ELECTRICAL SYSTEMS

service manual

FORM 73146366 English

(Replaces 70695436, 73063024, 70696657)

SAFETY RULES

GENERAL

Study the Operation and Maintenance Instruction Manual before starting, operating, maintaining, fueling, or servicing machine.

Read and heed all machine-mounted safety signs before starting, operating, maintaining, fueling or servicing machine.

Machine-mounted safety signs have been color coded yellow with black border and lettering for ***WARNING*** and red with white border and lettering for ***DANGER*** points.

Never attempt to operate the machine or its tools from any position other than seated in the operator's seat. Keep head, body, limbs, hands and feet inside operator's compartment at all times to reduce exposure to hazards outside the operator's compartment.

Do not allow unauthorized personnel to operate service or maintain this machine.

Always check work area for dangerous features. The following are examples of dangerous work areas: slopes, over hangs, timber, demolitions, fire, high walls, drop off, back fills, rough terrain, ditches, ridges, excavations, heavy traffic, crowded parking, crowded maintenance and closed areas. Use extreme care when in areas such as these.

An operator must know the machine's capabilities. When working on slopes or near drop offs be alert to avoid loose or soft conditions that could cause sudden tipping or loss of control.

Do not jump on or off machine. Keep two hands and one foot, or two feet and one hand, in contact with steps grab rails and handles at all times.

Do not use controls or hoses as hand holds when climbing on or off machine. Hoses and controls are movable and do not provide a solid support. Controls also may be inadvertently moved causing accidental machine or equipment movement.

Keep operator's compartment, stepping points, grab-rails and handles clear of foreign objects, oil, grease, mud or snow accumulation to minimize the danger of slipping or stumbling. Clean mud or grease from shoes before attempting to mount or operate the machine.

Be careful of slippery conditions on stepping points, hand rails, and on the ground. Wear safety boots or shoes that have a high slip resistant sole material.

For your personal protection. Do not attempt to climb on or off machine while machine is in motion.

Never leave the machine unattended with the engine running.

Always lock up machine when leaving it unattended. Return keys to authorized security. Heed all shut down procedures of the Operation and Maintenance Instruction Manual. Always set the parking brake when leaving the machine for any reason.

Do not wear rings, wrist watches, jewelry, loose or hanging apparel, such as ties, torn clothing, scarves, unbuttoned or unzipped jackets that can catch on moving parts. Wear proper safety equipment as authorized for the job. Examples: hard hats, safety shoes, heavy gloves, ear protectors, safety glasses or goggles, reflector vests, or respirators. Consult your employer for specific safety equipment requirements.

Do not carry loose objects in pockets that might fall unnoticed into open compartments. Do not use machine to carry loose objects by means other than attachments for carrying such objects.

DO NOT CARRY RIDERS unless the machine is equipped for carrying people to reduce personal exposure to being thrown off.

Do not operate machinery in a condition of extreme fatigue or illness. Be especially careful towards the end of the shift.

Roll Over Protective Structures are required on wheel loaders, dozer tractors, track type loaders, graders and scrapers by local or national requirements. *DO NOT* operate this machine without a Roll Over Protective Structure.

Do not operate a machine without a falling object protective structure (FOPS).

Do not operate this machine without a rear canopy screen when machine is equipped with rear mounted towing winch.

Seat belts are required to be provided with roll over protective structures or roll protection cabs by local or national regulations. Keep the safety belt fastened around you during operation.

Where noise exposure exceeds 90 dBA for 8 hours, wear authorized ear protective equipment per local or national requirements that apply.

Keep clutches and brakes on machine and attachments such as power control units, winches and master clutches adjusted according to Operation and Maintenance Instruction Manuals of the manufacturers at all times. *DO NOT* adjust machine with engine running except as specified.

Do not operate a machine with brakes out of adjustment. See the Operation and Maintenance Instruction Manual.

Move carefully when under, in or near machine or implements. Wear required protective equipment, such as hard hat, safety glasses, safety shoes, ear protectors.

To move a disabled machine, use a trailer or low boy truck if available. If towing is necessary, provide warning signals as required by local rules and regulations and follow Operation and Maintenance Instruction Manual recommendations. Load and unload on a level area that gives full support to the trailer wheels. Use ramps of adequate strength, low angle and proper height. Keep trailer bed clean of clay, oil and all materials that become slippery. Tie machine down securely to truck or trailer bed and block tracks (or wheels) as required by the carrier.

To prevent entrapment in cabs or mounted enclosures, observe and know the mechanics of alternate exit routes.

On machines equipped with suction radiator fans, be sure to periodically check all engine exhaust parts for leaks as exhaust gases are dangerous to the operator. Keep a vent open to outside air at all times when operating within a closed cab.

STARTING FLUID IS FLAMMABLE. Follow the recommendations as outlined in the Operation and Maintenance Instruction Manual and as marked on the containers. Store containers in cool, well-ventilated place secure from unauthorized personnel. *DO NOT PUNCTURE OR BURN CONTAINERS.*

Follow the recommendations of the manufacturer for storage and disposal.

Wire rope develops steel slivers. Use authorized protective equipment such as heavy gloves, safety glasses when handling.

OPERATION

Before starting machine, check, adjust and lock the operator's seat for maximum comfort and control of the machine.

DO NOT START OR OPERATE AN UNSAFE MACHINE. Before working the machine, be sure that any unsafe condition has been satisfactorily remedied. Check brakes, steering and attachment controls before moving. Advise the proper maintenance authority of any malfunctioning part or system. Be sure all protective guards or panels are in place, and all safety devices provided are in place and in good operating condition.

Check instruments at start-up and frequently during operation.

Do not run the engine of this machine in closed areas without proper ventilation to remove deadly exhaust gases.

Be sure exposed personnel in the area of operation are clear of the machine before moving the machine or its attachments. *WALK COMPLETELY AROUND* the machine before mounting. Sound horn. Obey flag man, safety signals and signs.

Know the principles of cross steering of crawler tractors. Read section in Operation and Maintenance Instruction Manual on cross steering.

Keep engine exhaust system and exhaust manifolds clear of combustible material. Equip machine with screens and guards when working under conditions of flying combustible material.

If engine has a tendency to stall for any reason under load or idle, report this for adjustment to a proper maintenance authority immediately. Do not continue to operate machine until condition has been corrected.

Never use bucket as a man-lift.

Use recommended bucket for machine and material load ability and heaping characteristics of material, terrain, and other pertinent job conditions.

Avoid abrupt starts and stops when transporting a loaded bucket.

Inspect your seat belt webbing and hardware at least twice a year for signs of fraying, wear or other weakness that could lead to failure.

Use only designated towing or pulling attachment points. Use care in making attachment. Be sure pins and locks as provided are secure before pulling. Stay clear of draw bars, cables or chains under load.

When pulling or towing through a cable or chain, do not start suddenly at full throttle. Take up slack carefully. Guard against kinking chains or cables. Inspect carefully for flaws before using. Do not pull through a kinked chain or cable due to the high stresses and possibility of failure of the kinked area. Always wear heavy gloves when handling chain or cable.

Be sure cables are anchored and the anchor point is strong enough to handle the expected load. Keep exposed personnel clear of anchor point and cable or chain. *DO NOT PULL OR TOW UNLESS OPERATOR'S COMPARTMENT OF MACHINES INVOLVED ARE PROPERLY GUARDED AGAINST POTENTIAL CABLE OR CHAIN BACKLASH.*

During operation always carry ripper in full raised position when not in use and lowered to ground when parked.

When counterweights have been provided, do not work machine if they have been removed unless their equivalent weight has been replaced. See the Operation and Maintenance Instruction Manual.

When operating a machine know what clearances will be encountered, overhead doors, wires, pipes, aisles, roadways; also the weight limitations of ground, floor, and ramps.

Know bridge and culvert load limits and do not exceed them. Know machine's height, width, and weight. Use a signal person when clearance is close.

Be sure that the exact location of gas lines, utility lines, sewers, overhead and buried power lines, and other obstructions or hazards are known. Such locations should be precisely marked by the proper authorities to reduce the risk of accidents. Obtain shut-down or relocation of any such facilities before starting work, if necessary.

Be certain to comply with all local, state, and federal regulations regarding working in the vicinity of power lines.

When roading find out what conditions are likely to be met - clearances, congestion, type of surface, etc. Be aware of fog, smoke or dust element that obscure visibility.

When backing, always look to where the machine is to be moved. Be alert to the position of exposed personnel. *DO NOT OPERATE* if exposed personnel enter the immediate work area.

SAFETY RULES

Never travel a machine on a job site, in a congested area, or around people without a signal person to guide the operator.

In darkness, check area of operation carefully before moving in with machine. Use all lights provided. Do not move into area of restricted visibility.

Maintain clear vision of all areas of travel or work. Keep cab windows clean and repaired. Carry blade low for maximum visibility while traveling. Obtain and use fan blast deflectors where tractors are used a pusher tractors in tandem.

Transport a loaded bucket with the bucket as far tipped back and in as low a position as possible for maximum visibility, stability, and safest transport of the machine. Carry it at a proper speed for the load and ground conditions.

Carry the bucket low when traveling with a load.

Maintain a safe distance from other machines. Provide sufficient clearance for ground and visibility conditions. Yield right-of-way to loaded machines.

Avoid going over obstacles such as rough terrain, rocks, logs, curbs, ditches ridges, and railroad tracks whenever possible. When obstructions must be crossed, do so with extreme care at an angle if possible. Reduce speed - down-shift. Ease up to the break over point - pass the balance point slowly on the obstruction and ease down on the other side.

Cross gullies or ditches at an angle with reduced speed after insuring ground conditions will permit a safe traverse.

Be alert to soft ground conditions close to newly constructed walls. The fill material and weight of machine may cause the wall to collapse under the machine.

Operate at speeds slow enough to insure complete control at all times. Travel slowly over rough ground, on slopes or near drop offs, in congested areas or on ice or slippery surfaces.

Be alert to avoid changes in traction conditions that could cause loss of control. *DO NOT* drive on ice or frozen ground conditions when working the machine on steep slopes or near drop offs.

Keep the machine well back from the edge of an excavation.

Be especially careful when traveling up or down slopes. Position the bucket in such a way as to provide a possible anchorage on the ground in case of a slide.

When proceeding across a hill side proceed slowly. Never turn sharply up hill or down hill.

Avoid side hill travel whenever possible. Drive up and down the slope. Should the machine start slipping sideways on a grade, turn it immediately downhill.

In steep down hill operation, do not allow engine to over speed. Select proper gear before starting down grade.

There is no substitute for good judgement when working on slopes.

The grade of slope you should attempt will be limited by such factors as condition of the ground, load being handled, the type of machine, speed of machine and visibility.

NEVER COAST the machine down grades and slopes with the transmission in neutral on power shift machines, or clutch disengaged on manually shifted machines.

To reduce the danger of uncontrolled machine, choose a gear speed before proceeding down grade that will hold machine to proper speeds for conditions.

Operating in virgin rough terrain that includes previously mentioned hazards is called pioneering. Be sure you know how this is done. Danger from falling branches and upturning roots is acute in these areas.

When pushing over trees, the machine must be equipped with proper over head guarding. Never allow a machine to climb up on the root structure particularly while the tree is being felled. Use extreme care when pushing over any tree with dead branches.

