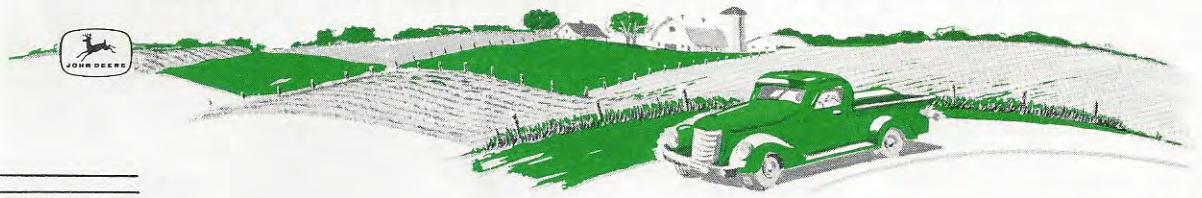
JOHN DEERE SERVICE BULLETIN



August, 1958 No. 268

24-VOLT ELECTRICAL SYSTEM

Twenty-four-volt electrical systems are new to John Deere Tractors. Since the introduction of the "720" Diesel (Electric Cranking) Tractors, a need has developed for information on this electrical system. This issue of the John Deere Service Bulletin is devoted exclusively to 24-volt electrical systems.

Because of the higher voltage, more than ordinary care must be taken when working around the system. Be extremely careful when working around the regulator, since the regulator cover is "hot" at all times. A short-circuit can burn the tool or serviceman, and damage the electrical equipment.

THE electrical system used on John Deere Diesel (Electric Cranking) Tractors is a 24-volt split-load system using 24 volts for the cranking and charging circuits and 12-volt circuits for the lighting and accessory load. Figure 41A is a schematic drawing of the system.

A 24-volt generator, controlled by a 24-volt regulator, supplies current to carry the electrical load and charge the four 6-volt batteries connected in series which supply current at 24 volts for cranking the engine.

The cranking circuit and the charging circuit are two-wire circuits—the entire circuit is carried through wires and no part of it is grounded to the tractor frame.

Two 12-volt circuits are obtained by installing a ground wire between the second and third batteries in the circuit and the tractor frame. Also, the combination switch is in reality two separate switches enclosed in a single housing and operated by a single lever. One of these switches controls current to approximately 1/2 of the load, the current being supplied by two of the batteries. The other switch controls current to the remaining 1/2 of the load, current being supplied by the two remaining batteries.

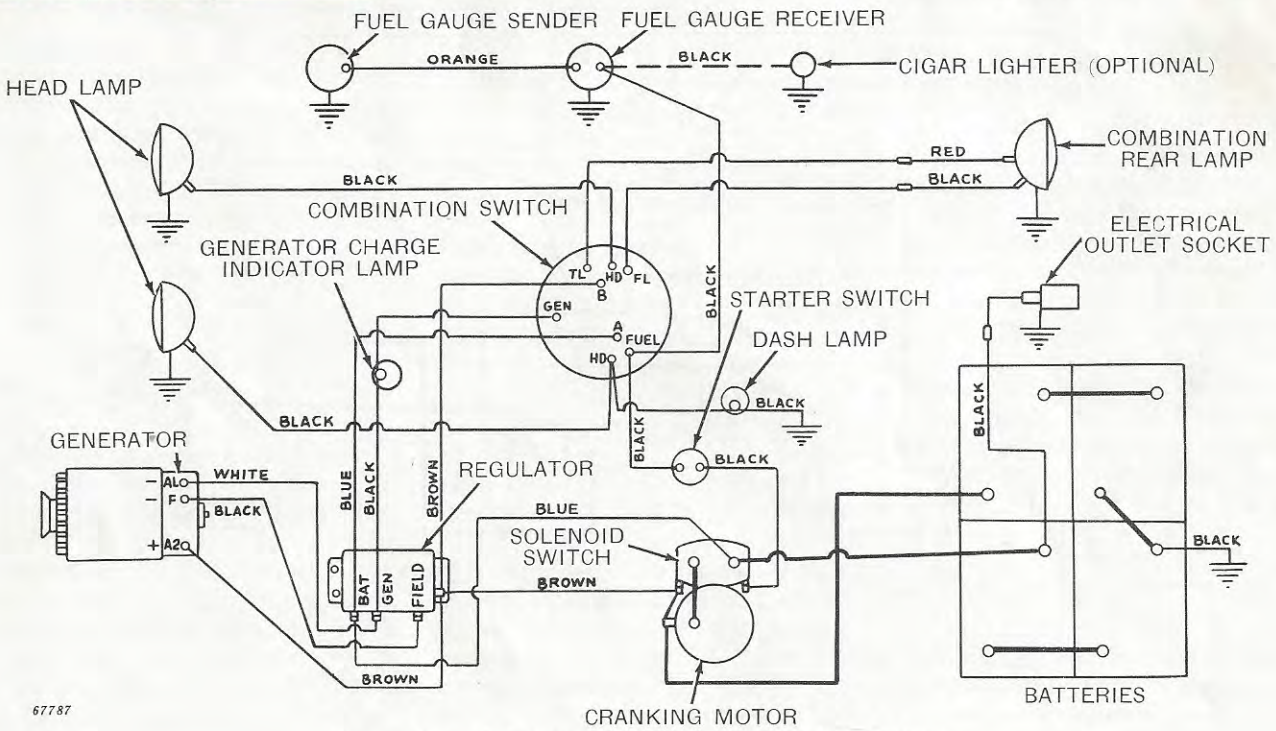


Figure 41A—Schematic Drawing of Electrical System

CRANKING CIRCUIT

When the engine is cranked, four electrical circuits are energized. They are:

1. Solenoid Switch Circuit
2. Cranking Motor Circuit
3. Generator Charge Indicator Lamp Circuit
4. Fuel Gauge Circuit

The combination switch (Figure 42A) must be turned to the "I" position before these circuits are energized.

Solenoid Switch Circuit

The flow of current in the solenoid circuit during the cranking operation is indicated by the thin solid green lines in Figure 42B.

When the solenoid control switch (STARTER SWITCH) is closed, current flows from the positive battery terminal, to positive motor terminal "C," to terminal "F" on the solenoid switch, through the solenoid windings to terminal "H," through the starter switch, and through the combination switch, to "BAT" terminal on the regulator, to "BAT" terminal "G" on solenoid switch, and then to the negative terminal of the batteries. This is a 24-volt circuit.

