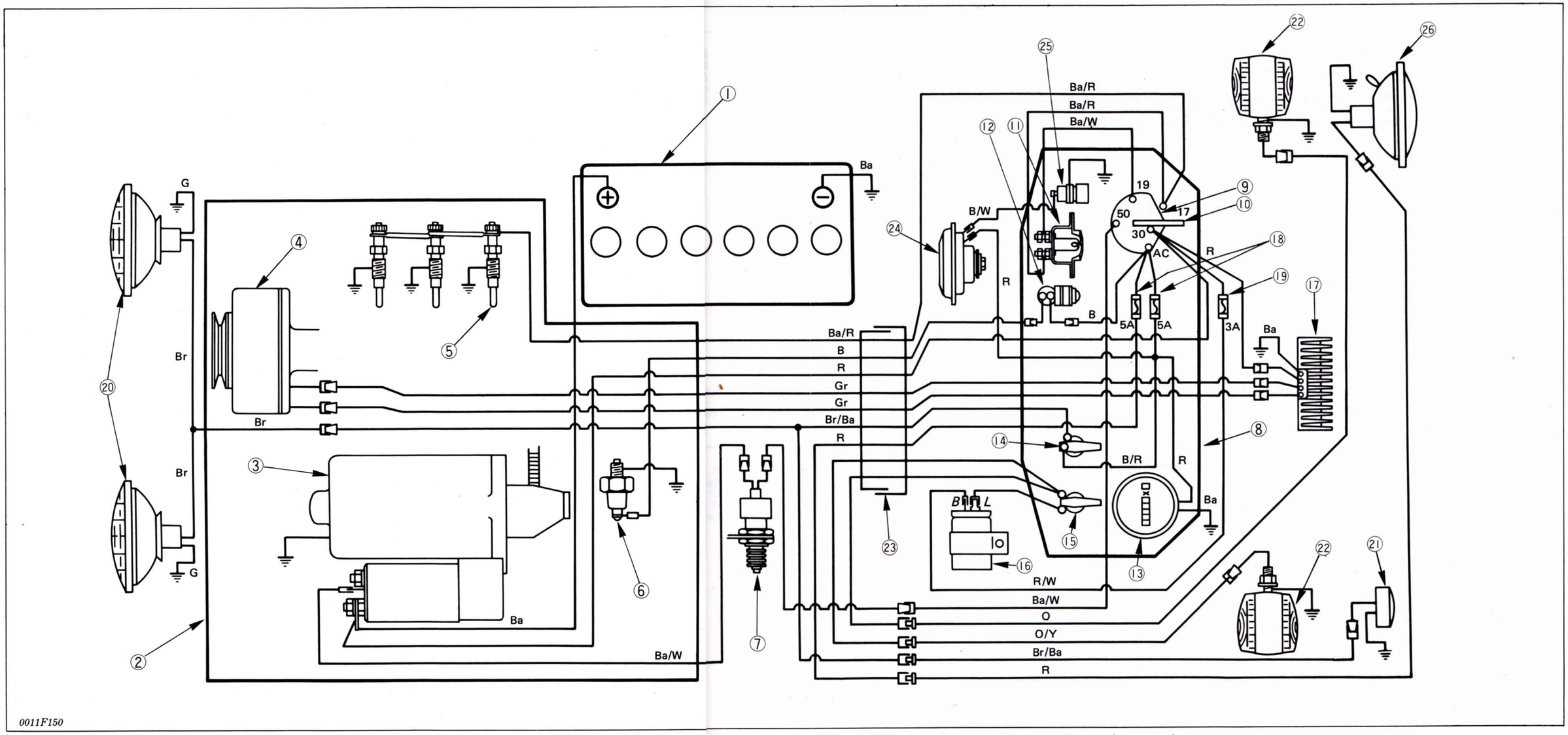
Group 1

General Description



0011F150

1. Battery (12V-45AH)
2. Engine Body
3. Starter
4. AC Dynamo
5. Glow Plug
6. Oil Switch
7. Safety Switch (12V-15A)
8. Meter Panel
9. Key Switch (12V-17-19 ··· 30A, 50 ··· 12A, AC ··· 10A)
10. Key
11. Glow Plug Lamp (20A)
12. Oil Lamp (12V-3.4W)
13. Hourmeter
14. Headlight Switch (12V-5A)
15. Hazard Switch
16. Hazard Unit (12V-43W)
17. Regulator (Regulated voltage: 14 to 15V)
18. Fuse (5A)
19. Fuse (3A)
20. Headlight (12V-15W)
21. Taillight
22. Hazard Lamp (12V-15W)
23. Coupler
24. Horn (12V-1.5AH) [option]
25. Horn Switch (3A) [option]
26. Work Light [option]

Fig. N-1 Electrical System

The electrical system of this tractor is composed a number of different function circuits making use of a 12V battery. The battery supplies power to all circuits. The battery also powers the starter which consumes a great deal of power. A charging system is used to charge the battery while the engine is running and supplies power to the all circuits. The control system consists of various lights and meters for monitoring tractor functions. All circuits are controlled by switches on the meter panel in front of the operator seat.

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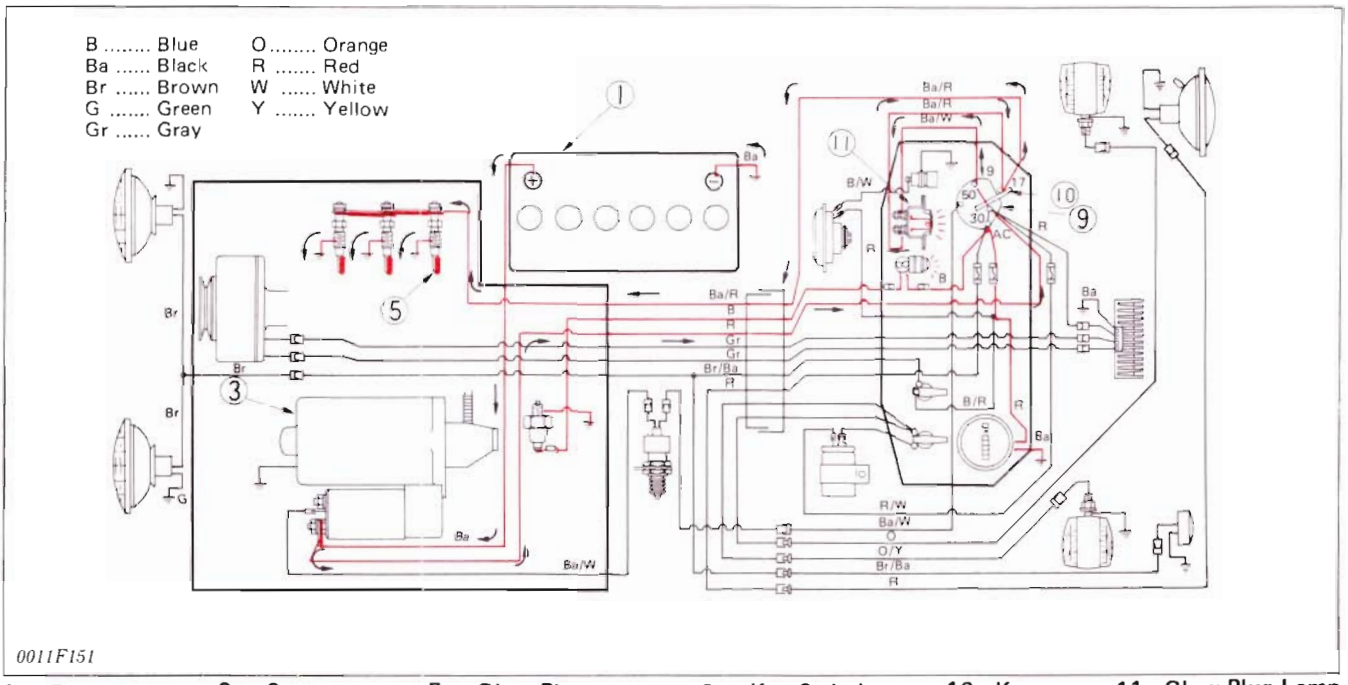
Cranking System

