ELECTRICAL SYSTEMS

for

crawler tractors, crawler loaders, tractor scrapers, elevating scrapers and motor graders

service manual

⚠ WARNING

STUDY THE OPERATION AND MAINTENANCE INSTRUCTION MANUAL THROUGH BEFORE STARTING, OPERATING, MAINTAINING, FUELING OR SERVICING THIS MACHINE.

⚠ The Operation and Maintenance Instruction Manual provides the instructions and procedures for starting, operating, maintaining, fueling, shutdown and servicing that are necessary for properly conducting the procedures for overhaul of the related components outlined in this Service Manual.

⚠ This symbol is your safety alert sign. It means ATTENTION! BECOME ALERT! YOUR SAFETY IS INVOLVED.

⚠ Read and heed all safety instruction carrying the signal words WARNING and DANGER.

⚠ Machine mounted safety signs have been color coded yellow with black borders and lettering for warning and red with white borders and lettering for danger points.

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SUPPLEMENT NO. 6

SERVICE MANUAL FORM 70696657

ELECTRICAL SYSTEMS

CRAWLER TRACTORS, CRAWLER LOADERS, TRACTOR SCRAPERS,

ELEVATING SCRAPERS and MOTOR GRADERS

(12-79)

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REPLACE the following like pages:

35 (No change)	35B (Revised)
35A (Revised)	36 (No change)

REASON: Add electrical system schematic for 262-B Tractor Scraper and 263-B Elevating Tractor Scraper.

NOTICE

THESE CHANGES ARE INCLUDED IN THIS COPY

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SUPPLEMENT NO. 5

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ELECTRICAL SYSTEMS

(9-79)

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Write in the following changes:

Page 21:

Replace the following like pages:

31 (No change)
31A (Added)
31B (Added)
32 (No change)

Reason: To add Electrical Schematics for 65-B Motor Grader.

NOTICE
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SERVICE MANUAL FORM 70696657

ELECTRICAL SYSTEMS

CRAWLER TRACTORS, CRAWLER LOADERS, TRACTOR SCRAPERS, ELEVATING SCRAPERS and MOTOR GRADERS

(11-78)

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Write in the following changes (changes are underlined)

Page 1	Add: 161 under ELEVATING SCRAPERS
Page 21	Add: 161 . . . . . 35C

Replace the following like pages:

35B(No change)	35D(Added)
35C(Added)	36 (No change)

Reason: Add electrical system schematic for 161 Elevating Tractor Scraper.

NOTICE
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SUPPLEMENT NO.3

SERVICE MANUAL FORM 70696657

ELECTRICAL SYSTEMS

FIAT-ALLIS

CRAWLER TRACTORS, CRAWLER LOADERS, TRACTOR SCRAPERS, ELEVATING SCRAPERS and MOTOR GRADERS

(3-77)

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Write in the following changes (changes are underlined)

Page 1	Add: 262-B 263-B
Page 21	Add: 262-B . . . . . 35A, B 263-B . . . . . 35A, B

Replace the following like pages:

35 (No change)	35B (Added)
35A (Added)	36 (No change)

NOTICE
THESE CHANGES ARE INCLUDED IN THIS COPY

Reason: Add electrical system schematic for 262-B Tractor Scraper and 263-B Elevating Tractor Scraper.

Printed in U.S.A.

SUPPLEMENT NO. 2
(Replaces supplement NO.1)

SERVICE MANUAL FORM 70696657

ELECTRICAL SYSTEMS

CRAWLER TRACTORS, CRAWLER LOADERS, TRACTOR SCRAPERS, ELEVATING SCRAPERS and MOTOR GRADERS

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(8-76)

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Write in the following changes (changes are underlined)

Page 1	CRAWLER TRACTORS	Add: 21-C
		Add: 31
Page 21	Crawler Tractor	Add: 21-C ---- 24A
		Add: 31 ------ 24B

Insert the following pages:

24A (Revised)

24B (Added)

NOTICE
THESE CHANGES ARE INCLUDED IN THIS COPY

Reason: Add electrical system schematic for 31 Crawler Tractor and optional 50 amp. alternator for 21-C Crawler Tractor.

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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 borders and lettering for warning and red with white borders and lettering for danger points.

Do not allow unauthorized personnel to service or maintain this machine. Do not perform any work on equipment that is not authorized. Follow the Maintenance and Service procedures. Study the Operation and Maintenance Instruction Manual before starting, operating, maintaining, fueling or servicing this machine.

Always wear safety glasses with side shields.

Do not wear rings, wrist watches, jewelry, or 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 use controls or hoses as handholds when climbing on or off machine. Hoses and controls are movable and do not provide a solid support. Controls may also be inadvertently moved causing accidental machine or equipment movement.

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

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.

Keep operator's compartment, stepping points, grab-rails and handles clean 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.

Never attempt to operate the machine or its tools from any other position than seated in the operator's seat.

Keep operator's compartment clear of loose objects.

If movement of an attachment by means of the machine's hydraulic system 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 attachment or tool, make sure to set brakes, sound horn and call for an all clear. Raise attachment slowly.

Always block with external support any linkage or part on machine that requires work under the raised linkage, parts, or machine per OSHA 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.

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

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

When servicing or maintenance requires access to areas that cannot be reached from the ground, use a ladder or step platform that meets OSHA requirements to reach the service point. If such ladders or platforms are not available, use the machine handholds 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.

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

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

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

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.

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 drawbars, cables or chains under load.

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.

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

Remove sharp edges and burrs from reworked parts.

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

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.

Never place gasoline or diesel fuel in an open pan.

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

When using compressed air for cleaning parts use safety

Safety Rules

GENERAL (Continued)

glasses with side shields or goggles. Limit the pressure to 30 psi according to local or national requirements.

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

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

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

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

When making equipment checks that require running of the engine, have an operator in the operator 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. Shut off engine and disengage the Power Take-Off lever before attempting adjustments or service.

Never use the bucket as a man lift.

The articulation point between frames will not clear a person. Stay clear when engine is running. Support, using device provided when servicing. Return support to carry position and secure before moving machine after servicing. See Operation and Maintenance Instruction Manual.

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.

Guard against kinking chains or cables. Do not lift or pull through a kinked chain or cable. 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 COMPARTMENTS OF MACHINES INVOLVED ARE PROPERLY GUARDED against accidental cable or chain backlash.

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

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

Before starting machine or moving attachment check and adjust and lock operator's seat. Be sure all personnel in the area are clear before starting or moving machine and any of its attachments. Sound horn.

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

Do not carry loose objects in pockets that might fall unnoticed into open compartments.

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 manufacturer at all times. DO NOT adjust machine with engine running except as specified.

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.

Wear welder's protective equipment such as dark safety glasses, helmets, protective clothing, gloves and safety shoes when welding. Wear dark safety glasses near welding. DO NOT LOOK AT ARC WITHOUT PROPER EYE PROTECTION.

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 for 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.

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

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.

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

Where it is necessary to use diesel fuel as a lubricant make sure all smoking material and open flames are extinguished or that no sparks are near. Place all parts in a closed container of clear diesel fuel for use as needed.

To minimize dangers of fire and explosion, it is recommended that before any welding is done on a fuel tank, the tank be completely drained of fuel, fuel lines disconnected and the ends closed to protect them, and the tank be steam cleaned. All traces of fuel must be removed before welding is started. Flood the tank with carbon dioxide (CO_2) before and during welding. Caps must be removed and vents and other openings left open during welding.

Dry ice (solid carbon dioxide) is extremely cold and will freeze flesh on contact. Use care to prevent contact with skin, eyes, or other parts of the body to avoid personal injury.

When work is required under or between components, block with an external support capable of holding the components in place according to local or national requirements.

START UP

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

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

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 recommendation of the manufacturer for storage and disposal.

Safety Rules

ENGINE

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.

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.

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

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

Never lubricate a machine with the engine running.

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

ELECTRICAL

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.

Always turn the master switch (key switch if so equipped) to the off position when maintaining or servicing machine.

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.

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

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.

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

HYDRAULIC

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 cardboard 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.

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.

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

ATTACHMENTS

Keep head, body, limbs, feet, hands and fingers away from blade, bucket or ripper when in raised position. Use authorized blocking as a safety measure before proceeding with service or maintenance per OSHA requirements.

If movement of an attachment by means of the machine's hydraulic system 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, make sure to set brakes, sound horn and call for an all clear. Raise attachment slowly.

Do not use machine to carry loose objects by means other than attachments for carrying such objects.

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

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 manufacturer at all times. DO NOT adjust machine with engine running except as specified.

TIRES (APPLICABLE MACHINES)

Be sure tires are properly inflated to the manufacturer's specified pressure. Inspect for damage periodically.

Stand to one side when changing inflation of tires.

Check tires only when the machine is empty and tires are cool to avoid overinflation. Do not use reworked wheel parts. Improper welding, heating or brazing weakens them and can cause failure.

Never cut or weld on the rim of an inflated tire. Inflate a spare tire only enough to keep rim parts in place — a fully inflated tire might fly apart when it is not installed on a machine.

Use care if you must transport (haul) a fully inflated tire.

When servicing tires block the machine in front and back of all wheels. After jacking up, place blocking under machine to protect from falling per OSHA requirements.

Deflate tires before removing objects from the tread.

Never inflate tires with flammable gases. Explosion and personal injury could result.

FOREWORD

This manual contains the Fiat-Allis approved procedures for the overhaul of electrical systems. The information and illustrations are generally applicable to units with the following model designations.

CRAWLER TRACTORS
- HD-6
- HD-11
- 11-B
- 16-B
- HD-21
- 21-B
- 21-C
- 31

TRACTOR SCRAPERS
- 260-A
- 260-B
- 460-C
- 262-B

ELEVATING SCRAPERS
- 161
- 260E-A
- 261-B
- 263-B

CRAWLER LOADERS
- 6G
- 7G
- 7G-B
- 12G
- 12G-B
- HD-16G
- HD-21G

MOTOR GRADERS
- 65&65-B
- D
- DD
- M100
- 100-B
- 100-C
- 150-C
- 200-C

Assure best results and maintain original quality by always using Fiat-Allis parts.

Always furnish dealer with unit Serial Number when ordering parts.

Many equipment owners employ the dealer's Service Department for all work other than routine lubrication, adjustments and minor service. This practice is encouraged, as our dealers are well informed and equipped to render excellent service.

IMPORTANT

The information in this manual was current at the time of publication. It is our policy to constantly improve our product; therefore, design changes may affect procedures outlined in this manual. If variances are observed, verify the information through your Dealer.

TABLE OF CONTENTS

NOTICE

CONSULT FIAT-ALLIS DEALER FOR OTHER SERVICE MANUALS AVAILABLE FOR YOUR UNIT. SEE TECHNICAL PUBLICATIONS INDEX (FORM 70658800) FOR ALL AVAILABLE PUBLICATIONS.

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.

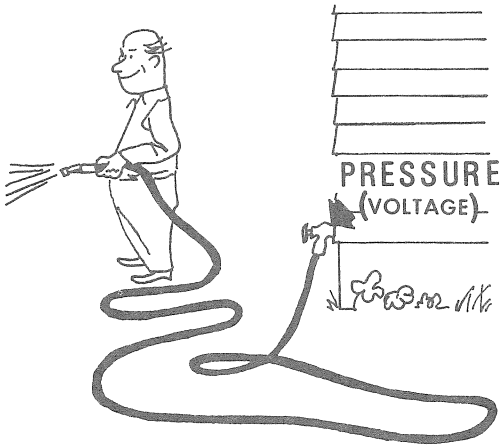
The scope of this manual is limited to instruction in the troubleshooting of an electrical system to isolate faulty components and in the minor servicing of some components, and to the provision of electrical system schematics to assist service personnel in the troubleshooting, repair, and maintenance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

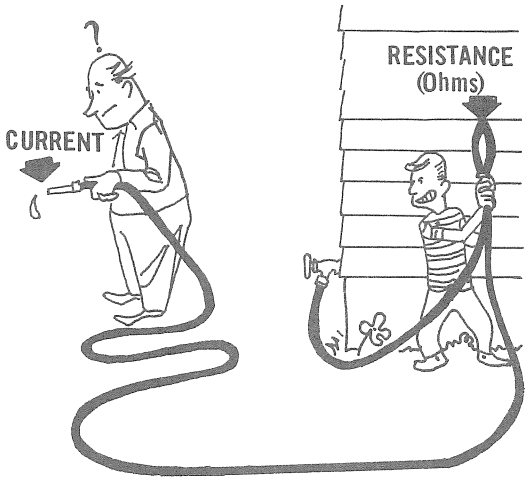


T-74522

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.

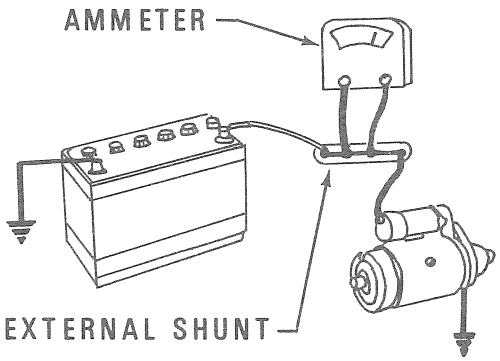
2.1.3
The Ammeter—The current past a point in an electrical circuit can be compared to the quantity of water that can flow through a particular pipe in a water system. The amount of current (measured in amperes) that will flow depends on the voltage (like pressure) available to push the current and on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



T-74524

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



T-74523

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.)

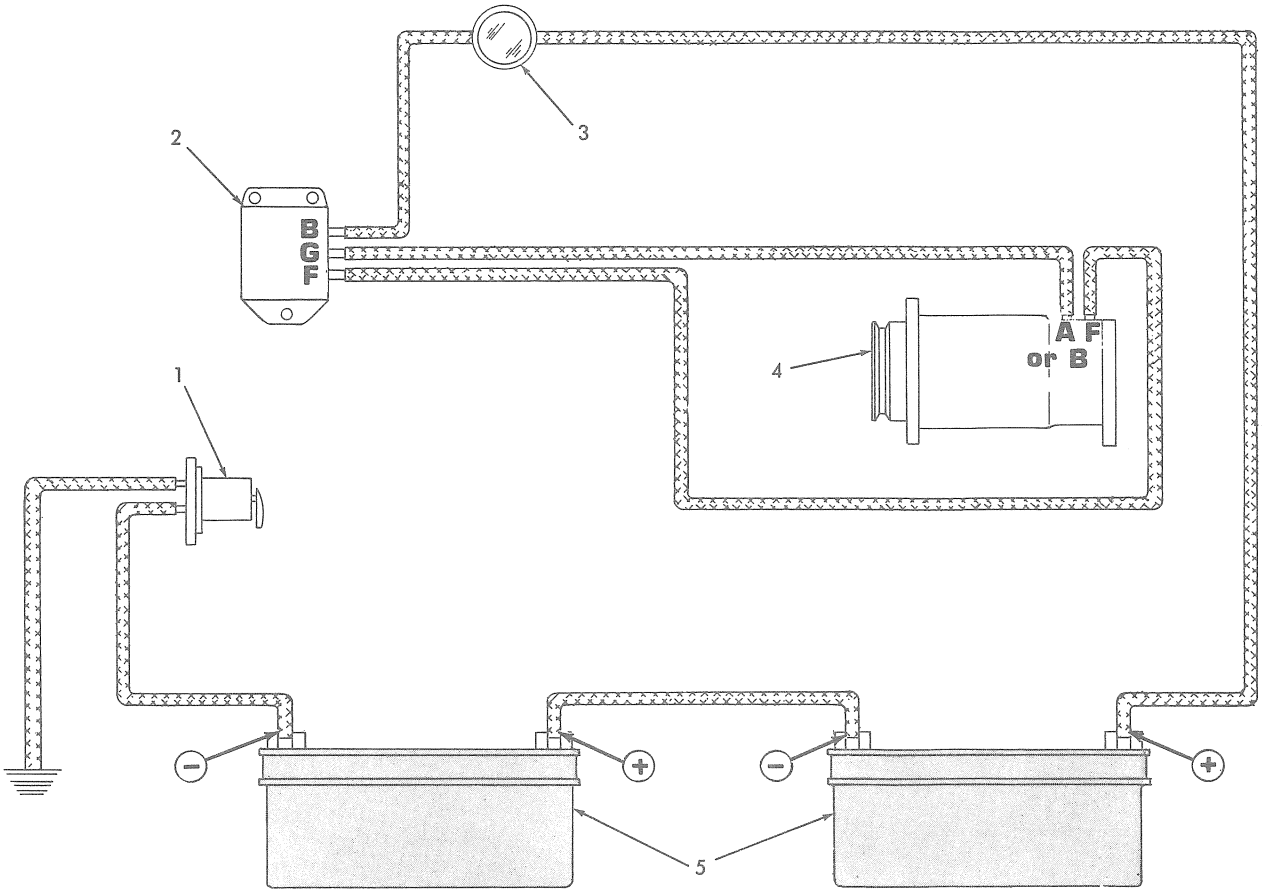
Each possible cause listed in the above table refers to a device that may or may not be in the specific electrical system being repaired. If the device mentioned is not a part of the electrical system (although most of them will be), the instructions pertaining to the device should be ignored.

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



T-73676

FIGURE 4 TYPICAL CHARGING CIRCUIT SCHEMATIC

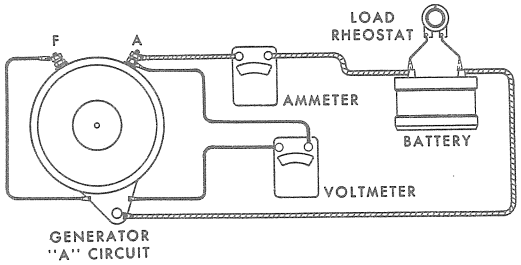
1. Switch, master
2. Regulator
3. Ammeter
4. Generator or alternator
5. Batteries

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.)



T-76843

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:

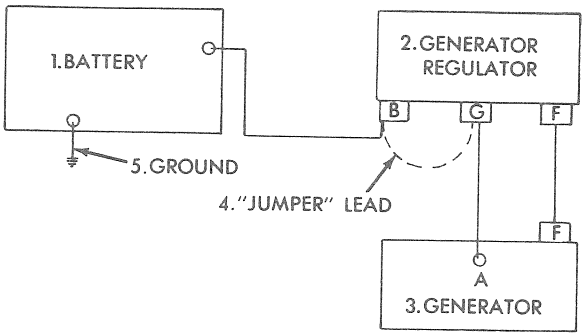
1. Turn the electrical system master switch to OFF, disconnect the wiring harness from the generator, and label the wiring for faster reinstallation.
2. Remove the capscrews attaching the generator to its mounting bracket and to its adjusting strap.
3. Remove the generator.

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*.

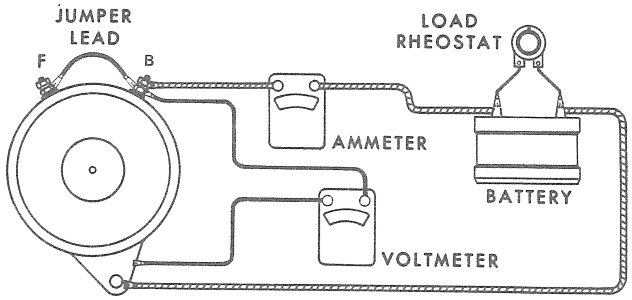


T-18731
FIGURE 6 POLARIZING CIRCUIT SCHEMATIC

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.



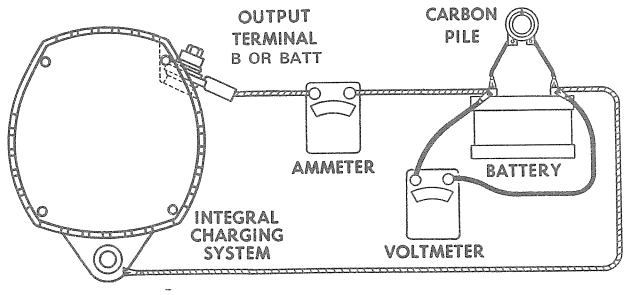
T-76844
FIGURE 7 CONNECTIONS FOR CHECKING OUTPUT OF ALTERNATORS.

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 Figure 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.



T-76845

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 sent to a dependable electrical repair shop. 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
Servicing—Servicing of the regulator is not recommended. If it is malfunctioning, it should be removed and taken to a dependable electrical repair shop. If servicing must be done, it should be done with the most dependable test equipment and in strict accordance with the manufacturer's specifications.

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 9.) 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.