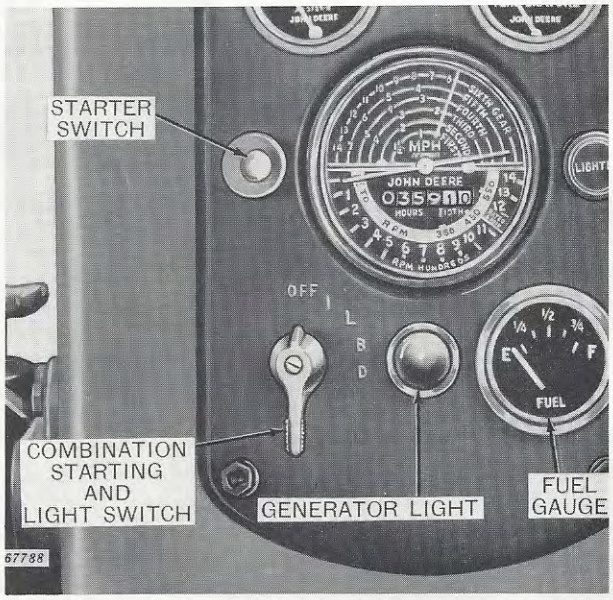


Figure 42A—Instrument Panel

Cranking Motor Circuit

The flow of current through the solenoid windings causes the solenoid plunger to be drawn into the opening inside the winding coils. This action engages the cranking motor pinion with the engine flywheel and closes the heavy solenoid contacts which connect the