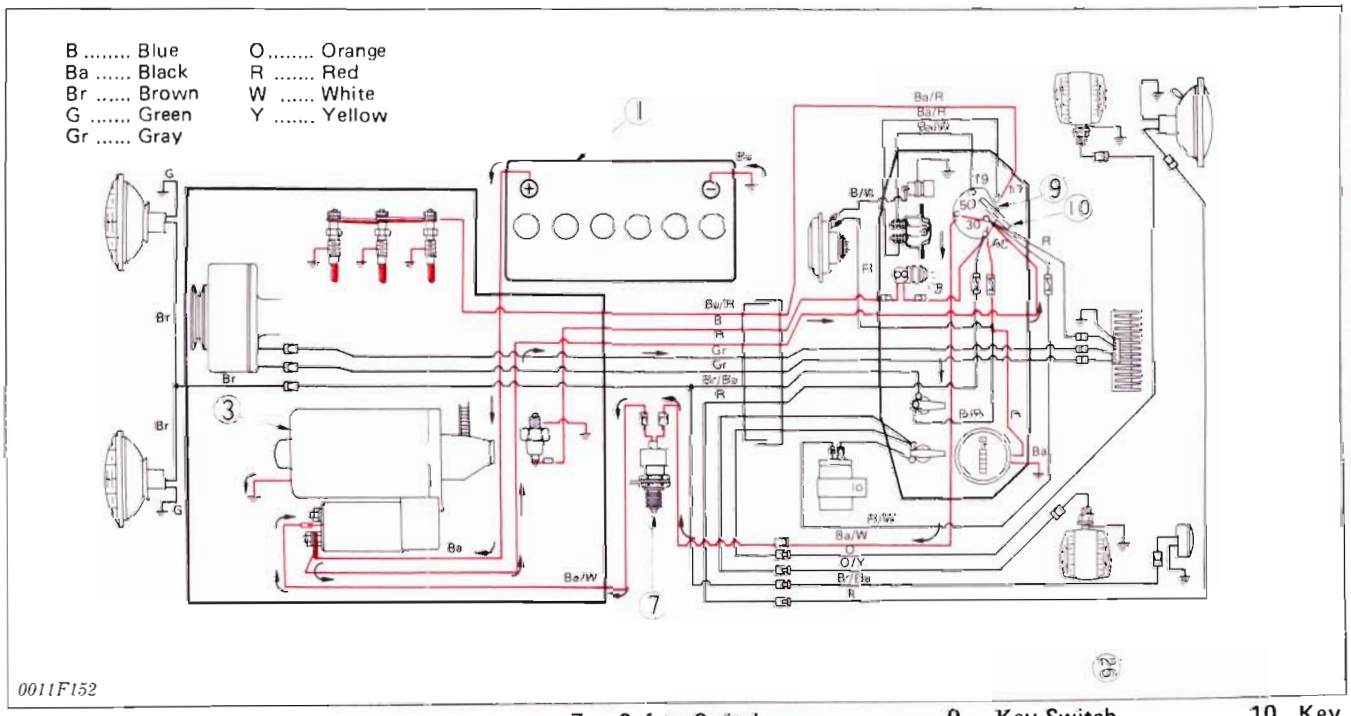
The engine is a diesel engine and is started in the following sequence:

Glow plug is heated. → Clutch pedal is depressed. (Conduction of safety switch) → Starter is operated.



1. Battery 3. Starter 5. Glow Plug 9. Key Switch 10. Key 11. Glow Plug Lamp

Fig. N-2 Glow Plug Heating Circuit

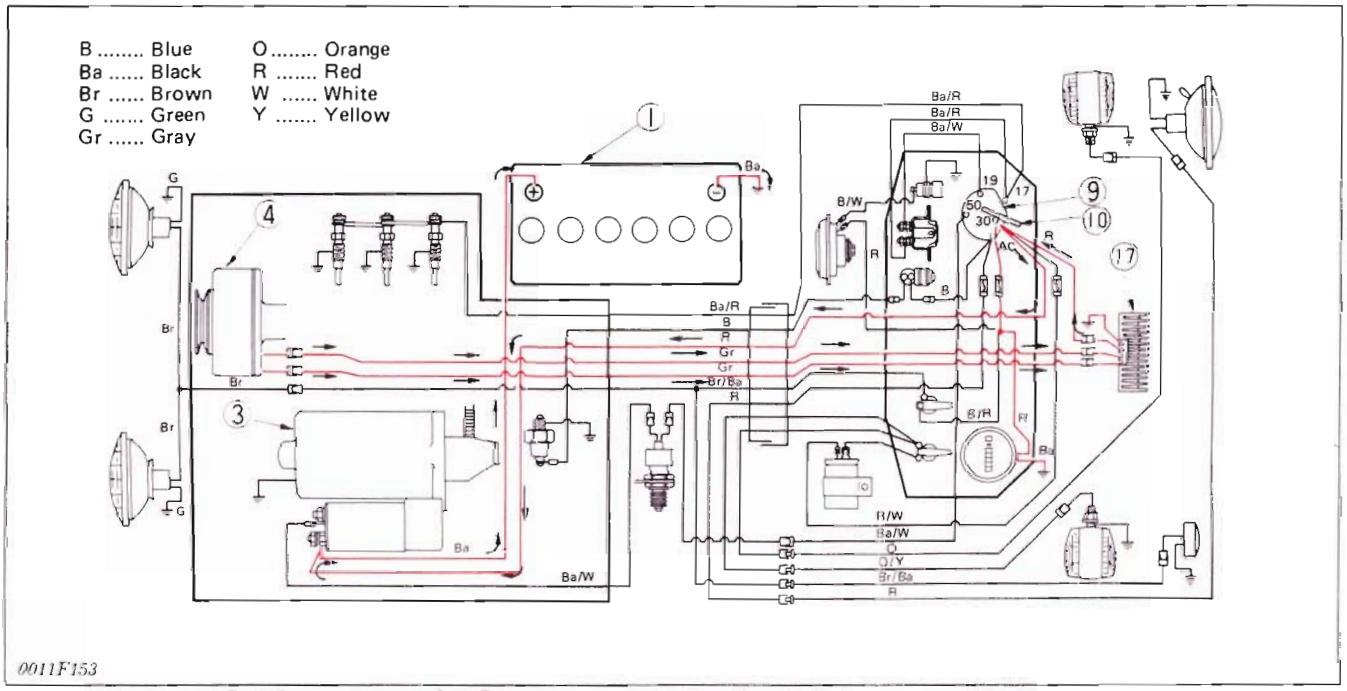


1. Battery 3. Starter 7. Safety Switch 9. Key Switch 10. Key

Fig. N-3 Starter Operating Circuit (with Clutch Pedal Depressed)