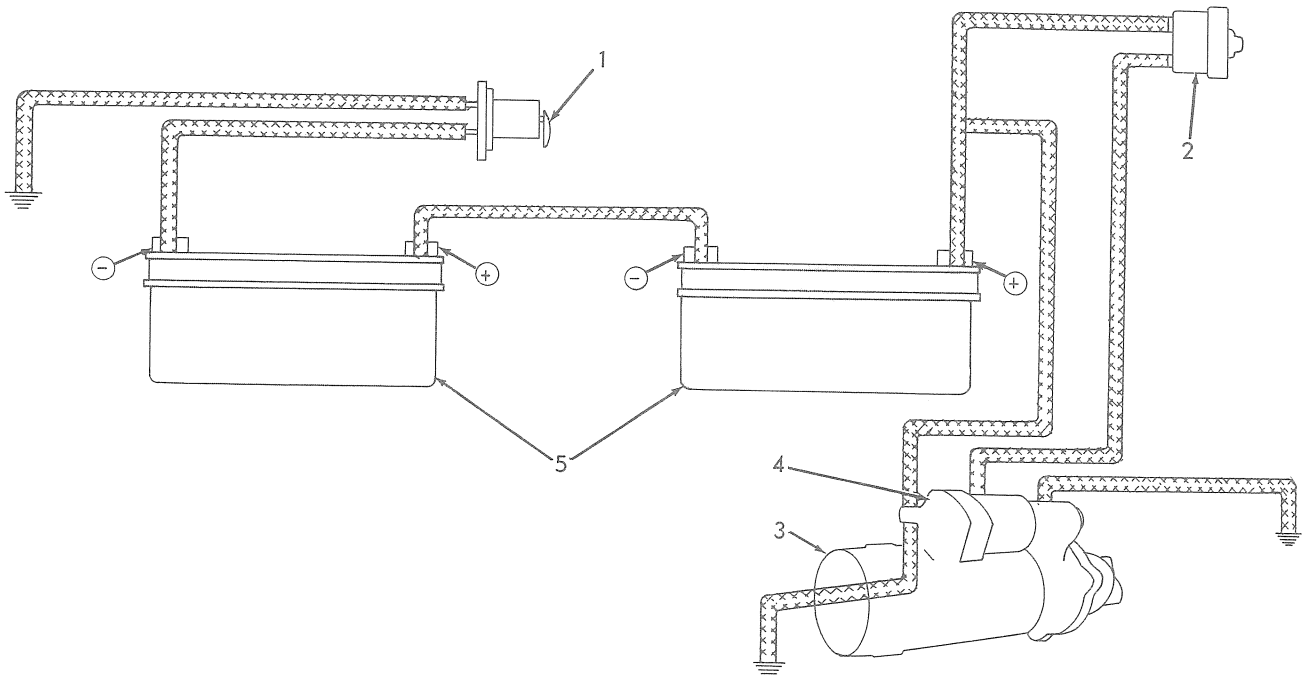
The solenoid should make a single, clean click when the starter switch is thrown. If the click is heard, but the starting motor does not work, then the trouble is most likely in the starting motor. If no click is heard, then the solenoid switch is not operating and the starting motor cannot work. (Before 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.



T-73675

FIG. 9 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 10.) 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 11.) 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 12. 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.

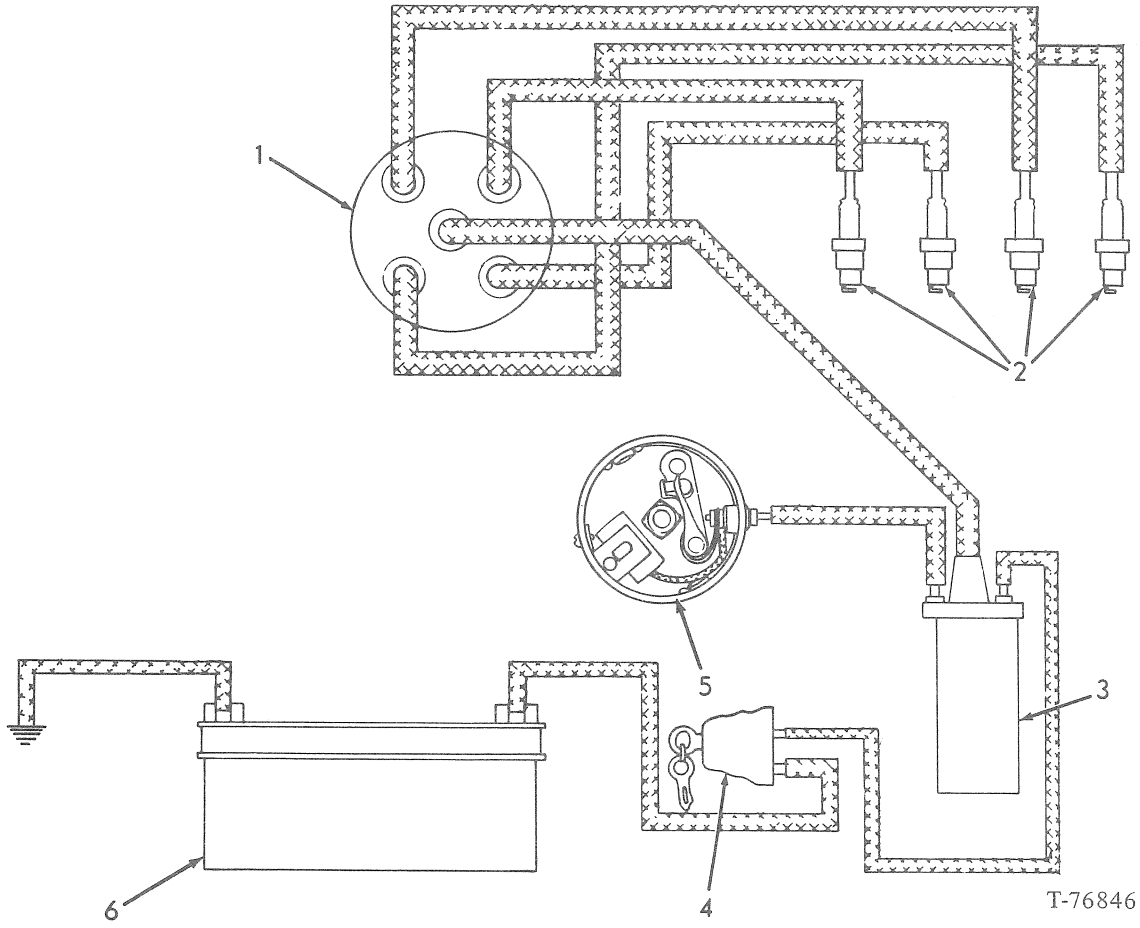


FIG. 10 IGNITION CIRCUIT SCHEMATIC

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

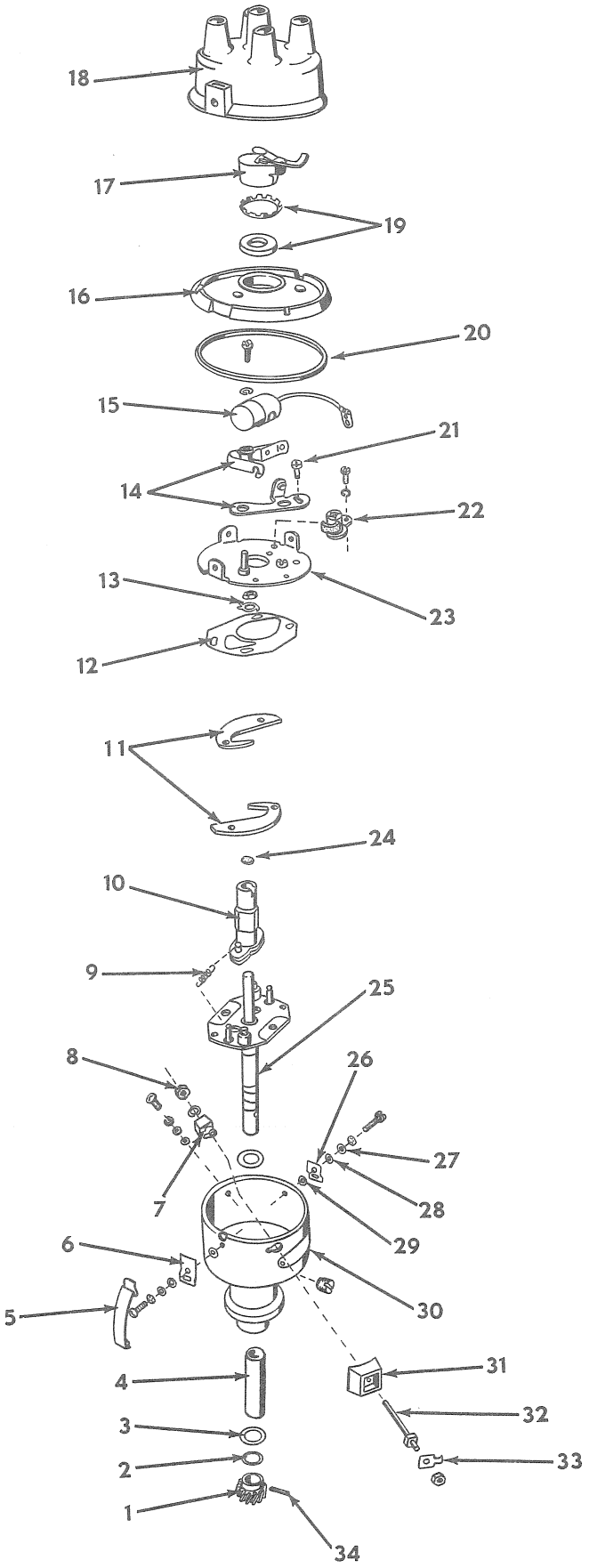
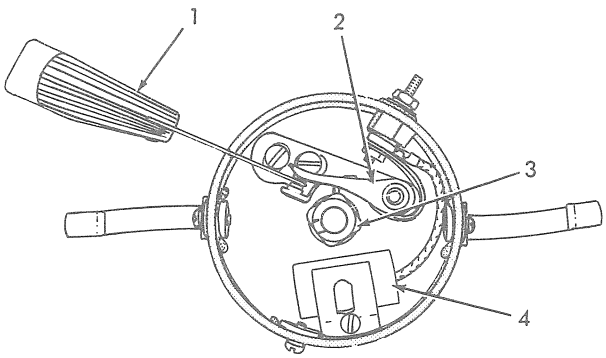


FIG. 11 DISTRIBUTOR PARTS
(T-3489)

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



T-73714

FIG. 12 SETTING BREAKER POINT GAP

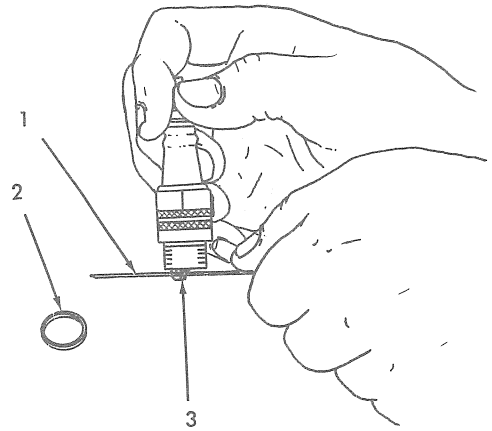
1. Feeler gauge
2. Breaker point set
3. Cam
4. Condenser

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.



(T-73715)

FIG. 13 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 13. The plugs should be reinstalled to 25 lbs.-ft. (3.45 Kg-m) of torque.

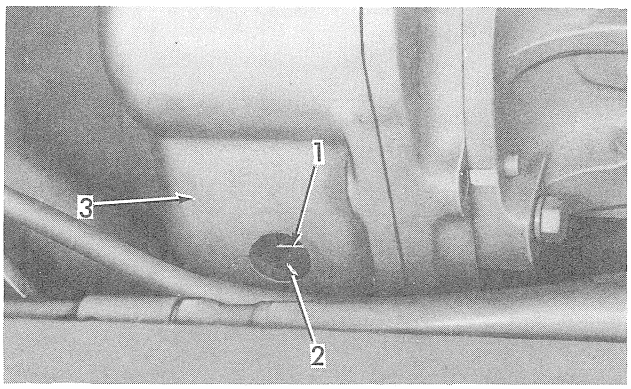
5.5 TIMING ADJUSTMENT

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 14.)

   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.



(T-23050)

FIG. 14 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.

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.

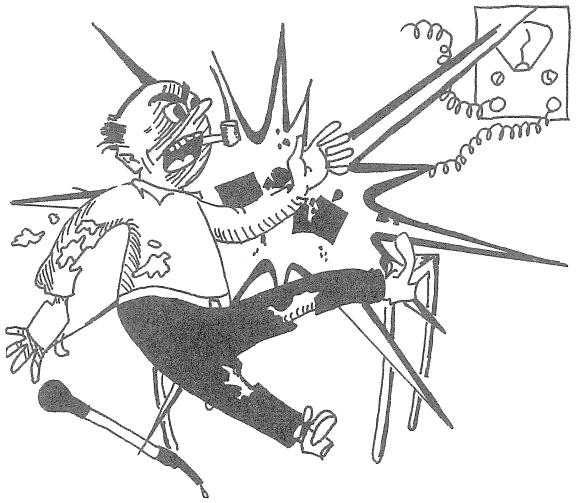
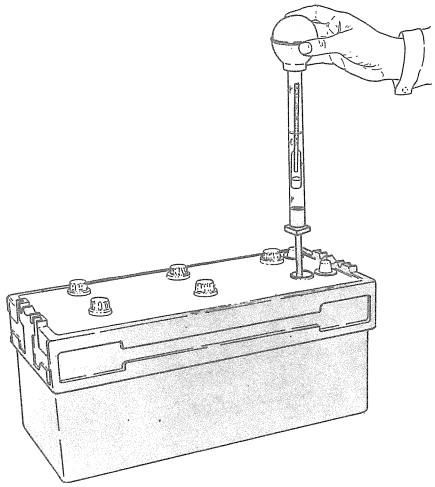


FIG. 15 T-74525

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 16.) 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.

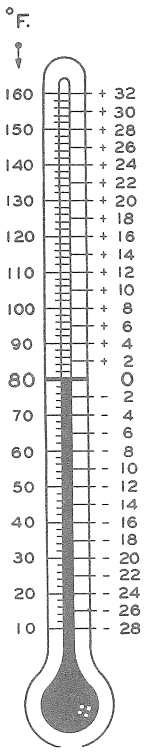


(T-73711)

FIG. 16 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 17 gives two examples of the calculation of the correction.



EXAMPLE No. 1 —
Temperature *below* 80°F.
Hydrometer Reading 1.250
Acid Temperature 20°F.
***Subtract* .024 Sp. Gr.**
Corrected Sp. Gr. is 1.226

EXAMPLE No. 2 —
Temperature *above* 80°F.
Hydrometer Reading 1.235
Acid Temperature 100°F.
***Add* .008 Sp. Gr.**
Corrected Sp. Gr. is 1.243

(T-74527)

FIG. 17 CORRECTION FOR HYDROMETER

CAUTION

The battery electrolyte is a corrosive, acid solution. Avoid any contact of the electrolyte with skin, eyes, or clothing. If spills occur, they should be washed immediately with large amounts of water and, if possible, soap.

7.3 MAINTENANCE

7.3.1
Basic Servicing—A battery is a perishable item requiring periodic service. When a battery is properly maintained, the reward will be long and trouble-free operation. Regular maintenance should include the following steps:

1. Check the electrolyte level. Add clean water (distilled, if available) to maintain the prescribed level, but do not overfill the battery cells and cause a loss of electrolyte from spillage. Excessive use of water indicates overcharging or possible leakage.

2. Keep the top of the battery clean. When necessary, wash corrosion off the terminals with a baking soda solution, and rinse them with clear water. Use a steel brush or steel wool, if necessary, to be sure that the terminals are really clean. Coat the connections and the terminals with a very light layer of grease to retard additional corrosion.

3. Inspect the cables, clamps, and hold-down brackets. Clean them, and replace them as necessary.

7.3.2
Temperature Considerations—The electrolyte of a battery, in various states of charge, will start to freeze at the temperatures indicated below. The given temperatures indicate the approximate temperatures at which ice crystals first begin to form in the electrolyte. The electrolyte will not freeze solidly until a slightly lower temperature is reached, but solid freezing of the electrolyte may crack the battery container or damage the plates.

Specific Gravity (Corrected to 80°F (27°C)	Freezing Temperature
1.280	-90°F (-69°C)
1.250	-62°F (-55°C)
1.200	-16°F (-27°C)
1.150	+ 5°F (-15°C)
1.100	+19°F (- 7°C)

A battery charged three-fourths or more is in no danger of freezing, so batteries should be kept at least three-fourths charged in winter weather.

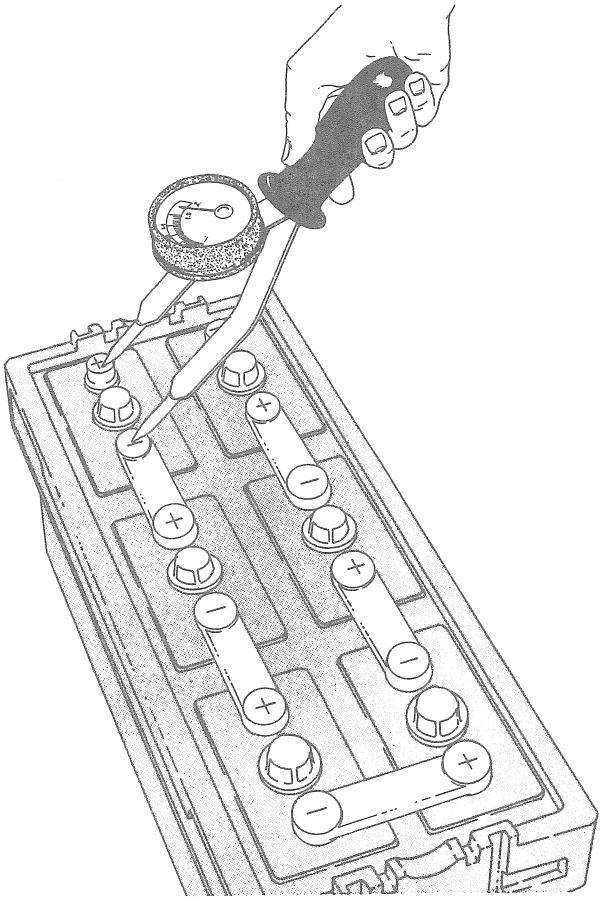
7.3.3
Storage—If the equipment is not going to be used for more than one month, the battery should be removed and stored in a cool, dry place. During extended storage, it should be checked periodically and recharged as necessary. A battery left unused for a long period of time is subject to the crystallization of lead sulfate on the plates; this deterioration will adversely affect future performance.

7.3.4
Testing on the Unit—The electrolyte level should be checked and corrected, and the battery should be visually inspected. Signs of damage or serious abuse, like excessive corrosion, a cracked or bulging case, or cracked cell covers, will mean that the battery has to be replaced. A hydrometer test also can be performed.

The voltage of each cell of the battery may be checked with a voltmeter to be sure that each cell is properly charged. It is possible that a single cell of the battery has gone bad and has become incapable of holding a charge. This will be evident either through a low battery voltage, or a low individual cell voltage. Figure 18 illustrates the use of a special voltmeter to check the battery. Any voltmeter can be used, and the voltmeter should indicate between 1.7 and 1.8 volts per cell for battery temperatures between 70°F and 90°F (21°C and 33°C). If any cell indicates a low voltage and the situation cannot be remedied by charging (as described in Section 7.3.6), the battery will have to be replaced.

It is possible for a faulty battery to indicate sufficiently high cell voltages on a voltmeter, but still not perform satisfactorily on the unit. This is because the voltmeter

really does not give the battery enough load to show that it is faulty. After checking the rest of the electrical sytem, and particularly the charging circuit, the battery condition can be determined by a load test performed in the following manner:



(T-73712)

FIG. 18 CHECKING BATTERY WITH VOLTMETER

1. Remove the vent plugs and make a hydrometer check (as described in Section 7.2), if one has not been made already. The battery temperature should be between 70°F and 90°F (21°C and 33°C), and the hydrometer reading must be at least 1.25 to perform the load test.

2. Activate the starter motor, and crank the engine just long enough to read the voltage of the cell being tested. Repeat this measurement for each cell, but do not crank the engine for more than 30 seconds straight, and allow two minutes between tests. (**Do not** allow the engine to start during these tests. If the equipment has a fuel shut-off valve, the valve should be turned off. In order to keep the battery from charging, it may even become necessary to disconnect the output from the alternator or generator.)

3. If the voltage of any cell falls below 1.5 volts, or if a difference of 0.2 volts or more is observed between cells, the battery will have to be replaced.

7.3.5

Testing off the Unit—To check the hydrometer reading of the electrolyte when the battery is fully charged, the battery may be charged up at the rate of 7% of its 20-hour rating. For example, a battery with a 20-hour rating of 150 amperes should be charged with a 10 or 11 ampere current. The charging should be continued until the battery cell specific gravities show no changes over three tests at one-hour intervals, and the battery cells are gassing freely.

