YANMAR
SERVICE MANUAL

DIESEL TRACTOR
(ELECTRICAL EQUIPMENT)

YM135(D)(T) YM155(D)(T)
YM240(T) YM330(T)

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I. BATTERY

I. BATTERY

A storage battery is an electric device which stores chemical energy converted from electric energy and permits electric energy to be extracted if necessary. Storage batteries differ from primary batteries (manganese dry battery, etc.) in that the action of a battery is reversible. A storage battery is often referred to as a secondary battery to differentiate it from a primary battery. The extraction of electric energy from a battery is called "discharging" and the supplying of electric energy is called "charging".

1. CONSTRUCTION

The main components are:

(1) Anode plate [Positive plate of lead peroxide (PbO_2)].

(2) Cathode plate [Negative plate of sponge lead (Pb)]

(3) Electrolyte [*Dilute sulfuric acid: sulfuric acid (H_2SO_4) plus water (H_2O)]

(4) Separator and glass mat

(5) Electrolyte case

(6) Pole

(7) Connector

(8) Terminal

(9) Vent plug

Note: * An active substance directly related to storage action (electrochemical action)

Fig. 1.1 shows the relationship between the construction of a storage battery and an active substance. Fig. 1.2 diagrams the internal structure of the storage battery.

1.1 Pole

1.1.1 Construction

Storage battery plates for tractors are produced through the following method: Lead oxide powder (such as PbO_2 and PbO) is kneaded—mainly with dilute sulfuric acid—into a pasty substance. This substance is molded onto a lead-

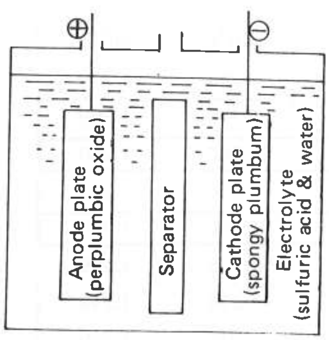


Fig. 1.1 Structure of Storage Battery and Active Substance

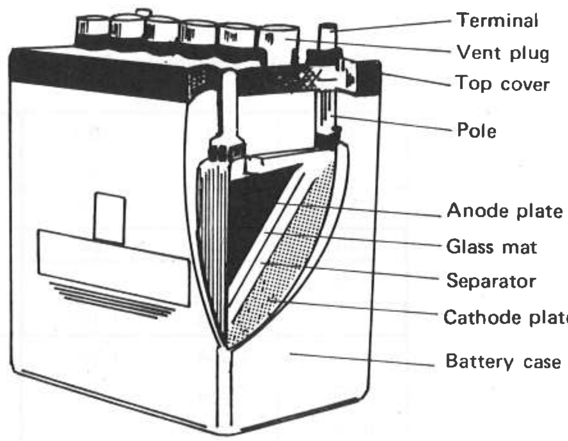


Fig. 1.2 Structure of Storage Battery

antimony alloy grid and dried. It then undergoes a chemical forming process (electric chemical treatment). Thus, an anode plate and cathode plate generate active substances—lead oxide and sponge lead, respectively. Both plates are paste-type plates.

1.1.2 Plate Thickness

Storage battery plates for tractors are compact and light and comparatively thin, nominally 2mm or 3mm.

The capacity of the storage battery is proportional to the effective surface area and the number of plates, and is also directly related to the thickness. However, in the case of high discharge, though the capacity is proportional to the effective surface area and the number of plates, thickness is not an important factor. Thus, for automobiles which require plates of the same volume and weight and goods starting properties, many thin plates are preferable to only a few thick plates.

1.2 Electrolyte

1.2.1 Electrolyte Purity

The electrolyte for storage batteries must be a colorless, odorless, highly pure sulfuric acid.

1.2.2 Specific Gravity of Electrolyte

The specific gravity of the storage battery electrolyte is normally 1.260 or 1.280 at an electrolyte temperature of 20°C when it is fully charged. The specific gravity corresponds to the conductivity peak of the sulfuric acid.

1.2.3 The Electrolyte Specific Gravity Changes by Temperature

The specific gravity of the diluted sulfuric acid changes with temperature and consequently has to be recorded together with its temperature or in terms of a standard temperature (20°C).

In the specific gravity range normally used for storage batteries, the temperature co-efficiency of the specific gravity (specific gravity change to a temperature change of 1°C) is estimated to be approximately 0.0007. Thus if the specific gravity at any temperature t°C is converted into the standard temperature 20°C, it is expressed as follows:

$$S_{20} = St + 0.0007\,(t-20)$$

where S_{20}: Specific gravity converted into standard temp. 20°C
St : Specific gravity measured at t°C
t : Dilute sulfuric acid temp. (°C)

Table 1.1 illustrates the relationship between dilute sulfuric acid specific gravity and temperature.

Table 1.1 Conversion Table of Electrolyte Specific Gravity/Temperature

-10°C	0°C	10°C	20°C	30°C	40°C	50°C
1.321	1.314	1.307	1.300	1.293	1.286	1.279
1.311	1.304	1.297	1.290	1.283	1.276	1.269
1.301	1.294	1.287	1.280	1.273	1.266	1.259
1.291	1.284	1.277	1.270	1.263	1.256	1.249
1.281	1.274	1.267	1.260	1.253	1.246	1.239
1.271	1.264	1.257	1.250	1.243	1.236	1.229
1.261	1.254	1.247	1.240	1.233	1.226	1.219
1.251	1.244	1.237	1.230	1.223	1.216	1.209
1.241	1.234	1.227	1.220	1.213	1.206	1.199
1.231	1.224	1.217	1.210	1.203	1.196	1.189
1.221	1.214	1.207	1.200	1.193	1.186	1.179

1.2.4 Determination of the Charging Condition

Eq. 1.1 : Electrolyte Specific Gravity and Quantity

$$\text{Discharge q'ty (Ah)} = \text{Storage battery capacity (Ah)} \times \frac{\text{Spec. gravity with full charge} - \text{measured spec. gravity}}{\text{Spec. gravity with full charge} - \text{final discharge spec. gravity}}$$

If the storage battery discharges, the specific gravity decreases in proportion to the discharge quantity. Therefore, the charge status can be seen by measuring the electrolytes specific gravity. Table 1.2 is an example of the electrolyte specific gravity charge. But if the storage battery continues to discharge, it causes various accidents. Therefore, it should be recharged when the specific gravity has dropped to about 1.200 (20°C).

Table 1.2 Electrolyte Specific Gravity & Residual Capacity

Electrolyte specific gravity		Residual capacity (%)
A	B	
1.280	1.260	100
1.230	1.210	75
1.180	1.160	50
1.130	1.110	25
1.080	1.060	0 (Total discharge)

Notes (A) : Storage battery, spec. gravity 1.280 (20°C) with full charge.

(B) : Storage battery, spec. gravity 1.260 (20°C) with full charge.

1.2.5 Electrolyte Freezing Point

The electrolyte freezing point varies with its density, i.e. specific gravity. Accordingly, the freezing points also vary with the discharge quantity of the storage battery.

As indicated in Fig. 1.3, the electrolyte cannot freeze if the battery is fully charged. But if discharged, the specific gravity may be nearly 1.1 and in cold districts may freeze.

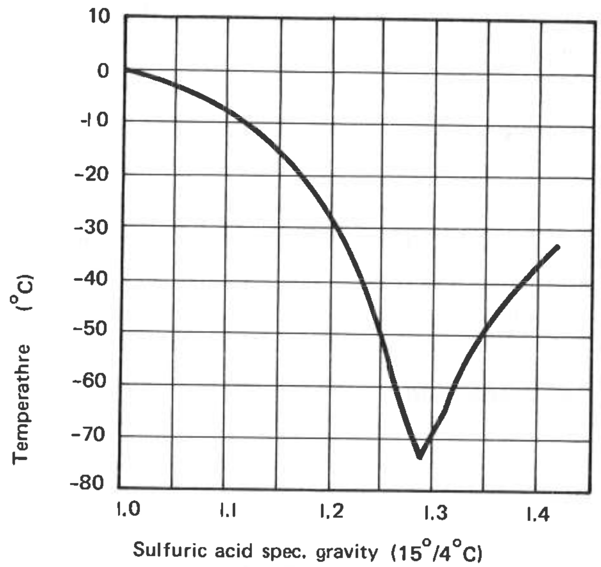


Fig. 1.3 Dilute Sulfuric Acid Freezing Point

1.3 Separator and Glass Mat

The storage battery will lose energy if the anode plate and the cathode plate are short-circuited. To prevent this energy loss, a thin porous board (separator) is inserted between the two plates. The separator is made of reinforced fibers (pulp reinforced by a synthetic resin), microporous rubber, a synthetic resin wooden board, etc. The anode plate can easily slip off the grid because its active substance's bonding strength is weak compared with the cathode plate. The anode plate active substance is supported by pressing a glass mat (glass fibers about 20 microns in diameter crossing each other like a woven mat) gently on the surface of the anode plate. The glass mat is not usually used alone, but is used together with the separator.