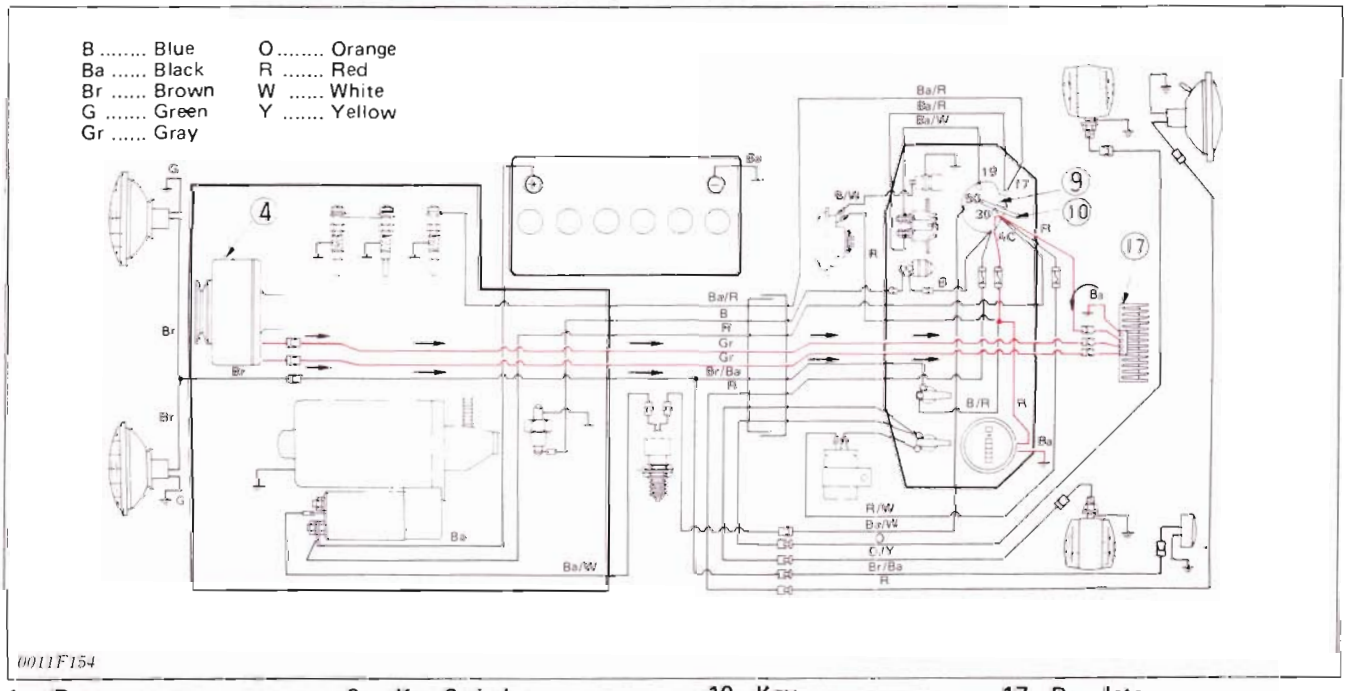
Charging System

The charging system is composed of the dynamo which generates AC power, and the regulator which performs rectification and voltage regulation. The AC dynamo generates AC current as it is driven by the engine. Generated voltage depends on the engine speed. The regulator converts this AC current into DC current and at the same time, provides a constant output voltage. The AC dynamo charges the battery and supplies DC power to the circuits through the regulator.



1. Battery 3. Starter 4. Dynamo 9. Key Switch 10. Key 17. Regulator

Fig. N-4 Circuit When Battery is Being Charged



4. Dynamo 9. Key Switch 10. Key 17. Regulator

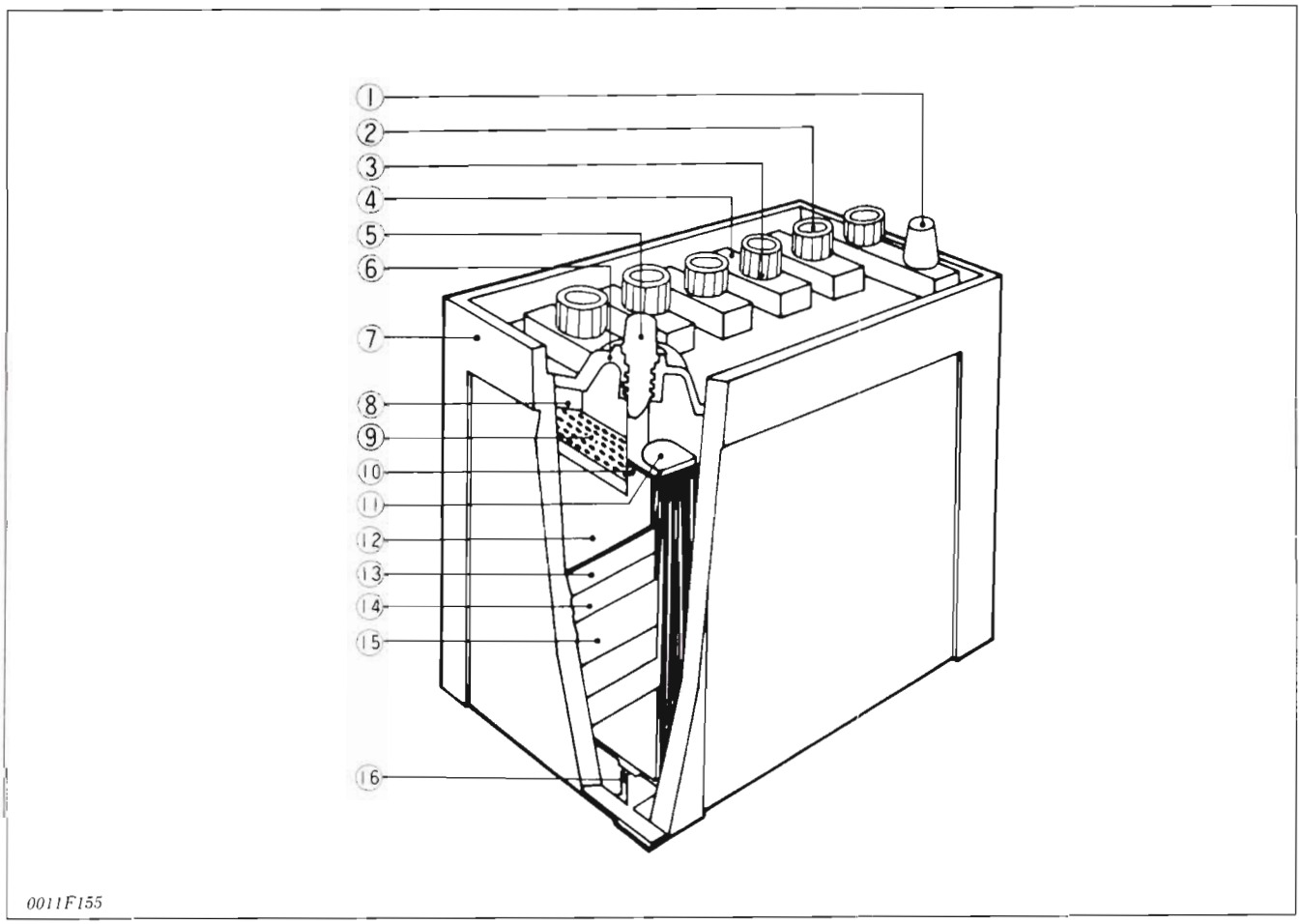
Fig. N-5 Circuit When Battery Is Fully Charged

Troubleshooting

SYMPTOM	PROBLEM	SOLUTION
Quick battery discharge	Defective dynamo	Repair or replace
	Disconnected wire harness (especially to regulator)	Check and connect
	Defective regulator	Replace
	Defective battery	Replace
	Low electrolyte level	Replenish distilled water and charge battery
Glow indicator (lamp) does not glow	Discharged or defective battery	Charge or replace
	Disconnected wire harness (Key switch to glow plug indicator or battery)	Check and connect
	Defective glow plug indicator	Replace
	Defective key switch	Replace
Starter does not turn	Safety switch does not operate	Step on clutch pedal
	Defective adjustment or defective safety switch	Adjust properly or replace
	Discharged battery	Charge battery
	Disconnected wire harness (starter to battery or key switch)	Check and connect
	Defective starter (motor or magnet switch, etc.)	Repair or replace
	Defective key switch	Repair or replace
	Seized engine parts	Repair engine
Headlights or hazard lamps do not light	Broken bulbs	Replace
	Blown fuse	Replace
	Disconnected wire harness (light switch to lights)	Check and connect
	Broken light switch or hazard lamp switch	Repair or replace

