FLIP CHART PROGRAM

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KOHLER ON TARGET TRAINING

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- VERTICAL CRANKSHAFT ENGINES
- DYNAMIC BALANCE SYSTEM

KOHLER CO., KOHLER, WISCONSIN

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CRANKING SYSTEMS

Two basic types of electric starting systems are used on the Kohler Single Cylinder Engines. One system uses a motor-generator which functions as a starting motor during cranking and also as a DC generator after the engine is running. The motor-generator is coupled to the engine through a V belt-pulley drive arrangement. The other system uses a compact starting motor which engages and disengages with engine through a Bendix type drive. Since the source of energy for both types is a 12 volt storage battery, the battery can be discussed first.

BATTERY

Storage batteries are usually of the lead-acid type. Lead is used in the construction of the cell-plates and sulfuric acid serves as the electrolyte. "Wet" batteries are filled with electrolyte and are stored ready to use provided satisfactory charge has been maintained. With "dry charged" batteries, the plates are charged but an electrolyte of specific grade must be added just before using. Both types function in the same general way.

The typical 12 volt battery has a hard rubber case with six individual compartments or cells. Each cell contains a specific number of sets of negative and positive plates. Generally the greater the number of plates per cell, the higher the ampere-hour rating of the battery. All plates of like charge are interconnected so that the accumulative charges are present at the positive and negative terminals of the battery.

Voltage Test: With a battery in good condition, each cell contributes approximately 1.95 to 2.08 volts. If battery charge is low and less than 0.05 volt difference is noted between the highest and lowest cells, the battery may be recharged. If this difference is more than .05 volts, this could indicate a cracked plate or other damage which could call for replacement of the battery.

Specific Gravity Test: As a battery discharges and the energy is not replenished, sulfuric acid is chemically withdrawn from the electrolyte and lead sulfate deposits continue to build up on the plates. This results in a diminishing specific gravity of the electrolyte. If the specific gravity drops below 1.240, the battery should be recharged. In fully charged condition, the specific gravity will be in the 1.260 - 1.280 range. In tropical areas where the temperature stays well above freezing, an electrolyte with lower specific gravity is often used--full charge specific gravity of this is 1.225.

As a battery is recharged, a reverse chemical reaction takes place which causes the lead sulfate deposits to be changed back to lead, lead dioxide and sulfuric acid. In effect, this reverses the discharge reaction and restores the materials to active condition. If sulfate deposits become too great or if the level of the electrolyte is not maintained above the level of the plates, the battery may be permanently damaged.
CAUTION: As a safety precaution, adequate ventilation must be provided when batteries are being recharged. In addition, sparks, open flames and smoking should be avoided since hydrogen gas is produced which, if ignited, can cause an internal explosion that can shatter the battery. This gas is produced in quantity only while the battery receives high rate of charge but can linger for several hours in a poorly ventilated area.

Service: To maintain battery in top condition, check and perform the following services at frequent intervals:

1. Regularly check level of electrolyte--add water as necessary to maintain level above plates--do not overfill as this can cause poor performance or early failure due to loss of electrolyte.

2. Keep terminals and top of battery clean. Wash with baking soda and rinse with clear water. Do not allow soda solution to enter cells.

3. Check other electrical components if battery repeatedly becomes discharged.

MOTOR — GENERATOR

A motor-generator is a single unit combining characteristics of both a motor and a generator. As a motor, it functions to convert electrical energy into mechanical energy to crank an engine for starting. As a generator, it functions to convert mechanical energy into electrical energy to recharge the battery.

Operation: These units feature both series (cranking) and shunt (generating) windings. The cranking winding, which is in series with the armature, consists of heavy gauge, low resistant wire to carry as high a current as possible. When cranking, the current from the battery is allowed to flow through

this circuit thus creating a high density magnetic field which interacts with the armature windings and forces the armature to rotate. The shunt field also contributes during starting. After the engine starts and the starting switch opens to break the cranking circuit, the unit functions as a conventional generator with the shunt field producing energy for recharging.

Motor generators mounted at front (flywheel) end of engine rotate in clockwise direction--units mounted at rear (PTO) end rotate in the reverse or counterclockwise direction when viewed from pulley end. Units with 10, 12, and 15 amp charging capacities are used depending on the engine model and application. 10 and 12 amp units are most common.
CAUTION: Never operate the motor-generator during cranking for more than 30 seconds at a time without pausing to allow it to cool for at least 2 minutes. Overheating, caused by excessively long cranking periods, may seriously damage motor-generator.

Service: At periodic intervals, units should be inspected to determine condition. Operating the unit in excessive dust or dirt, at high temperatures or continuously at full output are factors which increase bearing, commutator and brush wear. Frequent cranking due to numerous starts and stops, excessively long cranking periods caused by hard-starting engine conditions, excessively dirty or moist operating conditions or heavy vibration makes servicing necessary at frequent intervals. Service should include checking motor operation, check of the mounting, wiring and connections--all should be tight and in good condition.