Avoid brush piles, logs or rocks. *DO NOT DRIVE THE MACHINE ONTO BRUSH PILES, LOGS, LARGE ROCKS* or other surface irregularities that break traction with the ground especially when on slopes or near drop offs.

Avoid operating equipment too close to an over hang or high wall either above or below the machine. Be on the look out for caving edges, falling objects and slides. Beware of concealment by brush and under growth of these dangers.

Park in a non-operating and non-traffic area or as instructed. Park on firm level ground if possible. Where not possible, position machine at a right angle to the slope, making sure there is no danger of uncontrolled sliding movement. Set the parking brake.

Never park on an incline without carefully blocking the machine to prevent movement.

If parking in traffic lanes cannot be avoided, provide appropriate flags, barriers, flares and warning signals as required. Also provide advance warning signals in the traffic lane of approaching traffic.

Move the machine away from pits, trenches, overhangs and over head power lines before shutting down for the day.

When stopping operation of the machine for any reason, always return the transmission or hydrostatic drive control to neutral and engage the control lock to secure the machine for a safe start up. Set parking brake, if so equipped.

Never lower attachments or tools from any position other than seated in operator's seat. Sound the horn. Make sure the area near the attachment is clear. Lower the attachment slowly. *DO NOT USE* float position to lower hydraulic equipment.

Always before leaving the operator's seat and after making certain all people are clear of the machine, slowly lower the attachments or tools flat to the ground in a positive ground support position. Move any multi purpose tool to positive closed position. Return the controls to hold. Place transmission control in neutral and move engine controls to off position. Engage all control locks, set parking brake, and open and lock the master (key, if so equipped) switch. Consult Operation and Maintenance Instruction Manual.

Always follow the shut down instructions as outlined in the Operation and Maintenance Instruction Manual.

MAINTENANCE

Do not perform any work on equipment that is not authorized. Follow the Maintenance or Service Manual procedures.

Machine should not be serviced with anyone in the operator's seat unless they are qualified to operate the machine and are assisting in the servicing.

Shut off engine and disengage the Power Take Off lever if so equipped before attempting adjustments or service.

Always turn the master switch (key switch if so equipped) to the *OFF* position before cleaning, repairing, or servicing and when parking machine to forestall unintended or unauthorized starting.

Disconnect batteries and *TAG* all controls according to local or national requirements to warn that work is in progress. Block the machine and all attachments that must be raised per local or national requirements.

Never lubricate, service or adjust a machine with the engine running, except as called for in the Operation and Maintenance Instruction Manual. Do not wear loose clothing or jewelry near moving parts.

Do not run engine when refueling and use care if engine is hot due to the increased possibility of a fire if fuel is spilled.

Do not smoke or permit any open flame or spark near when refueling, or handling highly flammable materials.

Always place the fuel nozzle against the side of the filler opening before starting and during fuel flow. To reduce the chance of a static electricity spark, keep contact until after fuel flow is shut off.

Do not adjust engine fuel pump when the machine is in motion.

Never attempt to check or adjust fan belts when engine is running.

When making equipment checks that require running of the engine, have an operator in the operator's seat at all times with the mechanic in sight. Place the transmission in neutral and set the brakes and lock. *KEEP HANDS AND CLOTHING AWAY FROM MOVING PARTS.*

Avoid running engine with open unprotected air inlets. If such running is unavoidable for service reasons, place protective screens over all inlet openings before servicing engine.

Do not place head, body, limbs, feet, fingers, or hands near rotating fan or belts. Be especially alert around a pusher fan.

Keep head, body, limbs, feet, fingers, or hands away from bucket, blade or ripper when in raised position.

If movement of an attachment by means of machine's hydraulic system or winches is required for service or maintenance, do not raise or lower attachments from any position other than when seated in the operator's seat. Before starting machine or moving attachments or tools, set brakes, sound horn and call for an all clear. Raise attachments slowly.

Never place head, body, limbs, feet, fingers, or hands into an exposed portion between uncontrolled or unguarded scissor points of machine without first providing secure blocking.

Never align holes with fingers or hands - Use the proper aligning tool.

Disconnect batteries before working on electrical system or repair work of any kind.

Check for fuel or battery electrolyte leaks before starting service or maintenance work. Eliminate leaks before proceeding.

BATTERY GAS IS HIGHLY FLAMMABLE. Leave battery box open to improve ventilation when charging batteries. Never check charge by placing metal objects across the posts. Keep sparks or open flame away from batteries. Do not smoke near battery to guard against the possibility of an accidental explosion.

Do not charge batteries in a closed area. Provide proper ventilation to guard against an accidental explosion from an accumulation of explosive gases given off in the charging process.

Be sure to connect the booster cables to the proper terminals (+ to +) and (- to -) at both ends. Avoid shorting clamps. Follow the Operation and Maintenance Instruction Manual procedure.

Due to the presence of flammable fluid, never check or fill fuel tanks, storage batteries or use starter fluid near lighted smoking materials or open flame or sparks.

Rust inhibitors are volatile and flammable. Prepare parts in well ventilated place. Keep open flame away - *DO NOT SMOKE.* Store containers in a cool well ventilated place secured against unauthorized personnel.

Do not use an open flame as a light source to look for leaks or for inspection anywhere on the machine.

DO NOT pile oily or greasy rags - they are a fire hazard. Store in a closed metal container.

SAFETY RULES

Never use gasoline or solvent or other flammable fluid to clean parts. Use authorized commercial, non-flammable, non-toxic solvents.

Never place gasoline or diesel fuel in an open pan.

Shut off engine and be sure all pressure in system has been relieved before removing panels, housings, covers, and caps. See Operation and Maintenance Instruction Manual.

Do not remove hoses or check valves in the hydraulic system without first removing load and relieving pressure on the supporting cylinders. Turn radiator cap slowly to relieve pressure before removing. Add coolant only with engine stopped or idling if hot. See Operation and Maintenance Instruction Manual.

Fluid escaping under pressure from a very small hole can almost be invisible and can have sufficient force to penetrate the skin. Use a piece of card board or wood to search for suspected pressure leaks. *DO NOT USE HANDS.* If injured by escaping fluid, see a doctor at once. Serious infection or reaction can develop if proper medical treatment is not administered immediately.

Never use any gas other than dry nitrogen to charge accumulators. See Operation and Maintenance Instruction Manual.

When making pressure checks use the correct gauge for expected pressure. See the Operation and Maintenance Instruction Manual or Service Manual for guidance.

For field service, move machine to level ground if possible and block machine. If work is absolutely necessary on an incline, block machine and its attachments securely. Move the machine to level ground as soon as possible.

Brakes are inoperative when manually released for servicing. Provision must be made to maintain control of the machine by blocking or other means.

Block all wheels before bleeding or disconnecting any brake system lines and cylinders.

Never use make shift jacks when adjusting track tension. Follow the Undercarriage Service Manual.

Know your jacking equipment and its capacity. Be sure the jacking point used on the machine is appropriate for the load to be applied. Be sure the support of the jack at the machine and under the jack is appropriate and stable. Any equipment up on a jack is dangerous. Transfer load to appropriate blocking as a safety measure before proceeding with service or maintenance work according to local or national requirements.

Always block with external support any linkage or part on machine that requires work under the raised linkage, parts, or machine per local or national requirements. Never allow anyone to walk under or be near unblocked raised equipment. Avoid working or walking under raised blocked equipment unless you are assured of your safety.

When servicing or maintenance requires access to areas that cannot be reached from the ground, use a ladder or step platform that meets local or national requirements to reach the service point. If such ladders or platforms are not available, use the machine hand holds and steps as provided. Perform all service or maintenance carefully.

Shop or field service platforms and ladders used to maintain or service machinery should be constructed and maintained according to local or national requirements.

Lift and handle all heavy parts with a lifting device of proper capacity. Be sure parts are supported by proper slings and hooks. Use lifting eyes if provided. Watch out for people in the vicinity.

In lifting and handling heavy parts, slings must be of adequate strength for the purpose intended and must be in good condition.

Handle all parts with extreme care. Keep hands and fingers from between parts. Wear authorized protective equipment such as safety glasses, heavy gloves, safety shoes.

When using compressed air for cleaning parts use safety glasses with side shields or goggles. Limit the pressure to 207 kPa (30 psi) according to local or national requirements.

Wear welders protective equipment such as dark safety glasses, helmets, protective clothing, gloves and safety shoes when welding or burning. Wear dark safety glasses near welding. *DO NOT LOOK AT ARC WITHOUT PROPER EYE PROTECTION.*

Replace seat belts every two years on open canopy units and every three years on machines with cabs or at change of ownership.

Wear proper protective equipment such as safety goggles or safety glasses with side shields, hard hat, safety shoes, heavy gloves when metal or other particles are apt to fly or fall.

Use only grounded auxiliary power source for heaters, chargers, pumps and similar equipment to reduce the hazards of electrical shock.

Keep maintenance area *CLEAN* and *DRY*. Remove water or oil slicks immediately.

Remove sharp edges and burrs from reworked parts.

Be sure all mechanics tools are in good condition. *DO NOT* use tools with mushroomed heads. Always wear safety glasses with side shields.

Do not strike hardened steel parts with anything other than a soft iron or non-ferrous hammer.

Do not rush. Walk, do not run.

Know and use the hand signals used on particular jobs and know who has the responsibility for signaling.

SAFETY RULES

Face the access system when climbing up and down.

Apply the parking device and place the transmission in neutral before starting the machine.

Do not bypass the starter safety switch. Repair the starter safety controls if they malfunction.

Fasten seat belt before operating.

Steering should be checked to both right and left. Brakes should be tested against engine power. Clutch and transmission controls should be moved through or to neutral positions to assure disengagement. Operate all controls to insure proper operation. If any malfunctions are found, park machine, shut off engine, report and repair before using machine.

If the power steering or the engine ceases operating, stop the machine motion as quickly as possible. Lower equipment, set parking device and keep machine securely parked until the malfunction is corrected or the machine can be safety towed. Never lift loads in excess of capacity.

Should the machine become stuck or frozen to the ground, back out to avoid roll over.

Know and understand the job site traffic flow patterns.

Keep the machine in the same gear going down hill as used for going up hill.

When roading a machine, know and use the signaling devices required on the machine. Provide an escort for roading where required.

Always use the recommended transport devices when roading the machine.

Do not attempt repairs unless proper training has been provided.

Use extreme caution when removing radiator caps, drain plugs, grease fittings or pressure taps. Park the machine and let it cool down before opening a pressurized compartment.

Release all pressure before working on systems which have an accumulator.

When necessary to tow the machine, do not exceed the recommended towing speed, be sure the towing machine has sufficient braking capacity to stop the towed load. If the towed machine cannot be braked, a tow bar must be used or two towing machines must be used - one in front pulling and one in the rear to retard. Avoid towing over long distances.

Observe proper maintenance and repair of all pivot pins, hydraulic cylinders, hoses, snap rings and main attaching bolts.

Always keep the brakes and steering systems in good operating condition.

Replace all missing, illegible or damaged safety signs. Keep all safety signs clean.

Do not fill the fuel tank to capacity. Allow room for expansion.