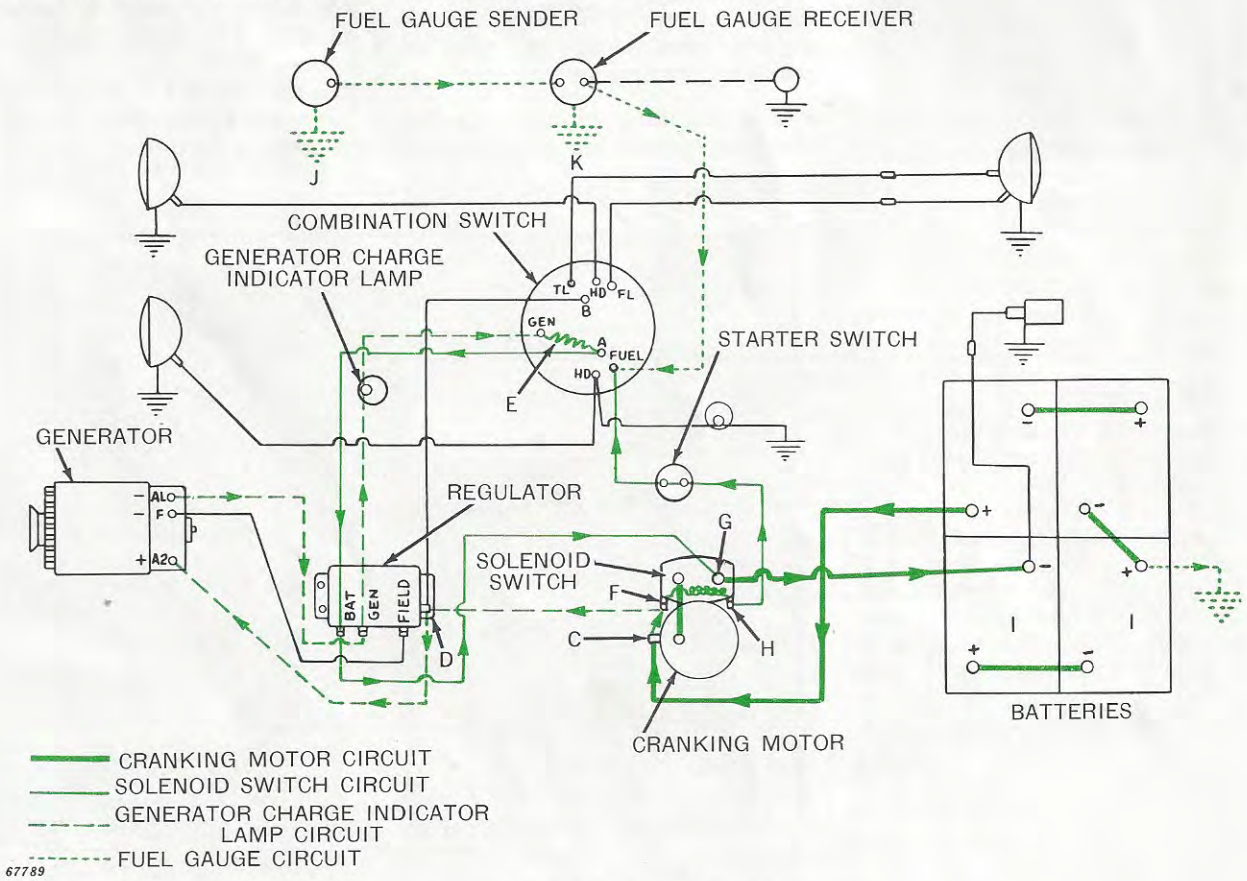


Figure 42B—Cranking Circuit

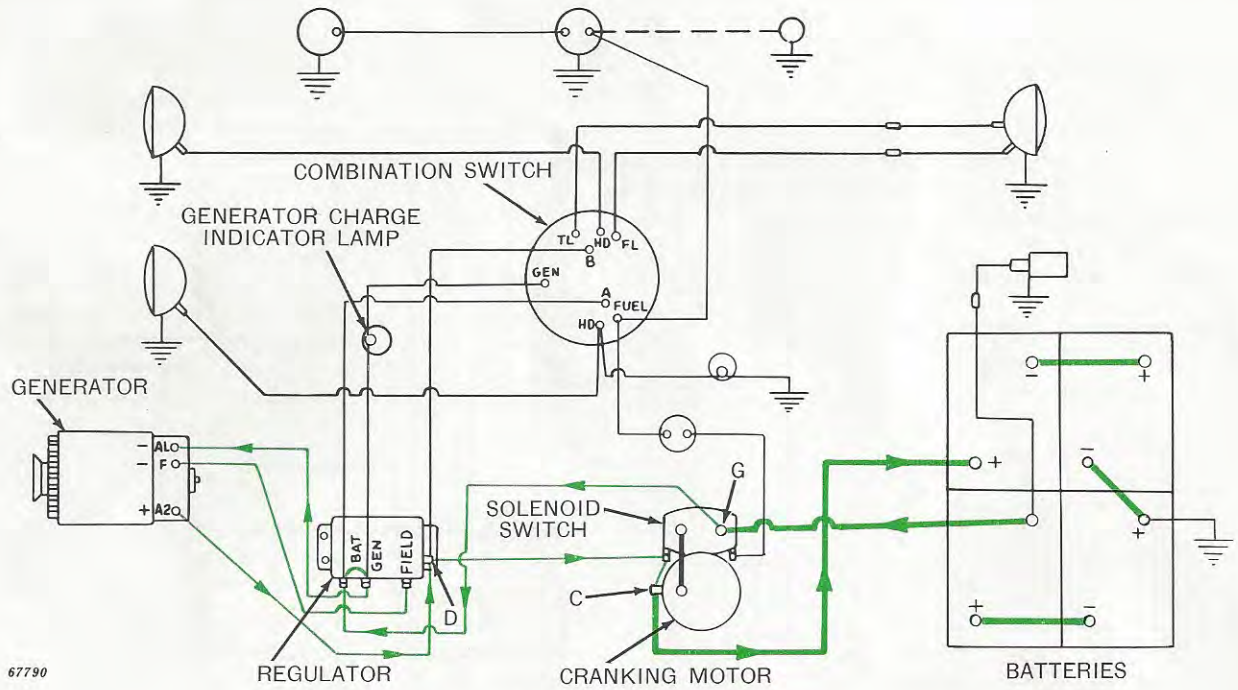


Figure 43A—Charging Circuit

batteries to the cranking motor. The cranking motor circuit is indicated by the heavy solid green lines in Figure 42B. Current flow is from the main positive terminal of the battery, to positive terminal "C" on the cranking motor, through motor to the "MOTOR" terminal on the solenoid switch, through heavy contacts in the switch, out at "BAT" terminal "G" of solenoid switch to main negative terminal of batteries. This is a 24-volt circuit.

Generator Charge Indicator Circuit

When the switch is turned to the "I" position the generator indicator lamp lights, indicating that the generator is not charging.

Flow of current to the generator indicator lamp is shown by broken green lines in Figure 42B. Originating at the main positive terminal of the batteries it flows to terminal "C" on the cranking motor, to positive terminal "D" on the regulator, to the "A2" terminal on the generator, through the generator, out at "A1" terminal, to "GEN" terminal on the regulator, through the lamp to "GEN" terminal on the combination switch, to "A" terminal on the switch, to "BAT" terminal on regulator, to "BAT" terminal "G" on the solenoid switch then to main negative terminal of the batteries.

While 24 volts is impressed on this circuit the resistor "E" on the combination switch limits the circuit to 12 volts so a 12-volt bulb is used in the lamp.

Fuel Gauge Circuit

When the combination switch is turned to the "I" position, the fuel gauge circuit is also energized. This circuit is shown by dotted green lines in Figure 42B. Current flows from the positive terminal of batteries "I" to ground, through the tractor frame to grounds "J" and "K," through fuel gauge sender and receiver through "FUEL" terminal, joining solenoid switch circuit at terminal "A" on the combination switch, then to "BAT" terminal on the regulator, to "BAT" terminal "G" on the solenoid switch then to the main negative terminal of the batteries. Note that only two of the 6-volt batteries are in the circuit, making it a 12-volt circuit.

CHARGING CIRCUIT

The charging circuit is indicated by the green lines in Figure 43A.

Current, originating in the generator armature is picked up by the positive brush, flows to generator "A2" terminal, to regulator positive terminal "D," to cranking motor positive terminal "C," to positive terminal of the batteries. Current passes through batteries to negative terminal, to "BAT" terminal "G" on the solenoid switch, to "BAT" terminal on regulator through regulator, out of regulator at "GEN" terminal to "A1" terminal on the generator.

As soon as the generator voltage is high enough to charge the batteries the cutout relay points in the regulator close. This action by-passes the current going to the generator indicator lamp circuit and the lamp goes out.

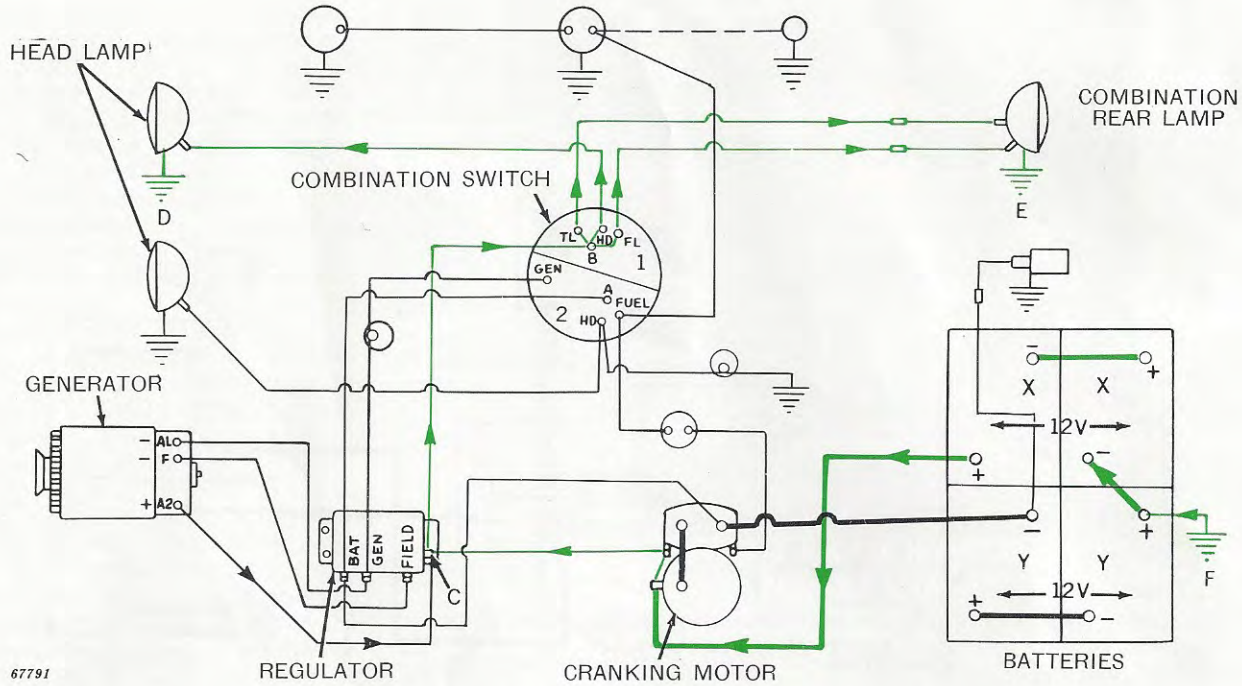


Figure 44A—No. 1 Lighting and Accessory Circuit

LIGHTING AND ACCESSORY CIRCUITS

There are two 12-volt circuits which supply current for the lamps and accessories. For the purpose of explanation the circuits have been numbered 1 and 2 at the switch. The No. 1 section of the switch controls the No. 1 circuit (Figure 44A) which supplies current for the right head lamp and combination rear lamp. This circuit is illustrated in Figure 44A by green lines.