Group 2

Battery



1. Positive Terminal
2. Vent Plug
3. Port Gasket
4. Sealing Compound
5. Negative Terminal
6. Cover
7. Battery
8. Upper Liquid Level Indicator
9. Splash Guard
10. Pole
11. Strap
12. Negative Plate
13. Separator
14. Glass Mat
15. Positive Plate
16. Element Rest

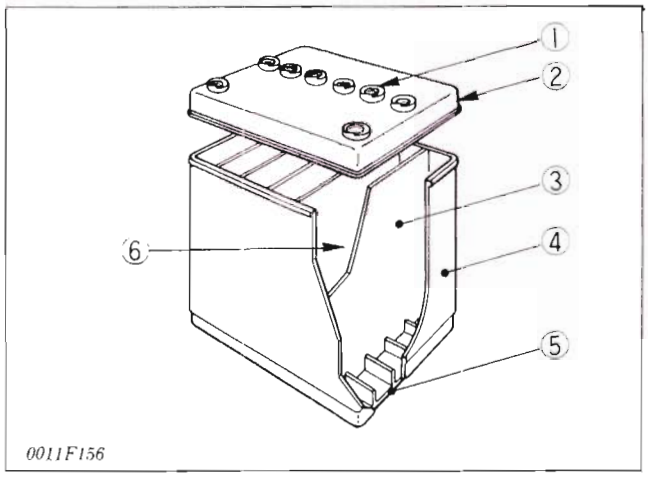
Fig. N-6 Battery Constraction

The battery converts electrical energy into chemical energy and stores it (charging). Electric energy is then released when required (discharging).

This process of charging/discharging can be constantly repeated.

Structure and Function

Battery Jar

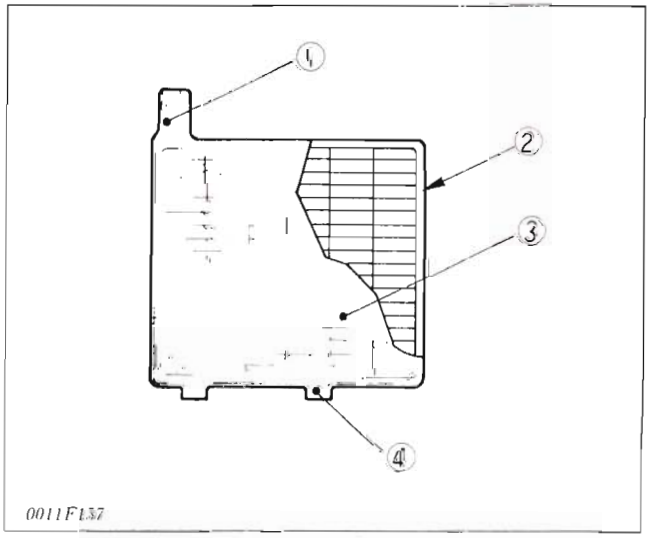


1. Liquid Port
2. Cover
3. Seperator
4. Battery Jar
5. Element Rest (for plate group)
6. Cell

Fig. N-7 Battery Jar, Cover

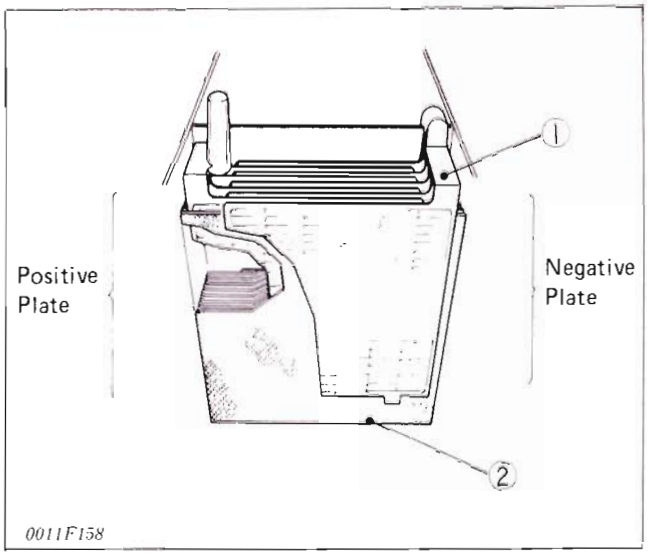
A battery jar is a receptacle containing electrolyte and pole plates. Each small chamber (cell) of a battery jar includes a pair of pole plate groups.
Cells are connected in series. That is, the positive pole plates of a cell are connected to the negative pole plates of the next cell. As a result, the total voltage of all cells is the battery voltage. A completely charged cell provides approx. 2V, therefore, a 6-cell battery provides 12V.

Positive and Negative Pole Plates



1. Projection (electrical terminal)
2. Grid (anti-corrosive lead alloy)
3. Active Material (storing DC electricity)
4. Foot

Fig. N-8 Plates (positive and negative)

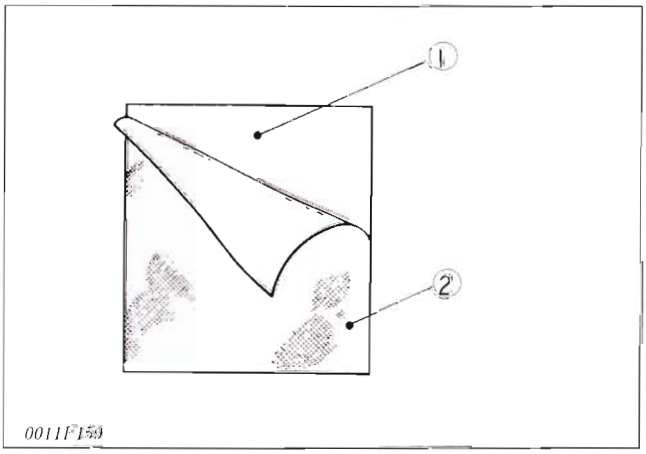


1. Strap
2. Separator, Glass Mat

Fig. N-9 Group of of Plates (elements)

The pole plates are made of lead and antimony. The positive pole plates are made of lead dioxide (chocolate color), and the negative pole plates are made of spongy lead (gray blue) and have extremely fine holes in them to allow the electrolyte to permeate and diffuse. Each cell contains a specific number of sets with negative and positive pole plates.

Separator



1. Separator
   (preventing shorts between positive and negative plates)
2. Glass Mat
   (To protect active material on positive plates from dropping and to protect separators from being oxidized.)

Fig. N-10 Separator, Glass Mat

A separator is inserted between positive and negative pole plates to prevent them from contacting. It is spongy to allow electrolyte to permeate through it and diffuse.
Separators are generally made of synthetic resins or glass fibers.

Electrolyte

Electrolyte is a mixture of distilled water and sulfuric acid. It is transparent, colorless and odorless. Specific gravity is 1.26 at 20°C (68°F) when fully charged (1.28 in cold weather).

The pole plates are completely immersed in the electrolyte, and active material and electrolyte react chemically to charge and discharge electricity.