After the battery is completely charged, the specific gravity of the electrolyte in each cell should be checked. If the individual cell readings range between 1.230 and 1.280, then the battery is ready for use. If the specific gravity of any cell is less than 1.230, the battery should be replaced. (If the battery has been in service less than three months, it may have been activated improperly before it was installed.)

The following table illustrates the typical ranges of specific gravity for a cell in various stages of charge. The values of specific gravity are given with respect to full charge reference values at 80°F (27°C) of 1.26 or 1.28.

TYPICAL RANGES OF SPECIFIC GRAVITY	
1.260 Sp. Gr. to 1.280 Sp. Gr.	100% charged
1.230 Sp. Gr. to 1.250 Sp. Gr.	75% charged
1.200 Sp. Gr. to 1.220 Sp. Gr.	50% charged
1.170 Sp. Gr. to 1.190 Sp. Gr.	25% charged
1.140 Sp. Gr. to 1.160 Sp. Gr.	Very little useful capacity
1.110 Sp. Gr. to 1.130 Sp. Gr.	Discharged

7.3.6

Charging—Depending on the amount of supply current and the length of time of its application, batteries can be recharged at different rates. Slow charging of the battery is done with a low current over a relatively long period of time (possibly as much as 24 hours). Fast charging is done with a high current applied over a relatively short period of time. In either case, the electrolyte level should be checked and corrected before any charging is attempted.

Slow charging of a battery is preferred, but fast charging can be used to some advantage if several precautions are observed. During fast charging, a battery cannot be fully charged, but it can be substantially 'boosted' or partly charged, as long as the electrolyte temperature is not allowed to reach 125°F (52°C). (Damage to the battery results if the electrolyte exceeds that temperature.) In order to bring the battery to a fully charged condition, the fast charging must be followed by a period of slow charging.

Recommended charging rates are as follows:

Amp Hour Capacity	Slow Charging	Fast Charging
100 or less	24 hrs 4 Amps	1.5 hrs 45 Amps
over 100	24 hrs 9 Amps	3 hrs 45 Amps

CAUTION

When connecting a battery charger or booster battery to a battery being charged, the positive terminals are connected together and the negative terminals are connected together. Excessive current will flow, like in a short circuit, if the terminals are mismatched. In addition (as previously stated in Section 7.2), the gases produced during charging are explosive. The battery vent plugs should be removed during charging to avoid concentrating the gases. No smoking should be allowed near a battery being charged; and live circuits, like the charging circuit, should not be broken at the battery because of the spark that usually results.

7.4 INSTALLATION

To properly install a battery, the following steps should be taken:

1. Clean the battery compartments.
2. Check the polarity of the battery to insure that it is not reversed with respect to the polarity of the electrical system.

CAUTION

Always make sure that the ground polarities of the battery and the alternator or generator are the same. Even if the battery is only connected momentarily with the polarity reversed, serious damage to the electrical system can result.

3. Be sure that the battery sits level in its compartment.
4. Tighten the hold-down clamps evenly until they are snug. Overtightening them may distort or crack the battery case.
5. Check the battery cables to be sure that they are in good condition. Make sure that the connections to the starter motor and to ground are particularly clean and tight.
6. Grease the battery terminals lightly to deter corrosion. When connecting the cable clamps to the battery, connect the grounded clamp last to avoid short circuits which could damage the battery or other parts of the electrical system. Also lightly grease the exteriors of the cable clamps to deter corrosion.

7.5 ACTIVATING "DRY CHARGE" BATTERIES

1. Fill each cell to indicator level with electrolyte solution of 1.250 - 1.265 specific gravity. Temperature of battery and solution must be between 60°F. and 90°F. (15°C and 32°C).

CAUTION

The battery electrolyte is a corrosive, acid solution. Avoid any contact of the electrolyte with skin, eyes, or clothing. If spills occur, they should be washed immediately with large amounts of water and, if possible, soap.

2. Allow battery to stand at least 20 minutes. Check each cell and add electrolyte as necessary to restore level to indicator.
3. Give battery a minimum charge. Charge 6 volt batteries at 70 amps. for ten minutes and 12 volt batteries at 35 amps. for ten minutes or until the temperature of the electrolyte reaches 80°F. (27°C).
4. If the outdoor temperature is below 40°F. (4°C) or if the battery is not to be put into service within 24 hours after activation, it should be fully charged (1.255 or higher specific gravity.)
5. After the battery has been activated and put into service, it should receive the same care as a wet battery. See 7.3.

TOPIC 8 ELECTRICAL SYSTEM SCHEMATICS

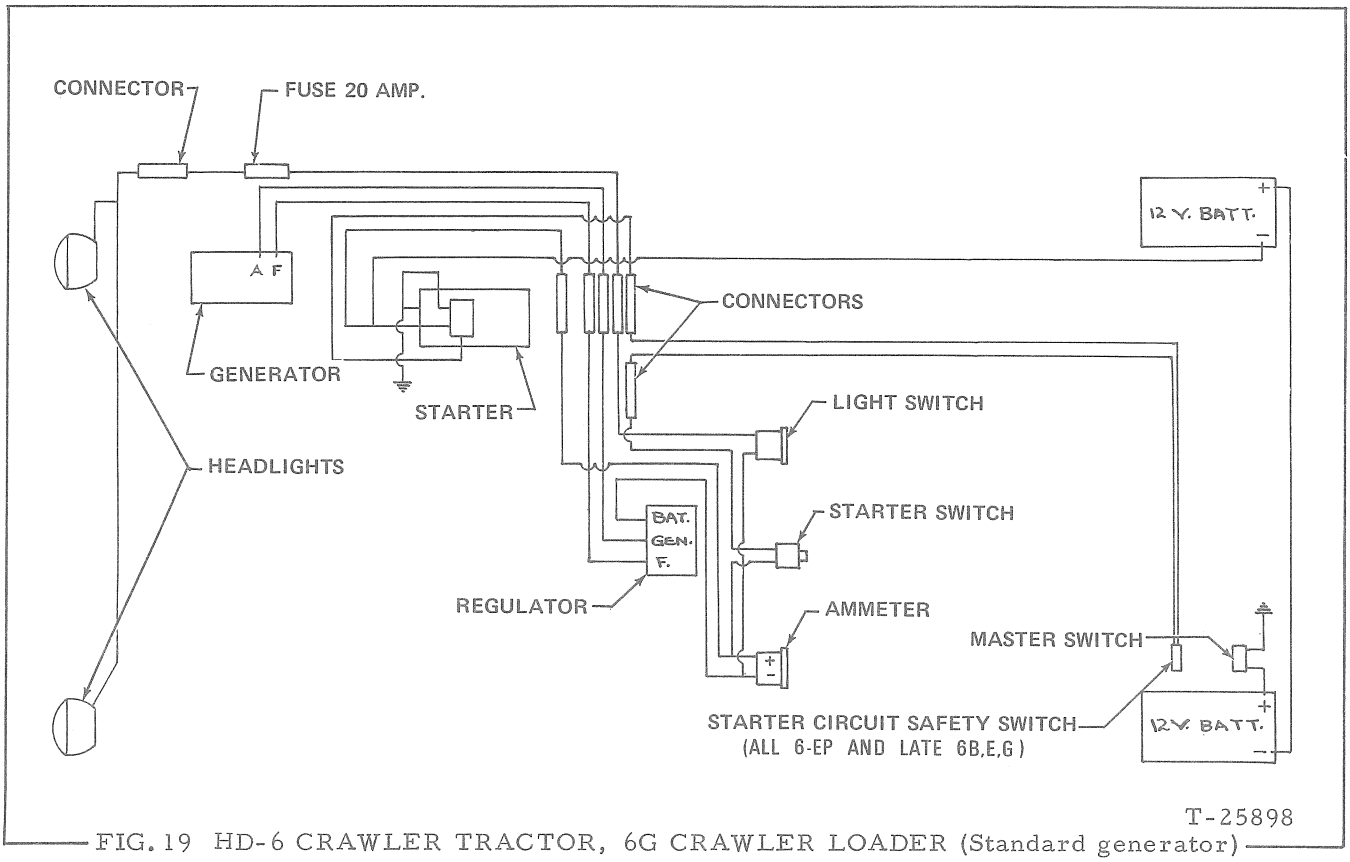


FIG. 19 HD-6 CRAWLER TRACTOR, 6G CRAWLER LOADER (Standard generator)

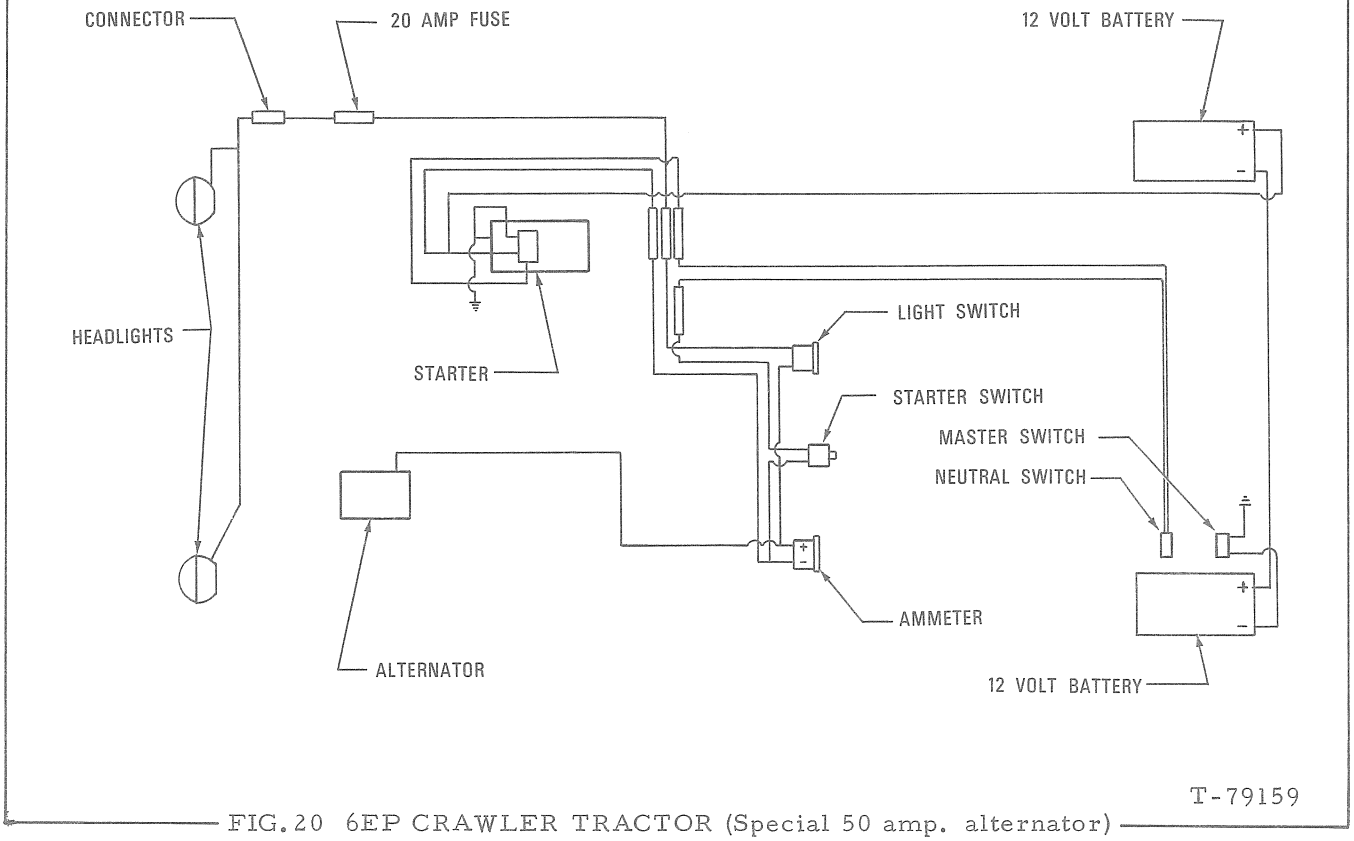


FIG. 20 6EP CRAWLER TRACTOR (Special 50 amp. alternator)

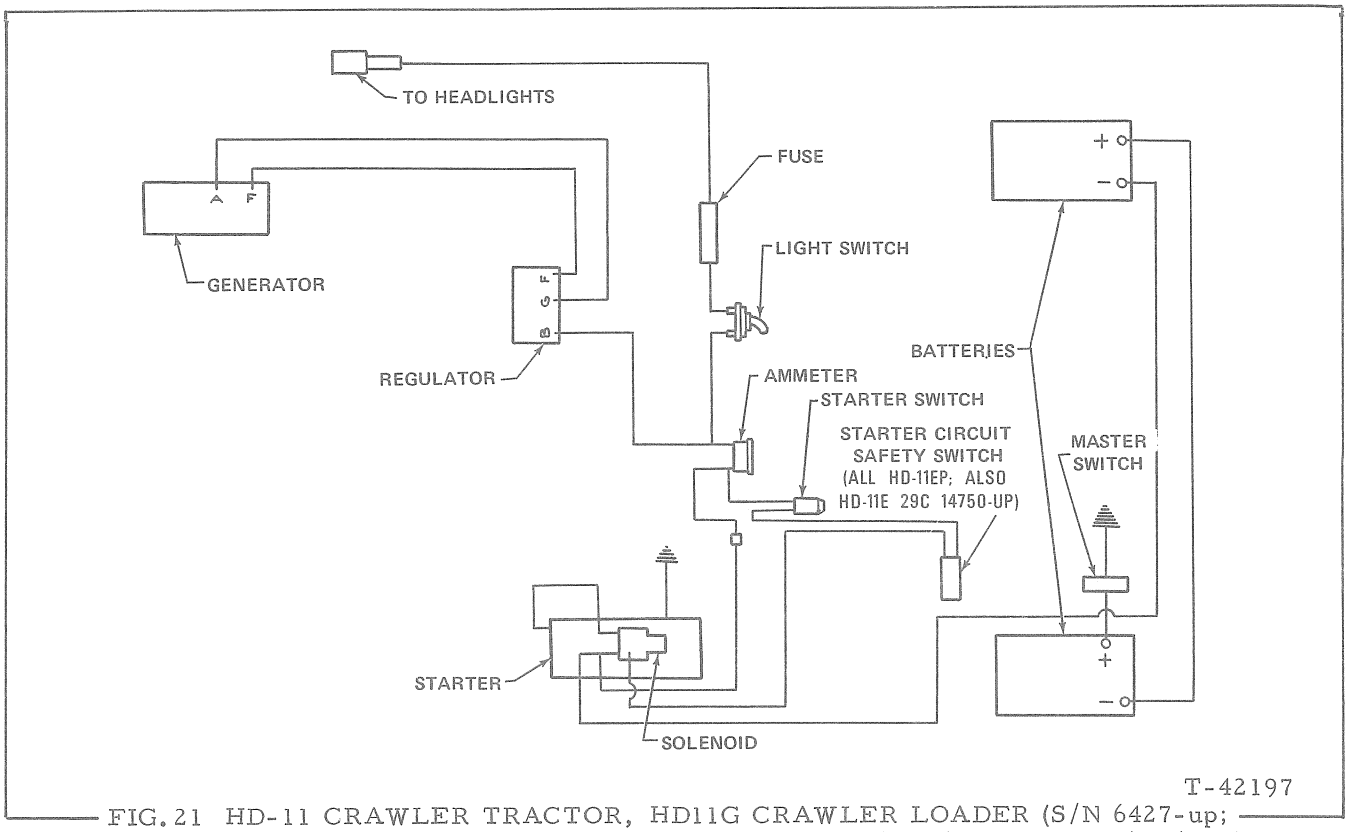


FIG. 21 HD-11 CRAWLER TRACTOR, HD11G CRAWLER LOADER (S/N 6427-up; 17L14651 through 17L16000; 29C14651 through 29C16000; 46Y14651 through 46Y16000)

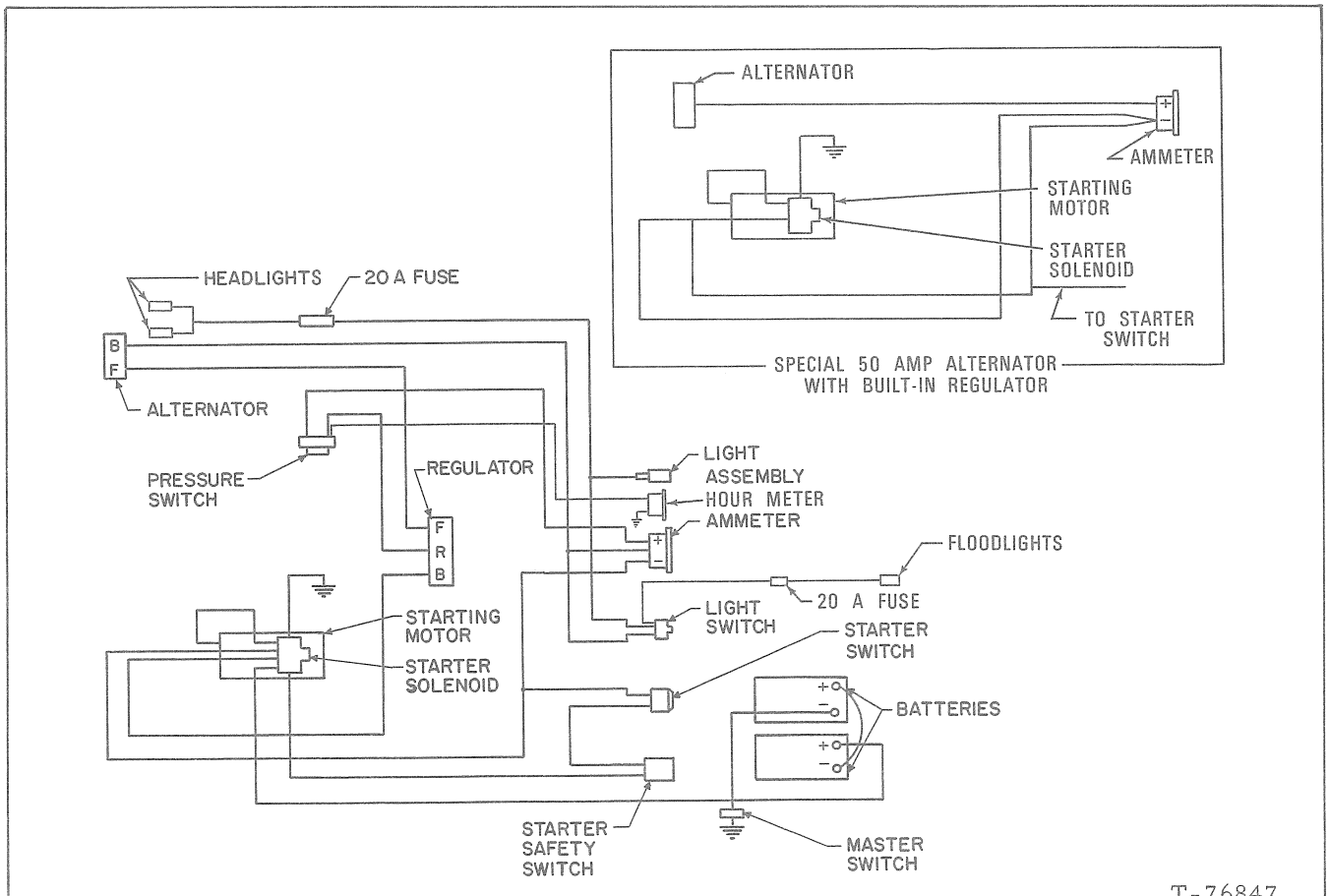


FIG. 22 11-B CRAWLER TRACTOR (S/N 16C16001-up; 25L16001-up)