Wipe up spilled fuel immediately.

Always tighten the fuel tank cap securely. Should the fuel cap be lost, replace it only with the original manufacturers approved cap. Use of a non-approved cap may result in overpressurization of the tank.

Never drive the machine near open fires.

Use the correct fuel grade for the operating season.

FOREWORD

Always furnish serial number if making an inquiry to dealer or factory about this machine.

Many equipment owners employ the Dealer Service Department for all work other than routine lubrication and minor service. This practice is encouraged, as our Dealers are well informed and equipped to render efficient service by factory trained mechanics.

Illustrations show standard and optional items.

IMPORTANT

The information in this manual was current at the time of publication. It is our policy to constantly improve our product and to make available additional items. These changes may affect procedures outlined in this manual. If variances are observed, verify the information through your Dealer.

Fiatallis is not responsible for any liability arising from any damage resulting from defects caused by parts and/or components not approved by Fiatallis for use in maintaining and/or repairing products manufactured or merchandized by Fiatallis.

In any case, no warranty of any kind is made or shall be imposed with respect to products manufactured or merchandized by Fiatallis when failures are caused by the use of parts and/or components not approved by Fiatallis.

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TOPIC 1 GENERAL DESCRIPTION

The electrical system supplies electrical energy to start and to operate the engine (on units using a spark to ignite the fuel-air mixture), and to operate all the electrical accessories of the units described in this manual.

Typical electrical systems include a starting or cranking circuit, a charging circuit, accessory circuits, and (on Model D and Model 65 graders) an ignition circuit.

Knowledge of the electrical systems of the units described in this manual and of the functions of their various components will provide a sound basis for performing troubleshooting and repair operations.

It is absolutely essential to have available the proper electrical testing equipment and to be proficient in its use if satisfactory troubleshooting and repair of electrical systems is to be accomplished.

It is not within the scope of this manual to explain electrical theory or the design of components; nor is it intended to provide the specifications or instructions for rebuilding components. The rebuilding of electrical system components should only be attempted by personnel having the proper facilities for checking and rebuilding the components in accordance with the manufacturers' specifications. Except for minor servicing, any components found to be malfunctioning or to have failed should be taken to a competent electrical repair shop for rebuilding.

The scope of this manual is limited to instruction in the troubleshooting of an electrical system to isolate faulty components and in the minor servicing of some components, and to the provision of electrical system schematics to assist service personnel in the troubleshooting, repair, and maintenance of electrical systems.

TOPIC 2 TROUBLESHOOTING

2.1 TROUBLESHOOTING INSTRUMENTS

2.1.1
Introduction—Many different tools and instruments have been developed for checking the mechanical or electrical condition of the components of an electrical system. This specialized equipment enables quick and accurate checks in a minimum amount of time. Three basic instruments are used in the testing of electrical equipment. These instruments are the voltmeter, the ammeter, and the ohmmeter.

2.1.2
The Voltmeter—Voltage in an electrical circuit is frequently compared to water pressure in a piping system (Figure 1). The voltmeter is used to measure this electrical pressure to assist in the location of electrical malfunctions. For the applications associated with electrical systems described in this manual, greater accuracy is desired in the voltmeter than in any of the other electrical checking instruments because the most accurate settings have to be made to the voltages in these systems.

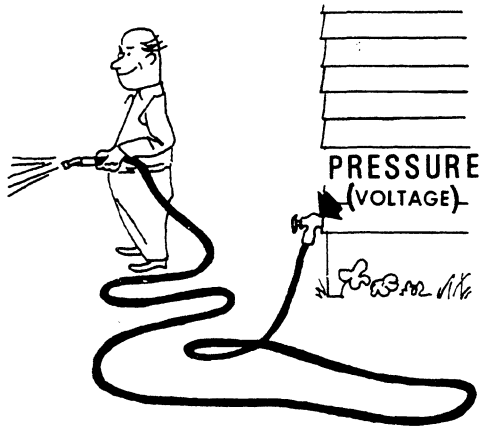

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FIG. 1 VOLTAGE IS SIMILAR TO PRESSURE IN A WATER HOSE

Voltmeters measure the difference in electrical pressure between the points where the voltmeter leads are attached. For example, a voltmeter connected across the terminal posts of a battery measures the difference in electrical pressure—the battery voltage—between the two terminals. A voltmeter connected across a resistor (in parallel, with one lead connected to each side of the resistor) measures the difference in voltage caused by the resistor. Typically, the voltage at a given point in a circuit is measured with respect to the voltage at some reference point, usually the return side of the circuit at the battery. It is often the case that one side of the battery is connected (grounded) to the conducting metal frame and chassis of the unit. In such cases, the chassis is used instead of many separate wires to the battery terminal. In general, the grounded battery terminal should be used as the reference point for the voltages in a circuit.

2.1.3
The Ammeter—The current past a point in an electrical circuit can be compared to the quantity of water that can flow through a particular pipe in a water system. The amount of current (measured in amperes) that will flow depends on the voltage (like pressure) available to push the current and on the amount of resistance encountered in the electrical circuit to impede it. (See Figure 2.)

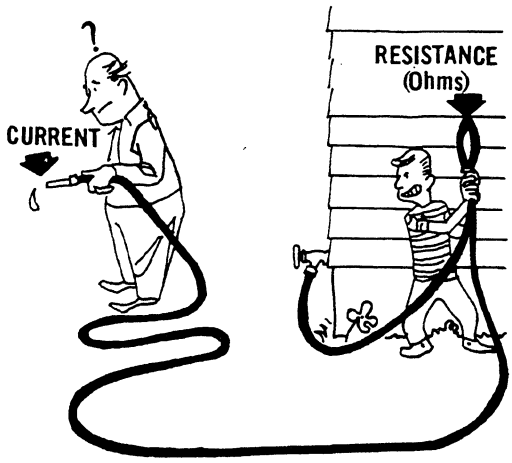

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FIG. 2 AMPS AND OHMS ARE SIMILAR TO CURRENT AND RESISTANCE IN A WATER HOSE

The ammeter is used to measure the flow of current. Since the current flows through the circuit, an ammeter must be connected in series with the circuit being measured. However, most ammeters cannot use all the current in the circuit in indicating a measurement, so a large, accurately measured fraction of the current is often diverted through an external path or shunt (shown in Figure 3) across the

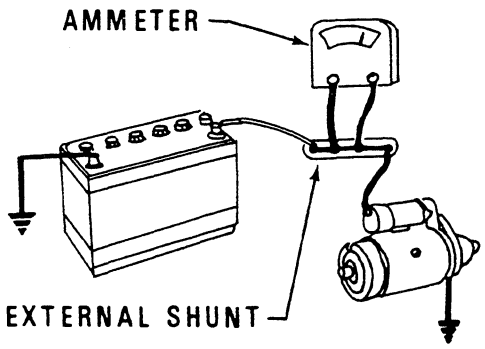

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FIG. 3 EXTERNAL SHUNT

meter terminals. Since the fraction of the total current being diverted is known, the meter can be calibrated to read in terms of the total current even though all the current is not flowing through it. For example, if a shunt is designed to divert three-fourths of the current flowing in an ammeter calibrated to use the shunt, and the ammeter reads four amperes with the shunt connected, then really only one ampere is flowing through the meter. The numbers on the scale of the ammeter all have been multiplied by four to indicate the total current. Therefore, despite the number on the meter scale, the meter should be checked to see if it requires a shunt to make the numbers meaningful and to prevent damaging the meter.

2.1.4
The Ohmmeter—The ohm is the unit of measurement of electrical resistance, the property of wiring and electrical devices which limits the flow of current through them. Resistance can be compared to the size of piping in a water system. It is an essentially constant property of every electrical device. Resistance is related to voltage and current in the following way:

$$\frac{\text{Number of volts}}{\text{Number of amperes}} = \text{Number of ohms}$$

Therefore, if the resistance of wiring or of an electrical device is known, the amount of current that will flow through it can be calculated if the voltage across it is known. If the current and the resistance are known, the voltage can be calculated.

Because of the relationship between voltage, current, and resistance, the resistance is usually measured indirectly by measuring current with respect to a constant voltage source. The meter is calibrated in terms of the resistance in ohms corresponding to each value of current, and such an instrument is called an ohmmeter.

Ohmmeters are connected across the portion of the circuit in which the resistance is to be measured. Because the ohmmeter has its own power source (usually a battery) that forces current through the circuit being measured, care must be taken to insure that the only path for the current is through that circuit and not through any other devices left connected to it. In addition, any power sources to the circuit or device being measured should be disconnected because such power sources will affect the current through the ohmmeter and cause an erroneous reading. Excess current from power sources in the circuit could damage the meter.

If the resistance through a circuit is too high, the cause may be poor connections, frayed or partly broken wires, or undersized wires. If the resistance is too low, the cause may be a short circuit or a similar shunting path across the circuit through which the excess current can flow.

2.1.5
Instrument Use—The most important thing to remember when using voltmeters or ammeters is to be sure that the instrument chosen will be capable of handling the voltage or current to be measured. It is far better to have a meter that is reading a low value on its scale than to have a meter that is burned out. Even though the current or voltage rating of a circuit may be given, these values may be far below the actual values in the circuit if it is malfunctioning.

2.2 ANALYZING AN ELECTRICAL SYSTEM

2.2.1
The objective of troubleshooting is to isolate the cause of the trouble in a particular part of the system. When located, the part can be repaired or replaced. The malfunction itself is often characteristic of the part of the system that is at fault. Knowing the malfunctions that can be caused by each part of the system, and observing the meters provided on the dashboard or control panel of the unit may be all that is necessary to diagnose a problem. However, the nature of the problem should be confirmed by using the equipment and the methods described in this manual.

2.2.2
The Charging Circuit—The reading on the dashboard ammeter and an inspection of the battery will usually indicate whether the charging circuit is operating properly. After the engine is started, the ammeter should indicate a slight rate of charge, while the engine is running, to replenish the electricity used in starting the engine. In addition, if the battery remains fully charged with a minimum addition of water (1 to 2 ounces per month), the charging circuit is in good condition.

If the ammeter continues to indicate a substantial charging rate while the engine is running, or if the battery remains undercharged or consistently becomes overcharged, as evidenced by the frequent addition of water, the charging circuit is malfunctioning in some way. The entire circuit must be analyzed to locate the cause of the trouble so that corrective action can be taken. In the absence of specific symptoms, the components of the charging circuit should be checked in the following order: the wiring; the battery; the alternator or generator; and then the regulator.

The wiring is often overlooked when troubleshooting. It should be checked carefully for frayed insulation or other evidence of damage. All connections should be inspected, and they should be cleaned or tightened as necessary. The resistance across good connections will be negligibly small.

The reason that the battery cannot be maintained properly charged may be due to a defect within the battery itself. Depending on the amount of use of the equipment, the amount of time between battery replacements will vary, but they will be inevitable. (Some units are equipped with an oil pressure switch that prevents charging of the battery when the oil pressure is low. On these units, the engine oil level and the switch also should be checked.)

Defects within the alternator or generator, such as open or shorted field windings, can cause the battery to become undercharged or overcharged. The output voltage of the generator or alternator should be checked (as described under Topic 3). If none of the components of the charging circuit prove defective, then trouble with the regulator is indicated.