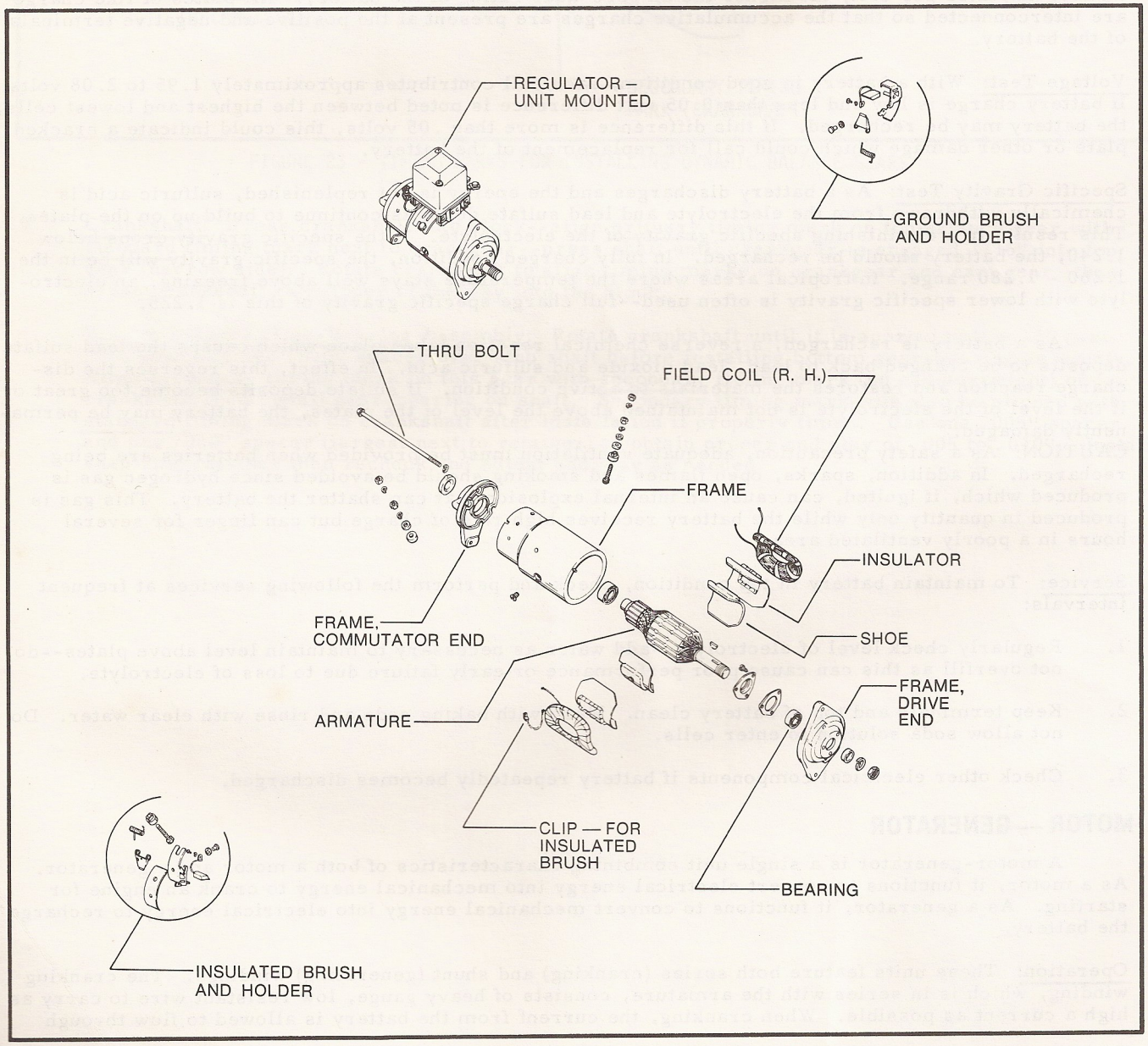


FIGURE 1 - MOTOR-GENERATOR, EXPLODED VIEW

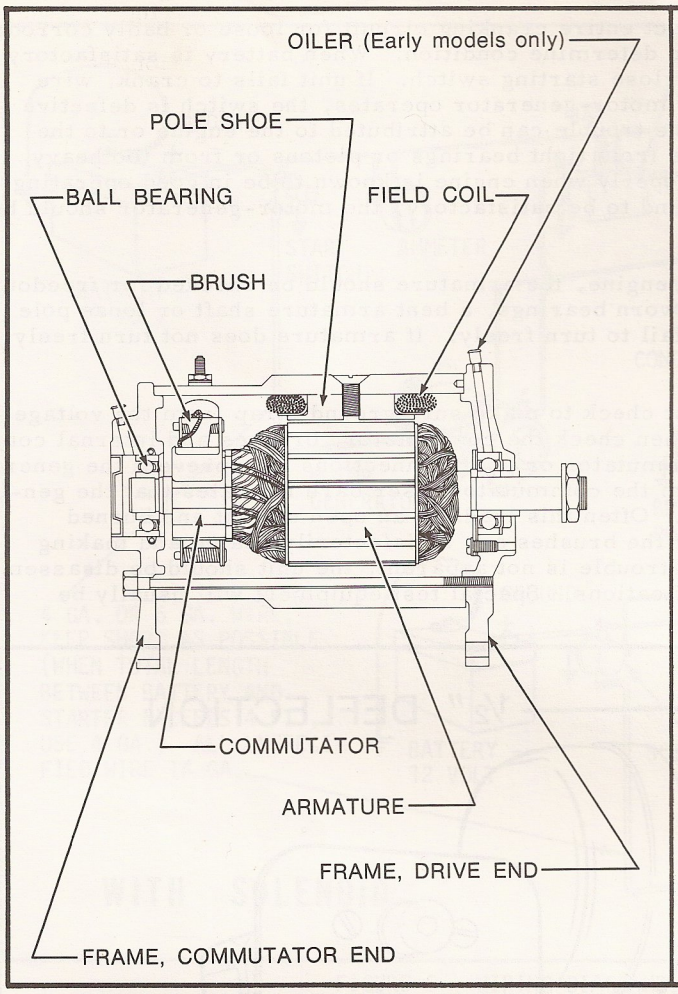


FIGURE 2 - MOTOR-GENERATOR, CUTAWAY VIEW

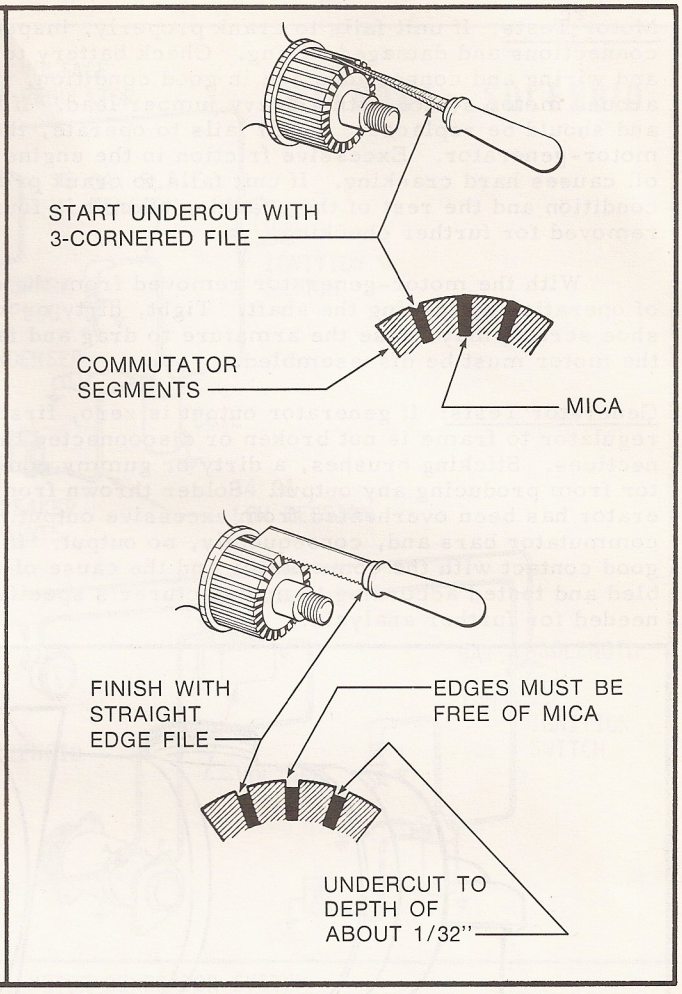


FIGURE 3 - UNDERCUTTING MICA ON COMMUTATOR

Brushes should be checked about every 200 hours--inspection can be made by removing the two thru bolts and CE frame. Brushes must be at the proper angle and in good firm contact on the commutator. Excessive spring tension will cause rapid brush and commutator wear. Insufficient tension will result in arcing and burning of the brushes and commutator. Correction in tension can be made by bending the brush spring as required. If brush spring shows evidence of overheating (blued or burned), a new spring should be installed. If brushes are worn down to 1/2 their original length, they should be replaced.