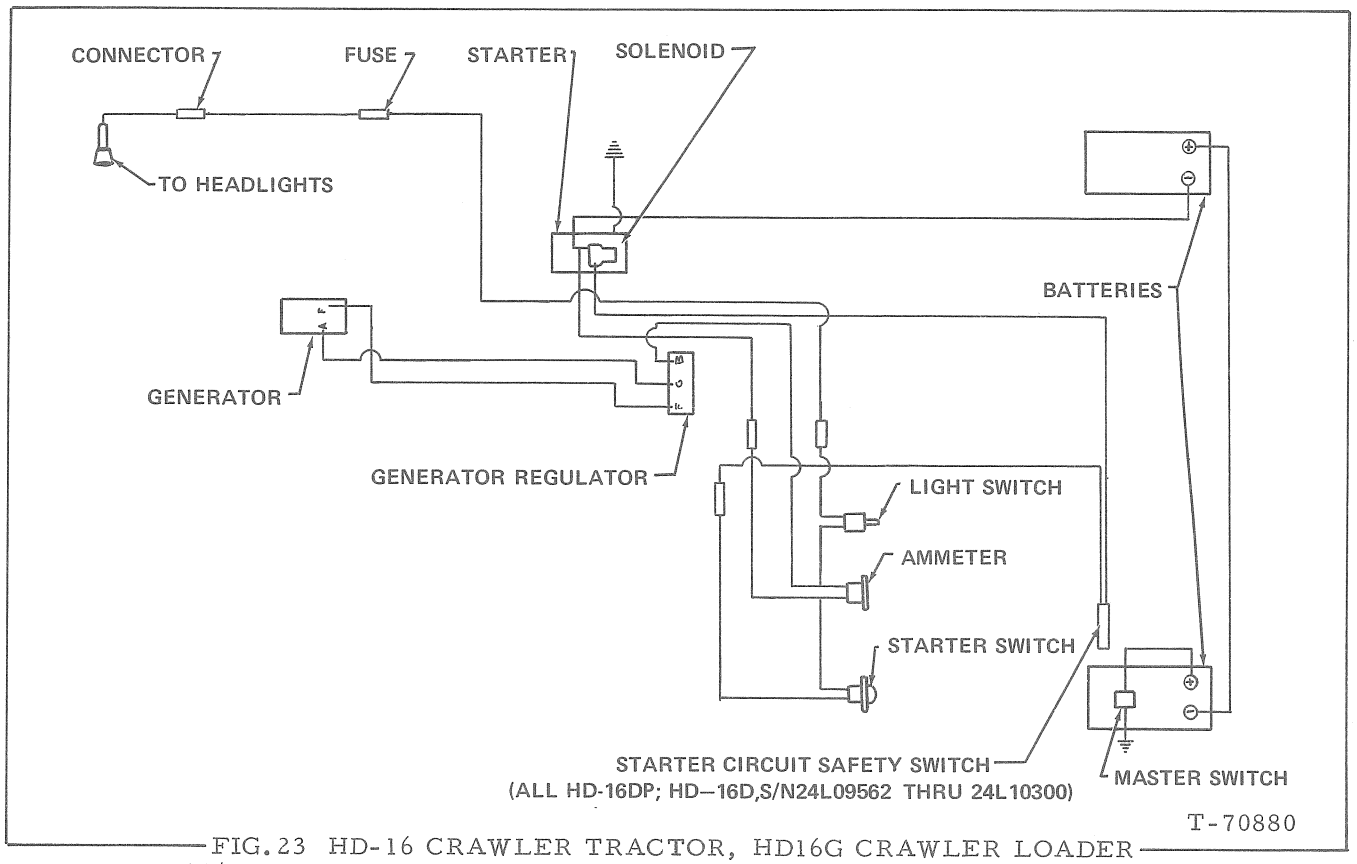


FIG. 23 HD-16 CRAWLER TRACTOR, HD16G CRAWLER LOADER
(S/N 5901 up; 24L09551 through 24L10300; 64A09551 through 64A10300)

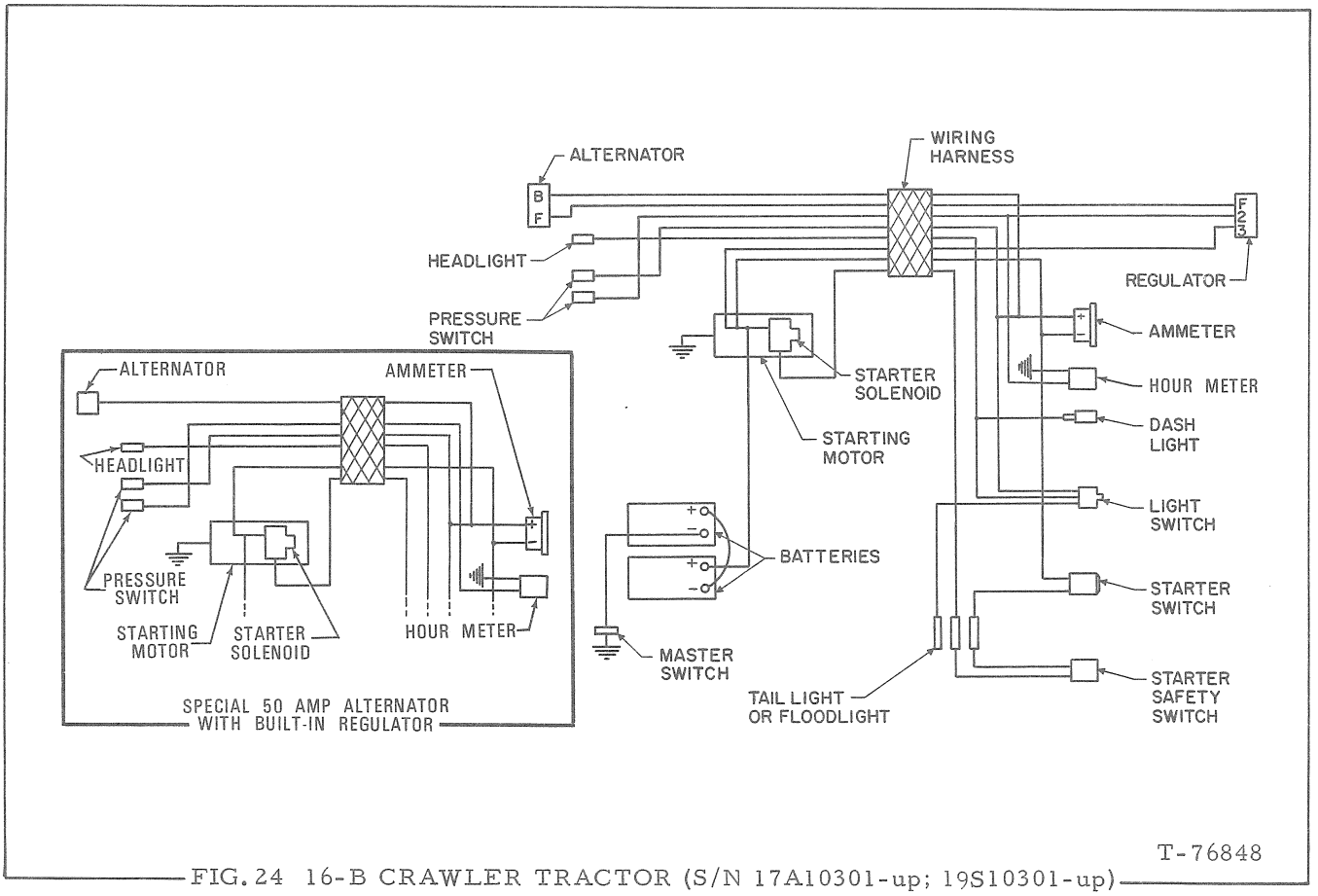
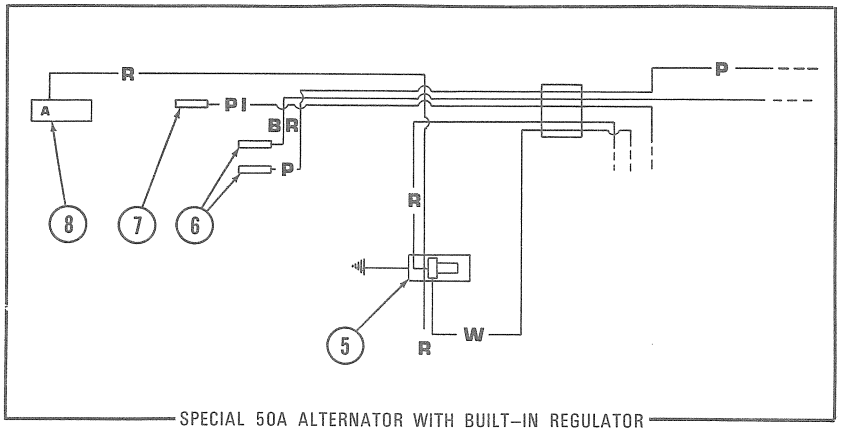


FIG. 24 16-B CRAWLER TRACTOR (S/N 17A10301-up; 19S10301-up)



SPECIAL 50A ALTERNATOR WITH BUILT-IN REGULATOR

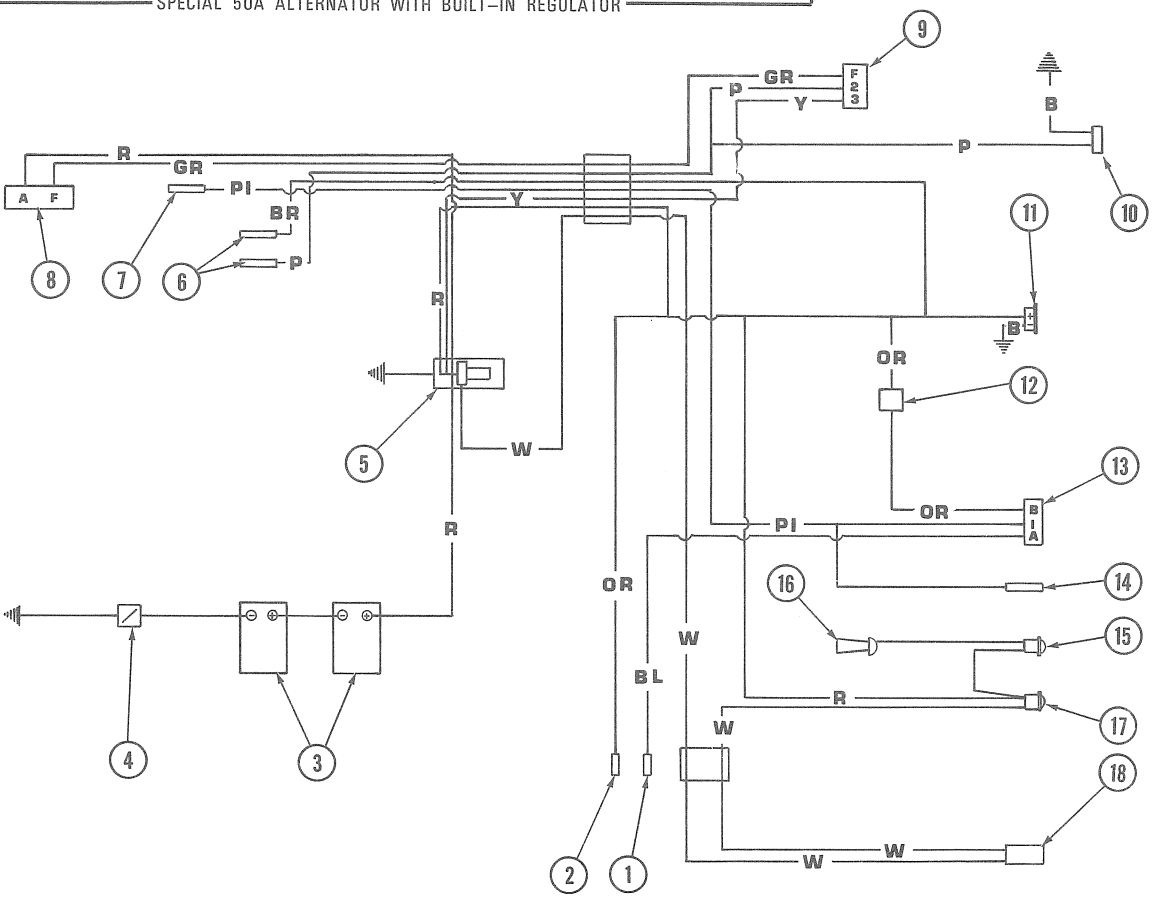


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FIG. 24A 21-C CRAWLER TRACTOR

1. Rear flood lights
2. Cab accessories
3. Batteries
4. Master switch
5. Starter solenoid
6. Pressure switch
7. Head lights
8. Alternator
9. Voltage regulator
10. Hour meter
11. Voltmeter
12. Circuit breaker
13. Light switch
14. Dash light
15. Horn switch
16. Horn
17. Starter switch
18. Neutral switch

B. black
BR. brown
BL. dark blue
G. light green
O. orange
P. purple
PI. pink
R. red
W. white
Y. yellow

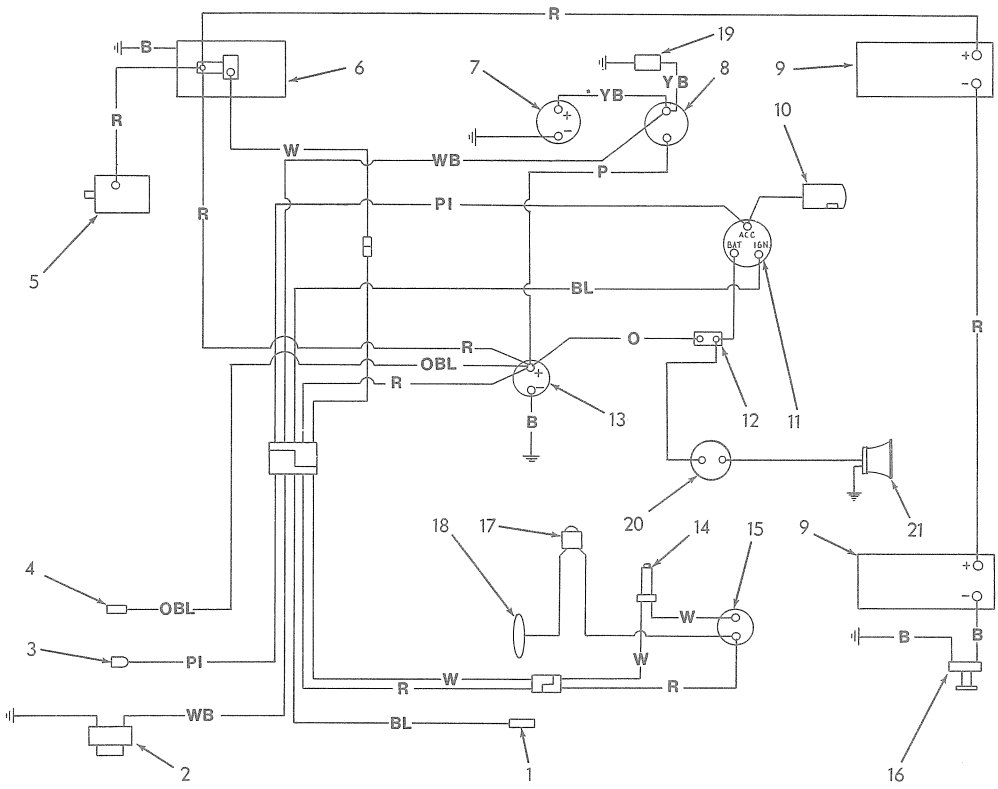

FIG. 24B 31 CRAWLER TRACTOR

1. Rear floodlight
2. Automatic fuel shut-off
3. Headlight
4. Cab electrical supply
5. Alternator (50 amp)
6. Starter
7. Hour meter
8. Pressure switch
9. Battery (12V)
10. Dash light
11. Light switch
12. Circuit breaker
13. Voltmeter
14. Neutral switch
15. Starter switch
16. Master switch
17. Horn switch
18. Horn
19. Fuel shut-off solenoid
20. Pressure switch (reverse)
21. Back-up alarm

B - Black
BL - Dark Blue
O - Orange
P - Purple
R - Red
W - White
OBL - Orange w/blue tracer
WB - White w/black tracer
YB - Yellow w/black tracer

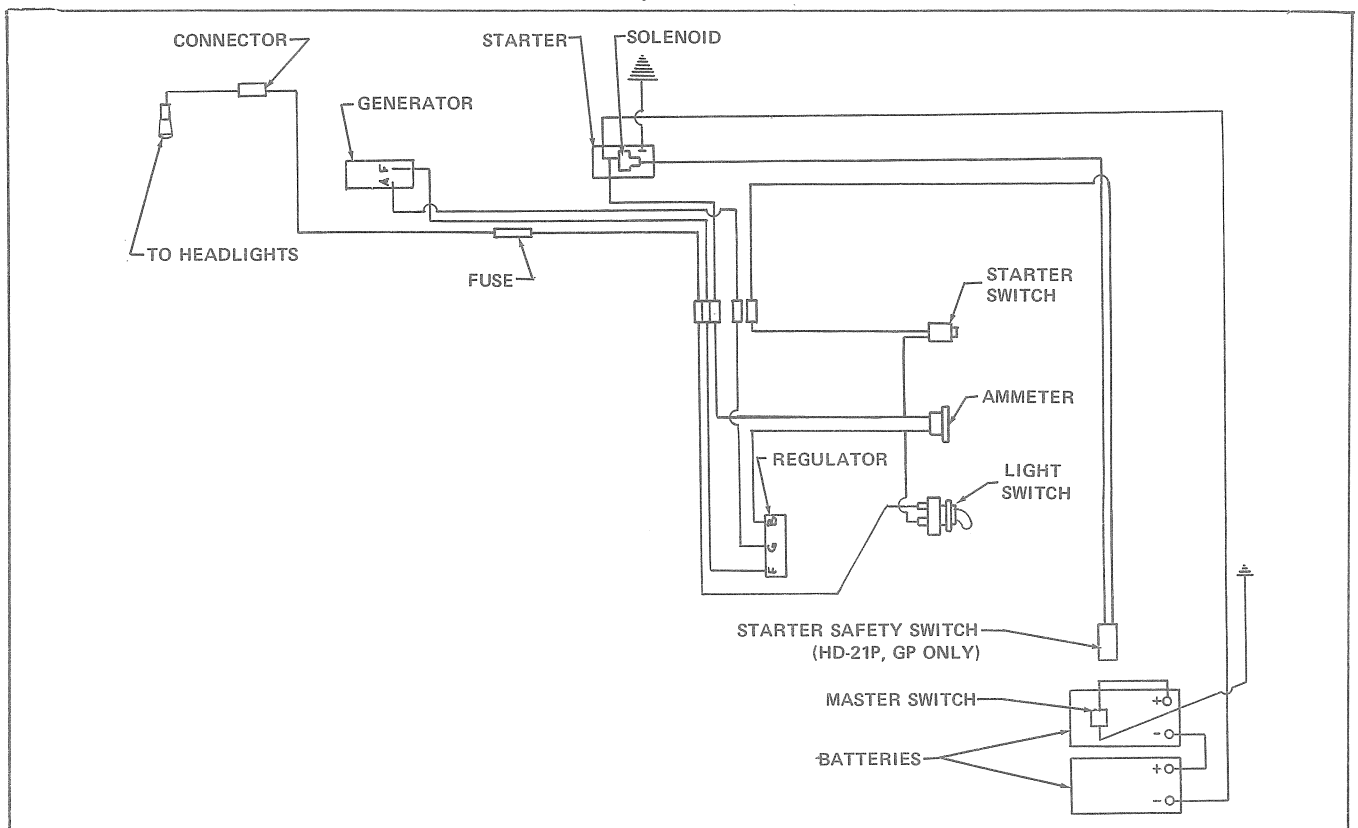

FIG. 25 HD-21 CRAWLER TRACTOR, HD-21 PIPELINER, HD-21G CRAWLER LOADER
(Prior to S/N 16001)

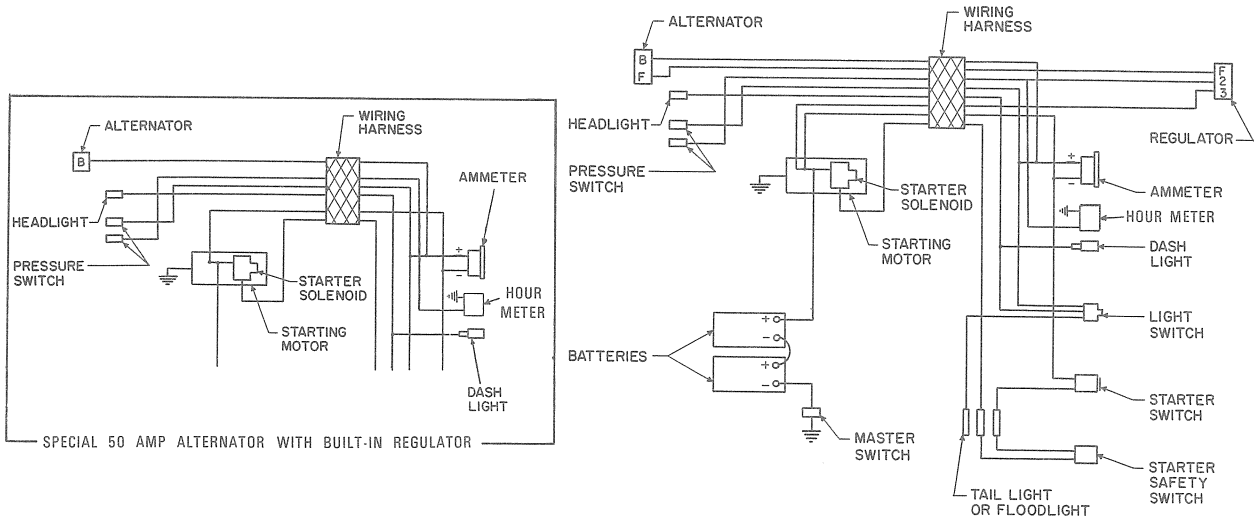

FIG. 26 21-B CRAWLER TRACTOR (S/N 16001-up; 10S16551-up)