2.2.3
The Starting Circuit—If the reason for the malfunction does not originate in the wiring or in the battery, then the starter and safety switches, the starter solenoid, and the starting motor should be checked (as described under Topic 4).

2.2.4
The Accessory Circuits–The accessory circuits include the headlights, the taillights, and other electrical equipment deriving power from the electrical system, but not associated with one of the main circuits described above. When an accessory malfunctions, the wiring and switches associated with it should be checked in addition to the accessory itself.

Since the accessory circuits can draw current from the battery when the engine is not running, they can cause the battery to run down. When the accessories and the engine are turned off, no current flow from the battery should be indicated on the dashboard ammeter of the unit being checked.

2.2.5
The majority of electrical system problems can be solved easily by a combination of knowledge of the functions of components and common sense. Some of the problems most likely to be encountered are:

(Refer to the appropriate Topics for further details.)

TROUBLE	POSSIBLE CAUSES	REMEDIES
Starting motor will not operate. (Accessories operate.)	Faulty starter safety switch. Faulty starter switch. Faulty ignition switch.* Faulty wiring. Starting motor or solenoid failure.	See Topic 4.
Starting motor will not operate. (Accessories will not operate.)	Battery failure. Faulty master switch. Faulty wiring.	Check and replace, if necessary. (See Topic 7 for batteries.)
Starting motor cranks too slowly	Partially discharged battery. Defective battery cable. Starting motor or solenoid failure.	Check and replace battery.** Clean connections or replace cable. (See Topic 4 for starting motor or solenoid.)
Starter chatters or clicks but does not operate.	Faulty starter solenoid. Partially discharged battery.	Check and replace starter solenoid. Check and replace battery.**
Battery will not remain charged. (Some charging current is indicated.)	Battery failure. Loose drivebelt to alternator or generator. Faulty wiring. Accessory current exceeds output of alternator or generator.	Check and replace battery.** Check and tighten drivebelt. Check and repair wiring. (See Topic 3 for alternator or generator.) Disconnect accessories.
Battery will not remain charged. (No charging current is indicated.)	Generator or alternator failure. Regulator failure. Faulty oil pressure switch (on some units).	(See Topic 3 for alternator or generator.) Check engine oil level and pressure switch.
Battery electrolyte level cannot be maintained.	Faulty alternator or generator. Faulty regulator.	(See Topic 3.)
Wiring burned or brittle.	Short in affected circuit.	Locate and repair short.
Accessory operates improperly or not at all.	Faulty wiring or switches in accessory circuit.	Check and replace or repair.

* Ignition switch is only on Model D or Model 65 graders.
**Battery should be replaced only if it cannot be recharged on or off the unit. (See Topic 7.)

Each possible cause listed in the above table refers to a device that may or may not be in the specific electrical system being repaired. If the device mentioned is not a part of the electrical system (although most of them will be), the instructions pertaining to the device should be ignored.

The following table pertains only to Model D and Model 65 grader ignition circuits. (See Topic 5.)

TROUBLE	POSSIBLE CAUSES†	REMEDIES
Engine will not start, but is cranking properly; or engine performance is poor or erratic.	Faulty breaker points or condenser. Spark plugs worn or fouled. Faulty wiring. Faulty ignition coil. Ignition timing out of adjustment. Moisture in distributor.	Repair or replace faulty wiring. (See Topic 5 for ignition circuit parts.)

†Assuming the problem has been isolated in the electrical system and not in the fuel system.

TOPIC 3 CHARGING CIRCUIT

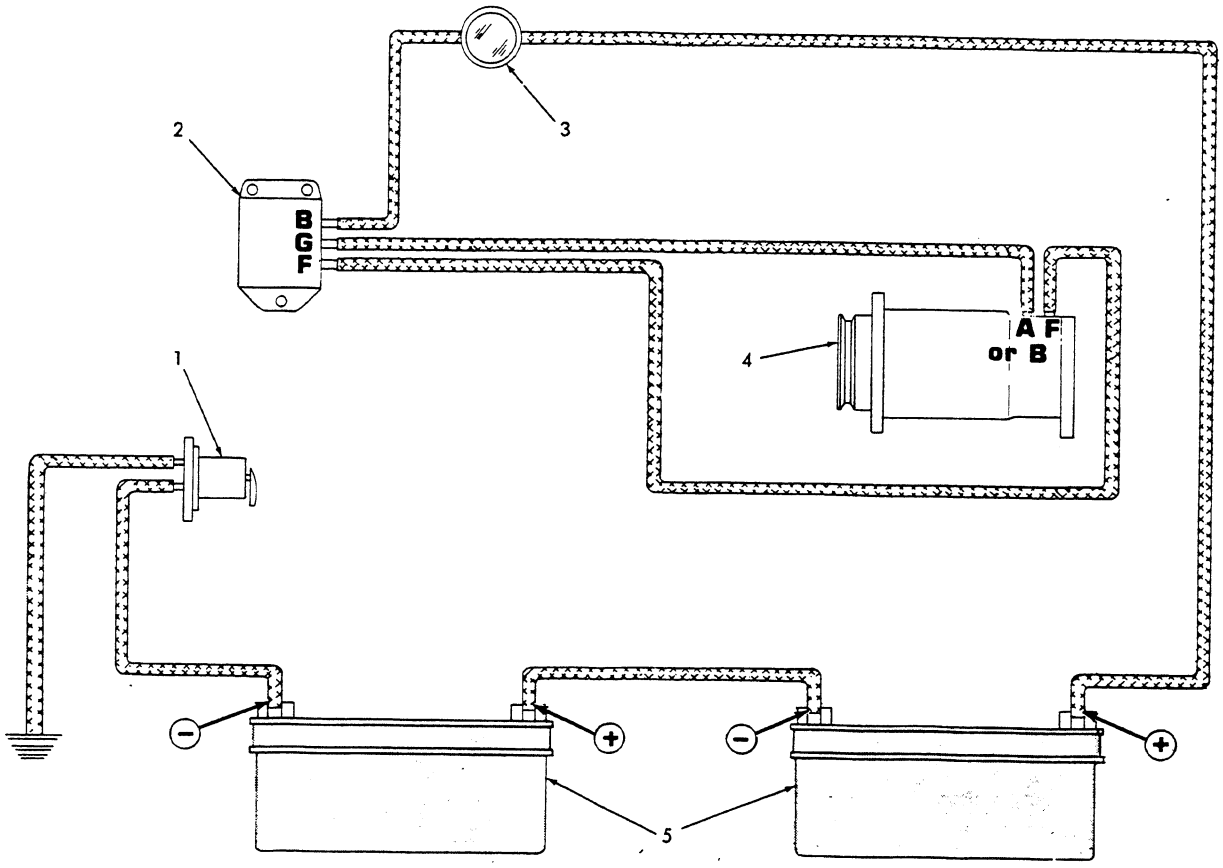

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FIGURE 4 TYPICAL CHARGING CIRCUIT SCHEMATIC

1. Switch, master
2. Regulator
3. Ammeter
4. Generator or alternator
5. Batteries

3.1 DESCRIPTION

The charging circuit consists of the batteries, the generator or alternator, the regulator, the wiring, and the master switch. (See Figure 4.) The charging circuit supplies the electrical energy necessary to keep the batteries fully charged.

3.2 GENERATOR (DC)

3.2.1
Testing—To check the output of a generator, connect an ammeter in series with the generator output ('A' or BATT terminal) and the batteries. This can be accomplished while the generator is still mounted on the unit by disconnecting the rest of the electrical system from the ungrounded side of the battery (or batteries) and from the generator output. The ammeter can be connected directly to these points, with the polarities of the battery terminal and its ammeter connection matching. Also connect a jumper cable between the generator field terminal (marked F) and ground, as shown in Figure 5. Finally, connect a voltmeter between the generator output and ground, and connect a load rheostat from the ungrounded side of the battery to ground. (Connect the rheostat last, and disconnect it as soon as possible when the engine is off or if the generator is malfunctioning. Otherwise, the battery will run down.)

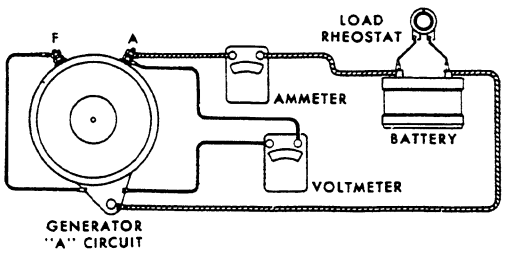

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FIGURE 5 CONNECTIONS FOR CHECKING OUTPUT OF DC GENERATORS.

With the engine of the unit running, adjust the engine speed and the rheostat to give the maximum amount of current flow at the rated voltage (stamped on the nameplate) of the generator. Now determine the ampere-hour rating (marked on the case) of the battery. The maximum generator current should be greater than one-fifth of the value of the ampere-hour rating. While this fraction of the ampere-hour rating does not represent an absolute measure of the requirements on the generator, it gives a reasonable number to compare against the generator output. More accurate checking of the generator output requires access to the manufacturer's specifications of the output capability.

3.2.2
Servicing–Servicing of the generator while it is on the equipment is limited to adjustment of the drive belt. If the drive belt is slipping because it is too loose, the generator will not operate properly. (Some early models also have a removable band on the generator to allow cleaning of its commutator. On these units, the commutator should be cleaned with #00 or finer sandpaper or a brush seating stone.

CAUTION

Never use emery cloth to clean the commutator, since particles of emery will embed and cause arcing, burning and rapid wear of the commutator and brushes.

If the generator does not perform satisfactorily, it should be removed for replacement or rebuilding. The following procedure should be employed when removing the generator:

1. Turn the electrical system master switch to OFF, disconnect the wiring harness from the generator, and label the wiring for faster reinstallation.
2. Remove the capscrews attaching the generator to its mounting bracket and to its adjusting strap.
3. Remove the generator.

The generator must be rebuilt and tested in accordance with its manufacturer's specifications. It should be taken to a dependable electrical repair shop where the necessary facilities and technical skill are available.

CAUTION

When reinstalling all DC generators, they must be polarized to prevent damage to the regulator. Polarization can be accomplished as follows:

1. Turn the electrical system master switch ON after the generator is installed and connected to the rest of the electrical system.
2. Using a short jumper lead, as shown in Figure 6, *momentarily* short the battery (B) and generator (G) terminals of the *regulator*.

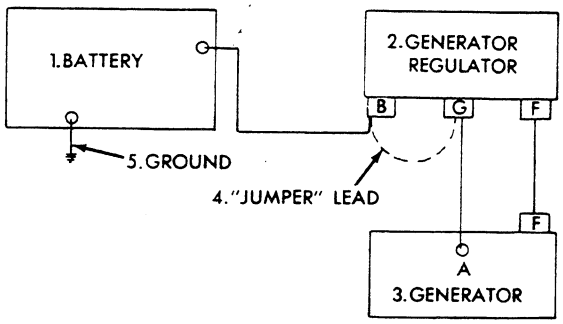

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FIGURE 6 POLARIZING CIRCUIT SCHEMATIC

3.3 ALTERNATOR

3.3.1
Testing–To check the output of an alternator with an external regulator, connect an ammeter in series with the alternator output ('B' or BATT terminal) and the batteries. This can be accomplished while the alternator is still mounted on the equipment by disconnecting the rest of the electrical system from the ungrounded side of the battery (or batteries) and from the alternator output. The ammeter can be connected directly to these two points, with the polarities of the battery terminal and its ammeter connection matching. Also connect a jumper cable between the field terminal and the alternator terminal, as shown in Figure 7. Finally, connect a voltmeter between the alternator output and ground, and connect a load rheostat from the ungrounded side of the battery to ground. (Connect the rheostat last, and disconnect it as soon as possible when the engine is off or if the alternator is malfunctioning. Otherwise, the battery will run down.)

