11. Reverse power level adjustment

a. The reverse power relay trip point can be approximately set without starting the engine. Its range of adjustment is 0% to 40% of generator load with 40% being fully clockwise.

b. If more precise adjustment is needed the generator can be loaded to the reverse power level desired by turning the frequency adjustment pot of the paralleled unit being checked down, and the RPL potentiometer slowly turned CCW until the reverse power relay opens.

Reverse power level must be monitored at the test points. The power monitor output does not indicate reverse power.

c. If the generator cannot be loaded into a reverse power condition, simulated reverse power can be used for calibration. Swap the CT leads at terminals 4 and 5, 6 and 7, and 8 and 9. Load the generator to the desired reverse power level but in forward power. Slowly turn the RPL potentiometer CCW until the reverse power relay opens. It may be wise to lock this adjustment also. Stop the engine and be sure to correct Terminals 4 and 5, 6 and 7, and 8 and 9.

Cummins

1400 73rd Avenue N.E.
Minneapolis, Minnesota
55432

Form 960-0503
11-89
Printed in U.S.A.