If commutator is glazed or dirty, it can be cleaned by placing armature in a lathe. While armature is rotating, hold a strip of #00 sandpaper lightly against commutator, moving sandpaper back and forth. Blow out all dust after sanding. If commutator is rough, out of round, has high mica or is extremely dirty, it should be turned down on a lathe and the mica should also be undercut between the bars. Start undercut with 3 cornered file and finish with straight edge file (or hacksaw blade)--make sure no mica remains on the inside edges of the commutator segments.

V belt should be checked to be sure it is in good condition and has correct tension. Low belt tension will permit belt slippage and result in rapid belt wear and either low or erratic generator output. Excessive belt tension will also cause rapid belt wear. Tension should be adjusted so that belt can be depressed 1/2" below tops of both pulleys at the approximate center of the upper span as shown in the accompanying illustration. To adjust, loosen capscrew holding motor-generator unit to upper bracket then shift position of unit until proper tension is obtained. Retighten capscrew after adjustment.

Lubrication: The hinged cap oilers on earlier units should be filled with 8 to 10 drops of light engine oil every 100 hours of motor-generator operation. Some ball bearings are greaseless and are lubricated by an oil-saturated felt pad. Upon disassembly of the unit, the felt pad should be resaturated with light grade engine oil. Do not pack this type ball bearing with grease. All other ball bearings (without felt pad) should be cleaned and repacked with ball bearing grease upon disassembly of the motor-generator. The armature shaft should be wiped clean and coated with a light grade engine oil.

Motor Tests: If unit fails to crank properly, inspect entire cranking circuit for loose or badly corroded connections and damaged wiring. Check battery to determine condition. When battery is satisfactory and wiring and connections are in good condition, close starting switch. If unit fails to crank, wire around motor switch with a heavy jumper lead. If motor-generator operates, the switch is defective and should be replaced. If unit fails to operate, the trouble can be attributed to the engine or to the motor-generator. Excessive friction in the engine from tight bearings or pistons or from too heavy oil causes hard cranking. If unit fails to crank properly when engine is known to be in good operating condition and the rest of the cranking circuit is found to be satisfactory, the motor-generator should be removed for further checking.

With the motor-generator removed from the engine, the armature should be checked for freedom of operation by turning the shaft. Tight, dirty or worn bearings, a bent armature shaft or loose pole shoe screws may cause the armature to drag and fail to turn freely. If armature does not turn freely, the motor must be disassembled.

Generator Tests: If generator output is zero, first check to make sure ground strap from the voltage regulator to frame is not broken or disconnected then check the commutator, brushes and internal connections. Sticking brushes, a dirty or gummy commutator or poor connections may prevent the generator from producing any output. Solder thrown from the commutator riser bars indicates that the generator has been overheated from excessive output. Often this leads to an open circuit and burned commutator bars and, consequently, no output. If the brushes are satisfactorily seated and making good contact with the commutator and the cause of trouble is not apparent, the unit should be disassembled and tested according to manufacturer's specifications. Special test equipment will usually be needed for further analysis.