With the engine of the unit running, adjust the engine speed and the rheostat to give the maximum amount of current flow at the rated voltage of the alternator. Information about the rated load capability of the alternator is stamped on the alternator nameplate. At the rated voltage, the maximum current flow should be within 10 percent of the rated current stamped on the nameplate. If the maximum is not within the 10 percent tolerance limit, the alternator must be removed for servicing.

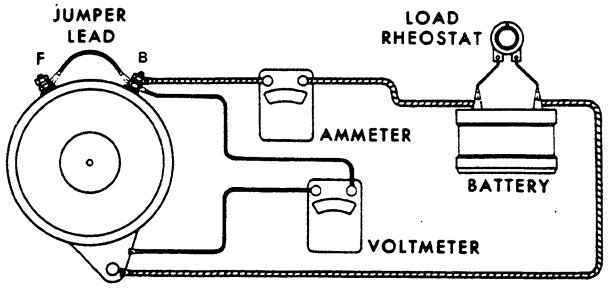

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FIGURE 7 CONNECTIONS FOR CHECKING OUTPUT OF ALTERNATORS.

3.3.2
Testing Integral Charging Systems - To check the output of an alternator with a built-in regulator (an 'integral charging system') the same connections, with one exception, must be made that are required to check the output of alternators without built-in regulators. (See Fig. 8). Building the regulator into the case of the alternator eliminates the need for the connection to the field terminal.

The field terminal is not accessible on integral charging systems. In addition, alternator and regulator are being checked simultaneously, so no separate regulator checks can be performed.

IMPORTANT: Delco-Remy equipment is not labeled in the standard manner. DC generators are referred to as such by that company, but alternators are referred to as Delcotron Generators. This system of labeling is often confusing, and has been avoided in this manual in favor of the more common nomenclature, reserving the name 'generator' for a DC power source and the name 'alternator' for an AC source. Integral charging systems are only of the alternator type.

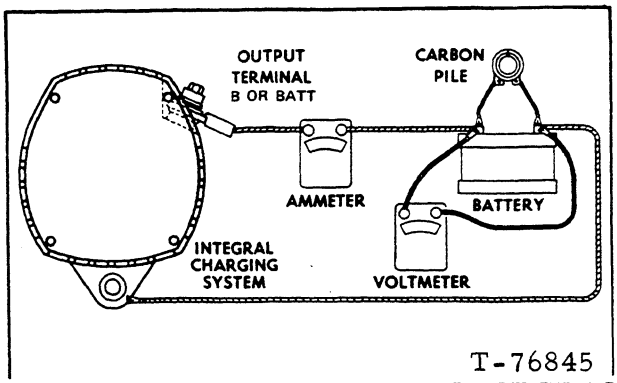

FIG. 8 OUTPUT CHECK OF INTEGRAL CHARGING SYSTEM (Hex bolt on output terminal is electrically insulated)

3.3.3
Servicing - If the alternator or integral charging system is found to be malfunctioning, it should be removed and repaired. (refer to ELECTRICAL COMPONENTS Manual 73116569). Removal of the alternator is accomplished in a manner identical to the method for generator removal. (See Section 3.2.2).

Do not attempt to polarize an alternator or an integral charging system when it is reinstalled.

3.4 REGULATOR

3.4.1
Testing - Testing or adjustment of the regulator should not be attempted without dependable test equipment and should be done in strict accordance with the manufacturer's specifications.

When the batteries and the wiring have been checked and found satisfactory, but the batteries are not receiving enough electricity to maintain them in a charged or nearly charged condition, then the generator or alternator or the regulator is malfunctioning. (An open oil pressure switch also will prevent charging of the battery on some units. The switch and the engine oil level should be checked. In addition, too much accessory equipment drawing power from the batteries can run them down even with everything else in the charging circuit functioning properly).

After the generator or alternator has been checked and found operational, the regulator should be examined for burned points or discolored coils. (Some regulator units are sealed permanently and must simply be replaced). If the generator or alternator proves to be malfunctioning, the regulator should be checked anyway because both units may have gone bad.

3.4.2
The voltage setting for one type of operating condition may not be suitable for another. Underhood temperatures, engine speeds and night time service are all factors which influence proper operating voltage. The ideal voltage setting is attained when the battery remains fully charged with a minimum use of water. If no circuit defects are found and the

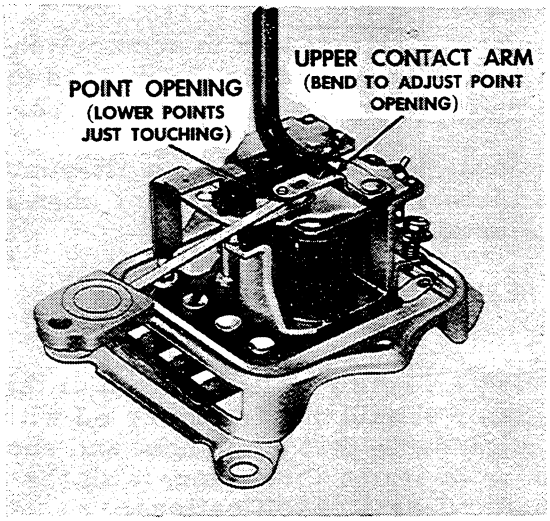

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FIG. 9 CHECKING VOLTAGE REGULATOR POINTS A.C.

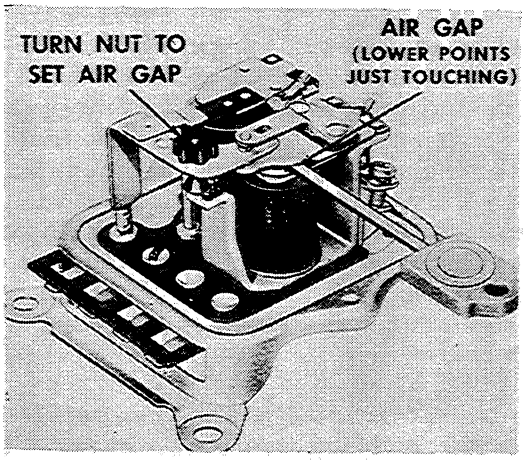

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FIG. 10 CHECKING VOLTAGE REGULATOR AIR GAP A.C.

battery remains undercharged, raise the voltage setting by .3 volts and then check for improved state of charge of the battery after a reasonable period of service. If the battery remains consistently overcharged, lower the voltage setting by .3 volts and recheck for improved battery condition. Voltage setting procedures are covered below.

3.4.2.1
Point opening - With the lower contacts points touching, check the point opening of the upper contacts as shown in Fig. 9 . If necessary, reset the opening to .010 - .020 in. (.254 -.507 mm) by bending the upper contact arm as shown in Fig. 9 .

3.4.2.2
Air gap - Measure the air gap between the armature and core, when the lower contacts are touching, as shown in Fig. 10 . The approximate setting is .067 in (1.702 mm). This setting is called approximate because the final setting must be whatever is required to obtain the specified difference in voltage (.1 - .8 volts) between the upper and lower sets of contacts as covered in the next subparagraph.

3.4.2.3
Voltage setting - The voltage at which the regulator operates varies with ambient (surrounding) temperatures. The ambient temperature is that measured 1/4 in. (6.350 mm) from the regulator cover.

Temperature Voltage Setting	65°F(21°C) 27.7-29.8	85°F(32°C) 27.4-29.4
Temperature Voltage Setting	105°F(40°C) 27.1-29.0	125°F(54°C) 26.8-28.5
Temperature Voltage Setting	145°F(66°C) 26.6-28.2	165°F(77°C) 26.3-27.9
Temperature Voltage Setting	185°F(88°C) 26.0-27.6	

3.4.2.4
To check and adjust setting, proceed as follows:

3.4.2.4.1
Connect an ammeter and a 1/4 ohm resistor with rating of 25 watts or more in series in the circuit at the "BAT" terminal on the alternator as shown in Fig. 11 .

Charging Circuit

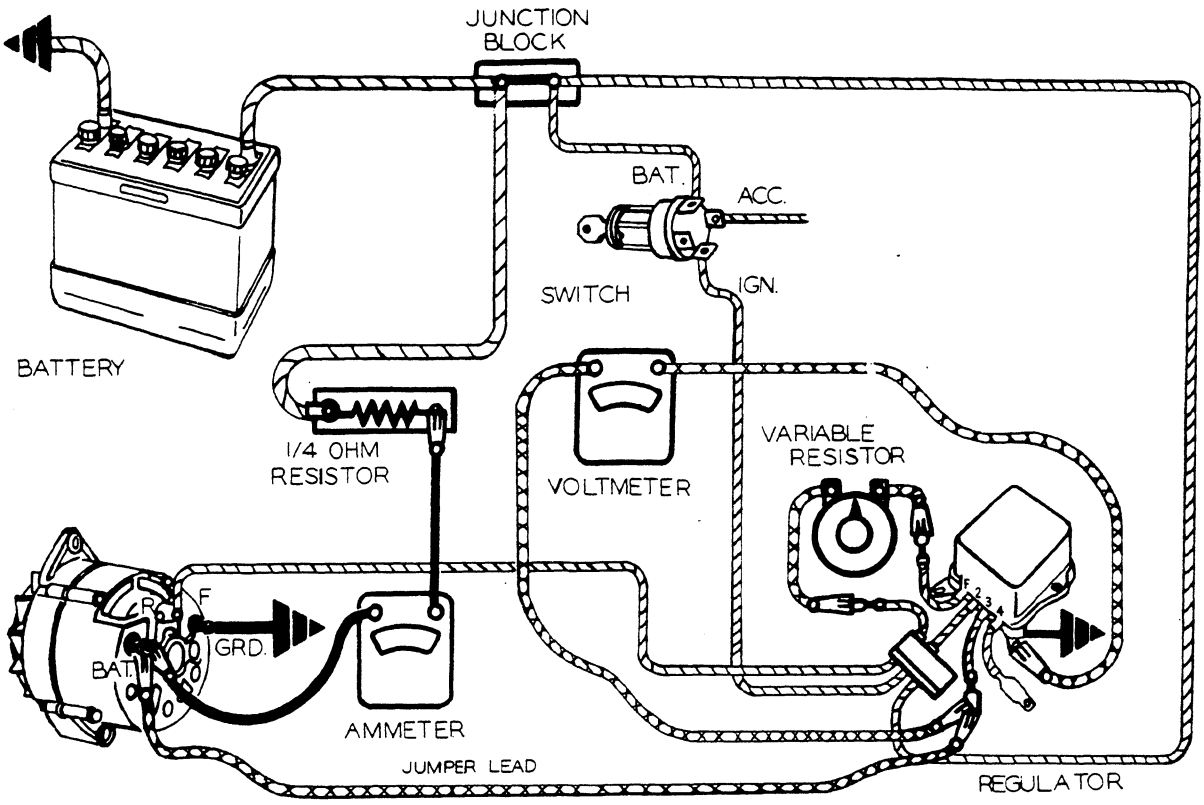

FIG. 11 CHECKING VOLTAGE SETTING A.C.