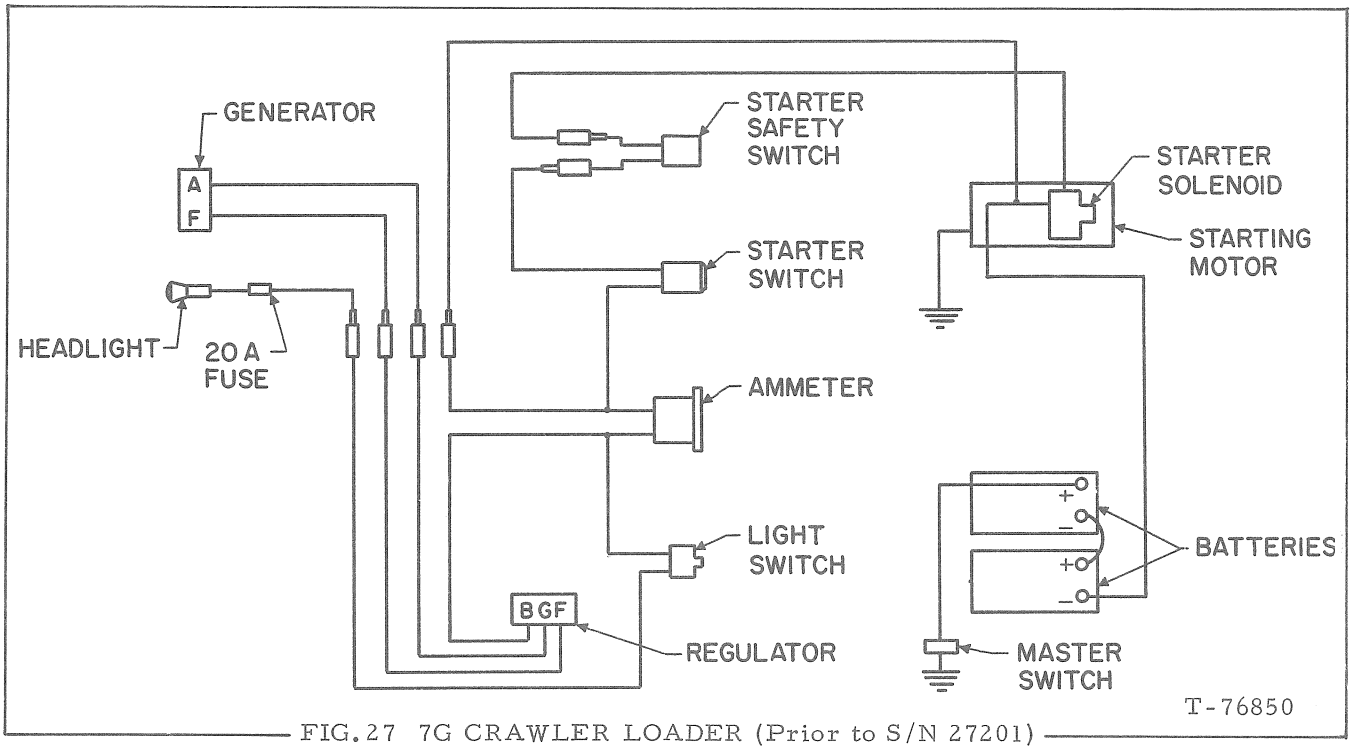

FIG. 27 7G CRAWLER LOADER (Prior to S/N 27201)

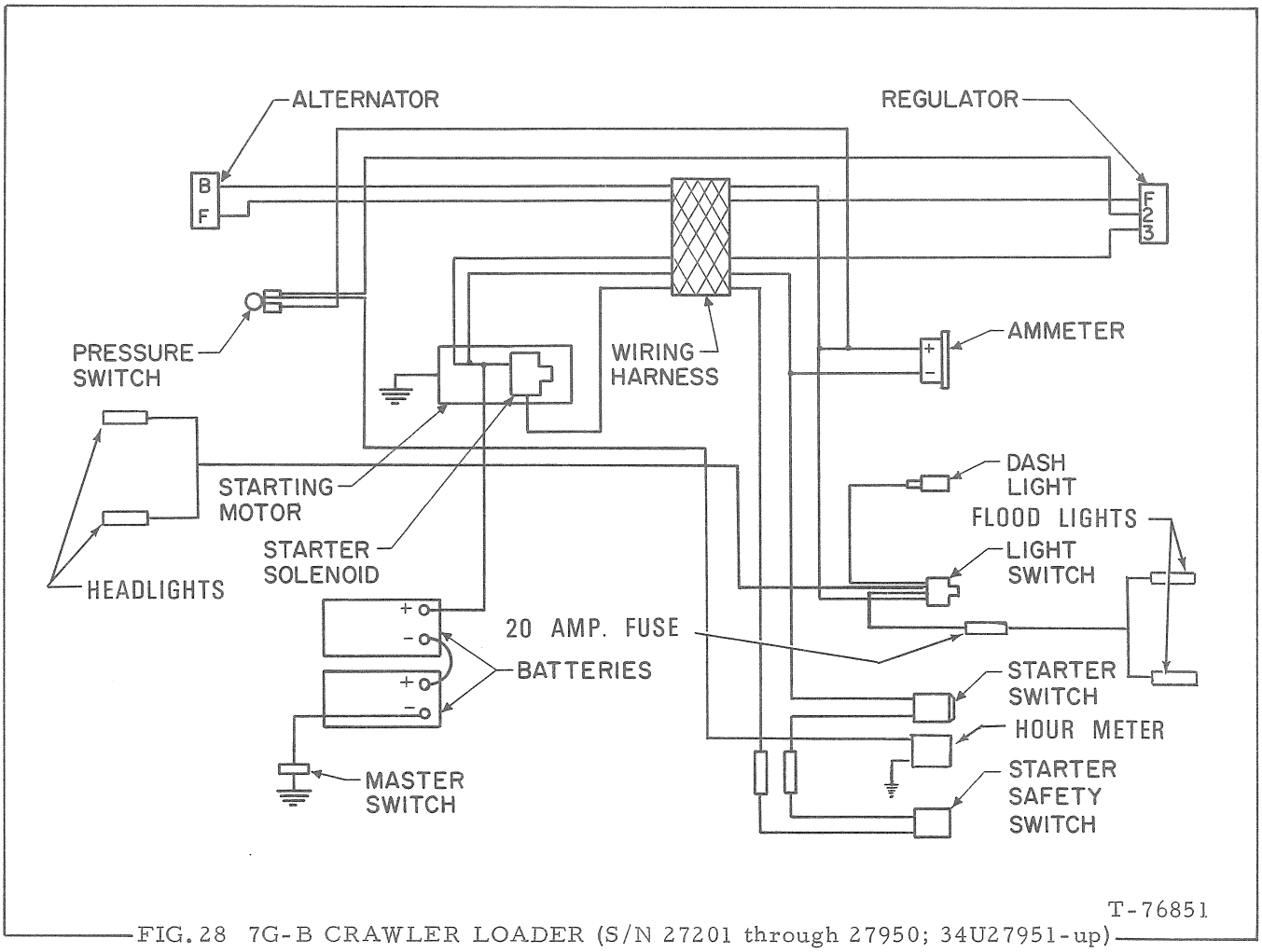

FIG. 28 7G-B CRAWLER LOADER (S/N 27201 through 27950; 34U27951-up)

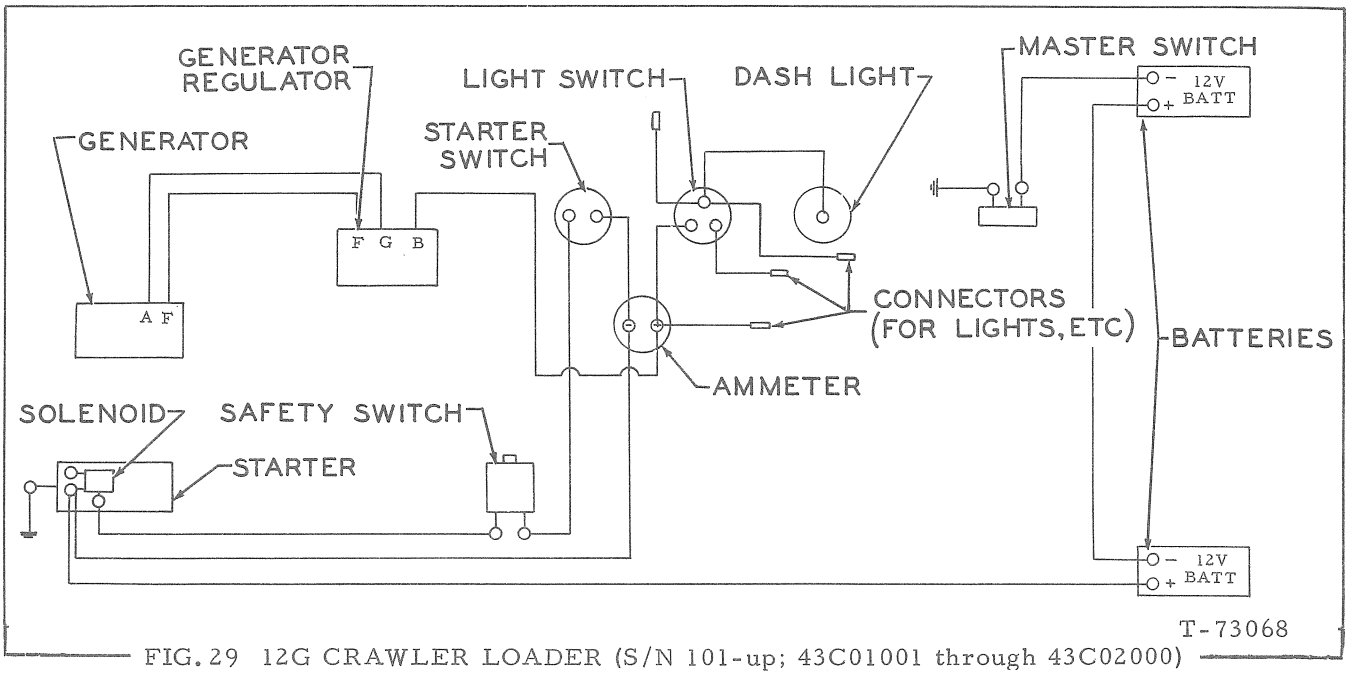

FIG. 29 12G CRAWLER LOADER (S/N 101-up; 43C01001 through 43C02000)

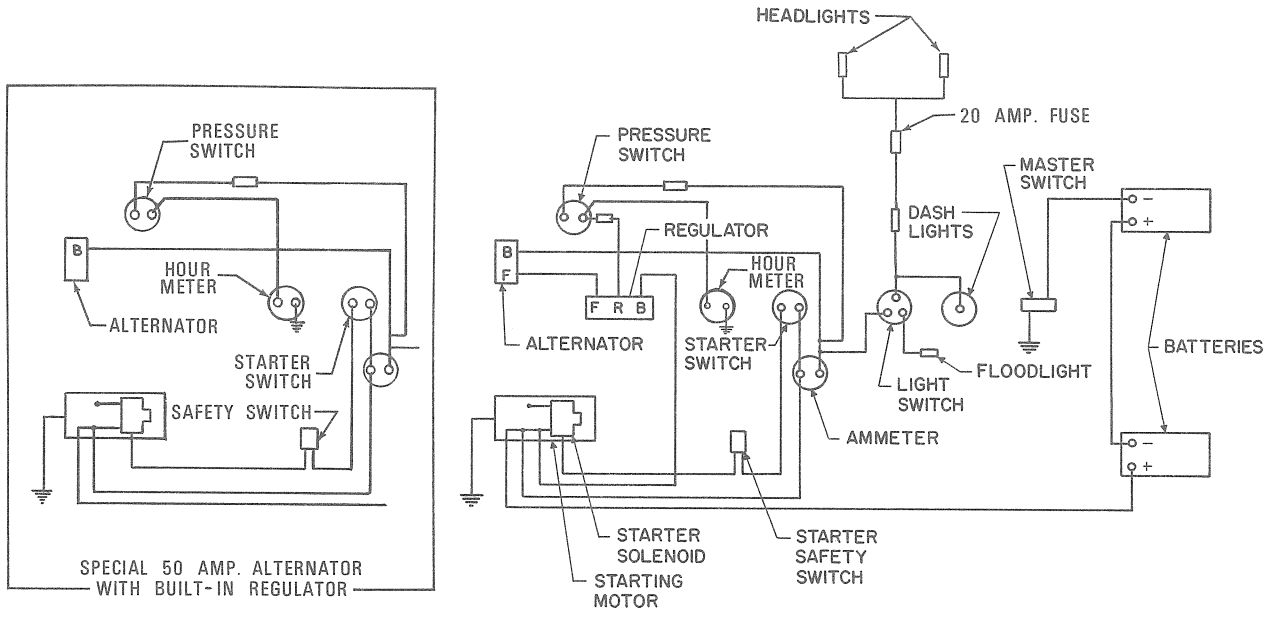

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FIG. 30 12G-B CRAWLER LOADER, 12G-B STEEL MILL SPECIAL (S/N 55M02001-up: 96Y02001-up)

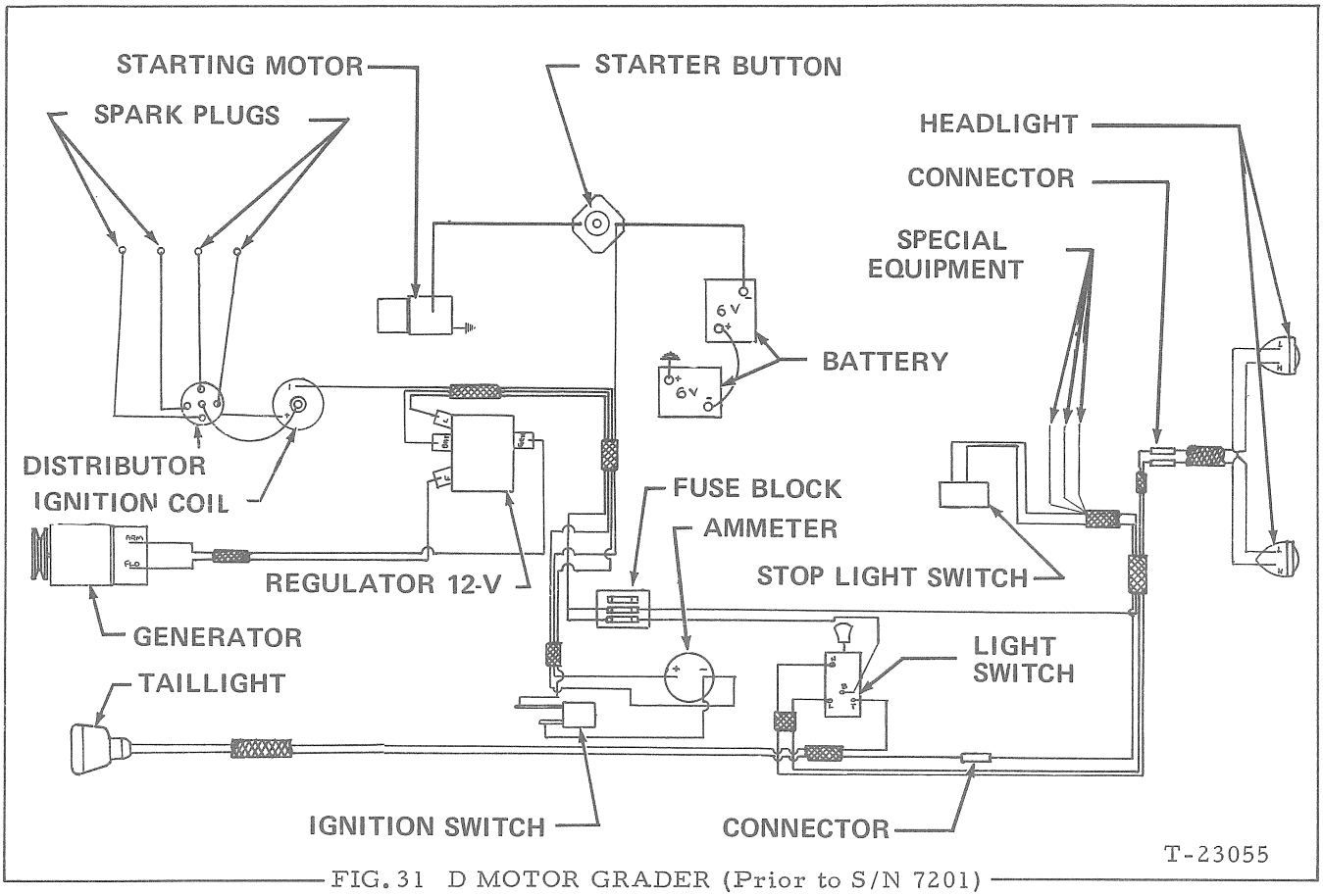


FIG. 31 D MOTOR GRADER (Prior to S/N 7201)

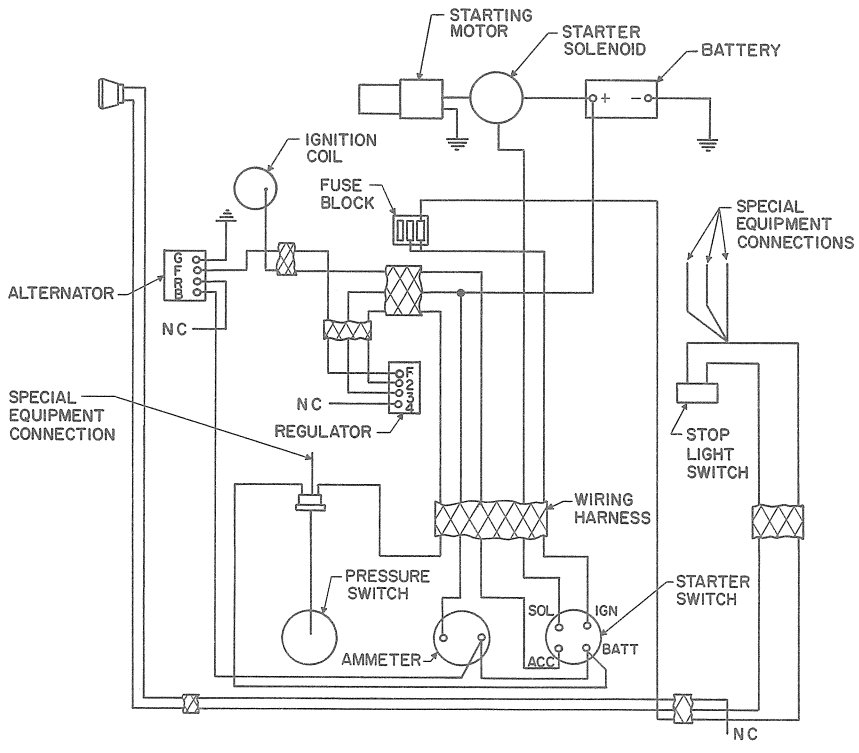


FIG. 32 D MOTOR GRADER (S/N 7201-up)