1.4 Electrolyte Case

The battery case is made of ebonite or synthetic resin. In most cases, a monoblock case composed of 3 or 6 cells is used. A wooden box containing a specific number of cells is also available.

1.5 Connector and Terminal

The cathode of a cell and the anode of the adjacent cell are joined with connectors to connect the cells in a series. Today, it is common practice to provide the connectors to prevent them from being shorted by tools or corrosion.
Terminals are provided on the cells at both ends of the storage battery for taking out a specific type of electricity. (+) is the anode terminal, and (-) is the cathode terminal.

1.6 Vent Plug

The vent plug filters the sulfuric acid mist which is produced by gas generated at the time of charging, returns the sulfuric acid into the electrolyte cell and exhausts only the gas to prevent the sulfuric acid from dampening the surface of the battery.
Should the battery surface be dampened with sulfuric acid, a current leak may result, or the battery container or some of the metal parts may be corroded.

2. CHARACTERISTICS

2.1 Chemical Change (electro reaction) in Storage Battery

Chemical changes during the storage battery charge and discharge is explained as follows:

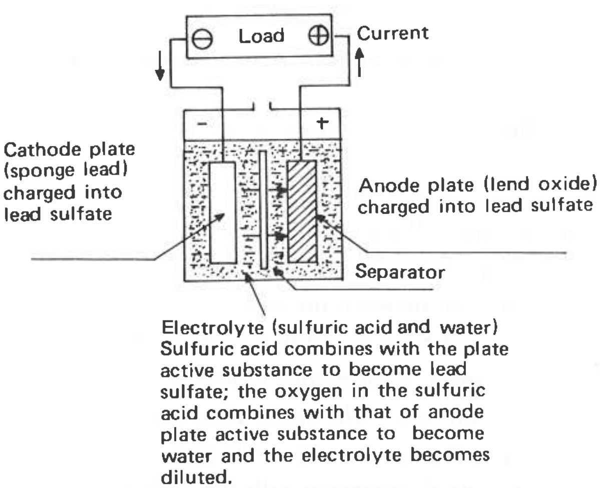


Fig. 2.1 Chemical Changes during Charge

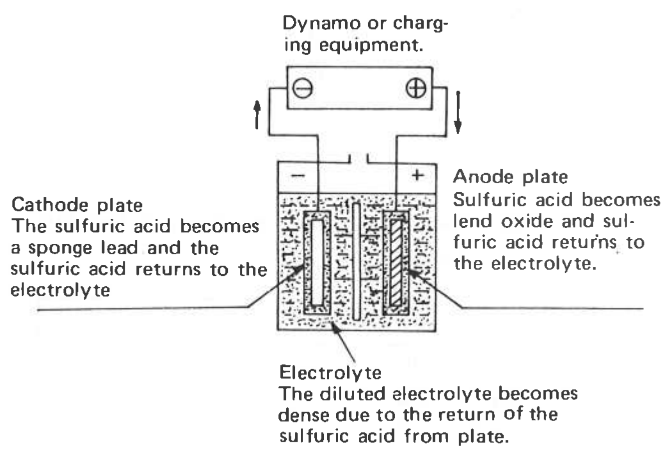


Fig. 2.2 Chemical Changes during Discharge

Eq. 2.1 : Chemical Changes during Charge and Discharge

$$Pb + 2H_2SO_4 + PbO_2 \underset{\text{Charge}}{\overset{\text{Discharge}}{\rightleftharpoons}} PbSO_4 + 2H_2O + PbSO_4$$

Cathode active substance (sponge lend)	Electrolyte (sulfuric acid)	Anode active substance (lead oxide)	Electrolyte	Anode active substance (lead sulfate)

2.2 Electromotive Force (E.M.F.) (open-circuit voltage)

The storage battery's open-circuit voltage (electromotive force) is normally about 2.1V per cell, but varies slightly with the electrolyte specific gravity, temperature and degree of discharge. Fig. 2.3 shows the electromotive forces at 25°C in relation to the electrolyte's S.G. Fig. 2.4 shows the electromotive forces at specific temperatures to the specific gravities of 1.26 (20°C).

Changes in the electromotive force by temperature are very small.

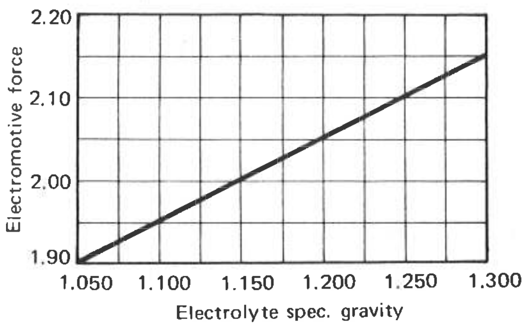


Fig. 2.3 Electromotive Force and Electrolyte Spec. Gravity

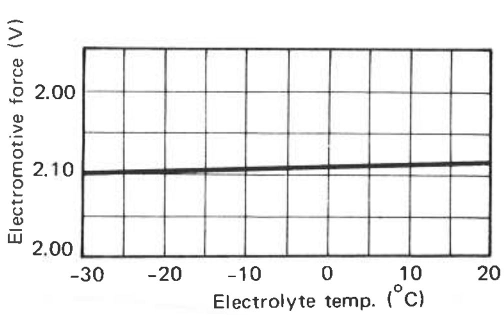


Fig. 2.4 Electromotive Force and Electrolyte Temp.

2.3 Discharge Rate

The characteristics of the storage battery are affected largely by the volume of the current. The discharge rate precisely denotes the volume of the current. Generally, the discharge rate is expressed in terms of the amount of time spent for the terminal voltage of the fully charged battery to reach the final discharge voltage. For example, a 20-hr. rate current denotes the current rate which requires 20 hours to reach the final discharge voltage. In other words, for a 20-hour rate discharge, the current reaches its final discharge voltage in 20 hours.

2.4 Voltage Change during Charging/Discharging

2.4.1 Change in Voltage during Discharge

As the process of discharging continues, the terminal voltage gradually drops, and registers a sharp fall when the discharge exceeds the limit, as shown in Fig. 2.5.

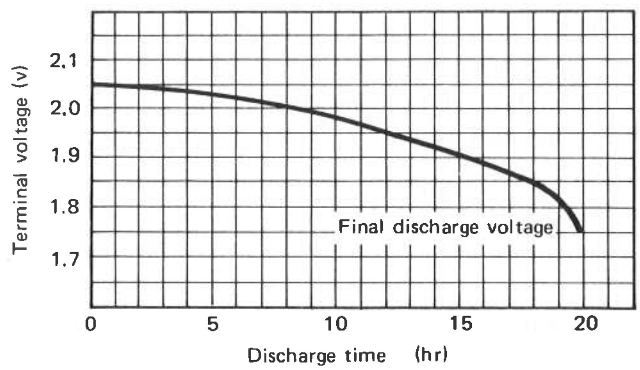


Fig. 2.5 Discharge Curve

2.4.2 Voltage Change during Charge

As the storage battery is charged, the voltage gradually rises until it reaches a peak, from which point the voltage will not change however much the battery is charged. Fig. 2.6 shows the changes in voltage.

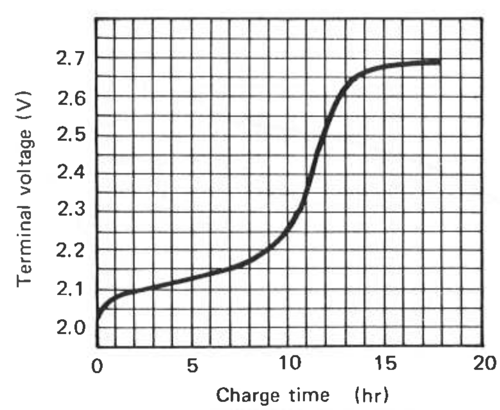


Fig. 2.6 Constant-Current Charge Curve

2.5 Final Discharge Voltage

Normally, beyond a specified level the storage battery will have a sharp drop in voltage till it finally reaches O (V). If this happens, the battery will be useless.

The specified limit for discharge is known as the final discharge voltage.
The final discharge voltage denotes the allowable limit of discharge.

2.6 Capacity

Battery capacity can be expressed in (1) ampere-hour capacity, the quality of electricity or electric energy that can be extracted from the battery until the specified final discharge voltage is reached, or (2) watt-hour capacity, the amount of work a fully charged battery can do continuously at a specified current for one hour.