3.4.2.4.2
Make connections to the regulator as shown in Fig. 11. Use a 25 ohm 25 watt variable resistor in series with the alternator field winding at the regulator "F" terminal and connect a jumper lead from the adapter to the alternator "BAT" terminal as shown. Also, connect a voltmeter from the adapter to ground as shown.

3.4.2.4.3
Turn the variable resistor to the closed or "no resistance" position. Do not allow the No. 4 lead to touch ground.

⚠ WARNING

- ⚠ If engine is to be started indoors, insure proper ventilation to remove deadly gases.
- ⚠ Warn all people who may be servicing or working around machine before starting engine.
- ⚠ Sound horn before starting.
- ⚠ Never leave machine unattended with engine running.

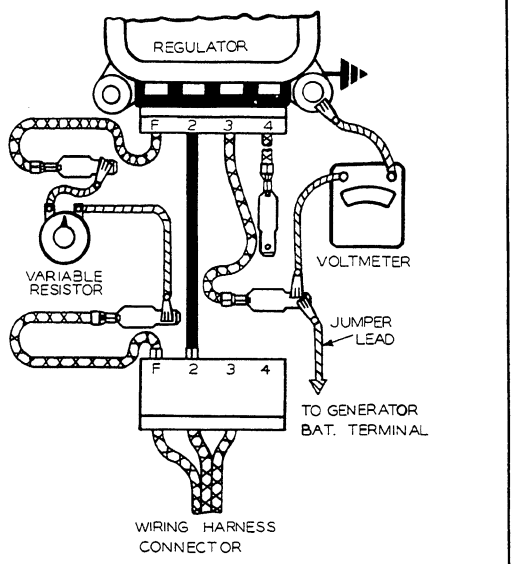

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FIG. 12 CHECKING VOLTAGE SETTING A.C.

3.4.2.4.4
Operate the alternator at approximately 1500 engine rpm for 15 minutes. Leave the cover on regulator to establish operating temperature. Accessories and lights should be turned off.

3.4.2.4.5
After the 15 minute warm-up, cycle the regulator as follows:

3.4.2.4.6
Turn the variable resistor in the field circuit to the "off" position.

3.4.2.4.7
Disconnect and then reconnect the jumper lead at the "BAT" terminal of the alternator.

3.4.2.4.8
Return the variable resistor to the closed or "no resistance" position.

3.4.2.4.9
Bring engine speed up to the maximum (about 2500) rpm and note the voltage setting. Refer to the temperature-voltage table in subparagraph 3.4.2.3

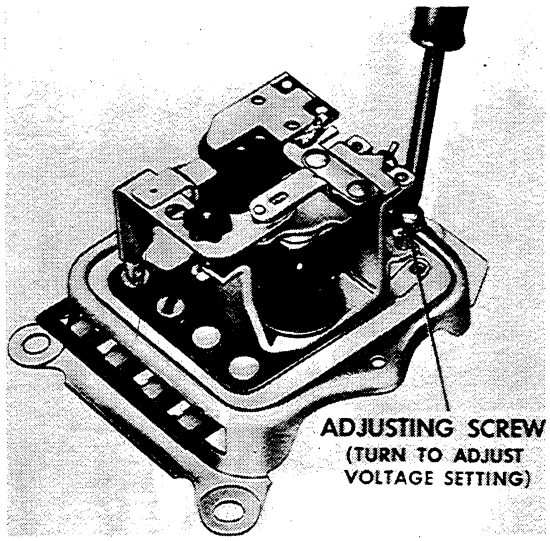

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FIG. 13 ADJUSTING VOLTAGE SETTING A.C.

for proper specification. The regulator should be operating on the upper or shorting contacts. If it will not operate on the upper contacts, the battery is extremely discharged and must be at least partially recharged before proceeding further.

3.4.2.4.10
If necessary to adjust the voltage setting, turn the adjusting screw as shown in Fig. 13.

NOTE: When removing or installing the regulator cover, always disconnect the jumper lead at the "BAT" terminal of the alternator to avoid accidental grounds. Always make the final setting of the voltage adjustment by turning the screw clockwise to insure the spring holder is snug against the adjusting screw.

3.4.2.4.11
After adjusting the setting, cycle the regulator as described in paragraph number 3.4.2.4.6 thru 3.4.2.4.9.

3.4.2.4.12
Operate the engine again at 2500 rpm and note the setting. Readjust if necessary. Always cycle the regulator be-

fore reading the final setting on the voltmeter. Always read the final setting with the regulator cover in place.

3.4.2.4.13
After adjusting the voltage setting while operating on the upper set of contacts, check the setting while operating on the lower set of contacts. Slowly increase the resistance of the variable resistor with the engine operating at 2500 rpm until the regulator begins to operate on the lower contacts. Note the voltage reading and refer to the temperature-voltage table in sub-paragraph 3.2.2.3 for proper specification.

NOTE: If increasing the variable resistance does not cause the regulator to operate on the lower set of contacts, return the resistor to "no resistance", turn on the lights or use a similar drain and readjust the resistor.

3.4.2.4.14
The difference in operating voltage between the upper and the lower set of contacts can be increased by slightly increasing the air gap and decreased by slightly decreasing the air gap. See Fig. 10 for details on changing the voltage regulator air gap. If it is found necessary to adjust the air gap, it will also be necessary to recheck the final voltage setting with the cover in place.

3.4.3 MAINTENANCE

3.4.3.1
The voltage regulator contacts do not normally require cleaning unless electrical performance indicates it is necessary. Sooty or discolored appearance of the contacts is normal after a short period of operation. However, if the voltage flunctuates as evidenced by an unsteady voltmeter reading when checking the voltage setting, the contacts may be sticking or have excessive resistance and should be cleaned. Before cleaning the contacts, make sure the unsteady voltage is not due to loose connections or high resistance elsewhere in the system. Clean the contacts as follows:

⚠ DANGER

DENATURED ALCOHOL IS FLAMMABLE. Extinguish all smoking materials or open flames before washing parts with alcohol.

3.4.3.2
The contacts on the voltage regulator unit are made of a soft metal and must not be filed. A folded strip of No. 400 silicon carbide paper (or equivalent) pulled back and forth between the contacts is recommended for cleaning. After cleaning, wash the contacts with alcohol or trichlorethyelene to remove residue. If the voltage control does not improve, repeat the cleaning and washing process

3.4.3.3
To clean the field relay points, use a thin, fine-cut, flat file. Remove the minimum material necessary to clean the points.

3.4.3.4
Do not use sandpaper or emery cloth to clean contact points.

MEMO

TOPIC 4 STARTING CIRCUIT

4.1 DESCRIPTION

The starting or cranking circuit consists of the battery or batteries, the starting motor with a solenoid switch, and a starter switch. (See Figure 14 Several other switches also may be included in series with the starter switch. A starter safety switch (either manual or automatic) prevents starting of the unit when the transmission is not in neutral. Finally, the electrical system master switch must be mentioned in the starting circuit because it controls the flow of electricity from the battery, and the starting circuit relies entirely on the current from the battery to operate.

4.2 STARTING MOTOR AND SOLENOID

4.2.1
Testing—After the battery has been checked and the wiring has been examined and the switches have been shown to be functioning, the starter solenoid and the starting motor should be checked.

The solenoid should make a single, clean click when the starter switch is thrown. If the click is heard, but the starting motor does not work, then the trouble is most likely in the starting motor. If no click is heard, then the solenoid switch is not operating and the starting motor cannot work. (Before assuming that either the solenoid or the starting motor is at fault, make absolutely certain that the more common problems of a weak battery or bad connections are not causing the trouble.)

4.2.2
Servicing—Because the solenoid switch and the starting motor typically are mounted together as a single unit, both items should be removed if one proves to be malfunctioning.

Field service on the starting motor is limited to cleaning of the commutator. If the starter solenoid is malfunctioning, it must be replaced. Any other adjustments or repairs require the use of special equipment. When more complicated repair work is required, the starter assembly should be taken to a dependable electrical repair shop.

The following inspection procedure should be used when servicing the starter assembly:

1. The commutator should be clean, not excessively worn, and without high mica or burned bars. A glazed or blued commutator does not indicate a condition requiring service. A dirty commutator should be cleaned with #00 or finer sandpaper, or a brush seating stone.

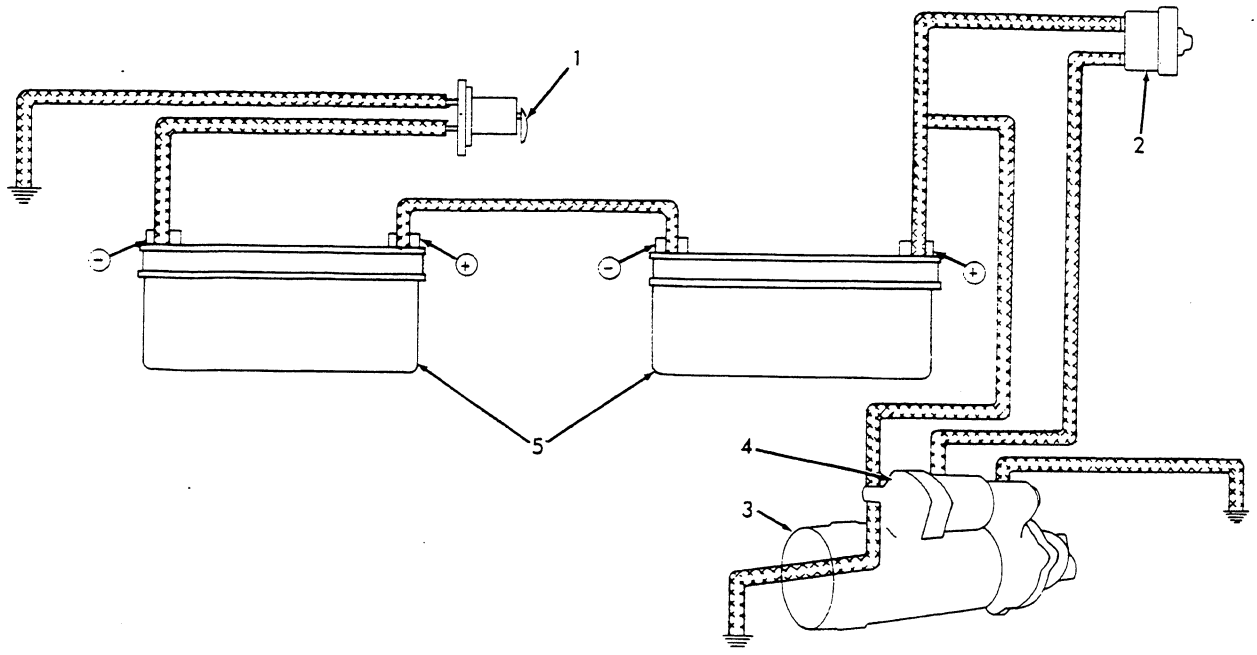

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FIG. 14 TYPICAL CRANKING CIRCUIT SCHEMATIC

1. Master switch
2. Starter switch
3. Starting motor
4. Solenoid
5. Batteries

CAUTION

Never use emery cloth to clean the commutator, since particles of emery will embed and cause arcing, burning and rapid wear of the commutator and brushes.