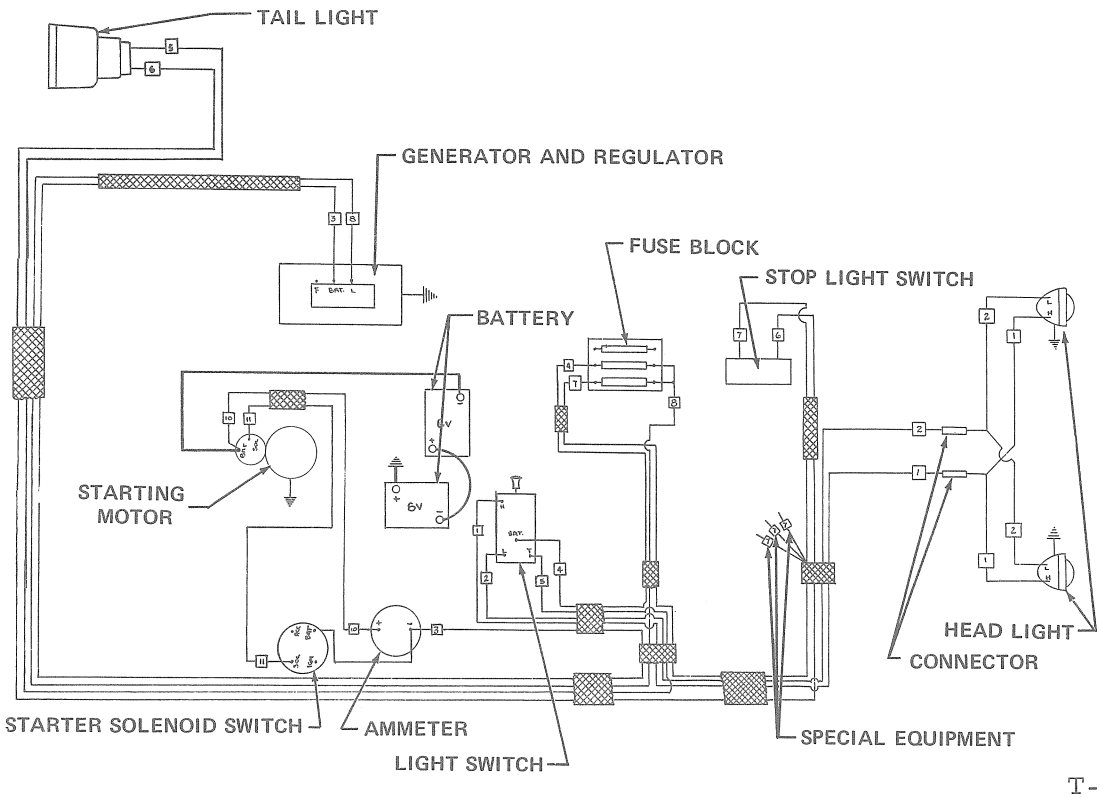


FIG. 33 DD MOTOR GRADER (Prior to S/N 2493)

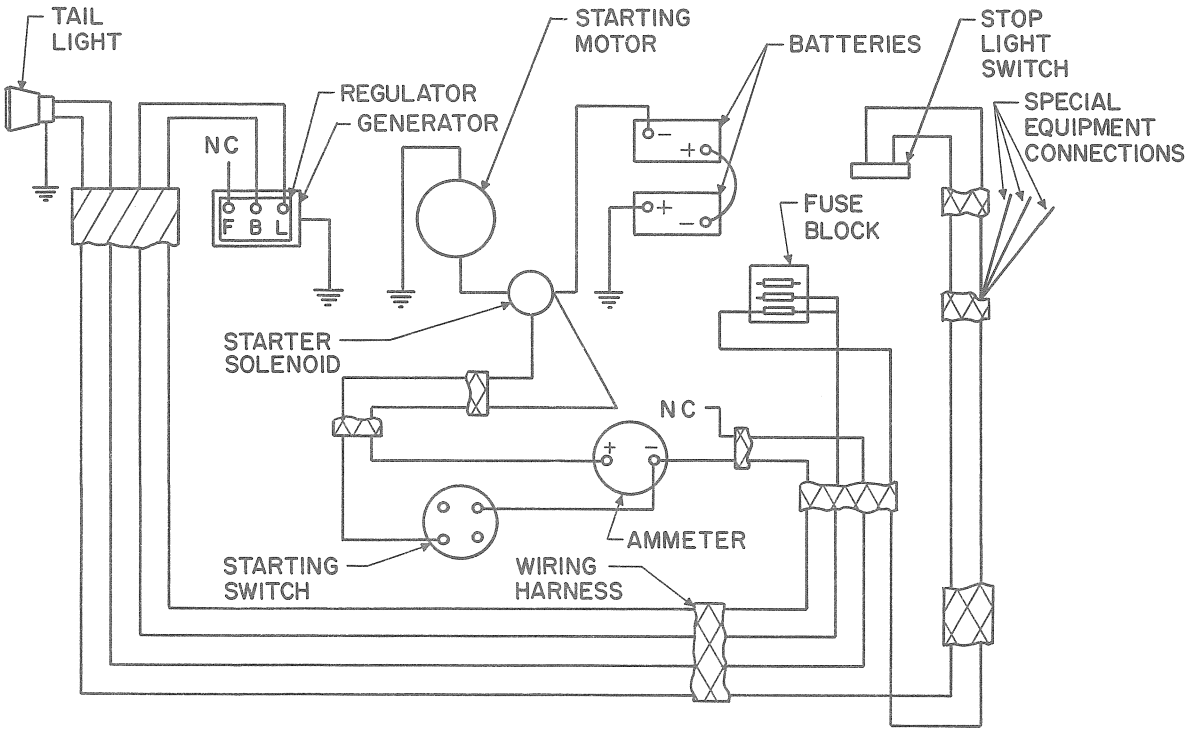


FIG. 34 DD MOTOR GRADER (S/N 2493-up; 73L04501 through 73L04506)

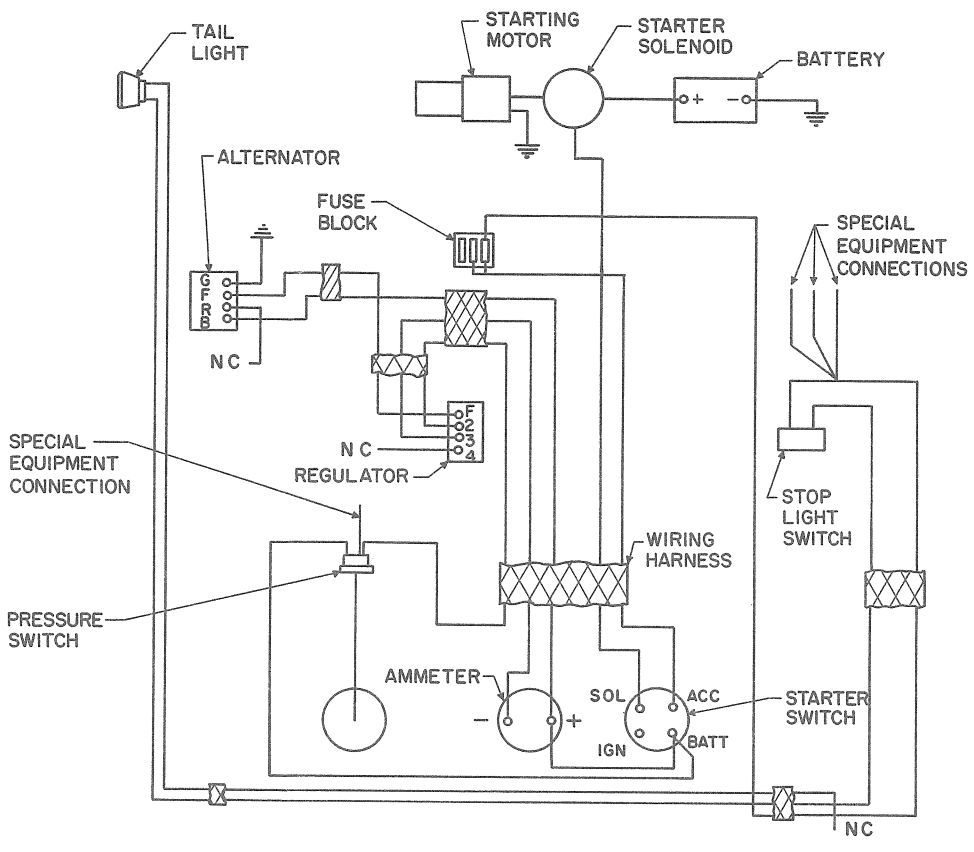
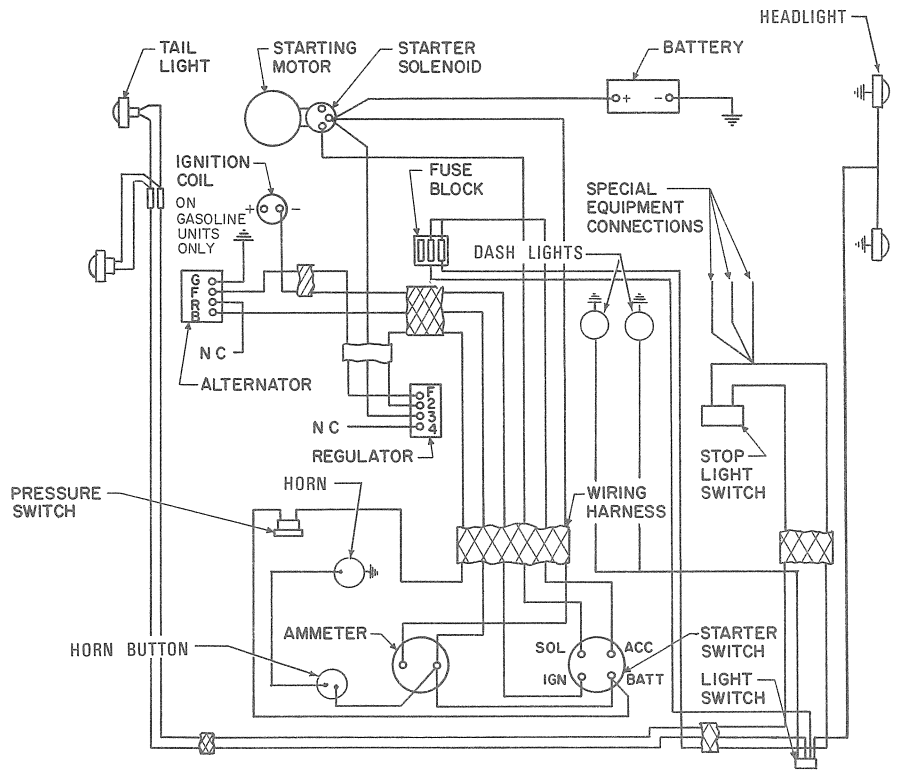


FIG. 35 DD MOTOR GRADER (S/N 73L04507-up)



T-76856

FIG. 36 65 MOTOR GRADER (S/N 24A00201 through 24A01527; 75Y00201-up)

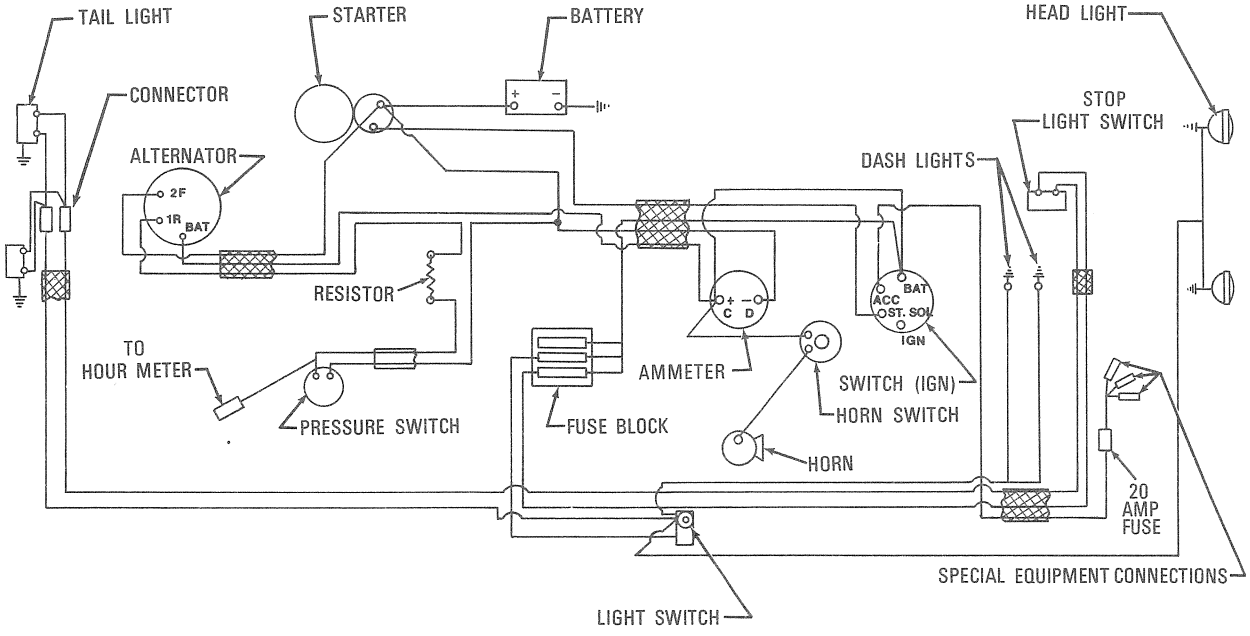


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FIG. 37 65 MOTOR GRADER (S/N 24A01528-up)

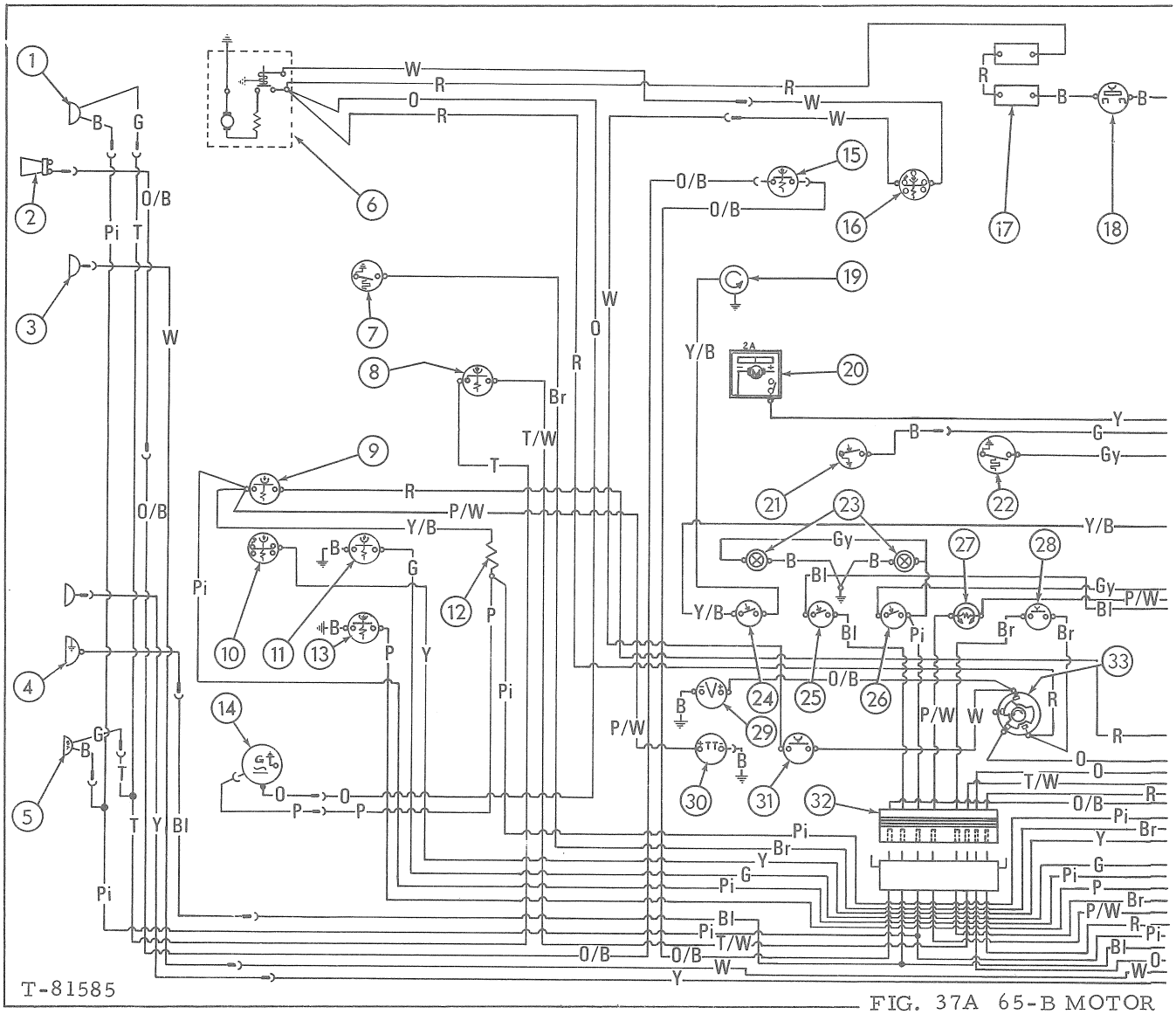
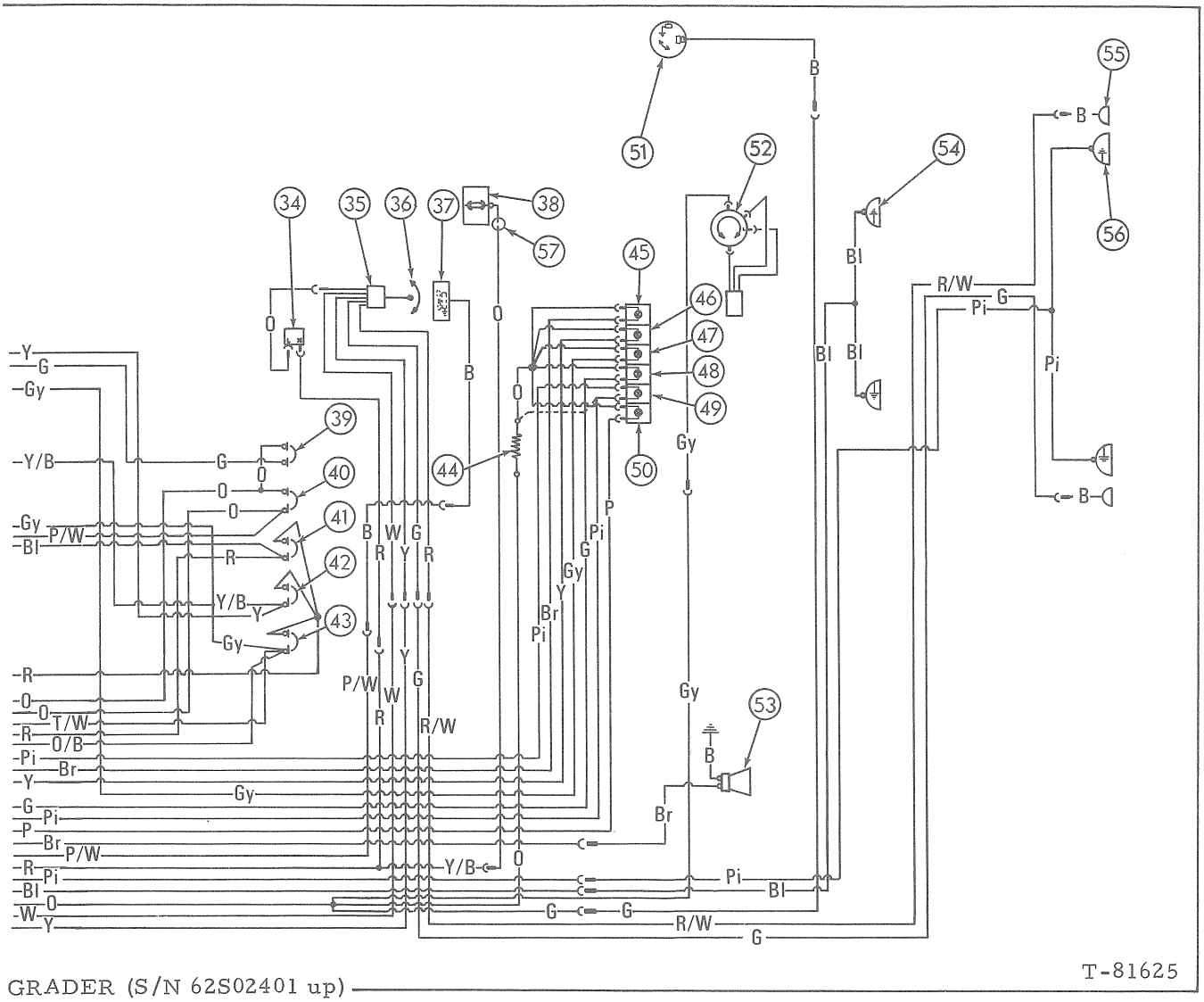


FIG. 37A 65-B MOTOR

* Special Equipment

To Indicator Lights

1. Tail and stop light
2. Reverse alarm
*3. Turn signal, rear
*4. Flood light, rear
*5. Tail and stop light
6. Cranking motor
*7. Engine water temperature switch
8. Stop light pressure switch
9. Hour meter pressure switch
*10. Engine oil pressure switch
*11. Transmission oil pressure switch
12. Resistor
13. De-clutch pressure switch
14. Alternator
15. Reverse alarm pressure switch
16. Neutral start switch
17. Batteries
18. Master switch
*19. Revolving light
*20. Rear window wiper switch
*21. Dome light
*22. Transmission oil temperature switch
*23. Dash light
*24. Revolving light switch
*25. Flood light switch
*26. Dash, head, tail, light switch
*27. Heater switch
28. Horn switch
29. Voltmeter
30. Hourmeter
31. Cranking motor switch
32. Wire connector
33. Ignition switch
*34. Flasher
*35. Turn signal switch
*36. Turn signal lever
*37. Heater
*38. Cab pressurizer
*39. Circuit breaker
*40. Circuit breaker