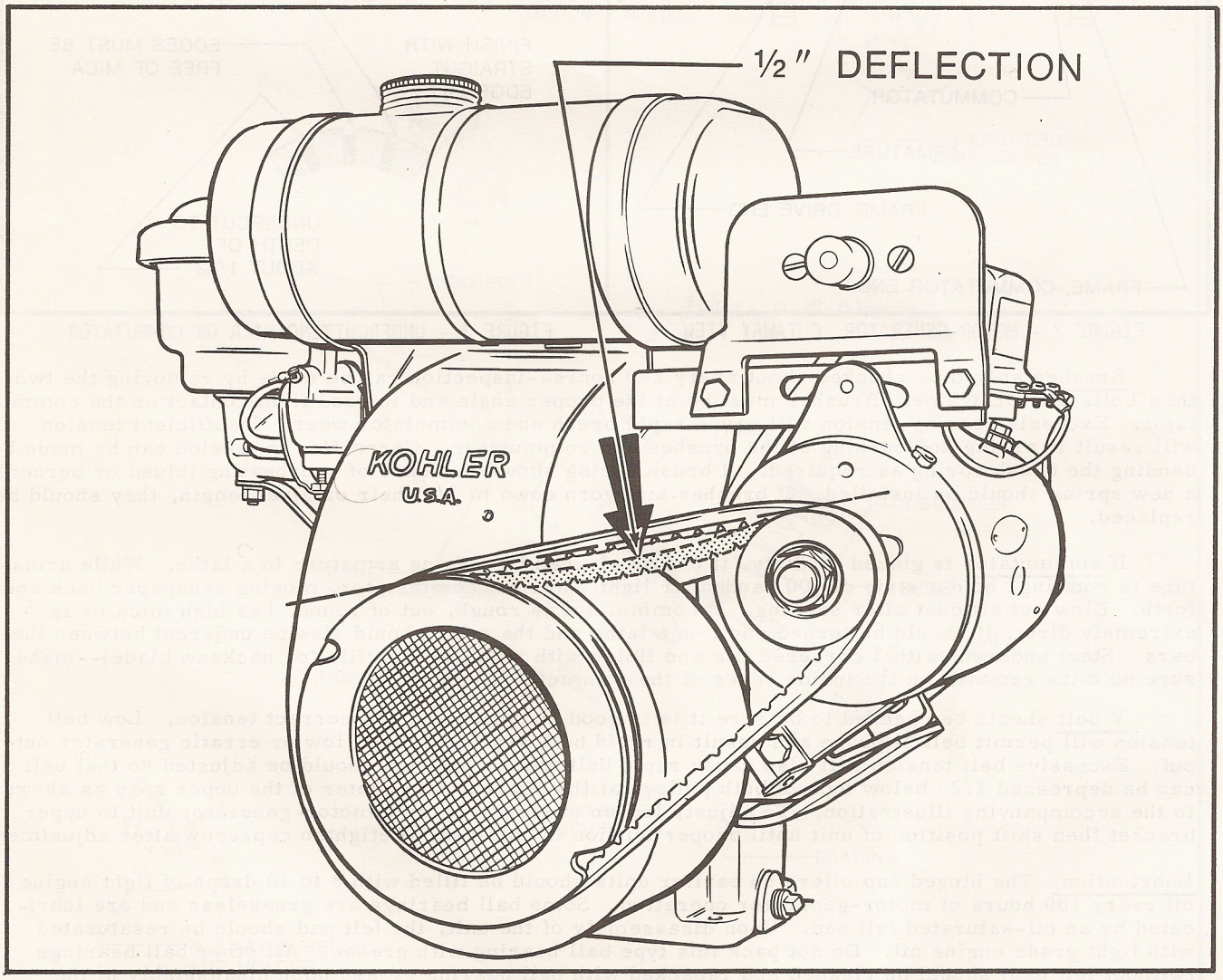


FIGURE 4 - PROPER V BELT TENSION

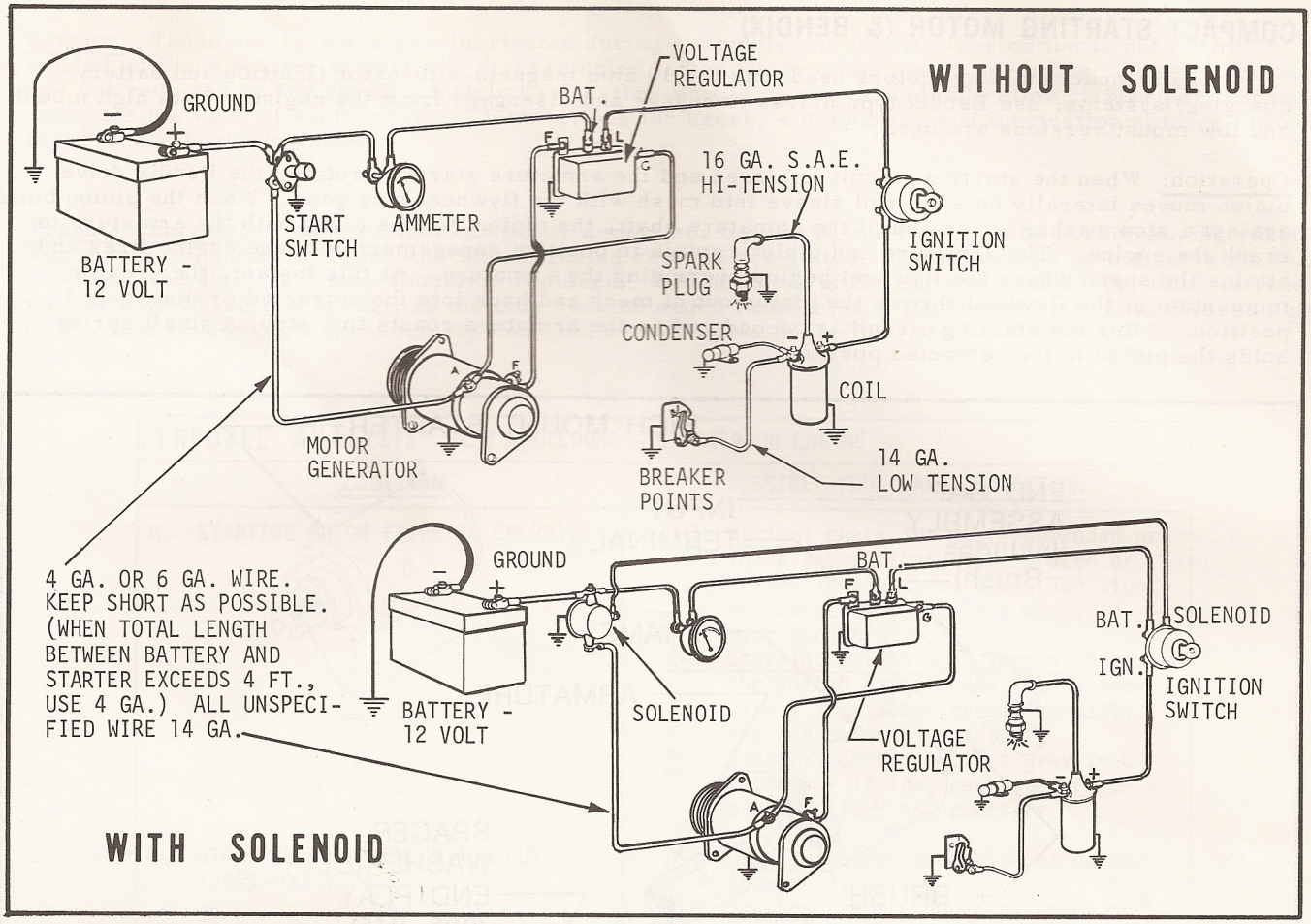


FIGURE 5 - WIRING DIAGRAMS, MOTOR-GENERATOR SYSTEM

Disassembly: Noise emanating from a generator may be caused by a loose mounting or drive pulley. It can also be caused by worn or dirty bearings or improperly seated brushes. Dirty bearings may sometimes be saved by cleaning and relubrication, but worn bearings should be replaced. Excessive noise may result if the brush holder is bent resulting in improper seating of the brush. Such a brush holder should be replaced. The end frames, bearings and armature can be removed or replaced without disturbing any electrical connections. The brush holder assemblies are mounted individually on the walls of the field frame. To disassemble motor-generator, use the following procedure:

1. Unscrew thru bolts and remove commutator end frame from the field frame.

2. Place armature in a vise with soft jaws and remove shaft nut, pulley and the drive end frame.

3. Remove brush holders if new ones are to be installed, by drilling out the rivets holding them to the field frame. Install new holders, securing them to frame with new rivets or screws, nuts and washers.

4. The armature or field coils must not be cleaned in degreasing tank or with degreasing compounds since insulation damage might occur. Ball bearings should be thoroughly cleaned and repacked with high melting point ball bearing grease. Other parts should be cleaned and carefully inspected for wear or other damage. Any defective part should be repaired or replaced. On reassembly, all soldered electric connections should be made with rosin flux. Acid flux must not be used on electrical connections.

When reassembling unit, make sure pulley retaining nut is tightened to the correct torque value (600-720 inch lbs.) as this properly pre-loads the bearings.

COMPACT STARTING MOTOR (& BENDIX)

The compact starting motors used with the 10 amp magneto-alternator (ignition and battery charging) systems, use Bendix type drives to engage and disengage from the engine. Both high mount and low mount versions are used.

Operation: When the starting circuit is closed and the armature starts to rotate, the Bendix drive pinion moves laterally on a splined sleeve into mesh with the flywheel ring gear. When the pinion butts against a stop washer at the end of the armature shaft, the pinion rotates along with the armature to crank the engine. The armature and pinion remain in positive engagement until the engine fires and attains the speed where the flywheel begins overriding the armature. At this instant, the greater momentum of the flywheel throws the pinion out of mesh and back into the retracted or disengaged position. After the starting circuit is opened and as the armature coasts to a stop, a small spring holds the pinion in the retracted position.