The current flow through the circuit is the same whether it is furnished by the generator or the battery. In either it originates at the positive terminal, flows to the positive terminal "C" on the regulator to the "B" terminal on the

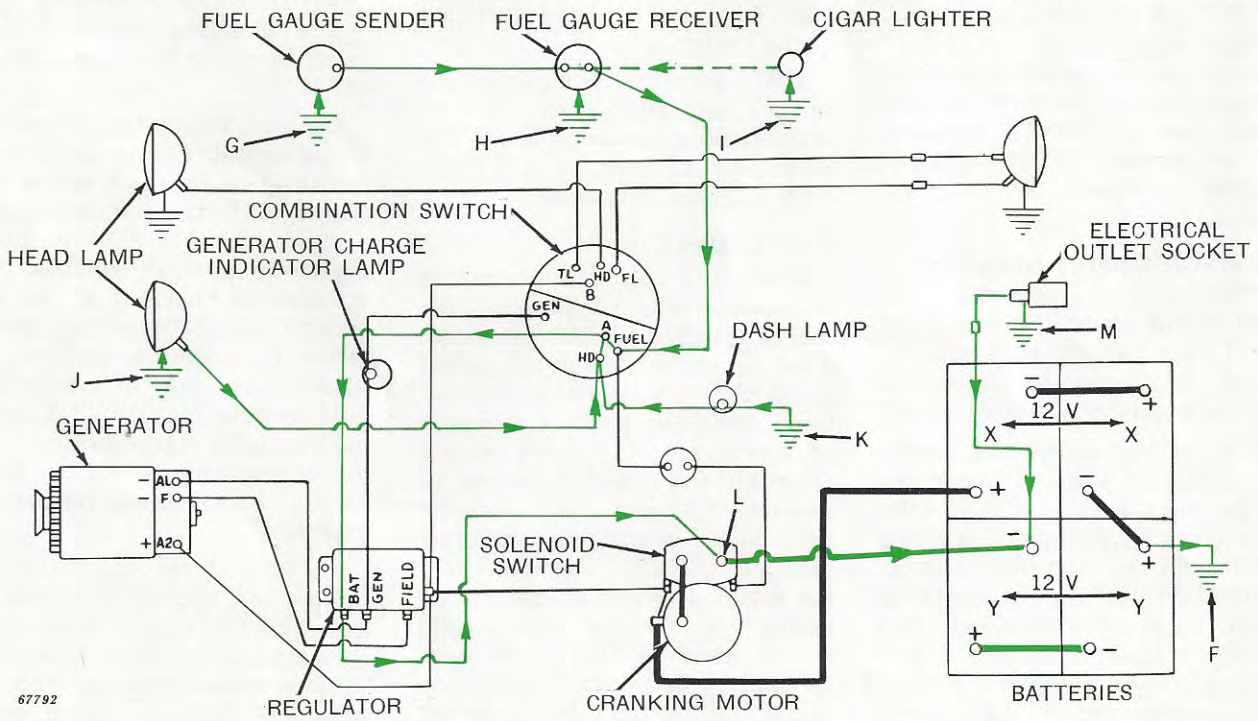


Figure 44B—No. 2 Lighting and Accessory Circuit

combination switch, through the contacts in the switch, out at terminals "HD" to right head lamp and either "TL" or "FL" to the combination rear lamp. Then through the lamps to grounds "D" and "E," through the tractor frame to battery ground "F," and through battery ground wire to the negative terminal of batteries "X." Note that only two 6-volt batteries are in this circuit, so it is only 12 volts.

The No. 2 Section (Figure 44B) of the switch controls the No. 2 circuit which supplies current for the fuel gauge sender and receiver, cigar lighter, left head lamp and dash lamp. This circuit is indicated by the green lines.

Current flow in No. 2 circuit is from the positive terminal of the batteries, "Y," through the ground wire to ground on tractor frame at "F," through tractor frame to grounds at "G," "H," "I," "J," and "K" to the fuel gauge sender and receiver, cigar lighter, left head lamp and dash lamp. From these units current flows to terminals "HD" and "FUEL" on switch, through switch contacts to terminal "A" on switch to "BAT" terminal on the regulator, to "BAT" terminal "L" on solenoid switch then to negative terminal of batteries "Y." Again, since there are only two 6-volt batteries in the circuit the current is supplied at 12 volts.

Note that while the outlet socket is not connected through the combination switch, its current is supplied at 12 volts from batteries "Y." Current flow is from positive terminal to ground "F," to ground "M" through outlet socket and back to negative terminal of batteries "Y."

CHECKING THE ELECTRICAL SYSTEM

A volt-amp tester is used to check the electrical system. An Allen Tester is used in the illustrations, but any volt-amp tester of similar functions and capacity can be used. It must be of at least 30-volt capacity and have a fixed resistance of 7 ohms. Follow tester manufacturer's instructions.

Whenever the generator fails to maintain the batteries at or near full charge, if the batteries use too much water, or if the cranking motor fails to crank the engine properly, the electrical system should be systematically checked.

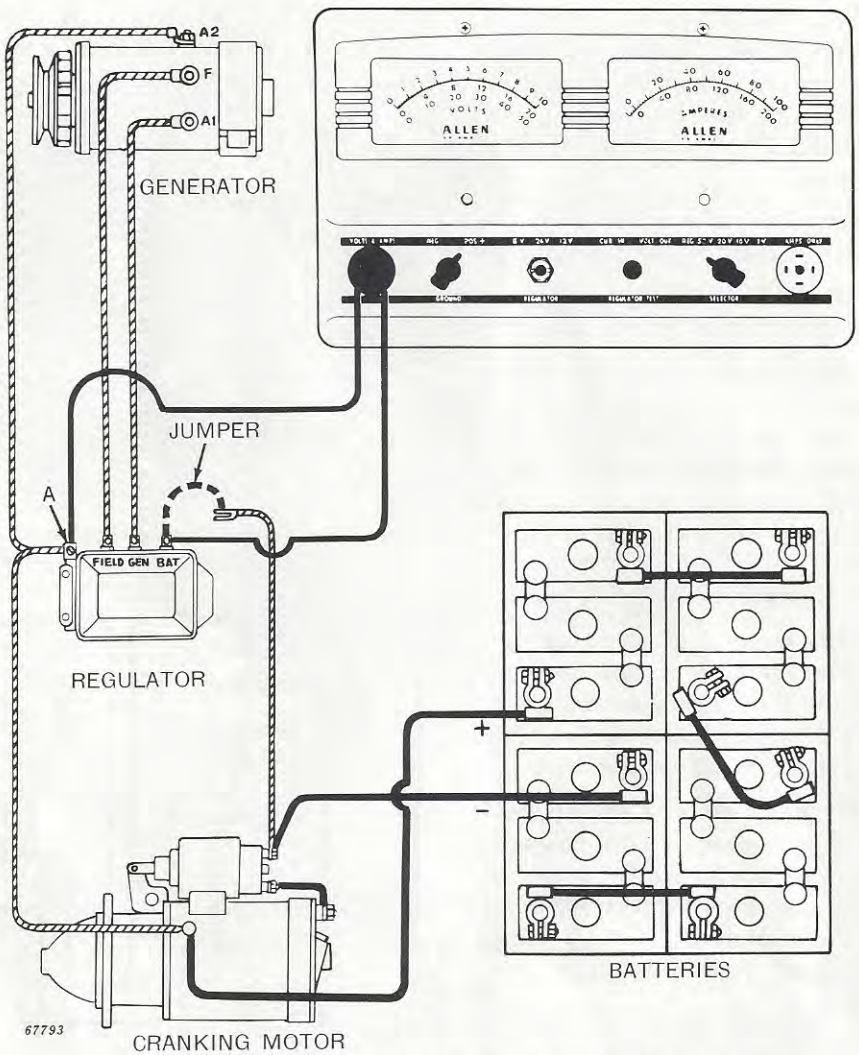


Figure 45A—Testing Charging Circuit Without Batteries

CHARGING CIRCUIT

If the generator fails to maintain the battery charge or if the batteries use too much water, the charging circuit should be checked.