Discharge

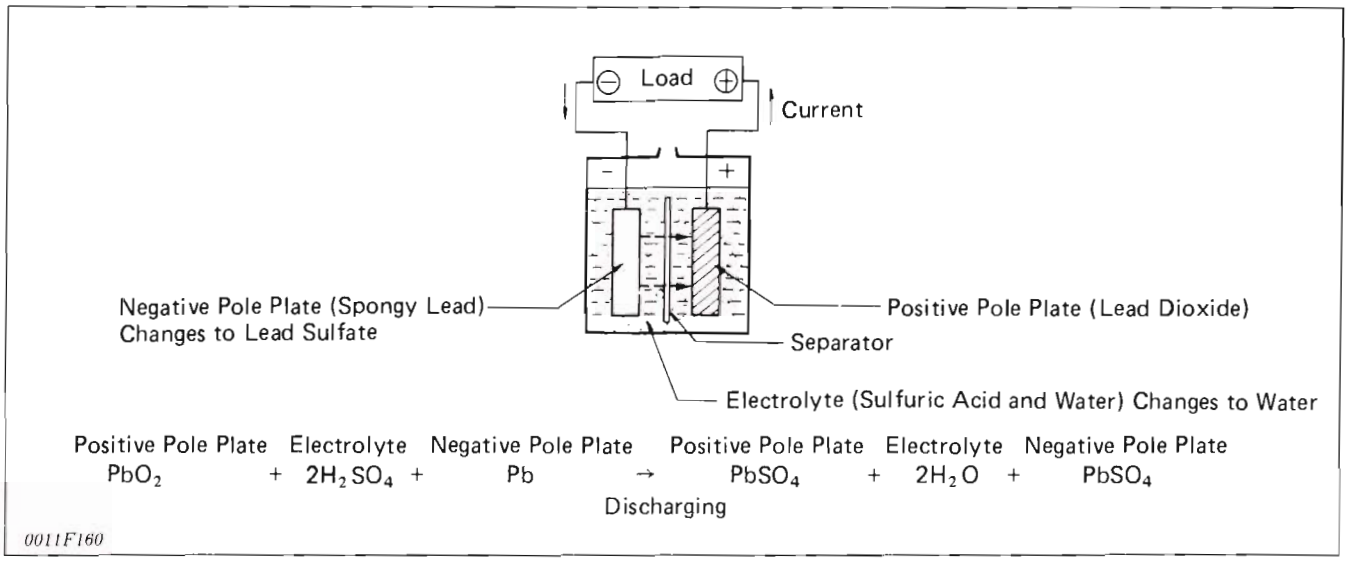


Fig. N-11 Chemical Change During Discharge

When the engine is started or a light is turned on (discharge), the sulfate radical in the electrolyte reacts with the positive and negative pole plates to form lead sulfate. As a result, the sulfate radical in the electrolyte decreases to decrease concentration (specific gravity).

The positive and negative pole plates and electrolyte change as follows:

- Positive Pole Plates (Lead Dioxide) → Lead Sulfate
- Negative Pole Plates (Spongy Lead) → Lead Sulfate
- Electrolyte (Sulfuric Acid Solution) → Water

Charge

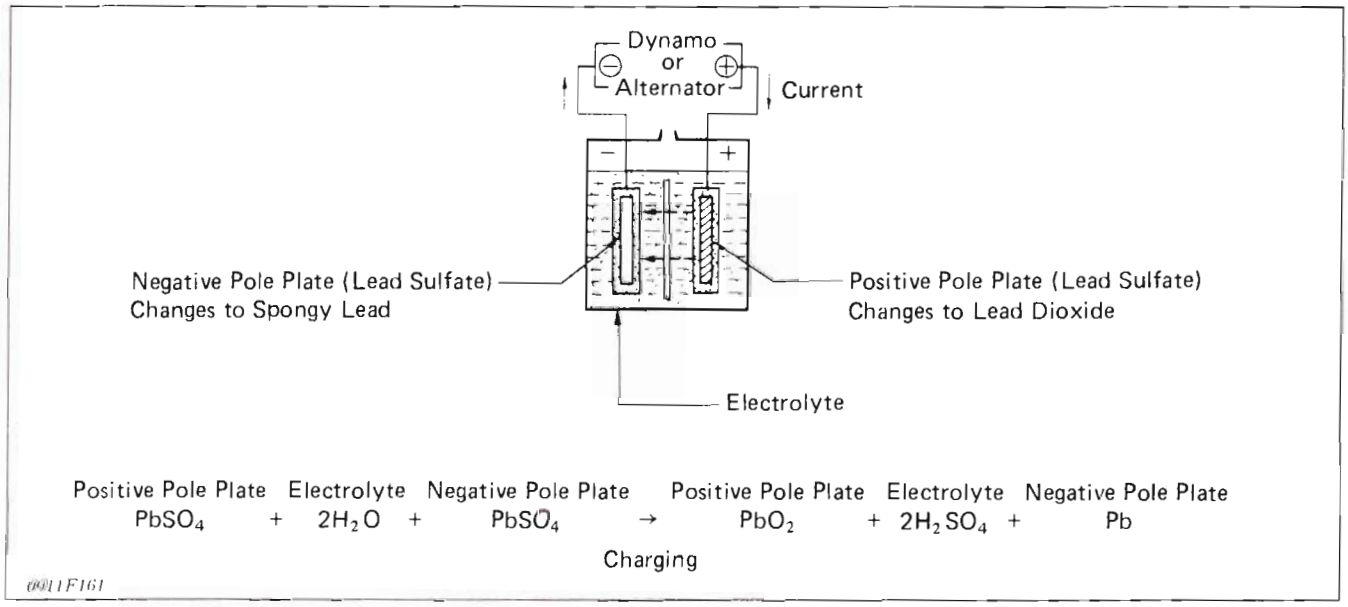


Fig. N-12 Chemical Changes During Charging

When an external DC current is applied to a discharging battery (i.e., when the battery is being charged), the sulfate radical which had chemically combined with pole plates is extracted from the pole plates to return to the electrolyte. As a result, positive and negative pole plates are returned to lead dioxide and spongy lead.

The sulfate radical in the electrolyte is supplied from the pole plates to increase the specific gravity of the electrolyte and to increase the voltage between positive and negative pole plates.

Near the completion of charging, some of charging current begins to electrolize the water in the dilute sulfuric acid, generating oxygen from the positive pole plates and hydrogen from the negative pole plates. The positive and negative pole plates and electrolyte change as follows:

- Positive Pole Plate (Lead Sulfate) → Lead Dioxide
- Negative Pole Plate (Lead Sulfate) → Spongy Lead
- Electrolyte (Water) → Sulfuric Acid Solution

Temperature Effects and Self-discharging

Battery voltage is affected by the temperature of the electrolyte. Chemical reaction is accelerated at higher temperatures, and decelerated at lower temperatures (voltage drops).

If a battery is left unused for a long period, a chemical reaction occurs in the battery causing it to discharge slowly. This is referred to as "self-discharge". Self-discharge is accelerated at high temperatures. If a battery is left unused for an extended period, it must be periodically recharged.

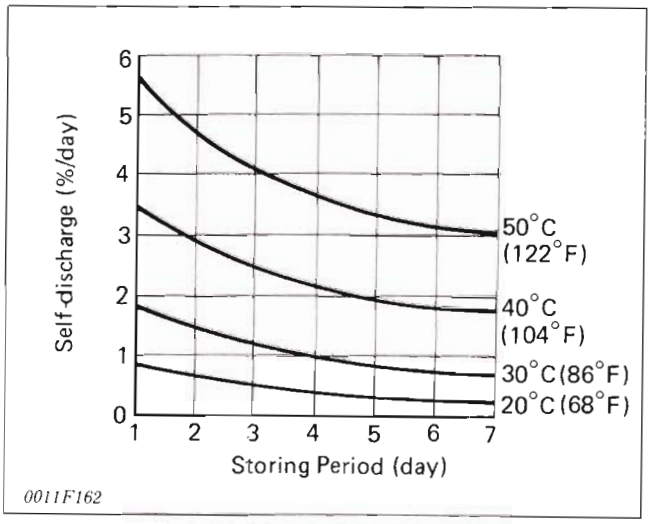


Fig. N-13 Change in Self-discharge (example)

Gas Generation During Charging

When the battery is almost fully charged, some of charging current is consumed to electrolize the water in the electrolyte. As a result, oxygen gas is generated from the positive pole plates and hydrogen gas from the negative pole plates.

After the battery is fully charged, all charging current is consumed for electrolization and heat generation.