Generally, the capacity of a storage battery is expressed in terms of the ampere-hour capacity.

Eq. 2.2 : Ampere-Hour Capacity & Watt-Hour Capacity

> Ampere-hour capacity (Ah) = Specific discharge current (A) x continuous discharge time to final discharge voltage (Hr).

> Watt-hour capacity (Wh) = Ampere-hour capacity (Ah). x average discharge coltage (V) to final discharge voltage.

As the capacity of a storage battery varies greatly with the discharge rate, electrolyte temperature, specific gravity, etc., these factors should be specified when the capacity is indicated. (Refer to Figs. 2.7, 2.8 and 2.9)

2.7 The Efficiency of a Storage Battery

The efficiency of a storage battery is likewise expressed in terms of the ampere-hour efficiency and watt-hour efficiency. The ampere-hour efficiency is expressed in terms of the ratio of the quantity of discharged electricity (Ah) to the quantity of electricity (Ah) required for re-charging the battery to bring it back to the fully charged condition. The watt-hour efficiency is expressed in terms of the ratio of the quantity of discharged electricity (Wh) to the quantity of electricity (Wh) required for charging the battery up to the fully charged condition. The efficiency of a storage battery when fully discharged by the specific current can ne expressed as Eq. 2.3.

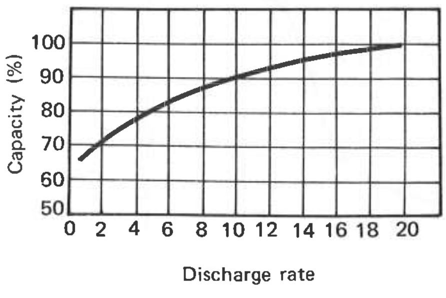


Fig. 2.7 Capacity & Discharge Rate

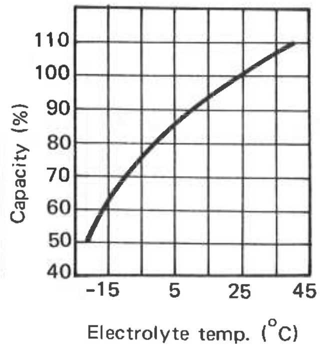


Fig. 2.8 Capacity & Electrolyte Temp.

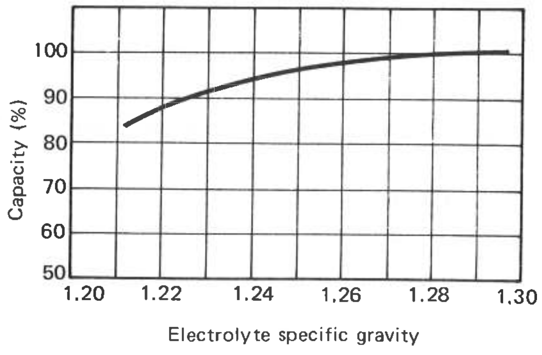


Fig. 2.9 Capacity & Electrolyte Specific Gravity

Eq. 2.3 : Ampere-Hour Efficiency and Watt-Hour

$$\text{Ampere-hour efficiency} = \frac{\text{(Discharge current) x (Discharge time)}}{\text{(Charge current) x (Charge time)}}$$

$$\text{Watt-hour efficiency} = \frac{\text{(Average discharge voltage)}}{\text{(Average charge voltage)}} \text{ x (Ampere-hour)}$$

As the efficiency is governed by the charge/discharge rate, temperature, etc., these must be specified for comparison.

2.8 Self-Discharge

Self-discharge is the process by which the electricity stored in a battery dissipates without being effectively utilized. The causes are as follows:

2.8.1 Self-Discharge Caused by Chemical Actions

The sponge lead (Pb) of the cathode plate acts upon the electrolyte (H_2SO_4), changing it gradually into lead sulfate ($PbSO_4$). Also, if the hydrogen and oxygen which are generated on the cathode and anode during charge contact the opposite pole, they either reduce or oxidize it, causing self-discharge.

2.8.2 Self-Discharge Caused by Electrochemical Actions

Impure metals in the plates in electrolyte constitute a local battery, causing self-discharge. The difference in temperature and density of the electrolyte in contact with the plates also constitute a battery, causing self-discharge as the electromotive force varies with the temperature and density of the electrolyte.

2.8.3 Self-Discharge Caused by Electricity Leakage

(1) Self-discharge caused by storage battery surface dampness

When dust sticks to the surface of the battery damp with surfuric acid, an electric circuit is formed through the battery fixtures, etc. and the current flows out. This is generally called a current leakage. The leakage causes not only discharge but also electrolytic corrosion (as the current flows into the electrolyte, the metal of the current outlet is steadily eluded into the electrolyte and is precipitated on the metal of the inlet.) As a result, the current outlet, namely, the pole connector near the positive (+) earth, is corroded, and becomes gradually thin.

(2) Self-Discharge Caused by Internal Short-Circuit

If an active substance accumulates at the bottom or sides of the battery, or the separator has broken, a short-circuit may result, causing self-discharge. This explains why an old battery discharges easily even after it is charged.

2.8.4 Self-Discharge Quantity

Table 2.1 shows the daily self-discharge quantity of a

Table 2.1 Self-Discharge Quantity

Temp.	Self-discharge q'ty (approx.)	Spec. gravity decrease (approx.)
30°C	1.0% per day	0.0020 per day
20°C	0.5% per day	0.0010 per day
5°C	0.25% per day	0.0005 per day

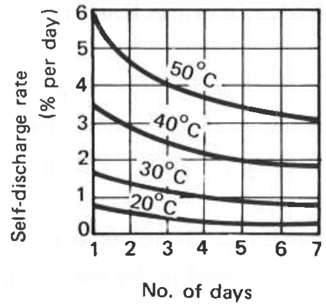


Fig. 2.10 Self-Discharge — No. of Days — Electrolyte Temp. Relationship Curve

tractor storage battery. If there is an internal short-circuit as the case of an old battery, the quantity is usually greater than the value indicated in Table 2.1 and Fig. 2.10.

2.9 Internal Resistance

The internal resistance peculiar to a storage battery is the sum of the resistance of the plate, separator and electrolyte, but its value is very small. When the current flows, the virtual internal resistance caused by an electrochemical action (polarization) increases. The internal resistance of the battery varies with the progress of charge or discharge and the temperature of the battery. This is because discharge changes the active substance of both plates into lead sulfate ($PbSO_4$) which has poor conductivity, and the lead sulfate density decreases while the electrolyte resistance increases.
Table 2.2 shows some examples of the internal resistances of various types of fully charged batteries. The values are obtained from a drop in voltage at a time of high discharge.

Table 2.2 Examples of Internal Resistances of Various Batteries

Type \ Temp.	25°C	-15°C
N 30	0.0160 Ω	0.0226 Ω
N 50	0.0120 Ω	0.0174 Ω
N 120	0.0052 Ω	0.0072 Ω

2.10 The Life of a Storage Battery

The service life of a storage battery is expressed in terms of the frequency of charge and discharge till the point when the battery capacity falls to the specified level or in terms of the quantity of electricity. Usually, it is expressed in terms of cycles – one charge or discharge tested under specific test conditions. This is meaningless unless the charge/discharge rate is indicated. Also, the life of a battery depends on its temperature and electrolyte specific gravity. Therefore, the temperature of the battery during use must be well watched.

3. KINDS OF BATTERIES

Generally, batteries are grouped as primary batteries (dry batteries) and secondary batteries (storage batteries). They are also classified by electrolyte into oxygen batteries, alkaline batteries, etc.

3.1 Uncharged Storage Battery

A storage battery produced at the factory is shipped without charging, and can be kept in stock for a considerable period of time without any deterioration in performance. Nevertheless, prior to being used, it should be charged for about 60 hours after being filled with electrolyte.

[Why is the initial charge necessary?]
The initial charge is the first charge for an uncharged storage battery after assembly. In the process of manufacturing or while the battery is kept in stock, sponge lead which is the cathode plate's active substance, acts upon oxygen, carbonic acid gas and water, and turns into lead oxide, lead carbonate and lead hydroxide once it comes in contact with air. If diluted sulfuric acid is injected into such an uncharged storage battery prior to use, the cathode plate's lead oxide acts upon the sulfuric acid and turns into lead sulfate. The charge for restoring this lead sulfate to the original sponge lead is called the initial charge, which is carried out for over 60 hours at the specified initial charge current (if it is unknown, with a 20-hour rate current).