Testing Generator and Regulator.

The generator and regulator action can be checked by connecting the tester as illustrated in Figure 45A.

CAUTION: A close examination of the wiring diagram will show that the positive wire from the battery is connected to the regulator base. Since the batteries have a ground to the tractor frame, any time contact is made between any part of the regulator and the tractor a short circuit occurs. Be extremely careful to avoid a short, as severe arcing will occur, causing burning of the tool, or possibly the operator, and can severely damage the electrical equipment.

Disconnect the wire from the "BAT" terminal on the regulator.

Connect one of the wires from the "VOLTS-AMPS" socket on the tester to the "BAT" terminal on the regulator.

Connect the remaining wire from the "VOLTS-AMPS" socket to the positive terminal on the regulator.

Set "GROUND" switch on tester to "POS" position. If, when the engine is started, the meter readings are reversed, set "GROUND" switch to "NEG" position.

Set "REGULATOR" switch on tester in the "24-volt" position.

Set "SELECTOR" switch on tester to "REG" position.

Temporarily connect a jumper wire from the wire that was disconnected from the regulator "BAT" terminal to the "BAT" terminal on the regulator and start the Diesel engine. As soon as the engine is running, **disconnect the jumper wire.**

This method of checking generator-regulator action does not include the battery in the circuit because condition of the batteries can affect regulator operation.

If the meters read approximately 8 amps at approximately 27 volts, the generator and regulator can be assumed to be in good condition. *NOTE: Read lower scale on both meters.*

If the readings are higher than those mentioned it is an indication that the regulator settings are too high and could cause the batteries to use too much water or the lamps to burn out. The regulator should be removed and adjusted to correct specifications. Regulator specifications are given below:

Cutout Relay

Air Gap (In.)	Point Opening (In.)
0.017	0.032

Voltage Regulator

Closing Voltage Range	Air Gap (In.)	Voltage Setting Range
24-27	0.075	27.5-29.5

Current Regulator

Air Gap (In.)	Current Setting Range
0.075	8.5-11.5

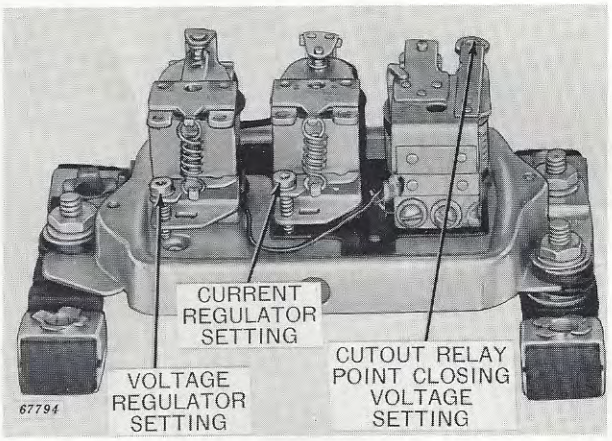


Figure 46A—Location of Adjustments for Setting the Regulator

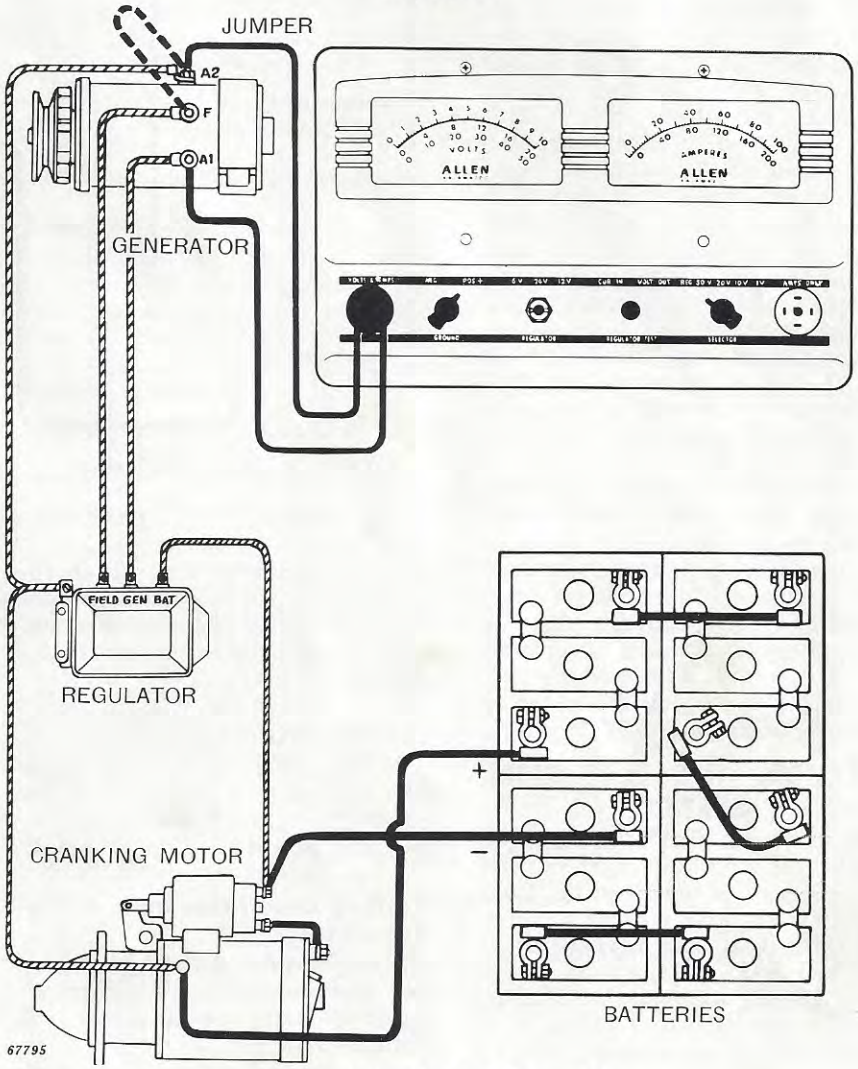


Figure 46B—Testing Generator

Testing Generator Only

If meter readings are much lower than those specified it is an indication that the generator is at fault and it should be checked separately. Connect the tester to the generator as illustrated in Figure 46B.