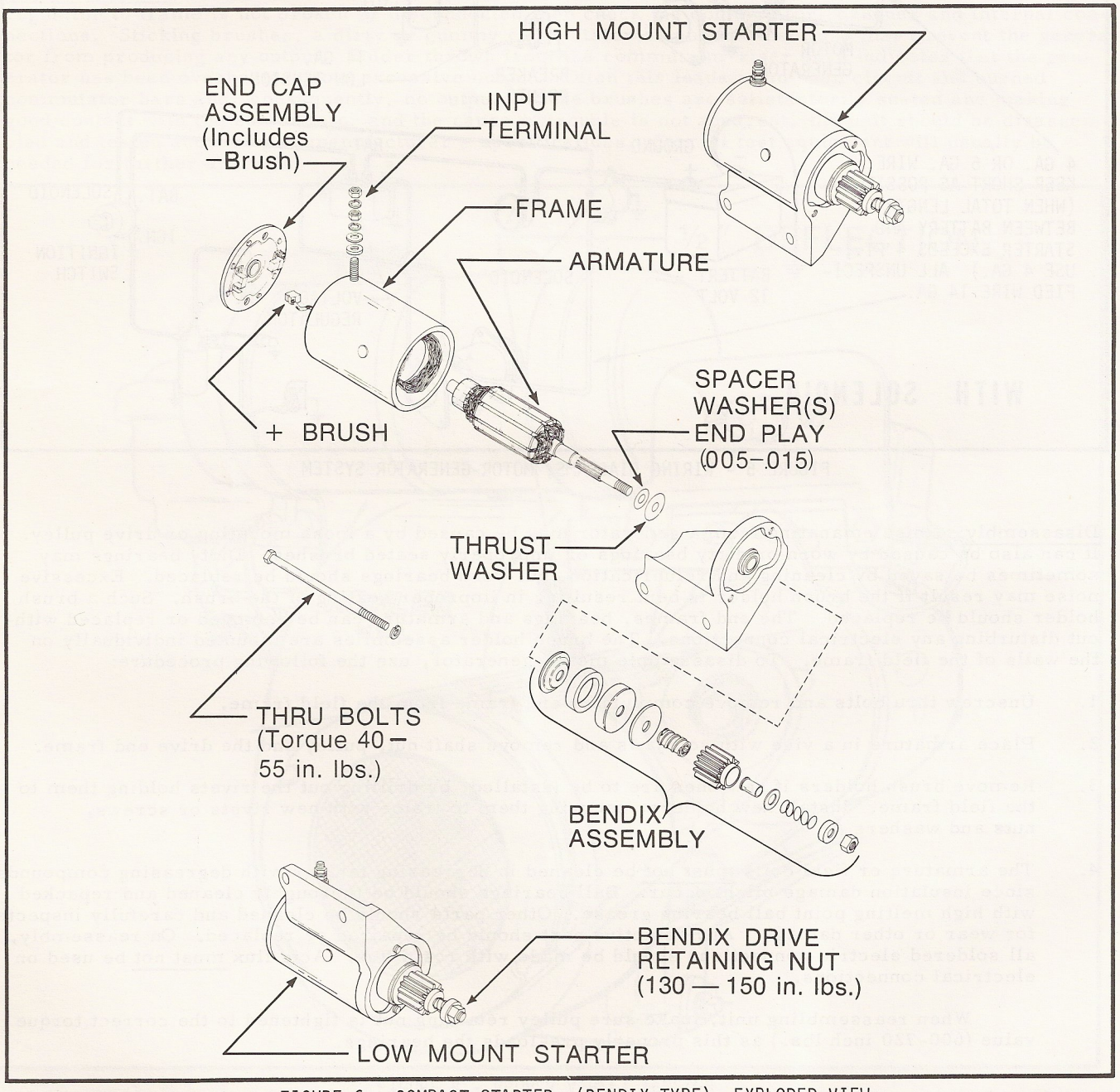


FIGURE 6 - COMPACT STARTER (BENDIX TYPE), EXPLODED VIEW

Service: These starters are pre-lubricated during assembly and further lubrication is not normally needed until the starter is partially disassembled for brush or commutator servicing. These services are not required at any specific hourly basis--they should be performed only after starter performance indicates the need of such service. Instructions for brush, commutator and lubrication service follow the Trouble Analysis Chart.

Trouble Analysis: Problems that can occur during normal usage are listed in the accompanying chart. The symptom, possible cause and the suggested remedy are stated. If these steps do not solve the problem, the starting motor should be replaced. Replacement of the end cap assembly, which includes the negative brush and spring, is the only recommended field service that requires partial disassembly of the motor--complete disassembly must not be attempted in the field.

TROUBLE ANALYSIS TEST PROCEDURE - STARTER ON ENGINE	
CONDITION	POSSIBLE FAULT AND CORRECTION
A. STARTING MOTOR FAILS TO ENERGIZE	A-1 Wiring; check for badly corroded or loose connections, also broken or frayed insulation. Clean and tighten connections, replace wires in poor condition. A-2 Starting Switch or Solenoid; bypass the switch or solenoid with jumper wire - if starter cranks normally, replace defective part. A-3 Battery; check specific gravity of battery - if low, recharge or replace battery as necessary.
B. STARTING MOTOR ENERGIZES BUT TURNS TOO SLOWLY	B-1 Battery; check condition of battery (See A-3). B-2 Brushes; remove end cap, check for unevenly worn or dirty brushes and commutator. Use a coarse cloth (not emery paper) to clean. Replace brushes if excessively or unevenly worn. See brush replacement procedure
TEST PROCEDURE - STARTER REMOVED (BUT NOT DISASSEMBLED)	
A. STARTER TURNS TOO SLOWLY	A-1 Armature Binding; remove starter from engine, turn armature shaft by hand - if it does not turn freely, the cause could be; too little end play, bushings not properly lubricated or badly worn.
B. STARTER SPINS WITHOUT ENGAGING	B-1 Drive Pinion Sticking; hold pinion, turn shaft in counter-clockwise direction -- pinion should move freely out on splined shaft. Note condition of spline, if dirty, clean and relubricate with light weight (SAE #10) oil. Check for nicks or score marks and replace Bendix if necessary. B-2 Drive Pinion Gear Damaged; this of course will be obvious as soon as starter is removed from engine. If teeth are worn or broken, replace Bendix assembly. Also check ring gear teeth for damage.