3.2 Charged Storage Battery

A charged storage battery is a battery which has been filled with electrolyte and initially charged. This battery can be used immediately upon arrival. If a charged battery filled with electrolyte is left as it is , its capacity, because of self-discharge, will gradually decrease and eventually expire. If kept in stock for a long time, the performance will deteriorate so that the battery will not operate. Therefore, a charged battery filled with electrolyte should be charged every month or every other month even if it is kept in stock. This charge is called "recharge".

3.3 Instant Storage Battery

An instant storage battery is also called a dry battery, which is fabricated using charged plates tes through a special manufacturing process.
The interior of an instant storage battery is air-tight with the vent plug sealed up. But, it cannot be instantly used if its plates are exposed to the air. If the seal is removed or the vent plug is left loosened during storage, air will get in and the battery will lose its power, necessitating it to be charged for many hours after filling it with electrolyte.
If it is kept in storage under proper conditions and for a short period of time, an instant battery has only to be filled with electrolyte without recharge prior to use. On most occasions, however, it is recharged before use for a short time after being filled with electrolyte.
Thus, an instant storage battery is most useful when the labor and time for the initial charge are to be reduced.

4. INSPECTION, CLEANING AND CHARGING

Periodical inspections are required for the full performance of battery. The major items to be inspected are as follows:

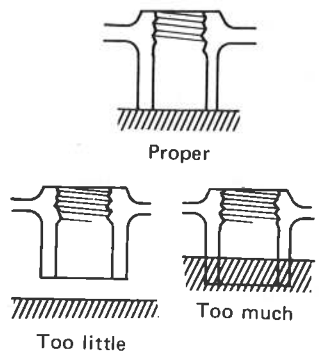
(1) Outward appearance
(2) Quantity of electrolyte
(3) Specific gravity of electrolyte
(4) Voltage test

4.1 External Inspection

(1) Check for case cracks, damage, electrolyte leakages.
(2) Check for looseness, corrosion, breakage of battery terminals.
(3) Check for terminal rust, corrosion, and cable breakage.
(4) Check for cap cracks, electrolyte leakage, and clogged vent holes.

4.2 Inspection to Check Quantity of Electrolyte

The electrolyte should be checked 3 or 4 times per month. The liquid should be 10 to 20mm above the plates

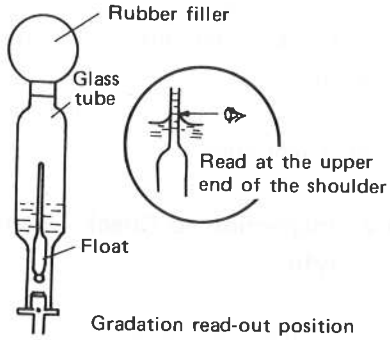


Notes:

(1) The level gradation is provided on the battery case.
(2) Only distilled water should be used for replenishment.
(3) If the electrolyte leaks, dilute it with sulfuric acid with the same specific gravity as the electrolyte

4.3 Measurement of Electrolyte Specific Gravity

Extract some electrolyte and measure its specific gravity with a hydrometer.



Notes:

(1) Read the figure at the upper level of the electrolyte.
(2) If the temperature of the electrolyte registers 20°C, a specific gravity of 1.280 means full charge, 1.210 means 50% charge. Less than 1.210 means it needs charging.
(3) If the specific gravity difference of all cells is ±0.01, the battery is in good condition.

4.4 Voltage Test

The discharge quantity of a battery can be measured from the voltage drop when the battery is discharged by a strong current. A battery tester is designed to measure voltage at the time of high discharge of a battery.

(1) Connect a proper tester to the battery. (Battery testers for 12V)
Adjust the current (A) adequate for the battery capacity.
(2) Connect the positive probe of the tester to the (+) terminal of the battery, and the negative probe of the tester to the (–) terminal of the battery.
(3) Read the meter after pushing the "TEST" button for 5 seconds.
Repeat the procedure to confirm that the pointer indicates the same position.

4.5 Cleaning

(1) Clean the exterior of the battery with a brush and running water or warm water. Take precaution not to let water in the battery.)
(2) If a terminal has been corroded due to an electrolyte leak, wash the sulfuric acid away.
(3) Check and clean the vent holes.
(4) Remove water completely with compressed air after cleaning. Attach cable and apply grease thin. Do not apply grease before attaching cables.

4.6 Recharge

There are two methods of recharging, but the "ordinary charge" is recommended.

(1) Ordinary charge: Use a current of less than 10% of the indicated battery capacity (for instance, less than 10 amp. for a 100Ah battery)
(2) Rapid charge: Use a current 20% to 50% of the indicated battery capacity for a short time. Be careful as the rapid charge causes the sudden rise of liquid temperature (20 amp.~50 amp. for a 100 Ah battery)

4.6.1 Charging Procedures

(1) Inspect the electrolyte specific gravity and adjust the quantity of liquid.
(2) Removal of the battery cable:
Remove the grounded end of the cable first to prevent a short during work.
(3) Connect the red clip of charging device to (+) terminal, and black clip to (-) terminal.
(4) Set a charging current suited to the battery.
(5) Measure the specific gravity during charge.
Measure that the specific gravity is high, reaches the specific value and much gas is generating. Check the charge condition.

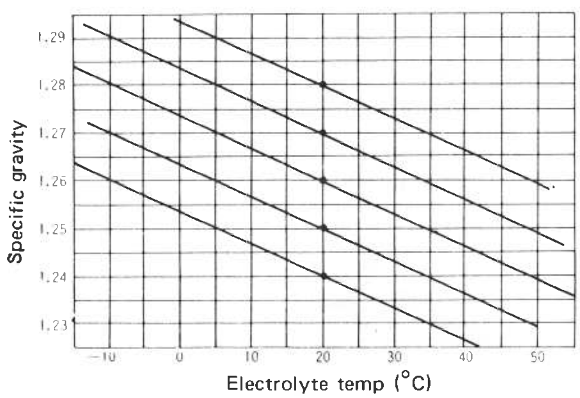
4.6.2 Precautions to be Taken during Charging

(1) Remove the vent plug to facilitate gas dissipation.

(2) Be sure the room is well ventilated and be careful not to light a match in the vicinity of the battery.

(3) Do not allow the electrolyte temperature to exceed 45°C.

(4) Be sure to remove the battery cable (+) to protect the diodes from burning.

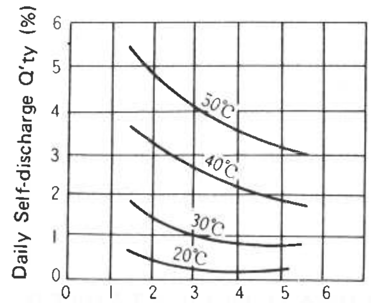


[Relationship between Electrolyte Temp. and Specific Gravity]

4.7 Cautionary Instructions for Long Periods of Storage

(1) After full charging, keep the battery in a well ventilated place.

(2) Because the battery will self-discharge at the rate of about 0.5% per day even when not in use it should be recharged once or twice a month during storage.



[Number of Days after Charge]

4.8 Life of a Battery

If a battery is used for a considerable length of time, it will reach the end of its life span, and won't be able to be restored through charging. The life of a battery depends largely upon the manner in which it is used. The span of its useful life is difficult to predict accurately but may be as long as 2 to 3 years. Factors which shorten the life are as folows:

(1) Sulfation due to insufficient charging

(2) Cathode curvature and sulfation due to overdischarge

(3) Rise of temperature, deterioration of the separator, cracks in the anode plate, softening of the anode plate paste due to overcharging

(4) Exposure and sulfation of the top of the plates due to insufficient electrolyte

(5) Electrolyte is too dense

(6) Electrolyte temperature is too high

(7) Impurities in electrolyte

(8) Internal short-circuit

(9) The battery is left unused without being recharged for a long period of time.

4.9 Capacity of Standard Equipped Battery

YM135(D)(T)	12V-35AH
YM155(D)(T)	12V-35AH
YM240(T)	12V-75AH
YM330(T)	12V-100AH

II. STARTER MOTOR

II. STARTER MOTOR

1. DETERMINATION OF STARTER MOTOR OUTPUT

Factors required for the starting system are specified torque and speed. The product of both factors becomes the output required for the starter motor.

$$\text{Output (PS)} = \frac{\text{Torque (kg-m) x speed (rpm)}}{716}$$

where torque and speed are mean values.

The starter motor is a DC series motor. As shown in Fig. 1.1, its torque decreases with an increase in speed and vice versa. Proof of its superior performance is the fact that torque can be generated with load torque varied.

When determining the starter motor output, the type of oil and its working temperature must be assessed in advance since the mean torque and speed vary with the type of oil used and its temperature. A starter motor with an output of S.A.E grade 10 W oil at an atmosphere temperature of -15°C is designed as a standard type

2. MOTOR CHARACTERISTICS

Motor torque and output are represented by the following expression.