Battery Voltage

When a discharged battery is charged with a constant current, battery voltage first gradually increases and then rapidly increases as gas generation becomes more active. After some time, however, the voltage stabilizes (final charge voltage). On the contrary, when a battery is discharged at a constant level, the voltage begins to decrease gradually, then it suddenly decreases rapidly (final discharge voltage). The final discharge voltage is generally approx. 1.7 to 1.8 V/cell.

If its voltage reaches the final discharge voltage, the battery can not be charged.

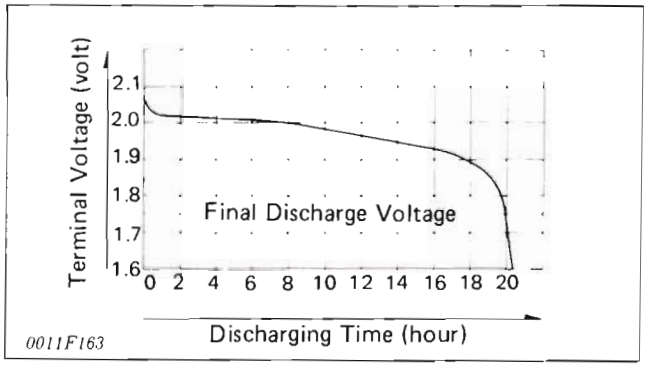


Fig. N-14 Discharging Curve

Battery Capacity

Battery capacity is defined as the amount of electric energy (amperage x time) which a fully charged battery delivers until its voltage drops to the final discharge voltage. Generally it is defined as how many amperes can be discharged for 20 hours (20-hour rate capacity).

Therefore, the 45 AH capacity of this tractor's battery means it can dischage a 2.25A current continuously for 20 hours.

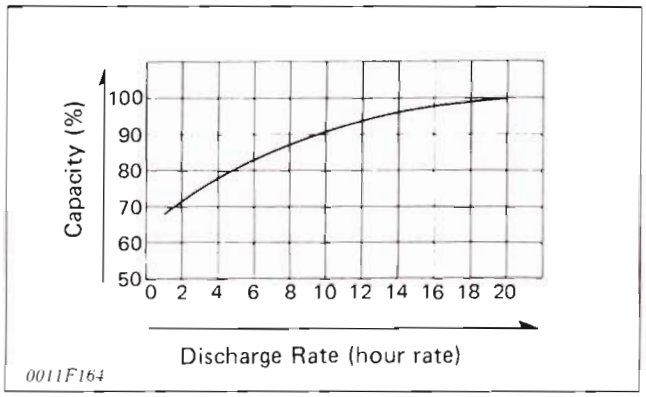


Fig. N-15 Relationship between Discharge Rate and Capacity

Specific Gravity and Charge Condition of Electrolyte

The specific gravity of the electrolyte provides an indication of the amount of electric energy stored in the battery.

Specific gravity increases with an increase of the sulfate radical in the electrolyte. It is also affected by temperature. Relationship between specific gravity and charge condition is shown below using 20°C (68°F) as reference.

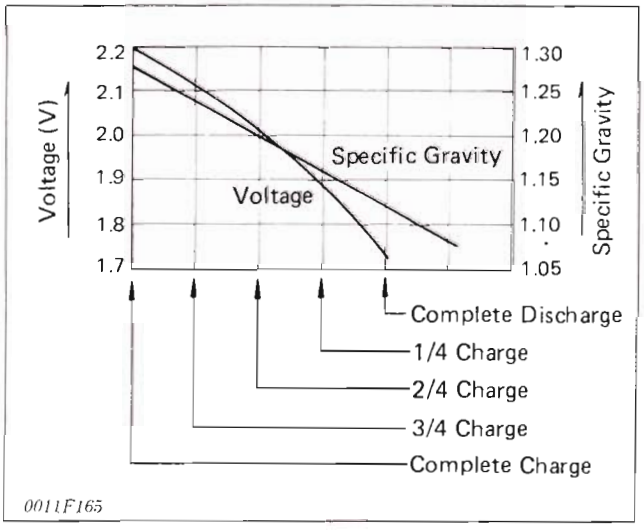


Fig. N-16 Specific Gravity and Battery Charging Condition

Servicing

Checking Battery Terminal and Bolt Tightness

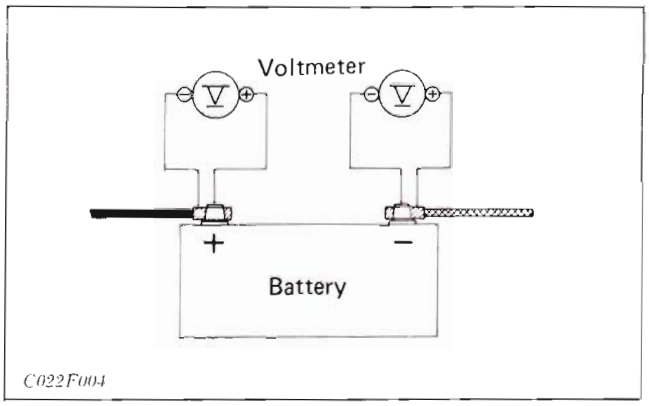


Fig. N-17 Checking Battery Terminal and Bolt Tightness

(1) Activate an electrical load, such as headlights.
(2) Connect battery (+) terminal to voltmeter (+) terminal, and (+) cord to voltmeter (−) terminal.
Under normal conditions, the voltmeter will indicate 0V.
(3) Check battery (−) terminal in the same manner as above. Under normal conditions, the voltmeter will indicate 0V.
(4) If the voltmeter does not show the reference value 0V, clean terminals and retighten the mounting bolts.
- Allowable limit: 0.1 V

NOTE: If starter does not operate, test with a circuit tester.

TEST EQUIPMENT: Circuit Tester

Cleaning Battery

Fig. N-18 Cleaning Battery

(1) Clean the battery surface, which is sometimes stained by electrolyte gas coming through the air vent.

Checking Electrolyte Level

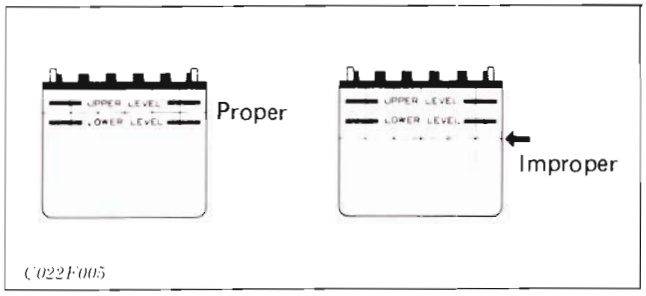


Fig. N-19 Checking Electrolyte Level

(1) Electrolyte is reduced by electrolysis during charging and by natural evaporation. Therefore, check the quantity of electrolyte periodically.
(2) Add distilled water until electrolyte reaches to the specified level.

Checking Battery Condition

Checking with a Hydrometer

Fig. N-20 Checking with a Hydrometer

(1) Suction electrolyte into the transparent tube holding the specific gravity meter. Then, read the specific gravity.

TEST EQUIPMENT : Hydrometer

Specific Gravity	Battery Conditions		
1.260 1.230	100% 75%	Charged	Usable
1.200 1.170 1.140	50% 25% 10%	Allowable limit Discharged	Must be recharged immediately
1.110	0%	Totally discharged	

(At an electrolyte temperature of 20°C, 68°F)

(2) Specific gravity slightly varies with temperature. Therefore, reading of specific gravity meter must be adjusted. Electrolyte specific gravity is reduced by 0.0007 (0.0004) with an increase of 1°C (1°F) in temperature, and is increased by 0.0007 (0.0004) with a decrease of 1°C (1°F). Therefore, using 20°C (68°F) as reference, measured specific gravity must be adjusted by the following formula:

Specific gravity at 20°C = Measure valve + 0.0007 x (Electrolyte temperature – 20°C)
Specific gravity at 68°F = Measured value + 0.0004 x (Electrolyte temperature – 68°F)

NOTE:
- Reading of specific gravity meter must be taken at the highest liquid level.
- Hold the hydrometer at eye level.
- Hold the hydrometer upright.
- Do not hold the hydrometer above the electrolyte port.