GRADER (S/N 62S02401 up)

* Special Equipment

To Indicator Lights

*41. Circuit breaker
*42. Circuit breaker
*43. Circuit breaker
*44. Resistor
*45. Indicator light, engine temperature
46. Indicator light, engine oil pressure
47. Indicator light, transmission oil temperature
48. Indicator light, transmission oil pressure
49. Indicator light, alternator
50. Indicator light, de-clutch
*51. Defroster fan switch
*52. Front window wiper switch
53. Horn
*54. Front flood light
*55. Front turn signals
*56. Headlights
*57. 20 amp. fuse (See item 38)

Electrical Wiring Color Coding

Code	Color
B	Black
G	Green
O	Orange
P	Purple
R	Red
T	Tan
W	White
Y	Yellow
Bl	Blue
Br	Brown
Gy	Grey
Pi	Pink
Bl/B	Blue and Black
G/W	Green and White
LBl	Light Blue
Pi/Gy	Pink and Grey
*G/W	Green and White Tracer (*)
*W/GY	White with Grey Tracer

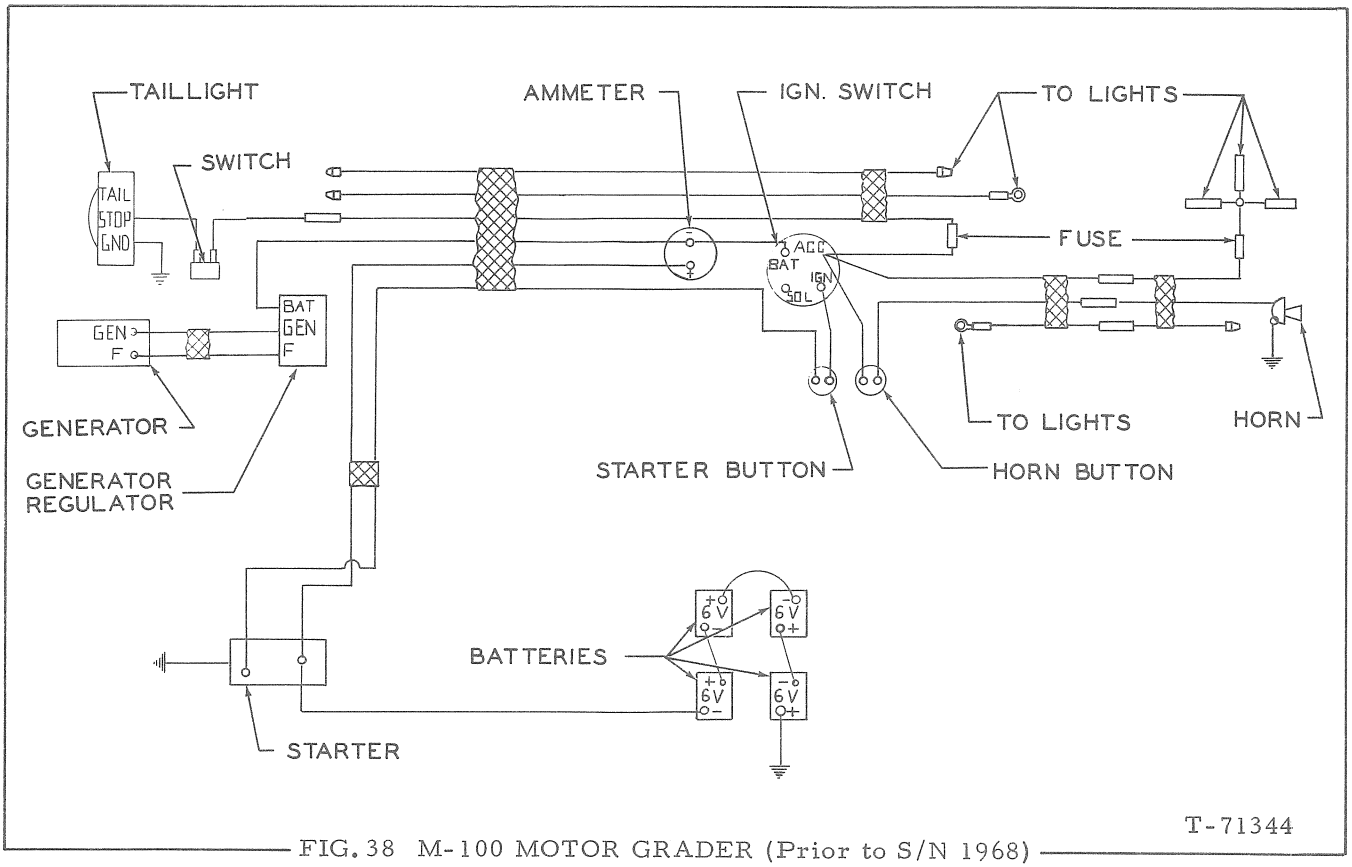


FIG. 38 M-100 MOTOR GRADER (Prior to S/N 1968)

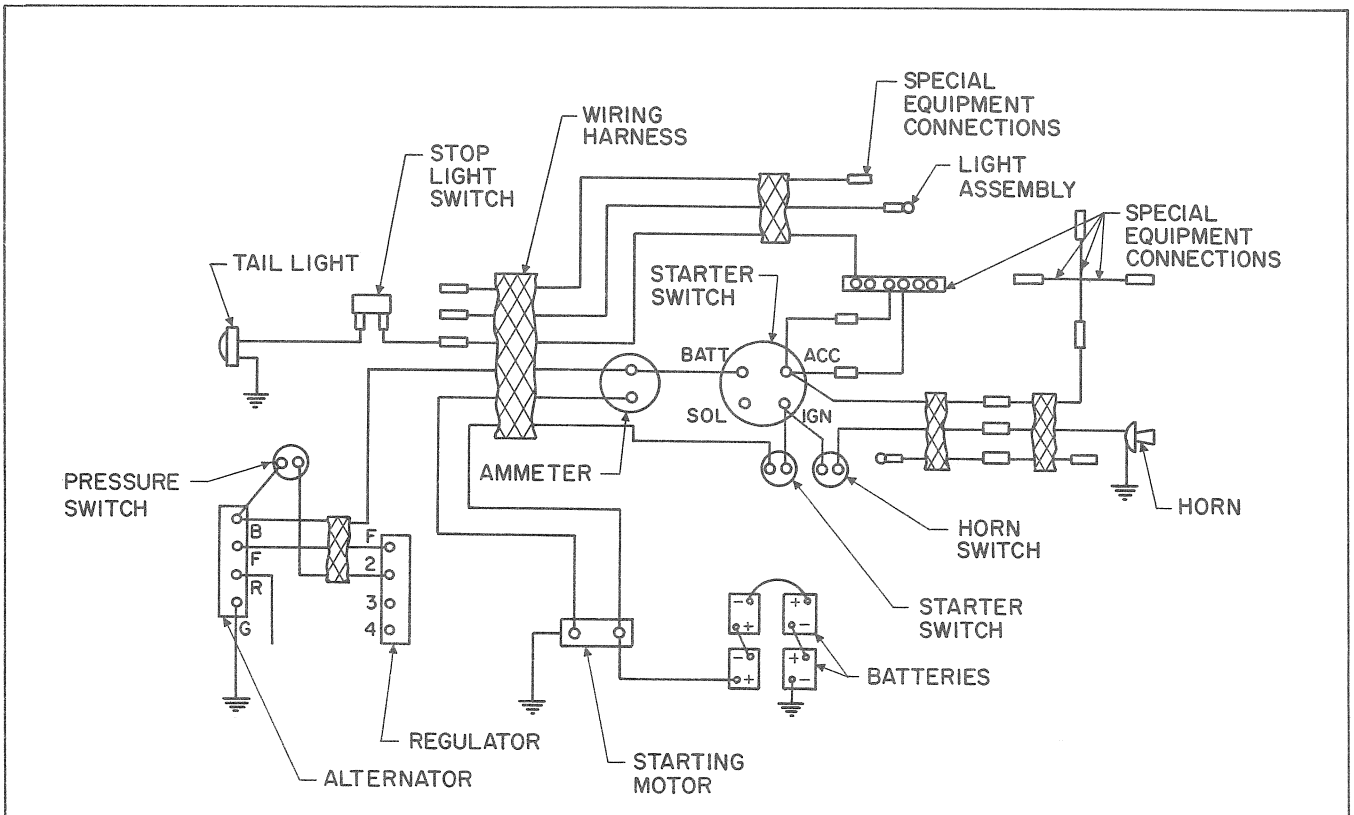
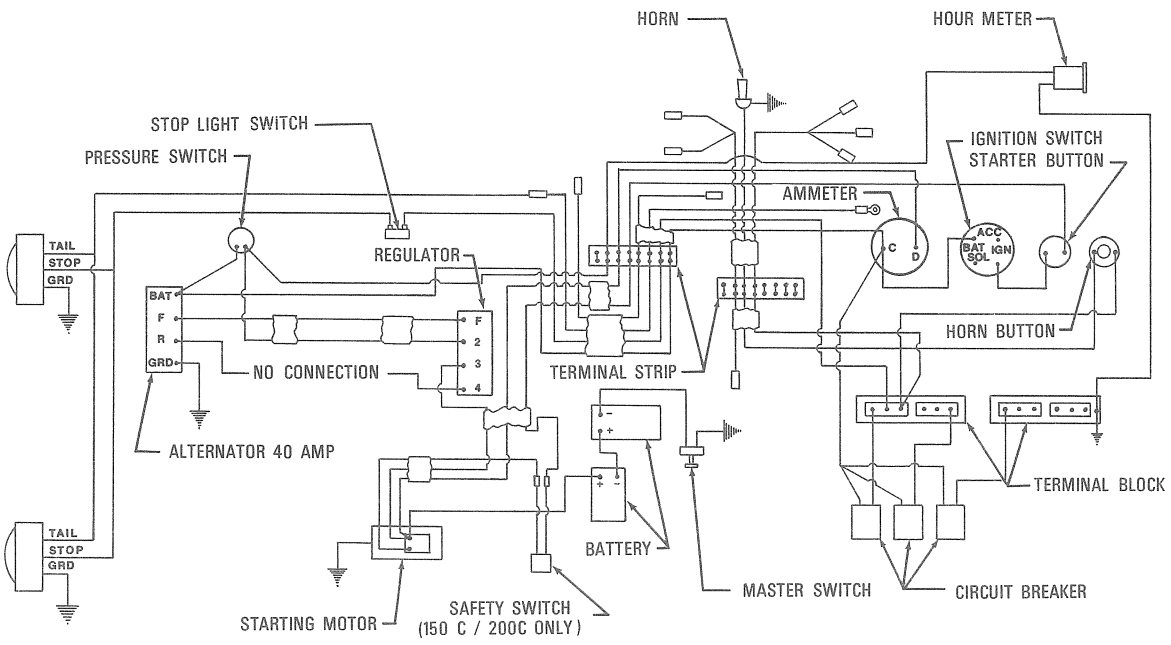
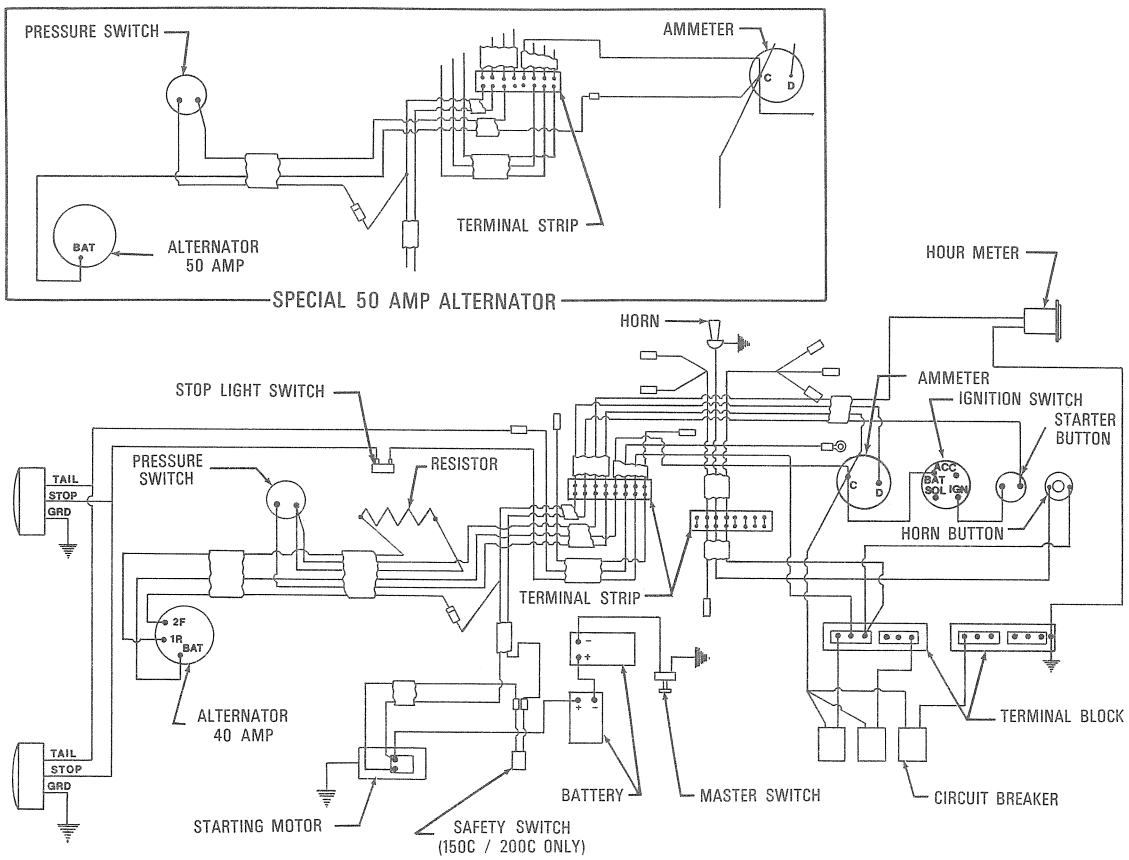


FIG. 39 M-100 MOTOR GRADER, 100-B MOTOR GRADER (S/N 1968-up; 67S05001-up)



T-79160

FIG. 40 100-C, 150-C, 200-C MOTOR GRADER (Prior to S/N 27Y08281; Prior to S/N 99C01047; Prior to S/N 90M01047)



T-79164

FIG. 41 100-C, 150-C, 200-C MOTOR GRADER (S/N 27Y08281-up; 99C01047-up; 90M01047-up)

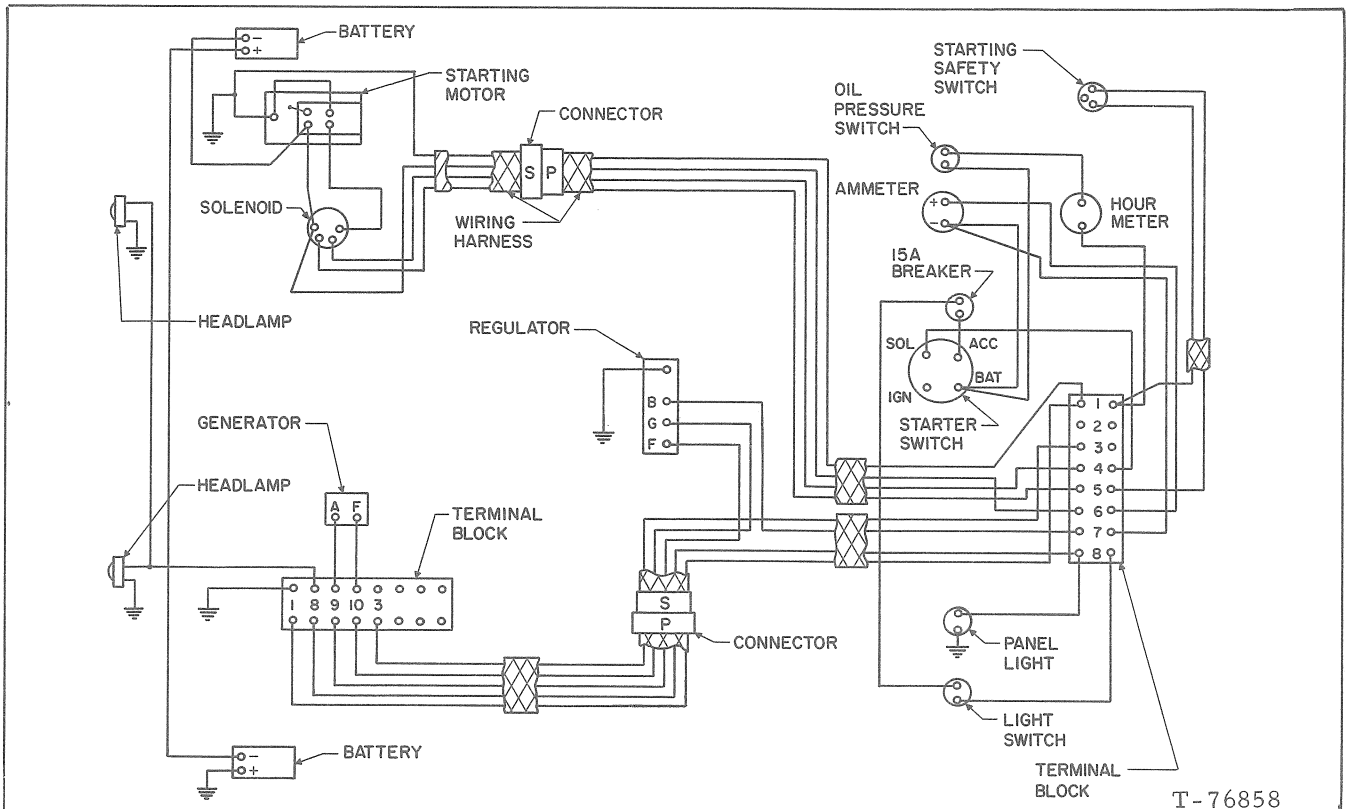


FIG. 42 260-A TRACTOR SCRAPER, 260E-A ELEVATING SCRAPER
(Standard generator; S/N 8051-up; 65A09501-up; 98C09501-up)