Connect one wire from the "VOLTS-AMPS" socket to the "A2" generator terminal, connect the remaining wire from the "VOLTS-AMPS" socket to "A1" terminal on the generator.

Set "GROUND" switch to "POS" position. If, when the engine is started, the meter readings are reversed, set "GROUND" switch to "NEG" position.

Set "REGULATOR" switch in the "24-volt" position.

Set "SELECTOR" switch on tester to "REG" position.

Start the engine and note the meter readings. Read lower scale on both meters.

If the generator is producing approximately 8 amps at approximately 27 volts it can be assumed that it is in good condition. If there is any doubt, connect a jumper, illustrated by the broken line in Figure 9, from the generator "F" terminal to the generator "A2" terminal. A generator in good condition should produce approximately 12 amps at approximately 45 volts with the jumper connected.

If the generator does not produce according to the above specifications, examine the commutator. If oily or dirty, or if it appears to be burned, use a piece of 00 sandpaper (not emery cloth) or a brush seating or bedding stone as illustrated in Figure 47A to clean the commutator. Inspect the brushes. If they are worn to 1/2 of their original length (original length is 7/8-inch) replace them. Be sure they have good contact on the commutator and that the brush springs have not been overheated or lost their tension.

Figure 47A—Cleaning Generator Commutator

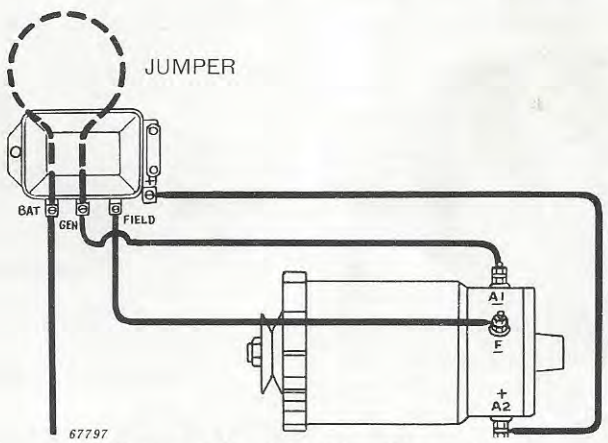


Figure 47B—Polarizing Generator

If this does not correct the generator output, remove the generator for further testing and reconditioning. Generator specifications are given below:

NOTE: The generator should be polarized whenever the generator or voltage regulator, or the batteries are disconnected or removed, after they have been installed and reconnected and before starting the engine. This is accomplished by momentarily connecting a jumper wire between the "BAT" terminal and "GEN" terminal on the regulator. See Figure 47B.

GENERATOR SPECIFICATIONS

Field Current 80° F.		Cold Output		Approximate
Amps	Volts	Amps	Volts	Rpm
0.75–0.85	24	10	28.5	2500

GENERATOR-REGULATOR-BATTERY CIRCUIT

If the batteries have been using too much water or if the lamps had been burning out (indicating too high charge rate) the irregularity should have been located by the foregoing tests.

But, if the generator has not been maintaining the batteries at or near full charge and the generator and regulator prove to be in good condition, the irregularity must be in the remainder of the charging circuit or in the batteries.

To test the charging circuit with the batteries in the circuit, connect the tester as illustrated in Figure 48A.

Plug the "100-AMP" shunt into the "AMPS-ONLY" socket on the tester.

Disconnect the wire from the "BAT" terminal on the regulator.

Connect the wire end of the shunt to the "BAT" terminal on the regulator.

Connect wire removed from "BAT" terminal on the regulator to clamp end of shunt.

Connect one wire from "VOLTS-AMPS" socket to positive regulator terminal "A."

Connect remaining wire from "VOLTS-AMPS" socket to "BAT" terminal on regulator.

Set "GROUND" switch to "POS" position. If, when the engine is started, meter readings are reversed, set "GROUND" switch to "NEG" position.

Turn "SELECTOR" switch to the "50-V" position.

Start the engine and note the meter readings. Read the lower scale on the voltmeter and the upper scale on the ammeter.

Meter readings obtained will depend upon the condition of the batteries.

If the batteries are at or near full charge, meter readings should be approximately 2 to 4 amperes at approximately 28 to 29 volts.

If the battery charge is low the readings should be approximately 8 amperes at approximately 27 volts.

The state of battery charge can be checked by testing the specific gravity of the electrolyte with a hydrometer as illustrated in Figure 48B. The hydrometer should be equipped with a thermometer so the reading can be corrected to correspond to the temperature of the electrolyte. Otherwise, the readings may be inaccurate. Readings are corrected to an electrolyte temperature of 80°F. For every 10°F. of electrolyte temperature above 80°F. four points (0.004) of gravity should be added to the hydrometer reading. For every 10°F. of electrolyte temperature below 80°F. electrolyte temperature four points of gravity should be subtracted from the reading.

Example: Hydrometer reading 1.250, temperature of electrolyte 20°F. Corrected reading is 1.250-.024 = 1.226, which is the actual specific gravity of the electrolyte.