2. All electrical connections should be clean and tight. The starting motor brush tension should be in accordance with the manufacturer's specifications. Brushes must not be worn shorter than half their original length.

Continued cranking of the starting motor after the starter has been released indicates shorted turns in the windings of the solenoid switch or that the switch is mounted out of line and its plunger is binding. Chattering of the solenoid switch indicates shorted turns in its windings or low batteries.

4.3 SWITCHES

4.3.1
Testing—If any of the switches in the starting circuit seem to be remaining off when they should be on, they may be tested by connecting a jumper cable across the appropriate terminals to complete the circuit. If the circuit functions properly with the jumper cable connected, then the switch being tested has gone bad and should be replaced. If the circuit still does not function, then the break in the circuit must be somewhere else. (The possibility of more than one switch being bad also must be considered because, in such a case, the jumper cable across any one switch will not make the circuit work.)

4.3.2
Servicing—If a switch proves to be malfunctioning, it should be replaced. However, before replacing any switches in the starting circuit, the conditions which the switches are supposed to monitor should be checked. It is possible that the transmission of the unit is not in neutral, so that a switch like the starter safety switch should be open.

TOPIC 5 IGNITION CIRCUIT (Model D and Model 65 Graders Only)

5.1 DESCRIPTION

The ignition circuit consists of the battery, the distributor, the ignition coil, and the spark plugs. (See Figure 15) The circuit consists of a primary (low voltage) section and a secondary (high voltage) section.

5.2 DISTRIBUTOR

5.2.1
Inspection—The distributor includes the breaker points and the condenser. (See items 14 and 15 of Figure 16) The distributor cap and rotor should be inspected for chips, cracks, or carbonized paths which would allow high-voltage leaks to ground. If inspection indicates one of the previously described conditions, the affected part should be replaced. If the breaker points appear to be badly burned, improperly aligned, or the performance of the engine indicates the need, the points should be replaced. A feeler gauge provides an accurate means of setting the point gap, as shown in Figure 17 The specified gap width is .018" to .022" (.457 to .559 mm). (If a dwell meter is used to adjust the points, the correct angle is between 28° and 30°.)

5.2.2
Testing—Suspected shorts or leakage paths to ground can be checked with an ohmmeter. With the ignition switch off, the resistance between any distributor connection and ground should be very high. The ohmmeter may deflect momentarily into a low resistance when it is connected to the condenser. However, it soon should rise to a high value.

Whenever the distributor cap is removed for inspection, it should be cleaned inside and out with a **dry** cloth. In addition, the precise order of the connections to the distributor should be noted to avoid making mistakes during reconnection.

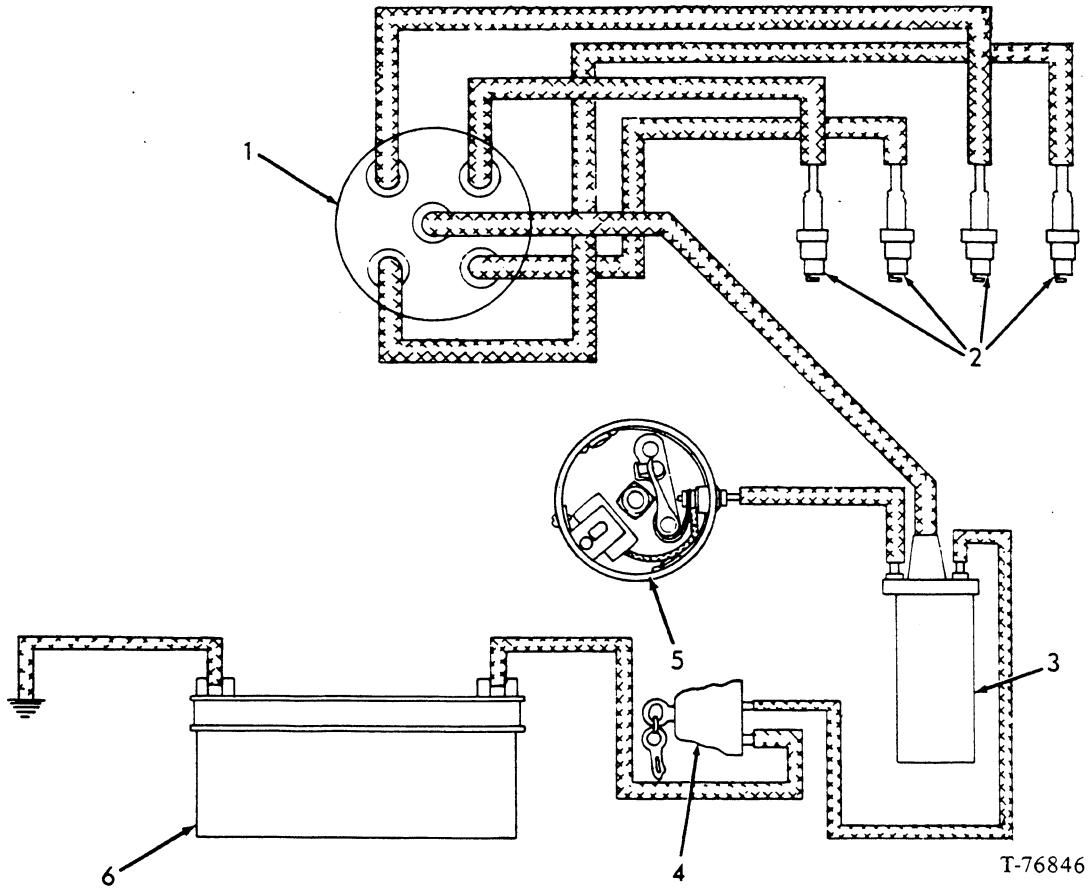

FIG. 15 IGNITION CIRCUIT SCHEMATIC

1.	Distributor cap	4.	Ignition switch
2.	Spark plugs	5.	Distributor
3.	Ignition coil	6.	Battery

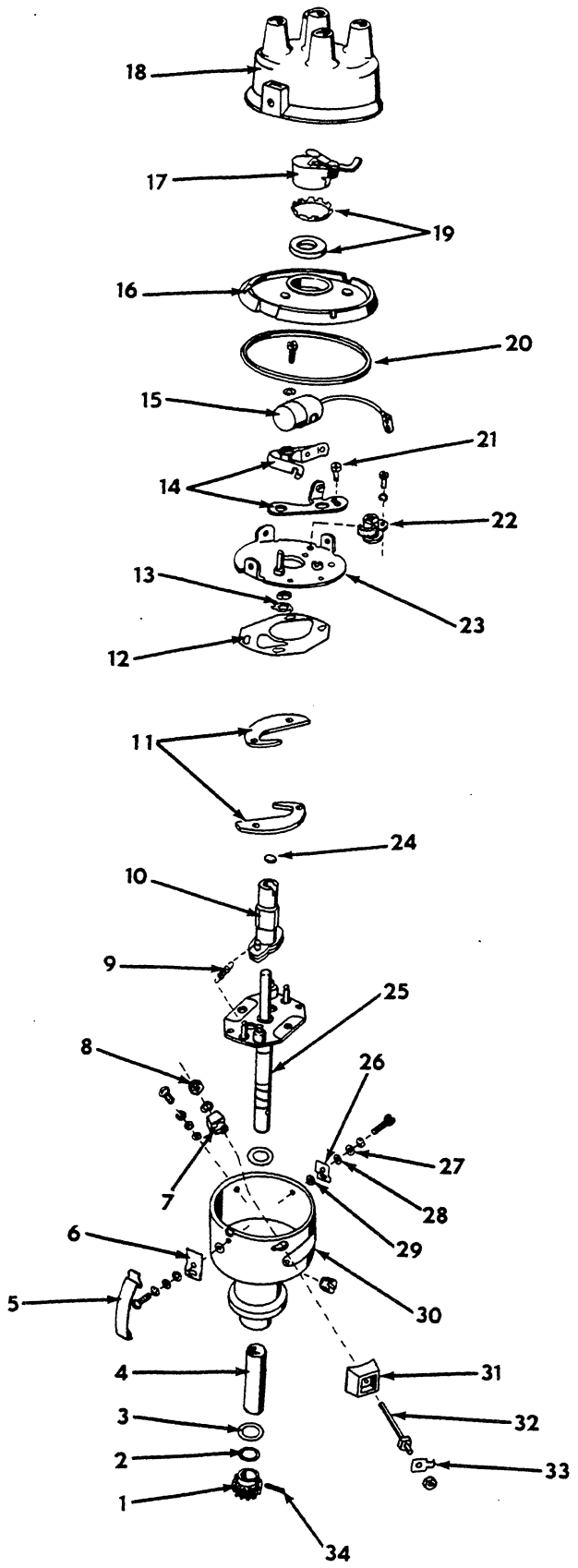

FIG. 16 DISTRIBUTOR PARTS
(T-3489)

1. Gear (12 teeth)
2. Gear driven shim (.005" thick)
3. Thrust washer
4. Bushing
5. Cap retaining clip
6. Clip support
7. Insulator
8. Nut
9. Advance weight spring
10. Cam assembly
11. Timing advance weight
12. Weight retaining plate
13. Lock (washer)
14. Breaker point set
15. Condenser
16. Cover
17. Rotor
18. Cap
19. Seal kit
20. Cap gasket
21. Screw
22. Lubricator (early units only)
23. Plate
24. Oiling wick
25. Shaft assembly
26. Support
27. Retainer
28. Gasket
29. Support gasket
30. Housing
31. Insulator
32. Stud
33. Lock
34. Pin

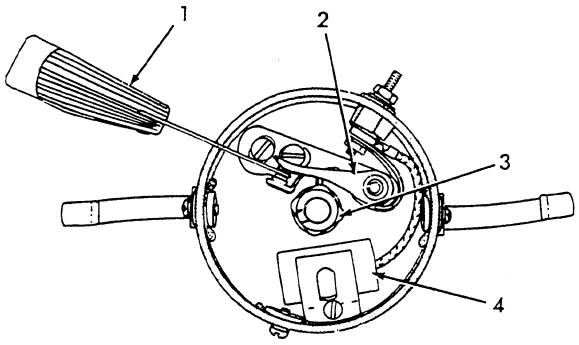

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FIG. 17 SETTING BREAKER POINT GAP

1. Feeler gauge
2. Breaker point set
3. Cam
4. Condenser

5.3 IGNITION COIL

The ignition coil requires no special service other than to keep the connections to it tight and clean. (The case of the coil should be grounded securely through the mounting bracket.) If the coil is malfunctioning, it should be removed and replaced.

5.4 SPARK PLUGS

5.4.1
Inspection—Visual inspection of the spark plugs is a simple way to judge the condition of the engine. Spark plugs operating normally will show a deposit of medium color and hardness. With the deposit removed, the insulator in the spark plug also should look normal.