2.1 Torque

$T = K_1 \Phi Ia$ [kg·m]

where

K_1 : constant

Φ : magnetic flux [Wb]

Ia : armature current [A]

2.2 Speed

$$N = \frac{E - Ia(R + ra)}{K_2 \Phi} \text{ [rpm]}$$

where

E : supply voltage [V]

Ia : armature current [A]

R : external wiring resistance [Ω]

ra : armature resistance [Ω]

K_2 : constant

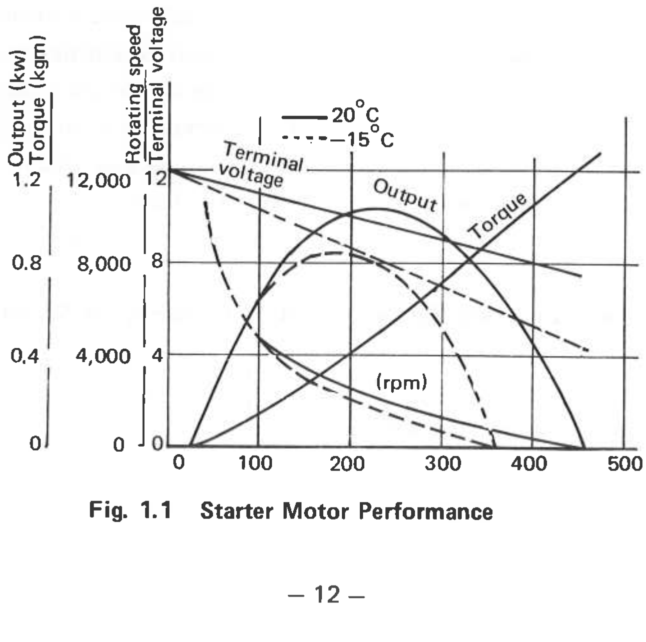


Fig. 1.1 Starter Motor Performance

2.3 Output

W = 1.03TN [W]
where
N : speed [rpm]
T : torque [kg·m]

Conventionally, output is represented by horsepower with 1 horse power = 736 W.

2.4 The Bendix System

This is a system which engages the motor with a ring gear using pinion inertia, and is also known as the inertia sliding system. When the engine starts operation and its speed increases, a force direction is reversed by action of a square screw, thus automatically disengaging the motor. In other words, engagement and disengagement are automatically performed. Fig. 2.1 shows an example of the Bendix system. The screw sleeve is coupled with the armature shaft in a linear spline.

3. CONSTRUCTION AND OPERATION

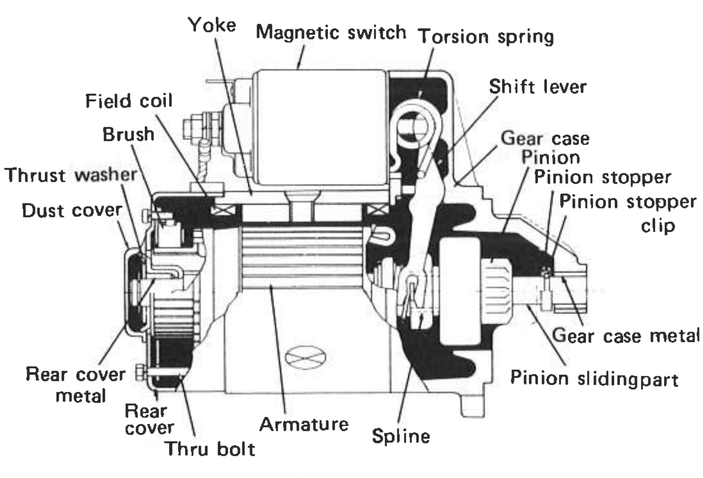
3.1 Composition

The starter motor being described in this section is the conventional pre-engaged multi-pole starter motor with a screw roller drive clutch.
The starter motor is composed of three major parts as follows:

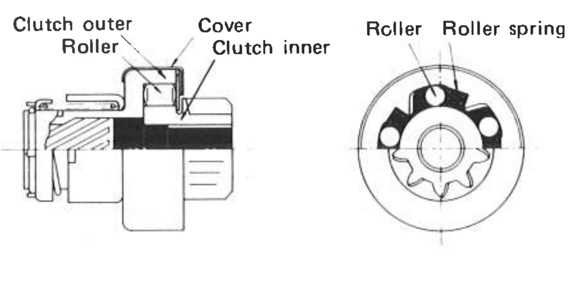
3.1.1 Magnetic Switch
Moves plunger to engage and disengage pinion, and through the engagement lever, opens and closes main contact (moving contact) to stop the starter motor.

3.1.2 Motor
A continuous current series motor which generates rotational drive power.

3.1.3 Pinion
Transfers driving power from motor to ring gear. An over-speed clutch is employed to prevent damage if the engine should overrun.



Construction



Over-Running Clutch

Fig. 2.1 Example of Bendix System

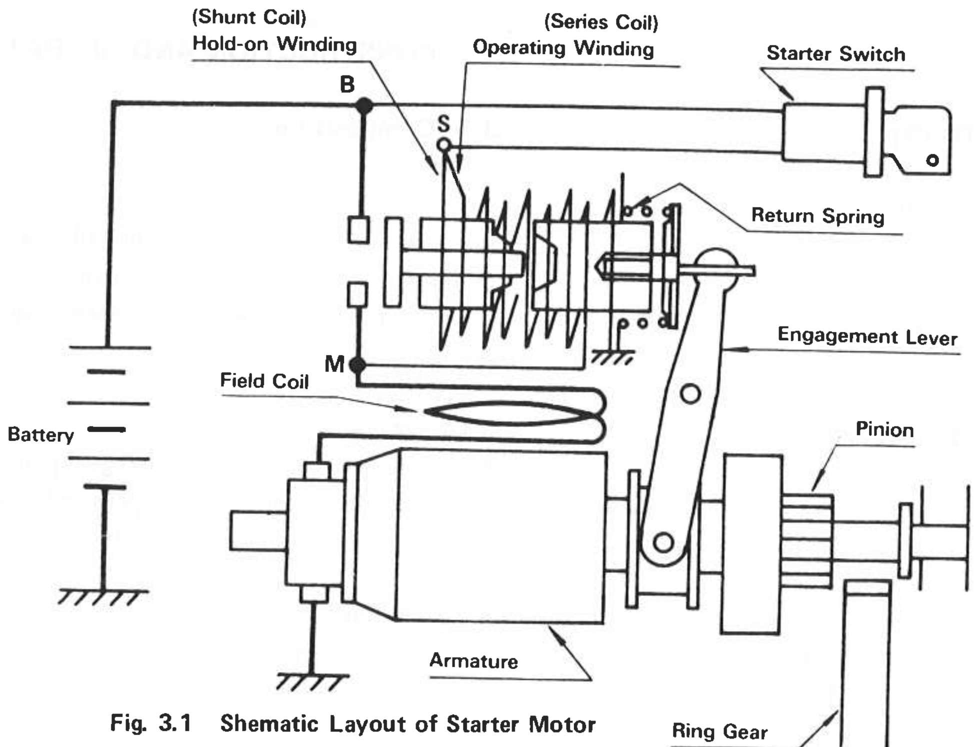


Fig. 3.1 Shematic Layout of Starter Motor Electrical Circuit

3.2 Operation

Turn on the starting switch → Current will flow into the series coil and shunt coil → The plunger is attracted, the shift lever moves and the pinion is pulled out →

- (When the pinion runs in normally) → Pinion engages with the ring gear → The contacts of the main contactor close and current flows → *
- (When the pinion clushes the ring gear) → Pinion does not engage with the ring → The torsion spring is compressed and the plunger moves → **

* → The armature turns → This rotates the ring gear →

** → The contacts of the main contactor close and current flows → Armature is rotated → The pinion gear engages with the ring gear to turn it →

→ Turn off the starting switch after motor is fully started → The magnetic switch is de-energized →

→ The pinion is reset to the regular position via the shift lever by the torsion spring and contact opens → The motor (armature) stops turning

4. INSPECTION

When the starter motor is felt to be malfunctioning, it should be dismantled for detailed inspection.

4.1 Armature

Coil and commutator inspection:

a) Layer short test

Coil is broken or disconnected. Rotate the armature on the "growler" with a thin steel strip placed on the armature surface. Vibration of this strip indicates a short circuit of the armature winding.