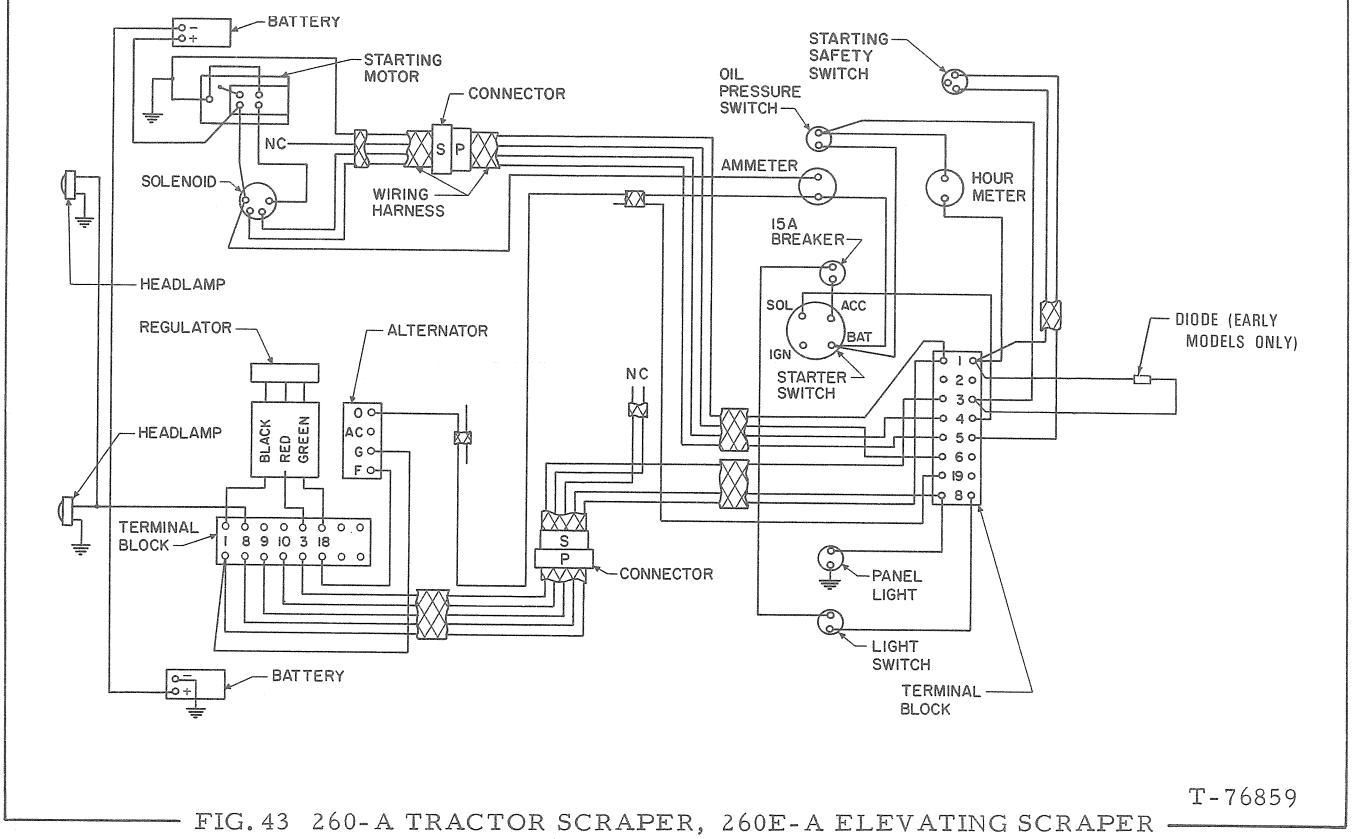
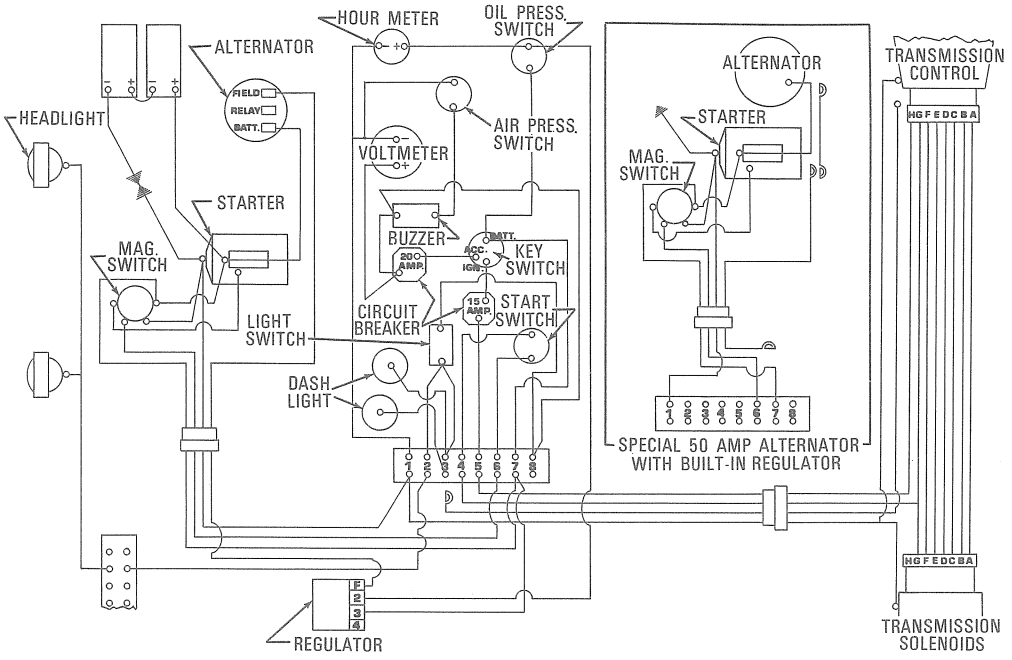
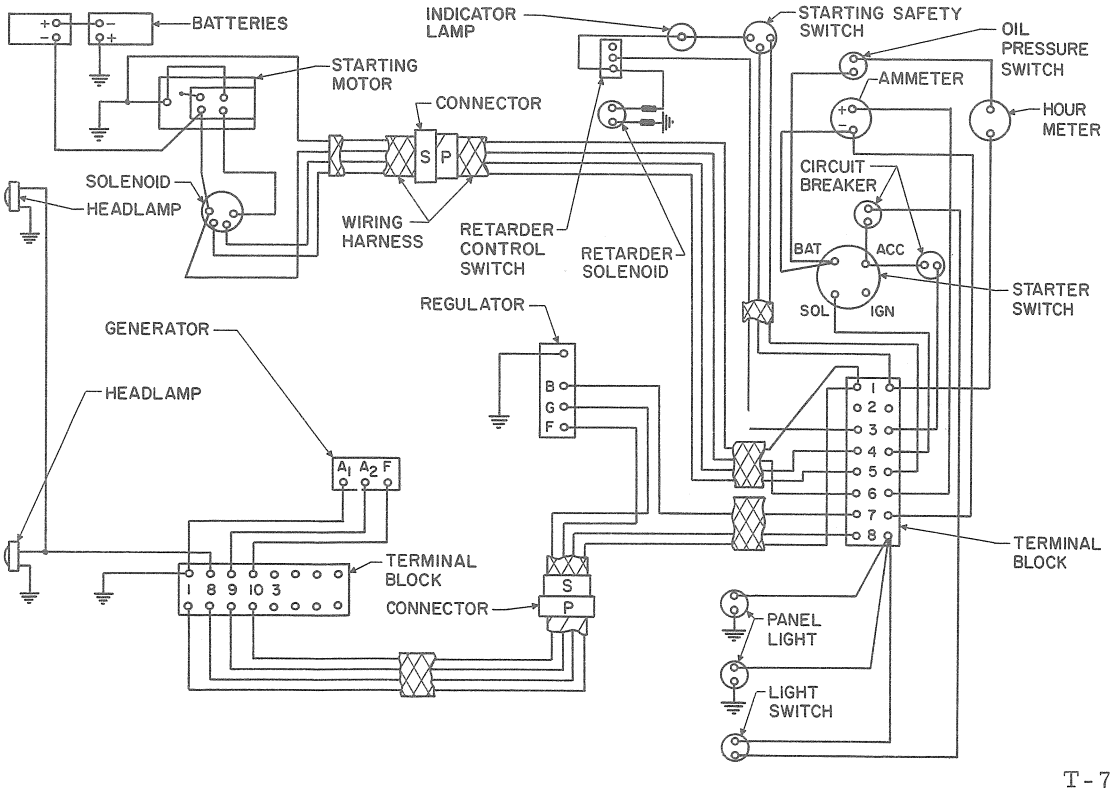


FIG. 43 260-A TRACTOR SCRAPER, 260E-A ELEVATING SCRAPER
(Special alternator; S/N 8051-up; 65A09501-up; 98C09501-up)



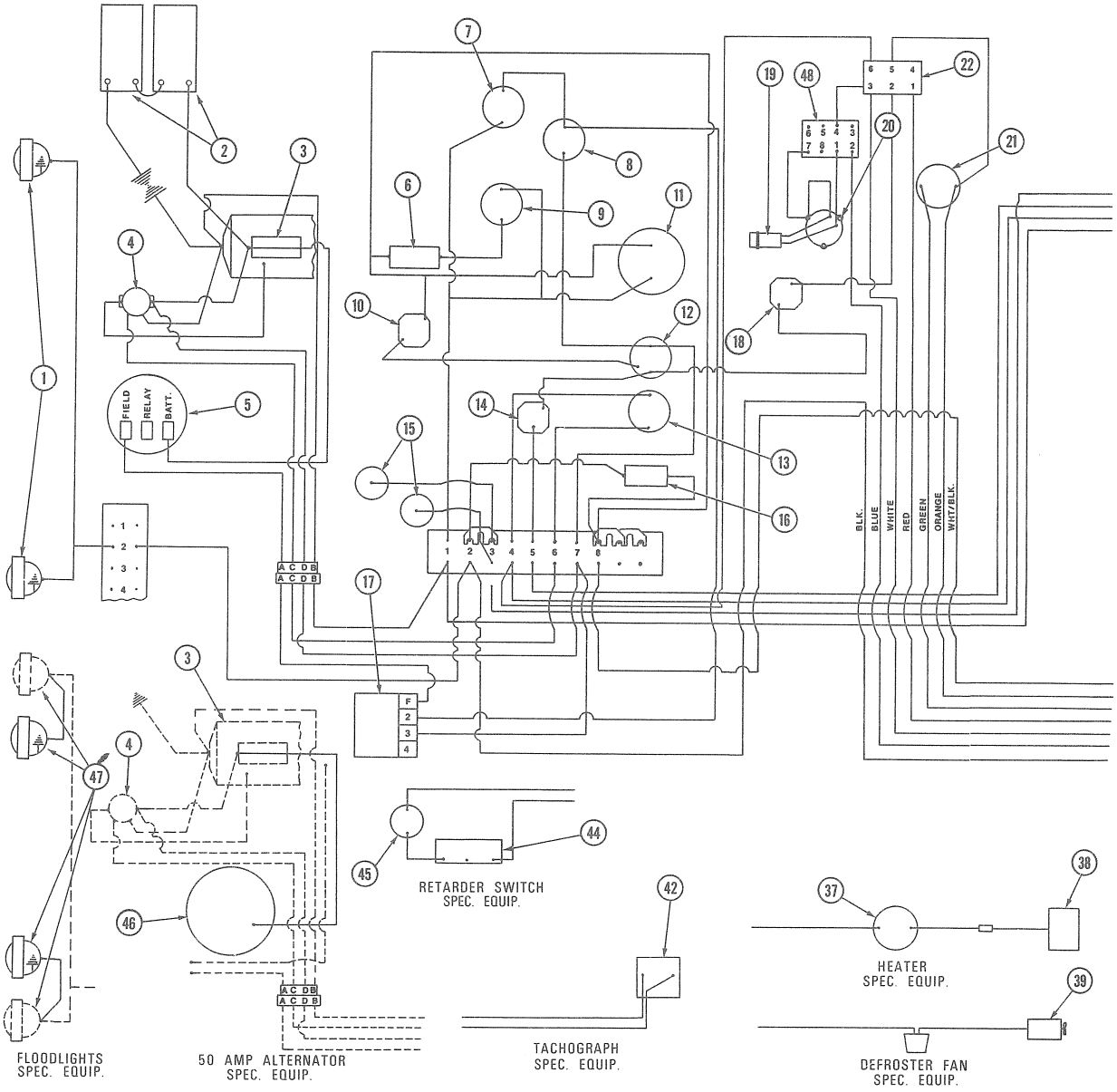
T-79165

FIG. 44 260-B TRACTOR SCRAPER, 261-B ELEVATING SCRAPER



T-76860

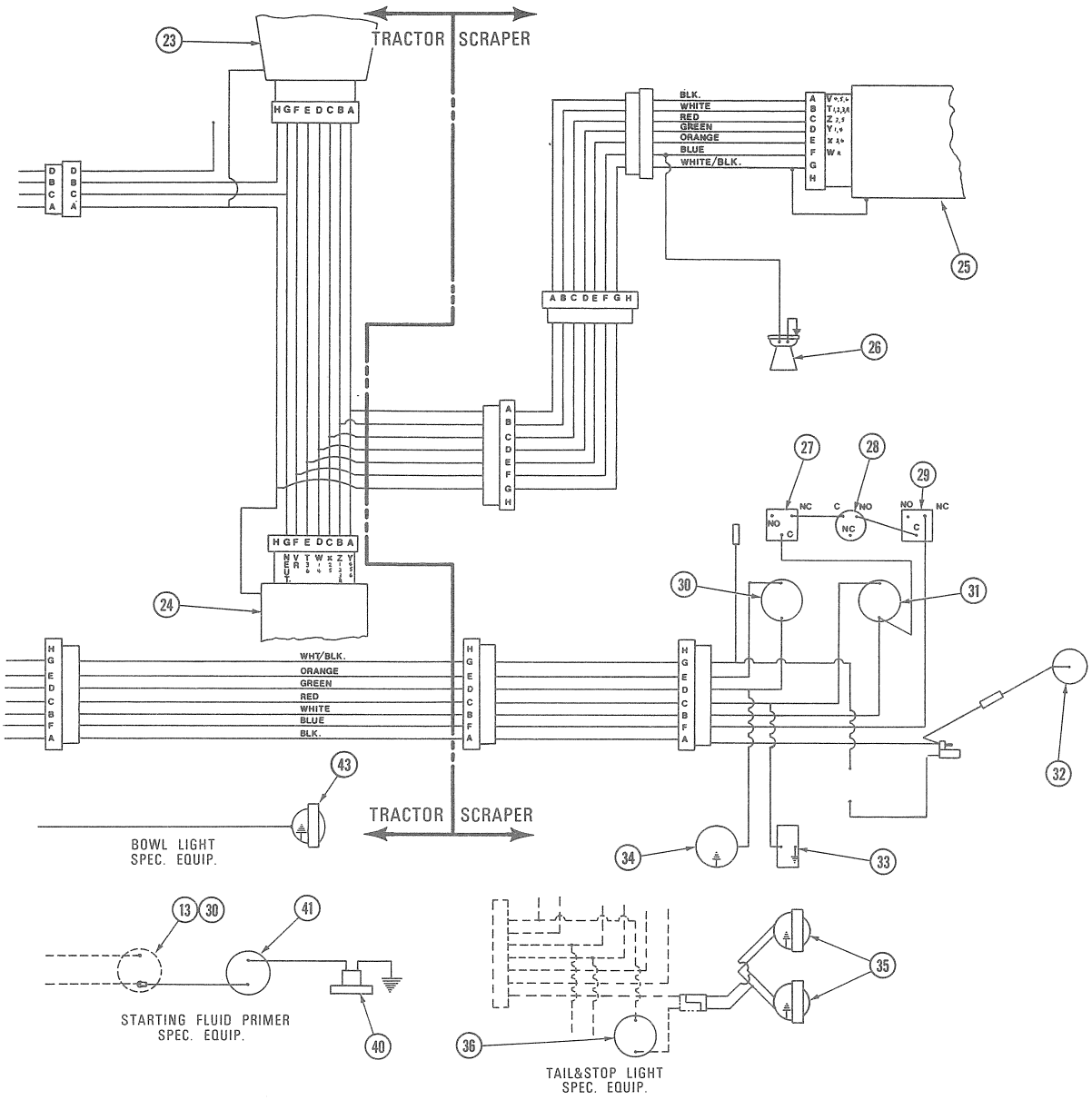
FIG. 45 460-C TRACTOR SCRAPER (S/N 5105-up; 13U05501-up)



T-80064

FIG. 46 262-B TRACTOR SCRAPER,

1. Headlights
2. Batteries
3. Starter solenoid
4. Magnetic switch
5. Alternator (30 amp)
6. Buzzer (low air pressure)
7. Hourmeter
8. Oil pressure switch
9. Air pressure switch
10. Circuit breaker (20 amp)
11. Voltmeter
12. Key switch
13. Starter switch
14. Circuit breaker (15 amp)
15. Dash light
16. Light switch
17. Alternator regulator
18. Circuit breaker (5 amp)
19. Warning light (rear engine)
20. Warning horn (rear engine)
21. Starter switch (rear engine)
22. Run - stop switch (rear engine)
23. Transmission control
24. Transmission solenoids (front)



T-80065

263-B ELEVATING TRACTOR SCRAPER

25. Transmission solenoids (rear)
26. Back-up alarm
27. Alarmstat (rear torque converter temperature)(220°F/104°C)
28. Alarmstat (rear engine oil pressure) (3 psi/0.2 kg/cm²)
29. Alarmstat (rear engine temperature) (210°F/99°C)
30. Start switch (rear engine)
31. Stop switch (rear engine)
32. Dash light (rear dash)
33. Rear engine fuel shut-off
34. Starter solenoid (air starter)
35. Stop/tail lights (special)
36. Stop light switch (brake air pressure)
37. Heater switch (special)
38. Heater
39. Defrost fan
40. Ether primer head (special)
41. Primer switch
42. Tachograph (special)
43. Bowl light (special)
44. Retarder light switch (special)
45. Retarder indicator light (special)
46. Alternator (50 amp) - special
47. Flood lights (special)
48. Relay and socket

(Revised December 1979)

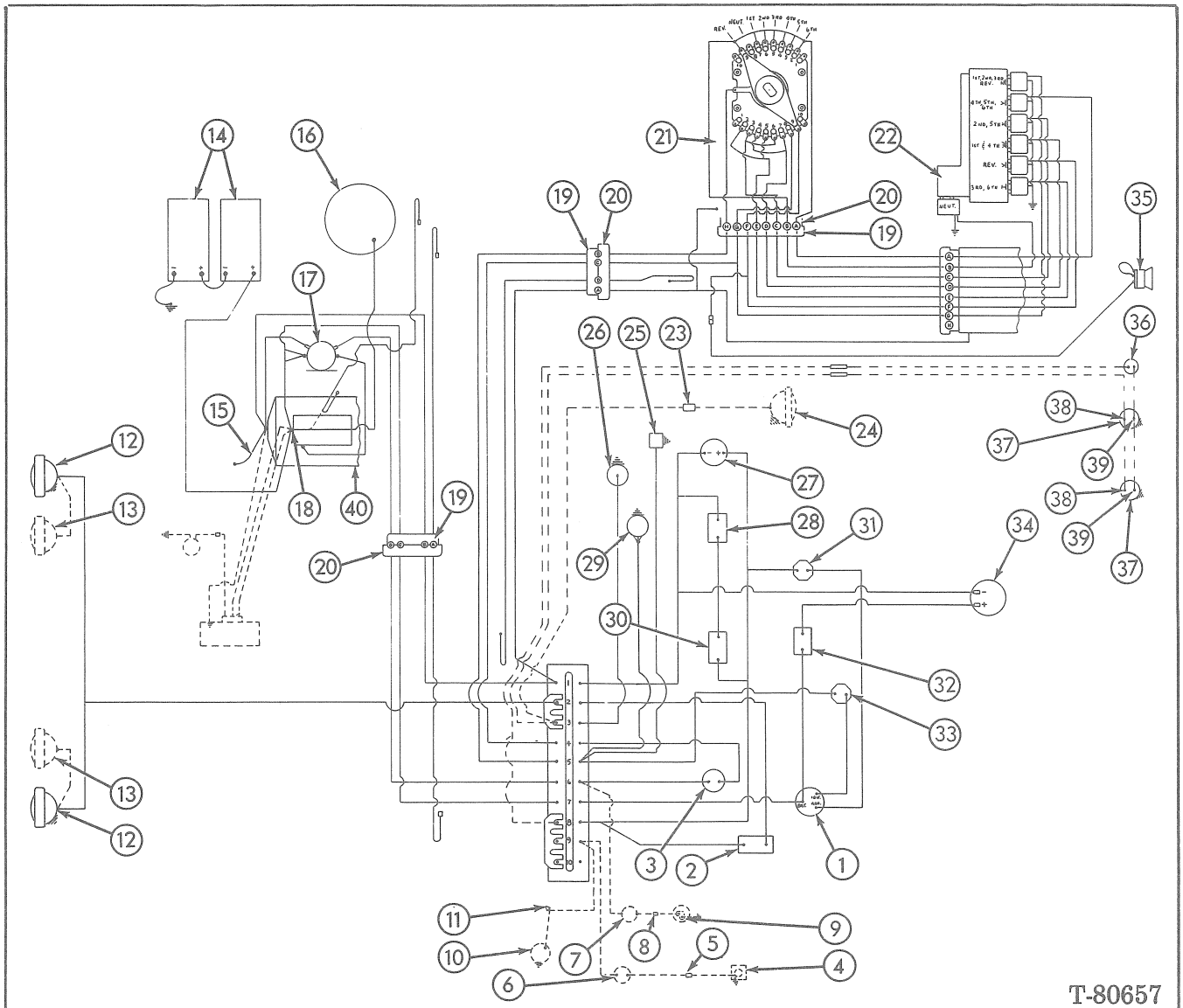


FIG. 47 161 ELEVATING TRACTOR SCRAPER

1. Key switch
2. Light switch
3. Starter switch
* 4. Heater fan
5. Terminal connector
* 6. Heater fan switch
* 7. Engine primer switch
8. Connector
* 9. Primer solenoid
*10. Defroster fan
11. Connector
12. Head light
13. Front flood light
14. Batteries
15. Ground strap
16. Alternator (50 amp)
17. Magnetic switch
18. Solenoid battery terminal
19. Socket
20. Plug
21. Transmission control switch
22. Transmission solenoids
23. Connector
24. Bowl light
25. Fuel shut off solenoid
26. Instrument panel light
27. Voltmeter
28. Air pressure warning buzzer
29. Air valve (parking brake)
30. Air pressure switch
31. Circuit breaker (20 amp)
32. Engine oil pressure switch
33. Circuit breaker (15 amp)
34. Hour meter
35. Reverse alarm
36. Brake pressure switch
37. Stop and tail light
38. Tail light terminal
39. Stop light terminal
40. Starter

*Special Equipment

ALPHABETICAL INDEX