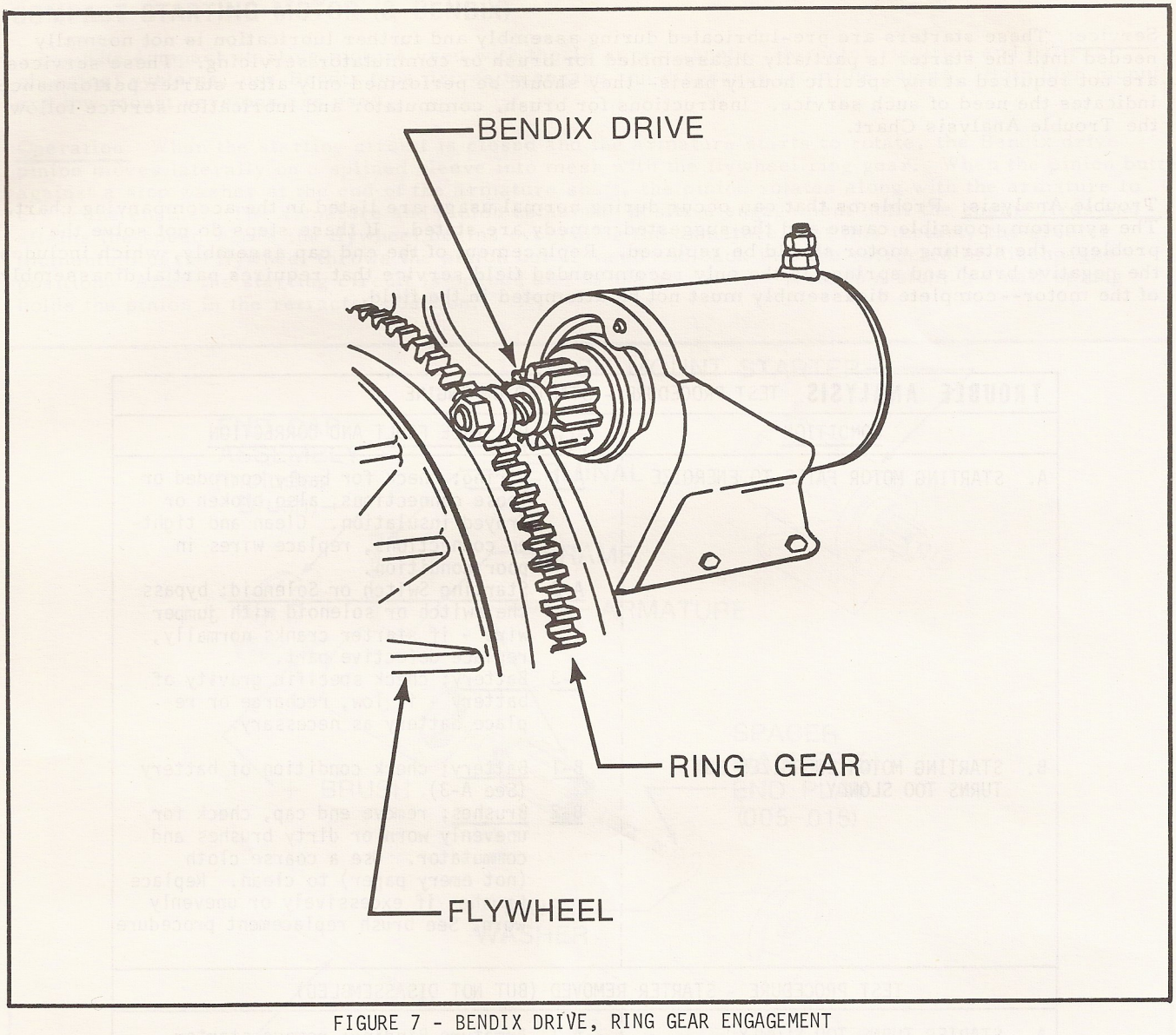


FIGURE 7 - BENDIX DRIVE, RING GEAR ENGAGEMENT

Precautions: In the event of a "false start", that is, if the engine gets up sufficient speed to disengage the starter but fails to continue running, the engine must be allowed to come to a complete halt before a restart attempt is made. If the flywheel is still rotating when the starter is engaged, the pinion and ring gear will clash and almost certainly be damaged.

Also, as with all starting motors, the cranking time must be limited to prevent overheating of the starter. On these compact starters, the maximum time allowed for cranking is 60 seconds followed by a 30 second cooling period. The cranking limit is not unreasonable for if an engine fails to start after this length of time, ignition or carburetion troubles are indicated and these should be corrected before the engine is placed in operation.

Service and Replacement Procedure

The end cap assembly must be removed to inspect and service the brushes and commutator. Remove the two thru bolts then carefully slip end cap off end of armature. Lift spring and remove positive brush from holder if complete removal of end cap is necessary.

Brush-Commutator Service: Use a coarse cloth to clean brushes and commutator. If commutator is grooved or extremely dirty, use a commutator stone or fine sandpaper to polish--do not use emery cloth.

Brush Replacement: Brushes should be replaced if unevenly worn or worn to less than 5/16" in length. Brush replacement is made with Brush Kit. The Kit contains both brushes and springs. The rivet holding the negative brush must be drilled out and the new brush riveted in its place. Make sure good mechanical and electrical contacts are made. Positive brush is affixed to field winding. Peel back insulating material, remove old brush. Solder or clip new brush to same spot, rewrap insulating material around new joint.

End Cap Installation: Before reassembling new or serviced end cap assembly, lightly coat bushing and end of the armature shaft with SAE #10 oil--make sure there is no excess of oil to splatter from these parts.

Insert positive brush in holder. Hold positive brush spring away with a needle nose pliers, then carefully guide end cap into position--release brush spring after brushes are started on commutator. Secure end cap to frame with two thru bolts. Tighten bolts to 40 - 55 inch lb. torque value.

Bendix Drive Assembly: To inspect and service the Bendix drive, remove starter from engine (remove two mounting bolts). If drive pinion or splined sleeve is damaged, replace Bendix drive assembly. If Bendix is in good condition, wipe clean but do not lubricate--leave completely dry.

Make sure the special mounting bolts (and lock washers) are used when reinstalling starter. In addition to securing the starter to the machined surface on the crankcase, these special bolts provide proper alignment of the Bendix drive gear to the ring gear on the engine. Use of ordinary bolts will allow the starter to shift which could result in clashing and damage to the gears.

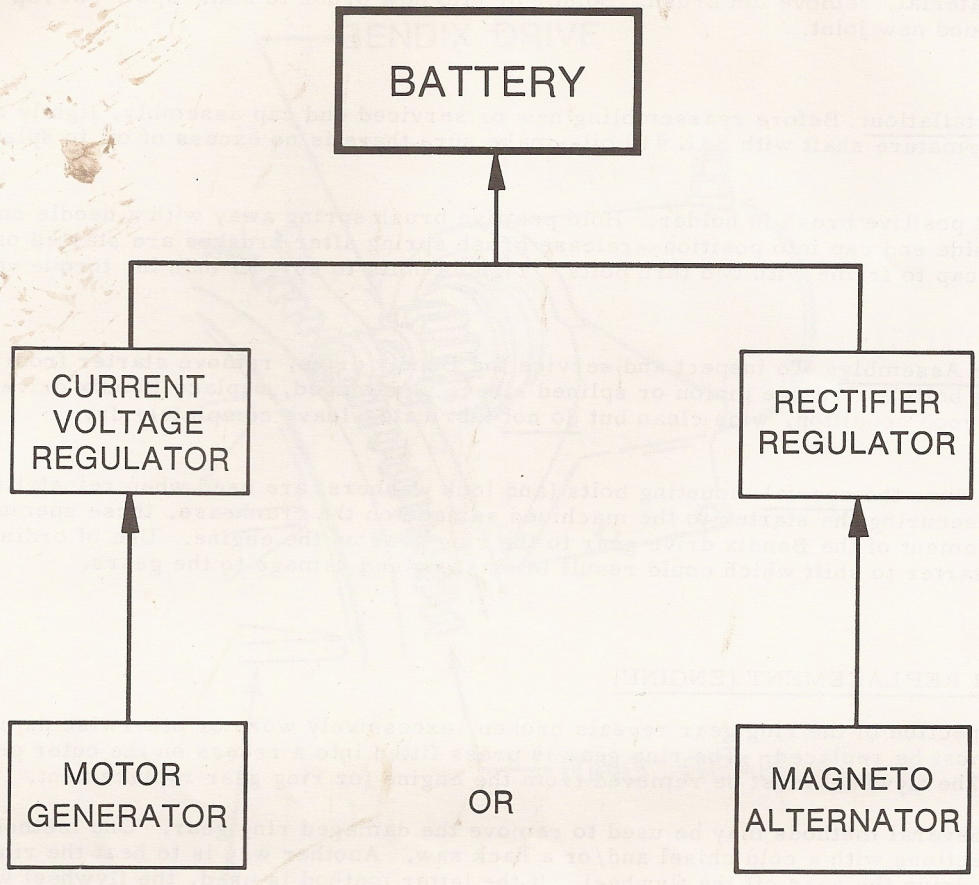
RING GEAR REPLACEMENT (ENGINE)

If inspection of the ring gear reveals broken, excessively worn or otherwise damaged teeth, the ring gear must be replaced. The ring gear is press fitted into a recess on the outer perimeter of the flywheel. The flywheel must be removed from the engine for ring gear replacement.