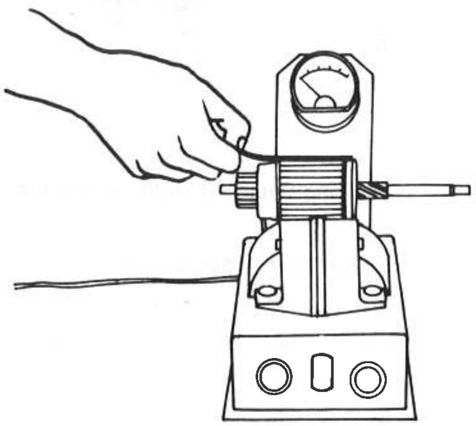


Fig. 4.1 Checking Commutator for Insulation Defects

b) Insulation test

Between commutator and armature core or distortion shaft (See Figs. 4.1 and 4.2)

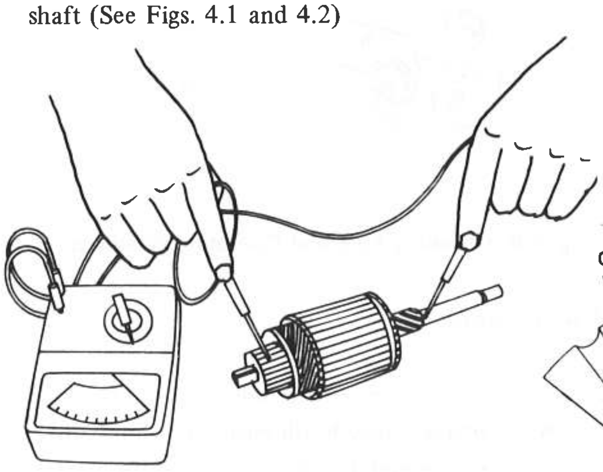


Fig. 4.2 Checking Armature Windings for Insulation Faults

With a circuit tester of a specified resistance measuing range, check insulation between the commutator and armature core or shaft. No reading indicates that armature is satisfactory.

4.2 Commutator

a) Commutator surface inspection

If the surface is not clean, polish it lightly with very fine sand paper. (See Fig. 4.3)

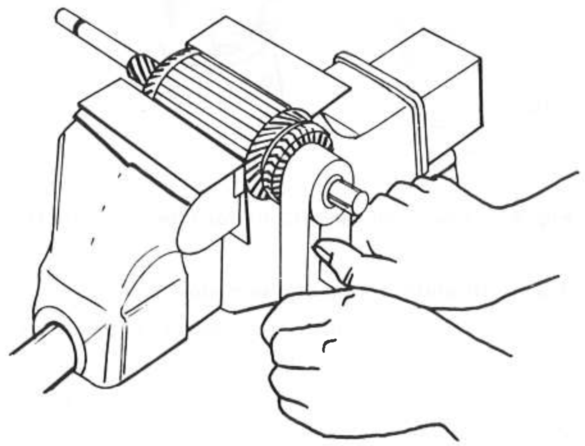


Fig. 4.3 Polishing Commutator with Fine Glass Paper

b) Commutator segment depth measurement

If the commutator is badly worn, make a light cut on the lathe with a sharp tool. After this, it should be polished with very fine sand paper. (See Fig. 4.4)

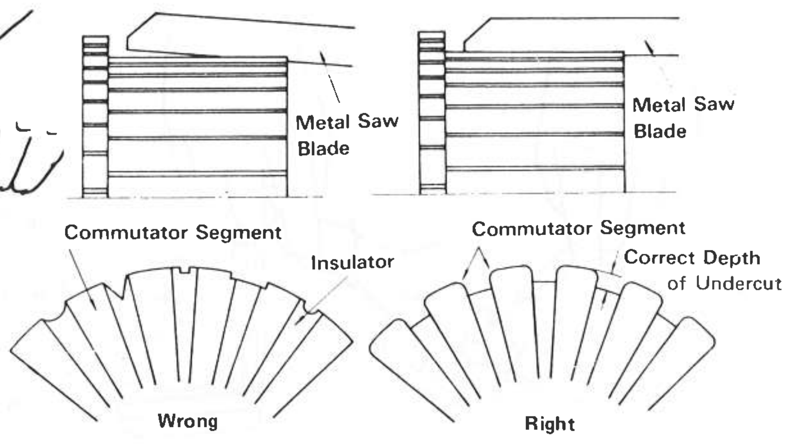


Fig. 4.4 Wrong and Right Methods for Under-Cutting Insulators on Commutator

4.3 Field Coil

Insulation test (See Figs. 4.5 and 4.6)

Fig. 4.5 Checking Field Coils for Open Circuit Defects

4.3.1 Insulation Test of the Field Coil

To check the field coils for insulation, connect a circuit tester to the terminals of the field windings. Check the meter reading. No reading indicates that the field winding opens.

4.3.2 Insualtion Test between the Field Coil and Yoke

Place one of probes of the tester on the field coil terminal and the other on the yoke and check the meter reading. No reading indicates that insulation between them is satisfactory.

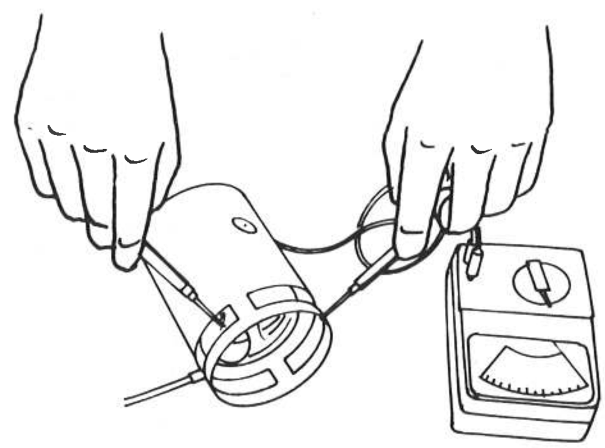


Fig. 4.6 Checking Field Coils for Insulation Defects

4.4 Magnetic Switch

4.4.1 Continuity Test of Shunt Coil

Place one test probe on the terminal S of the magnetic switch and the other on the metal section of the magnetic case. Check the hold-on windings (shunt coils) for continuity.

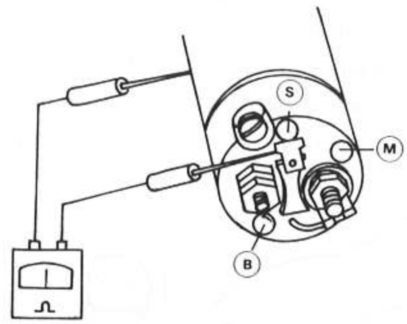


Fig. 4.7 Checking Solenoid Hold-on Windings

4.4.2 Continuity Test of Series Coil

Place one test probe on the terminal S and the other on the terminal M. Check the operating windings (series coils) for continuity. No reading indicates that this coil opens.

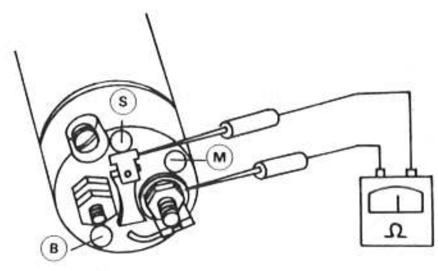


Fig. 4.8 Checking Solenoid Operating Windings

4.5 Brushes

Brushes worn in excess of the values should be renewed. When fitting a new brush ensure it is properly beded to the commutator face and is free in its holder.

5. ADJUSTMENT AND PERFORMANCE TEST

5.1 Setting Pinion Movement

(1) After complete assembly of the starter motor, connect the motor.

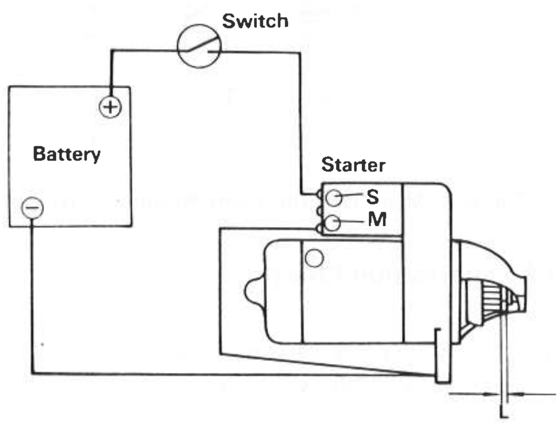


Fig. 5.1 Check the Gap between the Pinion and the Pinion Stopper (L-size)

(2) When the pinion is in the engaged position, measure the distance between the pinion and the stopper. This check should be made with the pinion pressed back lightly to take up any play in the engagement linkage.