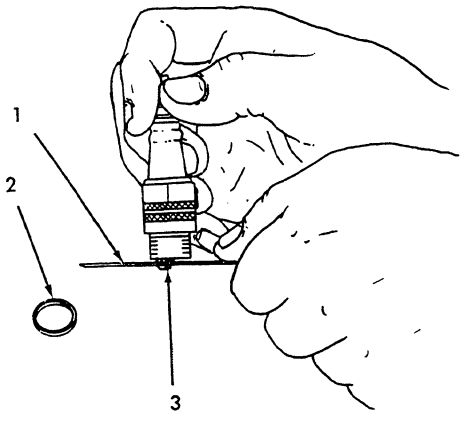

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FIG. 18 SETTING SPARK PLUG GAP

1. Wire gauge
2. Washer (copper)
3. Electrode (outer)

5.4.2
Servicing—If inspection reveals any cracks or chips in the spark plug insulator, or if the center electrode is worn within .0938" (2.38 mm) of the end of the insulator, the spark plug should be replaced.

Spark plugs should be cleaned in an apparatus designed for the purpose. Approximately every five hundred hours of operation, the gap between the electrodes should be reset between .028" and .033" (.711 to .838 mm) as shown in Figure 18. The plugs should be reinstalled to 25 lbs.-ft. (3.45 Kg-m) of torque.

5.5 TIMING ADJUSTMENT

5.5.1
Description—Properly adjusted timing assures that the distributor is causing the spark plugs to fire at just the right times in the engine cycle. If the timing is not adjusted properly, and if the engine is capable of running at all, then excess wear of the ignition circuit parts and excess fuel consumption will result.

5.5.2
Adjustment—The following procedure should be used to adjust engine timing.

1. Crank the engine until the Number 1 piston is approaching the top of its compression stroke. This can be determined by observing the cylinder valves. With both valves closed (valve pushrods at bottom of travel), crank the engine by hand until the plain timing mark on the engine flywheel is centered in the timing hole in the flywheel housing. (See Figure 19.)

   NOTE: There are two timing marks on the flywheel. One is stamped F25 and the other is plain. **Do not** use the mark stamped F25 at this time.

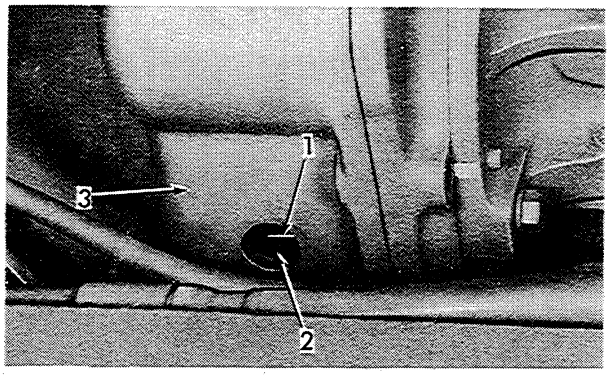

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FIG. 19 TIMING MARK ON ENGINE FLYWHEEL

1. Timing mark (for No. 1 cylinder)
2. Flywheel
3. Flywheel housing

2. Remove the distributor cap, the rotor, and the cover. Check and adjust the point gap as previously described, and reinstall the rotor on the distributor shaft. The rotor should be facing opposite the primary lead terminal. Loosen the distributor retaining clamp capscrews, and turn the distributor housing until the primary lead terminal is opposite the rotor, and the points are just beginning to open as the distributor is rotated counterclockwise. The distributor is now properly timed to the engine. The firing order of the engine is 1-2-4-3.

3. Tighten the distributor retaining clamp capscrews. Remove the rotor, and reinstall the cover. Then reinstall the rotor and the distributor.

   If the distributor has been removed from the engine, the timing procedure will be the same as the one previously described, after the distributor is reinstalled. When the distributor is installed on the distributor drive housing, the rotor must be turned so that it faces opposite the primary terminal and so that the primary terminal faces the coil.

4. After the timing has been adjusted, a timing light should be used to check the timing in the following manner:

   a. With the engine at normal operating temperature, set the engine speed at 250 to 300 rpm. At this speed, the distributor should be in the fully retarded position, and the plain timing mark should be visible and centered in the timing hole. If the timing mark is not clearly visible to make these adjustments, mark it with white chalk or paint.

   b. If the mark is not centered in the timing hole, the two distributor retaining clamp capscrews must be loosened, and the distributor housing must be turned to advance or retard the timing as necessary. (Turning the distributor housing clockwise retards the timing; turning the housing counterclockwise advances it.)

      NOTE: The automatic spark advance is set to automatically advance the spark 25° between 300 and 1600 rpm.

   c. Operate the engine at 1600 to 1700 rpm. The distributor should now be in the fully advanced position (25°), and the F25 timing mark should be visible and centered in the timing hole. If the F25 timing mark is not visible, the automatic advance mechanism in the distributor should be checked for worn or damaged parts.

TOPIC 6 ACCESSORY CIRCUITS

6.1 DESCRIPTION

The accessory circuits of a unit include all the electrical devices that are built into the unit or that may be attached to the unit, but that are not a part of either the starting circuit or the charging circuit. Such electrical devices as the headlights, the taillights, the horn, and the hour meter are on accessory circuits. The particular circuits will vary from one unit to the next, but the methods used to check these circuits are similar and may be applied to devices omitted in the following discussion.

6.2 GENERAL SERVICING

If an accessory is not functioning, the wiring and switches in the circuit should be checked to see if they are in good repair. The procedure, described in Section 4.3.1 for testing the switches in the starting circuit, is applicable to any of the switches in the electrical system. The wiring also should be checked for loose or corroded connections and for damaged or burned wires. If the possibility of a short exists, it should be checked with an ohmmeter.

6.3 ACCESSORIES

6.3.1
The Ammeter—If the ammeter does not register, the wiring to it should be checked. If the wiring is in good condition, the electrical connections to the ammeter should be disconnected and, using alligator clip leads, should be attached to a good meter. The ammeter, when functioning properly, will show a slight charging current after starting the engine.

In order to be sure that the ammeter is functioning properly, a slight load should be put on the electrical system. With the engine off, turn on the lights for one minute. The ammeter should indicate that the battery is discharging because the lights are on. Then start the engine. The ammeter should show charging. If the new meter connected in the circuit functions properly, and if the old meter did not, the old meter should be removed from the unit and the new one mounted in its place. (On units having an oil pressure switch in the charging circuit, the engine oil level and the pressure switch should be checked if the ammeter never indicates charging.) If the new meter also fails to function properly, the rest of the charging circuit should be checked carefully.

6.3.2
Lights—The lighting on the unit typically is controlled by one switch located on the instrument panel. By drawing current from the battery, the lights will operate even though the engine is not running. If the lights are flickering, check for a loose or broken connection. If the lights do not work at all, and if the switch and wiring appear to be in good condition, replace the fuse in the lighting circuit. (If the fuse is burned out, then excess current has been flowing in the lighting circuit. The circuit should be checked carefully for shorts before it is tried again.) Individual lights that do not work are probably burned out and should be replaced.

6.3.3
The Hour Meter—After checking the wiring to the hour meter, the connections to the hour meter should be removed and attached to a new meter. If the new meter functions properly while the engine is running, the old meter should be removed and replaced. If the new meter does not function, the charging circuit oil pressure switch may have failed and should be checked.

MEMO

TOPIC 7 BATTERIES

7.1 DESCRIPTION

All the batteries used in the units covered in this manual are of the lead-acid type. Although the number of batteries or the voltage may vary, the procedures for maintaining the batteries are the same for all the electrical systems described.

7.2 OPERATION

Gaseous oxygen and hydrogen are given off at the negative and positive plates, respectively, of a battery being charged. These gases are due to the decomposition of water in the battery by excess charging current not utilized by the plates.

CAUTION

These gases are highly explosive, and precautions must be taken to insure that no spark, arc, or flame comes in contact with them. The gases are particularly hazardous at the end of the charging period when less of the charging current is being used by the plates. **No smoking** should be allowed near a battery being charged.

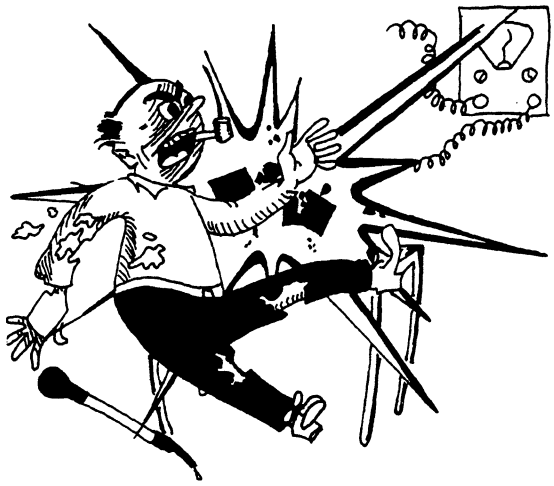

FIG. 20 T-74525

The state of charge of a battery may be measured by testing the specific gravity of the battery fluid (electrolyte). The specific gravity, measured with a hydrometer, is the ratio of the density of the electrolyte to the density of water. The specific gravity of the electrolyte in a fully charged battery is about 1.26, meaning that the electrolyte is about 1.26 times as heavy as the same volume of water.

A typical hydrometer consists of a glass barrel and bulb syringe for sucking up a sample of the electrolyte. (See Figure 21) The hydrometer measuring device is a sealed glass vial that floats on the electrolyte in the barrel. The stem of the device is calibrated with a paper scale to read in terms of specific gravity, and the depth to which the float sinks indicates the relative weight of the liquid in comparison to pure water. When the hydrometer floats high or low in the liquid being tested, the specific gravity is high or low, respectively. The value of specific gravity corresponds to the value on the paper scale that is even with the surface of the liquid being tested. The value should be read across the liquid surface with the hydrometer held at eye level.

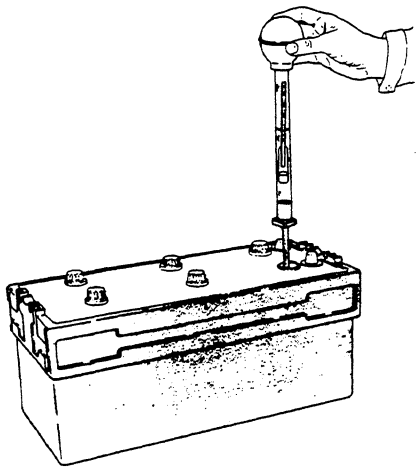

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FIG. 21 CHECKING BATTERY WITH HYDROMETER

The hydrometer reading will not be absolutely correct until a temperature correction has been applied. At ordinary temperatures, the error will be very small, and no correction will be needed. However, at extreme temperatures, the correction is important, so the method of correction is included below for reference.

The temperature correction depends on the temperature of the electrolyte in the battery, **not** on the temperature of the air. To make the correction, the temperature of the electrolyte must be measured. The hydrometer is calibrated to read correctly at only one temperature (80°F or 27°C). The difference between this temperature and the electrolyte temperature is used to make the correction, at the rate of 4 'points of gravity' (.004) for every 10°F (5.6°C) difference. Figure 22 gives two examples of the calculation of the correction.