Removal: Several methods may be used to remove the damaged ring gear. One method is to break the gear into sections with a cold chisel and/or a hack saw. Another way is to heat the ring gear with a torch, then drive the gear off the flywheel. If the latter method is used, the flywheel will also absorb some heat and it must be allowed to cool before the new ring gear can be installed.

Reinstallation: The new gear must be expanded with heat before installation. This can be done by submerging the gear in hot oil or heating in an oven to about 400° F. Make sure the ring is evenly heated. Position the heated gear on the flywheel, then after making sure it is not cocked, either press the gear on with an arbor press or drive it on with a soft-head hammer. As the gear cools, it will contract to form a tight press fit on the flywheel. Be sure to tighten the flywheel retaining nut to the proper torque value after reinstalling the flywheel on the engine.

CHARGING SYSTEMS



A charging system has a dual purpose--it must generate sufficient power to supply all immediate electrical requirements and at the same time replenish energy in the storage battery. The basic components of the different systems used are shown schematically in the above diagram.

MOTOR — GENERATOR TYPE

In a generator a large number of wire loops are used to increase the flow of current. These are wound around an iron core to form the assembly known as the armature. The armature is surrounded by field coils which consist of wire coiled around the pole pieces. When the armature is revolved by the mechanical action of the engine, electric current is produced in the armature windings. The field coils are connected to the armature so that a portion of the current from the armature flows through them to strengthen the magnetic field and thereby to increase the current induced in the coils of the armature.

In order to collect the current and feed it to the battery, a device called a commutator is used at the end of the armature shaft. The commutator is divided into a number of segments which are insulated from each other, and each end of each loop of wire in the armature is connected to a commutator segment. Spring loaded carbon brushes ride on the commutator and pick up the electrical current.

The main function of the generator is to keep the battery in charged condition whenever the engine is operating. It does this by converting mechanical energy derived from rotation of the engine into electrical energy.

CURRENT-VOLTAGE REGULATOR

The current-voltage regulator is automatic in its control of current and voltage to battery. Many cases of regulator trouble can be eliminated by a simple cleaning of the contact points plus some possible readjustment. The flat point always develops a slight cavity and is the point that requires most attention. It is not necessary to have a perfectly flat surface on this point, but cleaning the surface down to pure metal with a fine cut riffel file will insure long periods of service without difficulty. The file should not be allowed to become greasy and should not be used to file other metals. After filing, wipe points with lintless cloth, saturated in carbon tetrachloride to insure clean surfaces. The flat point is in the armature. Clean by loosening the upper contact support and moving it to one side. CAUTION: NEVER USE EMERY CLOTH OR SANDPAPER TO CLEAN CONTACT POINTS.

Cutout Relay: This unit requires three checks and adjustments: air gap, point opening, and closing voltage. The air gap and point opening adjustments are made with the battery disconnected.

Air Gap: Place fingers on the armature directly above the core and press armature down until the points just close, then measure the air gap between the armature and the center of the core. Gap should be .020. Adjust by raising or lowering armature at its hinge mounting. Retighten screws after adjustment.

Point Opening: Adjust point opening by bending the armature stop. Opening should be .020.

Closing Voltage: Adjust closing voltage by turning screw clockwise to increase spring tension and voltage, counterclockwise to decrease spring tension and closing voltage. Be sure that closing voltage adjustment is at least 0.5 volt less than the current-voltage regulator unit setting. This should be 12.8 volts.