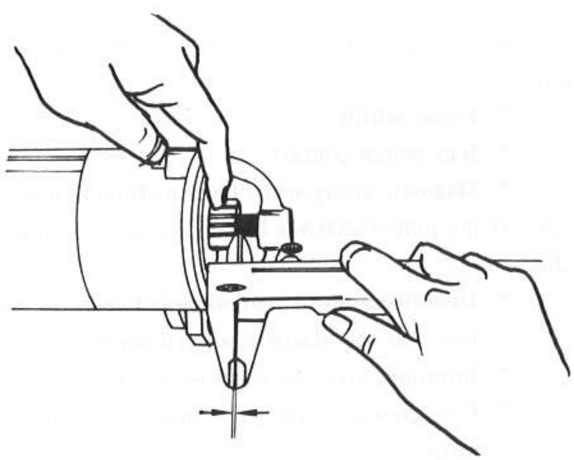


Fig. 5.2 Testing Circuit for Pinion Movement

(3) Plunger Movement

Adjust the stroke of the magnetic plunger to the prescribed value.

a) Shim adjusting type

If the gap between the pinion and pinion stoppper is too large, insert shims as shown in Fig. 5.3. Two shims of different thickness (0.4mm and 0.8mm) are available.

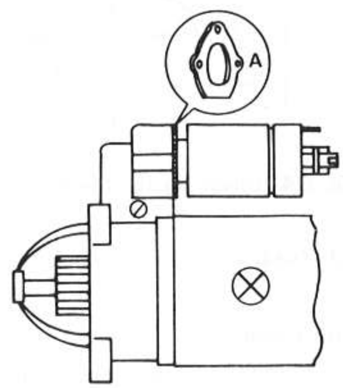


Fig. 5.3 Adjustment for Plunger Movement (Shim Adjusting Type)

b) Screw adjusting type

Push the plunger until it comes in contact with the magnetic solenoid surface as shown in Fig. 5.4. Measure the distance between the plunger and the solenoid and faces (size L) using verner calipers. Adjust the distance to the specified value by loosening or tightening the adjusting screw.

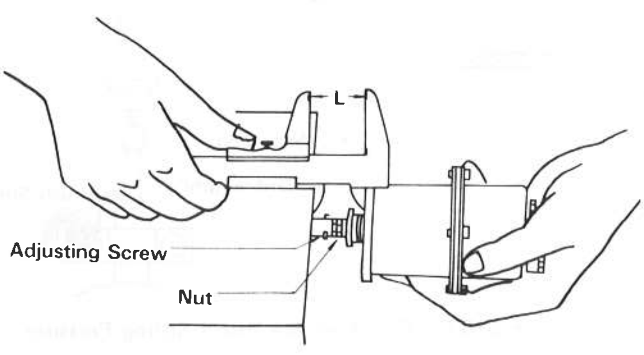


Fig. 5.4 Adjusting the Plunger Movement (Adjusting Screw Type)

(4) Mesh Clearance

Mesh clearance is the distance between the flywheel ring gear and the starter motor pinion in the rest position. This clearance should be between 3mm to 5mm.

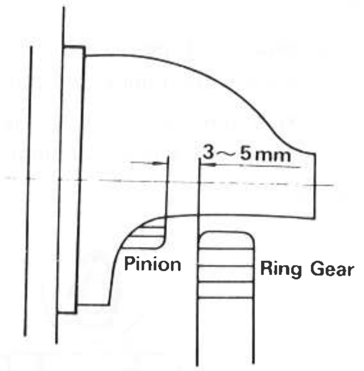


Fig. 5.4 Checking the Mesh Clearance

5.2 Brush Gear

5.2.1 Brush Length

Remove the commutator end cover. Check that the brushes move freely in the holds. Renew them if required.

5.2.2 Brush Spring Pressure

Measure the brush spring pressure as shown below: If the pressure does not meet the specifications, replace the brush spring. Also check the condition of the holder.

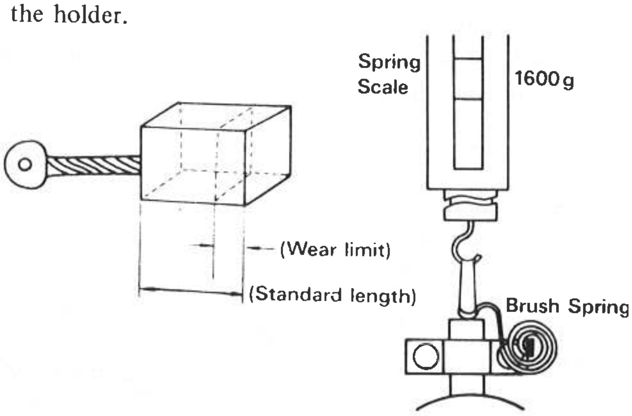


Fig. 5.5 Checking the Brush Spring Pressure

5.3 Light Running Current Test

With the starter motor clamped in a vice, connect the circuit as shown in Fig. 5.6.

(1)	Battery:	12V DC
(2)	Ammeter:	100A DC
(3)	Voltmeter:	20V DC
(4)	Tachometer:	10,000rpm

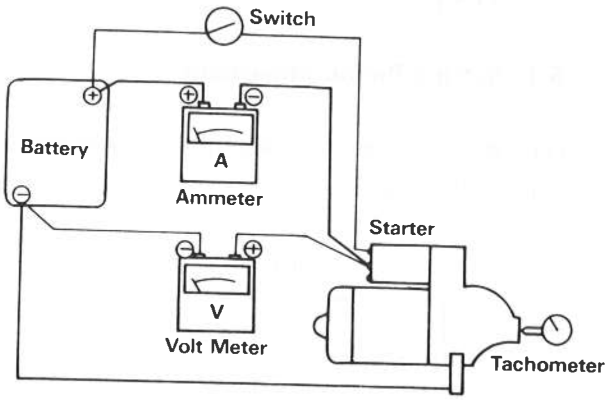


Fig. 5.6 Measuring the Light Running Current

5.4 Lubrication Chart

a) Ensure that the parts indicated in Fig. 5.7 are lubricated with "Shell Alvania Grease No. 2" or the equivalent high melting point grease.

b) Be sure to insert the thrust washer between the commutator end bracket and the armature.
If the end float is more than 0.3mm, more shims should be added.

6. MALFUNCTION AND TROUBLE SHOOTING

(1) If the pinion doesn't extend when the switch is on, check for

* Loose wiring.
* Bad switch contacts.
* Magnetic engagement lever malfunctioning.

(2) If the pinion extends but motor doesn't turn, check for

* Disconnection or grounding between the battery and the magnetic switch wires.
* Improper mesh between pinion and ring gear.
* Poor contact between brushes and commutator.
* Bad contact in the magnetic switch.

(3) If the motor turns before pinion meshes with ring gear, check for

* Maladjustment of the plunger gap.

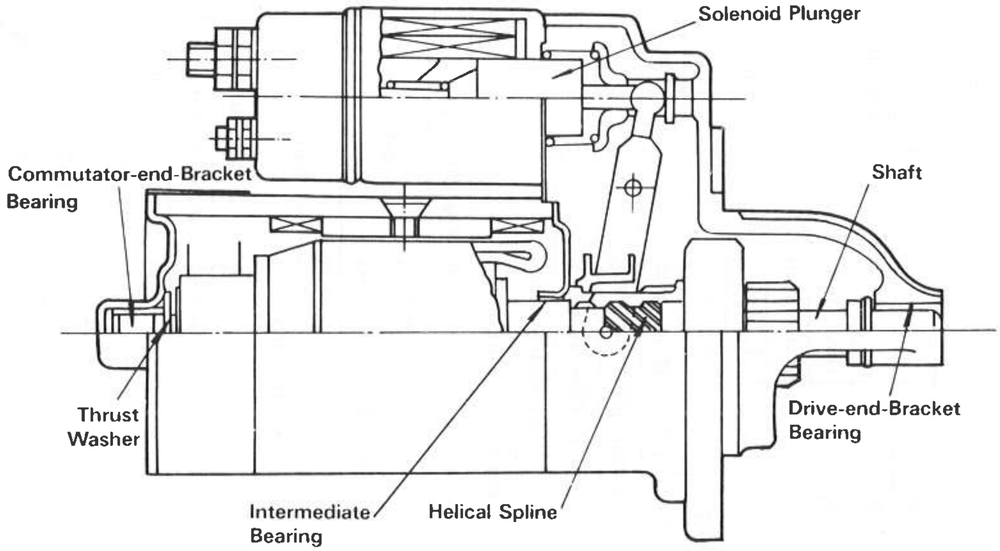


Fig. 5.7 Lubrication Chart

* Weak plunger spring.

(4) If the pinion engages and motor rotates, but drive force is not enough, check for

* Malfunctioning of the over speed clutch.

(5) If the engine doesn't stop when the switch is turned off, check for

* Malfunctioning of the main switch.
* Magnetic switch contacts are stuck in the closed position.
* Weak or broken return spring.

(6) If the speed torque and current consumption is low, check for

* Faulty internal or external connections.
* Dirty or burned commutator.
* Burned magnetic switch contacts.