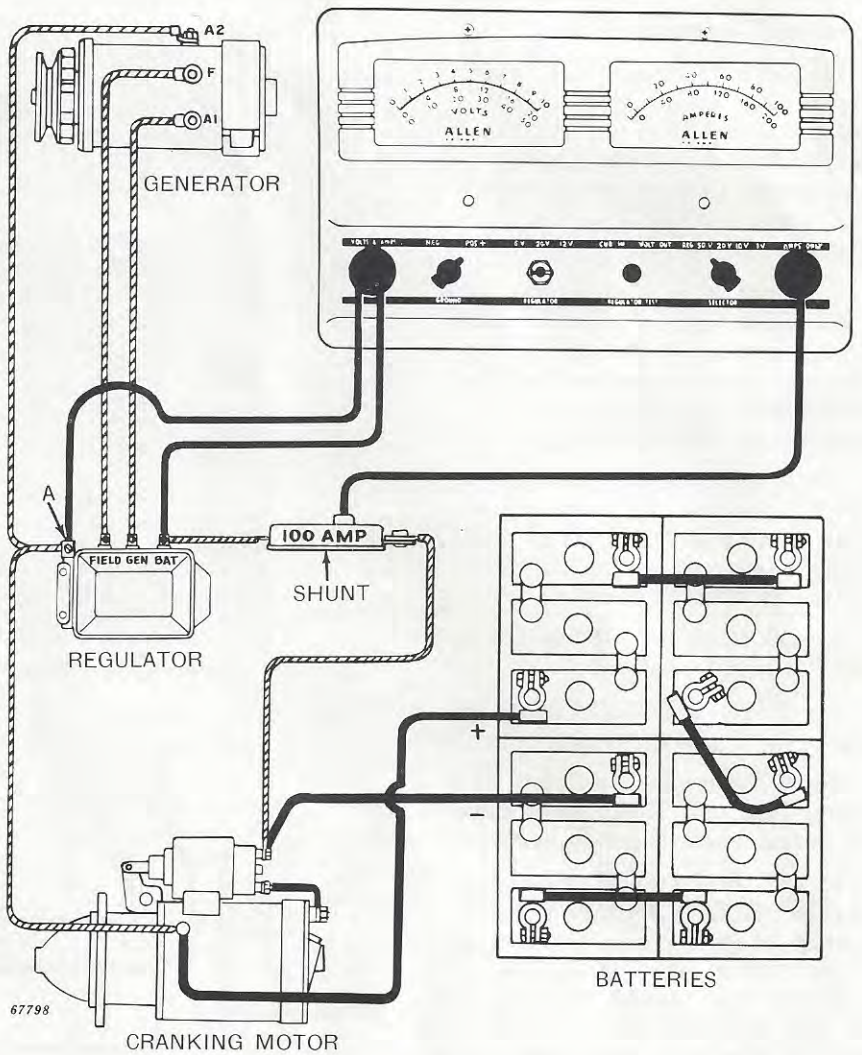


Figure 48A—Testing Charging Circuit, Including Batteries

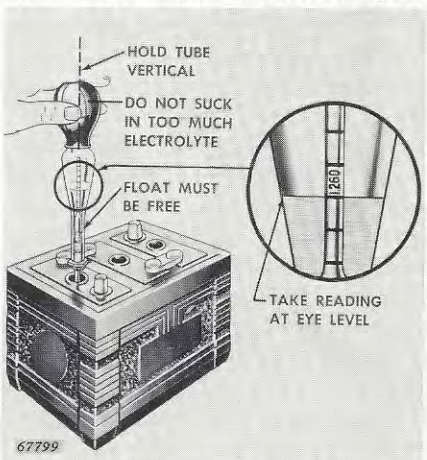


Figure 48B—Testing Battery with Hydrometer

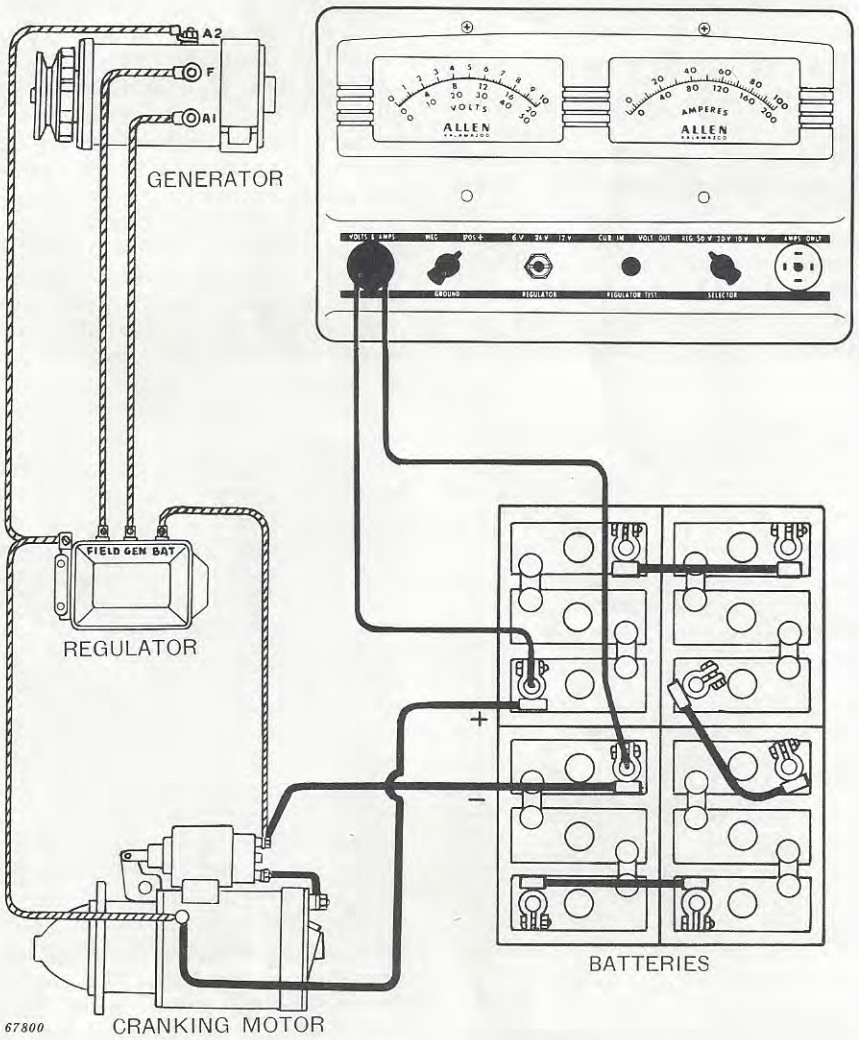


Figure 49A—Checking Battery Voltage

This is approaching half-charge and the batteries should be taken out and brought up to full charge.

If the corrected gravity is 1.250 or more and if the specific gravity does not vary more than 25 points between cells, the batteries can be assumed to be in good condition.

NOTE: The batteries have large electrolyte capacity, so gravity readings in a fully charged battery will vary from 1.250 to 1.270, depending upon the amount of electrolyte in the battery. The higher readings will be obtained when the electrolyte level is low.

Another method of checking the condition of the batteries is to check the voltage while cranking the engine on full compression.

CAUTION: The Diesel engine speed control lever must be in the "STOP" position while making this test.

Connect the volt-amp tester as illustrated in Figure 49A.

Connect one of the wires from the "VOLTS-AMPS" socket to the main positive battery terminal. Use pin connectors and connect directly to the battery post. Connect remaining wire to the main negative battery post in the same manner.

Set "GROUND" switch to the "POS" position. If, when making the test, the meter readings are reversed, set switch to "NEG" position.

Set "SELECTOR" switch on tester to "50-V" position.

With the Diesel engine at operating temperature and the speed control lever in the "STOP" position, crank the engine on full compression and note voltmeter reading. If the average reading is consistently below 18 volts the batteries are either partially discharged, have sulfated plates, shorted cells, or some other irregularity.

CAUTION: Do not operate cranking motor more than 30 seconds at a time without stopping for at least 2 minutes to allow it to cool.