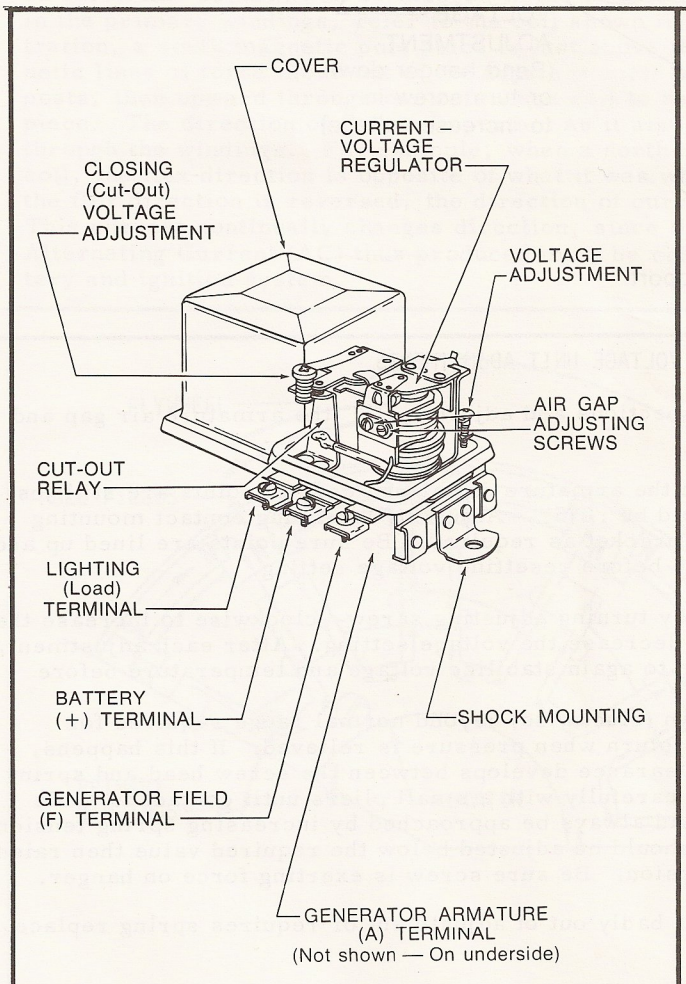


FIGURE 8 - TWO UNIT TYPE CURRENT-VOLTAGE REGULATOR

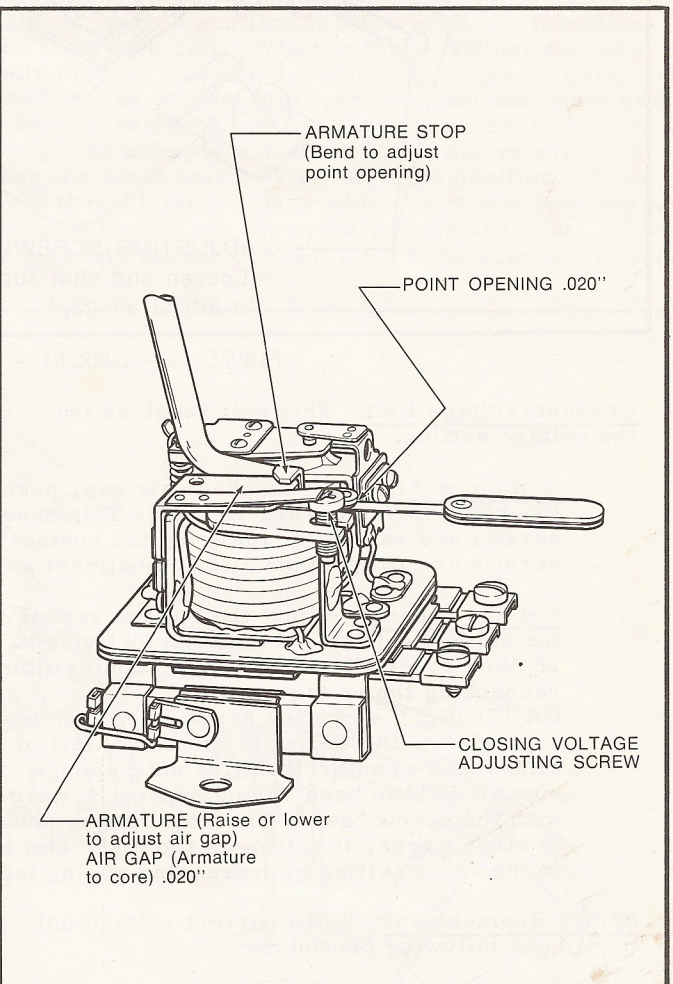


FIGURE 9 - CUTOUT RELAY UNIT ADJUSTMENTS

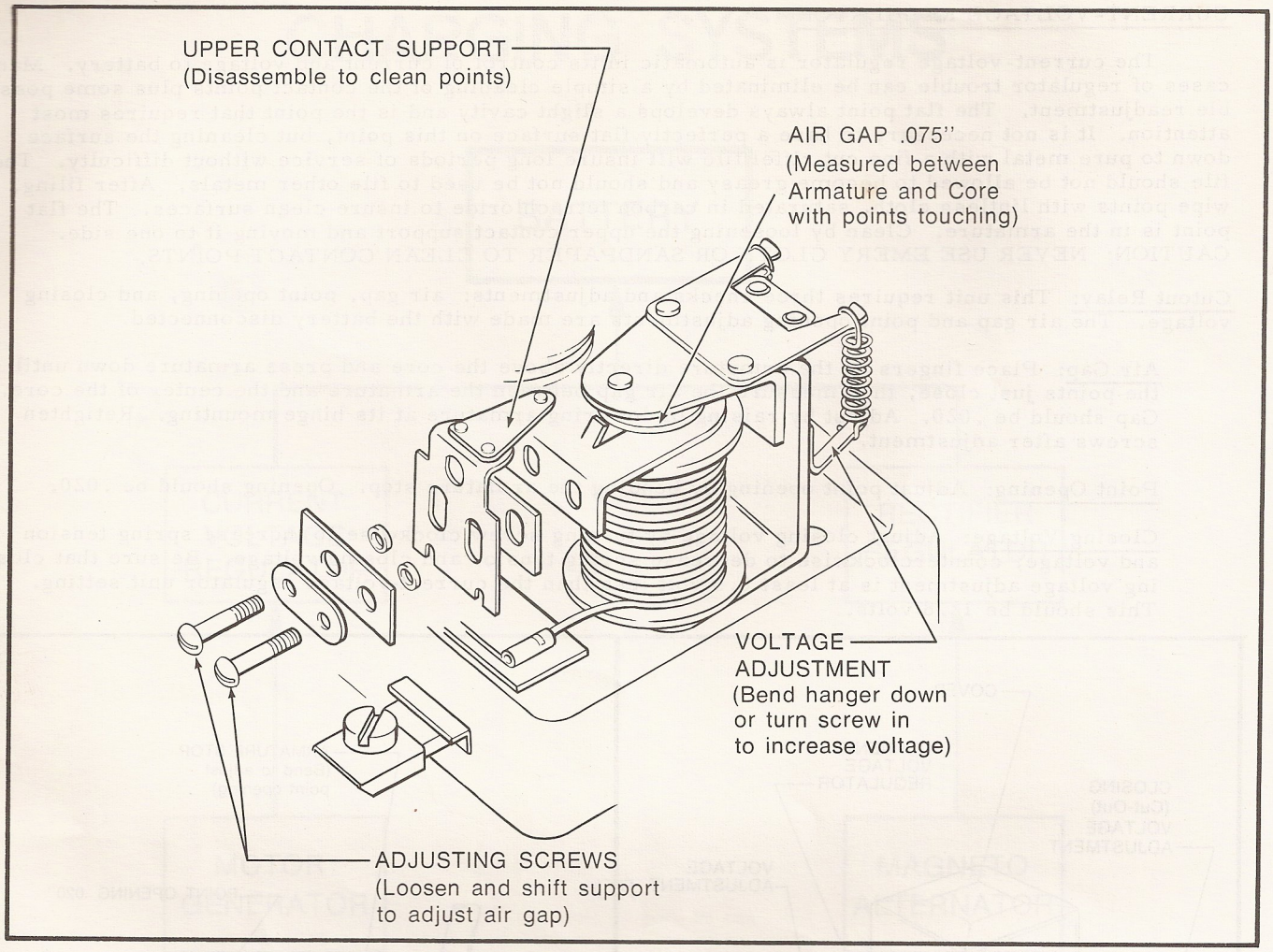


FIGURE 10 - CURRENT - VOLTAGE UNIT ADJUSTMENTS

Current-Voltage Unit: This unit requires two inspections and adjustments: the armature air gap and the voltage setting.

Armature Air Gap: To check air gap, push the armature down until contact points are still just touching, then measure air gap. This should be .075". Adjust by loosening contact mounting screws and raising or lowering the contact bracket as required. Be sure points are lined up and screws are retightened after adjustment and before resetting voltage setting.

Voltage Setting: Adjust the voltage setting by turning adjusting screw--clockwise to increase the the voltage setting and counterclockwise to decrease the voltage setting. After each adjustment, replace cover and allow ample running time to again stabilize voltage and temperature before rechecking the voltage setting.
CAUTION: If adjusting screw is turned down (clockwise) beyond normal range required for adjustment, the spring support may fail to return when pressure is relieved. If this happens, turn screw counterclockwise until enough clearance develops between the screw head and spring support. Then bend spring support upward carefully with a small pliers until contact is made with the screw head. The final setting should always be approached by increasing spring tension. In other words, if setting is too high, unit should be adjusted below the required value then raised to the exact setting by increasing spring tension. Be sure screw is exerting force on hanger.

Spring Replacement: When current-voltage unit is badly out of adjustment or requires spring replacement, use following procedure:

Replacing regulator spring requires care to prevent bending or distorting spring support or the armature hinge. Preferably spring should be hooked at lower end first then stretched up with a screwdriver blade or other suitable tool, inserted between the turns until the upper end of the spring can be hooked.