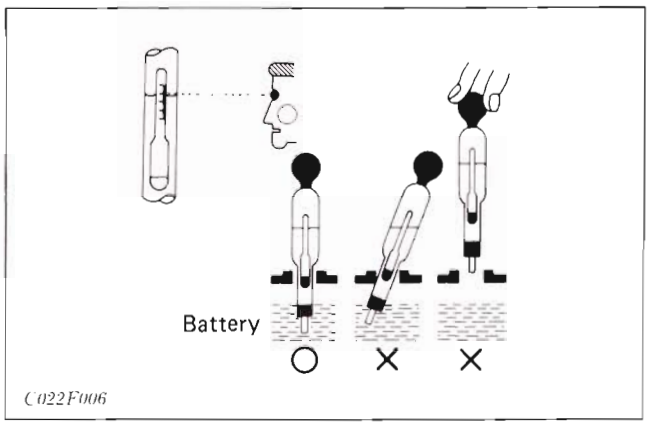


Fig. N-21 Precautions for Checking

Checking with a Battery Tester

Fig N-22 Checking with a Battery Tester

(1) Connect battery tester cords to battery (+) and (–) terminals, set the tester dial for the capacity of the battery to be tested, and keep the switch button pressed for approx. 5 seconds. Read the indication needle.

- Reference value:
  75% or more . . . . Good
  45% to 75% . . . . Needs recharging
  45% or less . . . . Needs recharging or replacement

TEST EQUIPMENT : Battery Tester

Checking Before and After Storage

(1) After charging fully, store the battery in a well-ventilated place out of direct sunlight.
(2) A battery in storage must be recharged monthly. This is because even in storage it self-discharges by approx. 0.5% per day.

- Reference value

Temperature	Self-discharging rate
30°C (86°F)	Approx. 1.0% per day
20°C (68°F)	0.5% per day
10°C (50°F)	0.25% per day

(3) When storing the battery mounted on the tractor, disconnect the negative cable from the terminal.

Recharging

Slow Charging

C022P006

Fig. N-23 Slow Charging

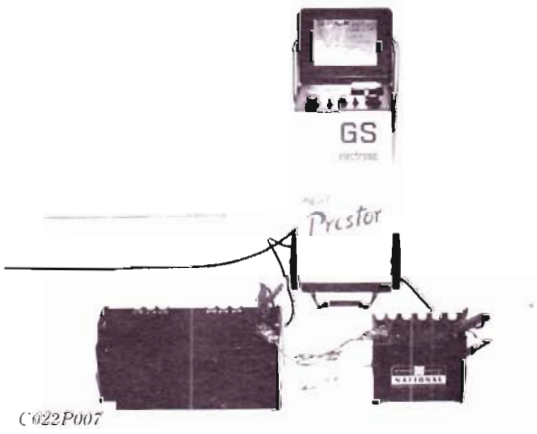
PRECAUTION: When charging a battery mounted on a tractor, disconnect the negative cable from its terminal.

(1) Add distilled water if electrolyte is insufficient. The level of electrolyte should be slightly lower than the specified level, otherwise charging will cause overflow.
(2) Connect battery and charging unit properly. The red cord of the charger must be connected to the battery (+) terminal, and black cord of the charging unit must be connected to the battery (–) terminal.
(3) Charging current must be 1/10 to 1/20 of battery electric capacity.
(4) Electrolyte temperature must not exceed 45°C (113°F) during charging. If it exceeds 45°C (113°F), lower the charging current or stop charging for a while.
(5) During charging, electrolyte generates gas. Therefore, remove all port caps.
(6) Charging time

$$\text{Charging time} = \frac{\text{Discharging current rate (AH)}}{\text{Charging current (A)}} \times (1.2 \text{ to } 1.5)$$

(7) When charging different capacity batteries at the same time, charging current must be set for the smallest capacity battery.

Quick Charging



C022P007

Fig. N-24 Quick Charging

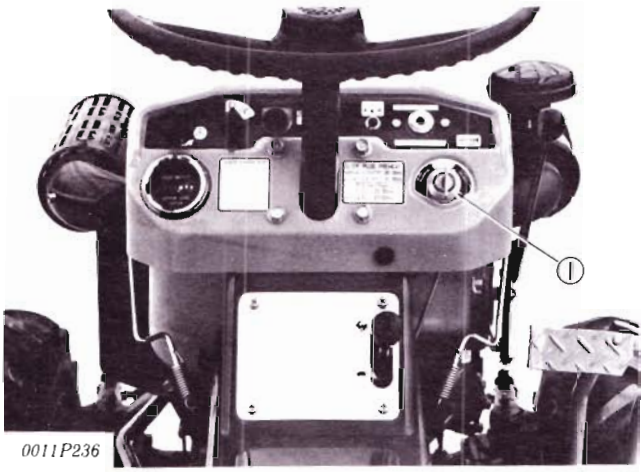
(1) Determine the proper charging current and charging time with the tester attached to the quick charger.
(2) Determine the proper charging current as 1/1 the battery capacity. If the battery capacity exceeds 50AH, however, consider 50A as the maximum.

(Precaution for handling a quick charger)

- Operation with a quick charger differs according to the type. Consult the instruction manual and use accordingly.

Group 3

Key Switch



1. Key Switch

Fig. N-25

Power is supplied to the circuits from the battery when the engine stops and from the dynamo when the engine rotates, depending on the position of key switch.