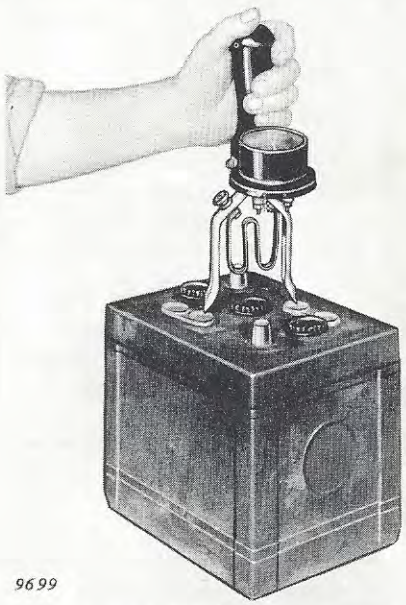


Figure 49B—High Rate Discharge Battery Test

If battery voltage is low, the individual battery cells can be tested further by using a high rate discharge tester as illustrated in Figure 49B. This tester checks cell voltage while under a heavy discharge. Cell voltage should not fall below 1.5 volts. If it does the cell is either discharged or some irregularity exists in the cell such as sulfated or shorted plates. There should not be more than 0.2 volt difference in voltage between cells.

If any of the above conditions exist when making the high rate discharge test, the battery or batteries should be removed for recharging, reconditioning, or replacement.

There are other conditions which can cause the battery voltage to drop excessively while cranking the engine, besides the condition of the batteries themselves. These can be high resistance caused by loose or dirty connections, some irregularity in the cranking motor or excessive drag in the Diesel engine such as too heavy oil or some other irregularity. These irregularities should be corrected as quickly as possible. Some of them will be discussed under paragraphs on the cranking motor which follow.

CRANKING MOTOR

There are several tests which can be made with the cranking motor which will indicate various irregularities in the circuit. These are made by turning on the head lamps and cranking the engine (speed control lever in "STOP" position) on full compression.

1. **If the lights go out instantly** it is an indication of a loose connection between the batteries and the cranking motor. This should be found and corrected.

2. **If the lights dim excessively** it is an indication of low battery charge, high resistance between the batteries and the cranking motor (caused by dirty or corroded connections), excessive drag in the cranking motor (possibly caused by the armature dragging on the field pole shoes) or excessive drag in the engine (caused by too heavy oil or some malfunction in the engine). These conditions, if present, should be located and eliminated.

3. **If the lights remain bright** and no cranking action occurs it is an indication of an open circuit between the batteries and the cranking motor, in the solenoid switch, or in the motor itself. The wiring from the batteries to the solenoid switch, and the wiring from the batteries to the cranking motor should be checked and any irregularity corrected.

A quick check of the solenoid switch can be made by using a heavy cable to **momentarily** short across the solenoid battery terminal and the terminal on the end of the cranking motor as indicated in Figure 50A. If the cranking motor turns the engine, the solenoid switch is at fault and it should be removed and repaired.

If no cranking action occurs the cranking motor is at fault and it should be removed for further tests and repair.

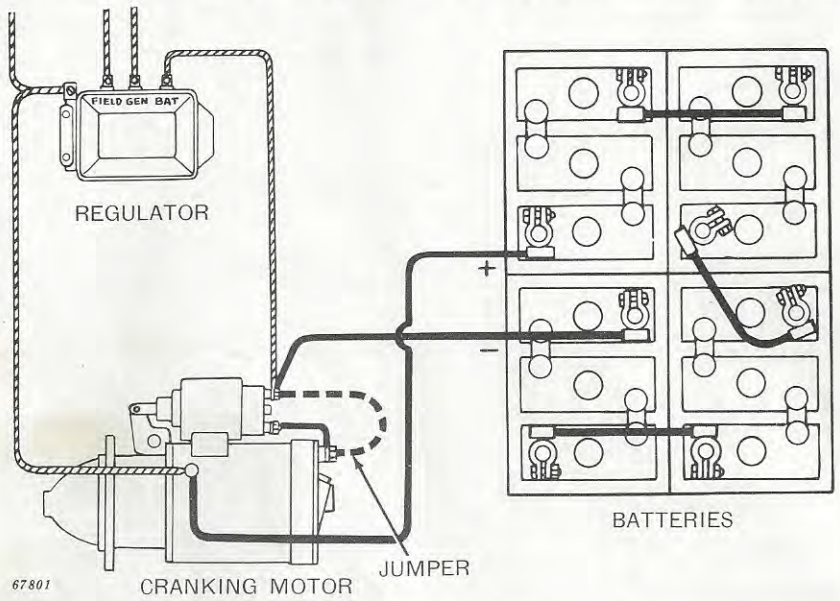


Figure 50A—Checking Solenoid

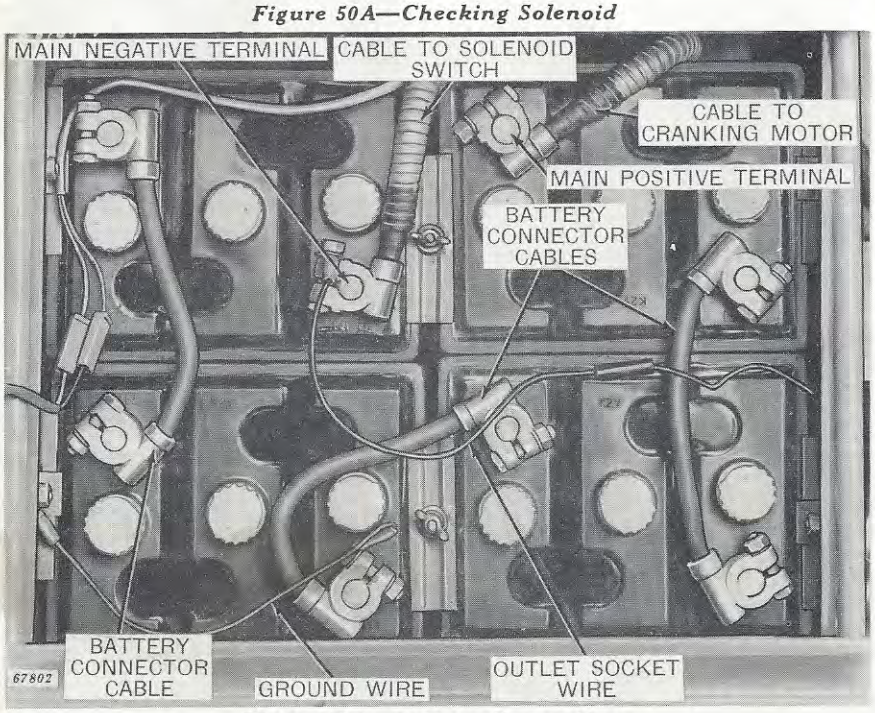


Figure 50B—Battery Connections

INSTALLING BATTERIES

When batteries are installed they should be connected as illustrated in Figure 50B. All connections should be cleaned thoroughly and tightened securely. It is a good practice to coat connections and battery posts after they are tightened with a mixture of baking soda and petroleum jelly (vaseline) to prevent corrosion.

BALANCING BATTERY LOAD

If one pair of batteries uses too much water, indicating possible over-charge the load may need balancing. Refer to Field Service Bulletin No. 264 for detailed instructions.