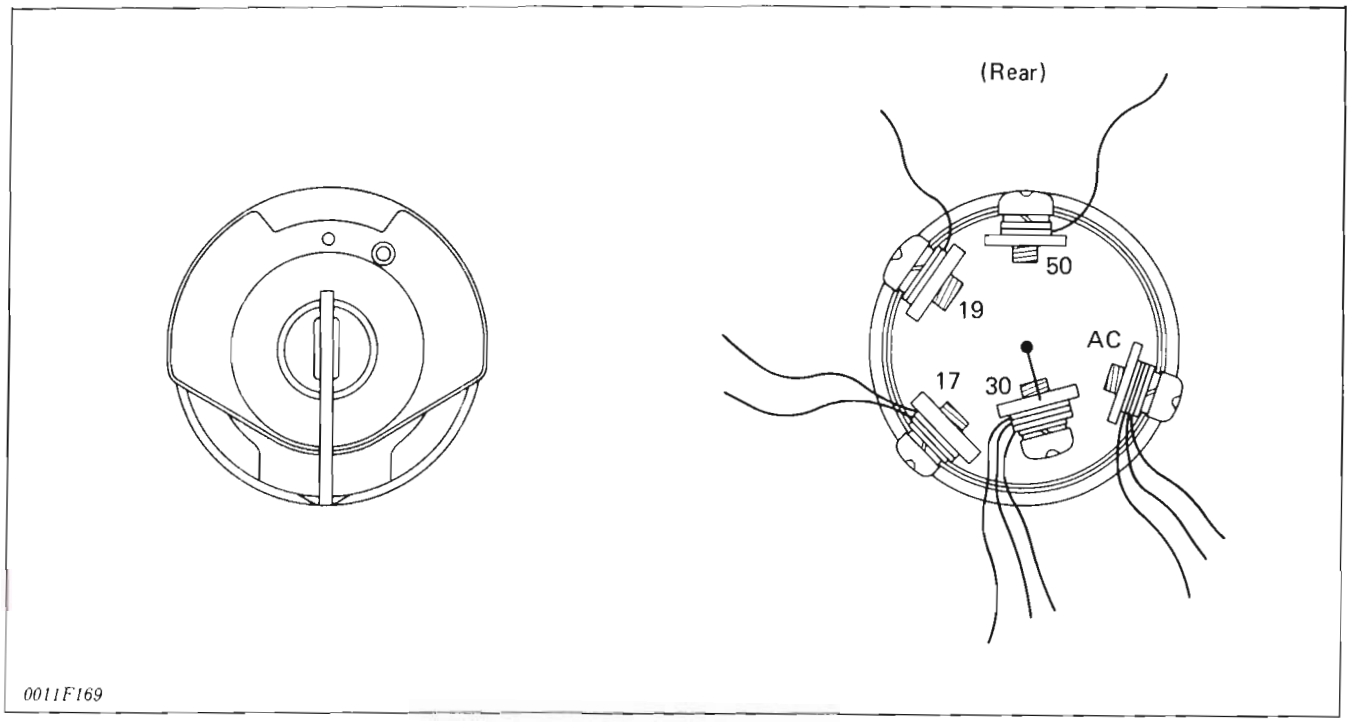


Fig. N-26 Key Position: OFF

The glow plug and glow plug indicator are on while the key is held at the left side and the battery current flows from terminal No. "30" to terminal No. "19". Simultaneously, the current flows from terminal No. "30" to the "AC" terminal to light the engine oil pressure lamp and activate the hourmeter. After preheating is completed and the key is released, the key will return to OFF by the action of a spring.

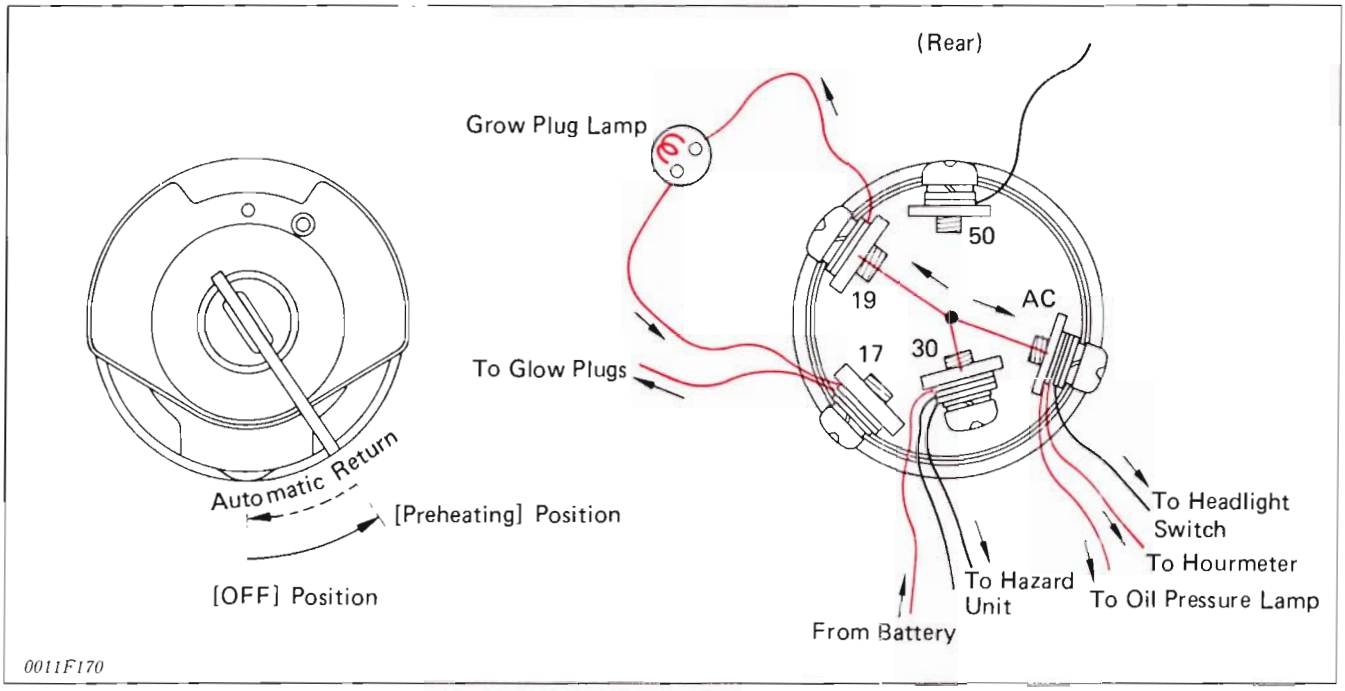


Fig. N-27 Key Position: Preheating

To operate the starter, turn the key to the right through the ON position " ◎ ". Then, battery current flows from terminal No. "30" to terminal No. "50", for activating the starter. Simultaneously, the battery current flows from terminal No. "30" to terminal No. "17" to heat the glow plug, and from terminal No. "30" to the "AC" terminal to activate the hourmeter and light the oil pressure lamp.

After the engine is started, release the key and the key will return to the ON position "◎" by the action of a spring.

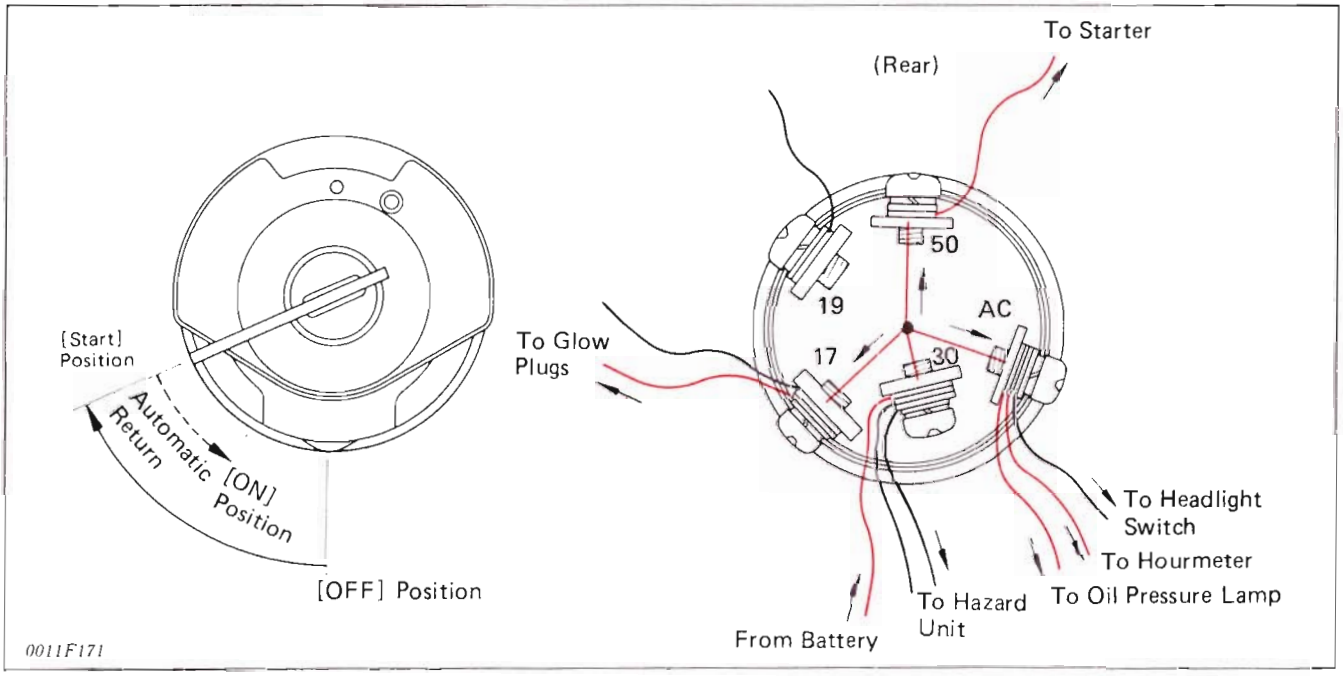


Fig. N-28 Key Position: START