(7) If the speed and torque is low but current consumption is high, check for

* Broken bearing.
* Bent shaft.
* Armature fouling pole shoes.
* Cracked spigot on drive end bracket.
* Short-circuited or grounded armature.

(8) If speed and current consumption is high but torque is low, check for

* Short-circuited windings in the field coil.

(9) If there is excessive arcing at the commutator, check for

* Defective armature windings.
* Sticking brushes or dirty commutator.

7. SPECIFICATION AND SERVICING STANDARD VALUE

Applicable tractor models			YM135(D)(T), YM155(D)(T)		YM240(T)	YM330(T)
			OLD	NEW		
Manufacturer			Hitachi	⇐	⇐	⇐
Manufacturer's code			S114-196	S114-219	S114-146	S12-23
Yanmar's code			124060-77010	124060-77011	124450-77010	124250-77010
Output (kw)/Weight (kg)			1.0/5.1	1.3/6.0	1.3/6	1.8/9.7
Direction of rotation (viewed from pinion side)			Clockwise	Clockwise	Clockwise	⇐
Mesh method			Magnetic shift	Magnetic shift	Magnetic shift	⇐
Light running	Terminal voltage (V)/Current (A)		12/less than 60	12/less than 60	12/less than 60	12/less than 55
	Speed (rpm)		Over 7000	Over 6000	Over 6000	Over 6000
Lock torque	Terminal voltage (V)/Current (A)		5/less than 330	5/less than 540	8.5/less than 350	5/less than 840
	Torque (kg-m)		Over 0.9	Over 1.6	Over 0.5	Over 2.8
Type of clutch/Maximum holding torque (kg-m)			Over-running	Over-running	Over-running	⇐
Pinion	Diametric pitch or module/No. of gear teeth		DP$\frac{10}{12}$/11	DP$\frac{10}{12}$/11	DP10/15	DP10/15
	Drive voltage (V)		less than 8	Less than 8	less than 8	less than 8
Brush	Spring strength (kg)		1.6	1.6	1.6	0.85
	Standard length (mm)/Wear limits (mm)		16/4	16/4	16/4.5	20/7
Magnetic switch resistance at 20°C (Ω)		Series coil/shunt coil	0.324/0.694	0.324/0.694	0.325/0.695	0.25/0.78
Commutator (mm)	Outer dia.	Standard dia./Wear limits	40ϕ/2	40ϕ/2	40ϕ/2	43ϕ/3
	Difference between max. & min. dia.	Correct limits/correct accuracy	0.4/0.05	0.4/0.05	0.4/0.05	⇐
	Insulator depth.	Correct limits/correct accuracy	0.2/0.5~0.8	0.2/0.5~0.8	0.2/0.5~0.8	⇐
Commutator end bracket (mm)		Shaft dia./bearing dia.	$12.5^{-0.032}_{-0.050}/12.5^{+0.027}_{0}$	$12.5^{-0.032}_{-0.050}/12.5^{+0.027}_{0}$	$12.5^{-0.032}_{-0.050}/12.5^{+0.027}_{0}$	$15^{0.032}_{-0.050}/15^{+0.015}_{0}$
Intermediate bracket (mm)		Shaft dia./bearing dia.				$20.3^{-0.040}_{-0.061}/20.5^{+0.021}_{0}$
Drive end bracket (mm)		Shaft dia./bearing dia.	$12.5^{-0.032}_{-0.050}/12.5^{+0.050}_{+0.030}$	$12.5^{-0.032}_{-0.050}/12.5^{+0.027}_{0}$	$12.5^{-0.032}_{-0.050}/12.5^{+0.050}_{+0.030}$	$14^{-0.032}_{-0.050}/14^{+0.048}_{+0.030}$
Pinion bearing (mm)		Shaft dia./bearing dia.	$12.5^{-0.032}_{-0.050}/12.5^{+0.027}_{0}$	$12.5^{-0.032}_{-0.050}/12.5^{+0.050}_{+0.030}$	$12.5^{-0.032}_{-0.050}/12.5^{+0.027}_{0}$	$14^{-0.032}_{-0.050}/14^{+0.018}_{0}$
L-size (mm) (gap between pinion end and pinion stopper)			0.3~1.5	0.3~1.5	0.3~1.5	0.2~1.5

III. CHARGING EQUIPMENT

III. CHARGING EQUIPMENT

1. AC Generator
2. DC Generator
3. Regulator
4. Inspection
5. Performance Test [For models YM240(T) & YM330(T)]
6. Performance Test [For models YM135(D)(T) & YM155(D)(T)
7. Trouble Shooting
8. Servicing Value
9. Starter Dynamo (Reference)

The electric power for electrical equipment is supplied by the battery, and the battery is charged by the generator. The generator, which supplies the charge power, charges when the power is slightly higher than the battery voltage. When the generator voltage is lower than the battery voltage, the battery is overdischarged. If the generator voltage is exceedingly high, the battery is overcharged and an adverse effect is exerted. The voltage generated by the battery is controlled by a regulator.

Currently available generator types are DC generators with semi-conductor rectifiers. AC generator output current can also be DC because of the built-in rectirectifier. A DC generator has a commutator based on a mechanical rectifying mechanism.
Therefore, if it is turned at high speeds, centrifugal force is intensified so that the commutator and the segment mica can bounce out. Thus, DC generators can become electrically incapable of rectifying and are unsuitable for high-speed engines.
AC generators, however, are applicable to high-speed engines since the rotor is different in structure from that of DC generators, a slip ring takes out the minimum current and the current direction does not change as it does with a commutator.

1. AC GENERATOR

1.1 Induced Electromotive Force

If a conductor in a magnetic field is moved (if a magnetic flux line is cut off), an electromotive force is generated in the conductor.
If the generator is turned in the direction of the arrow as in Fig. 1-1(a), coil (a) and coil (b) move up-

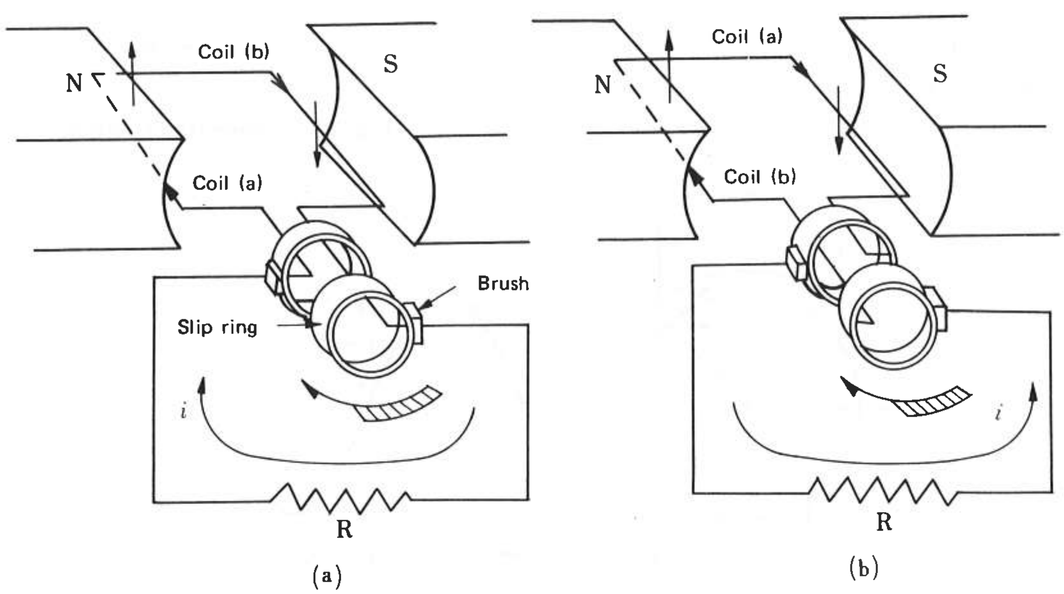


Fig. 1.1 The Principle of Generator

ward and downward, respectively. Therefore, according to Fleming's law, an electromotive force develops across coils (a) and (b) in the directions indicated by the arrows. If the electromotive force is connected through the slip ring to the outside resistor R, a circuit is created through which the current flows.

When the coil has rotated 180°, as represented in Fig. 1.1(b), the circuit is supplied with an inverse current. In other words, every time the coil rotates 180°, an AC curent in a different direction is generated. The magnitude of the electromotive force is governed by the strength of the magnetic field, the magnetic flux line cutting speed of the conductor, and the length of the conductor.

Fig. 1.2 shows an induced electromotive force.

Magnetic field strength: B

Speed along the peripheral of the conductor: v'

Angular velocity: ω [rad/sec]

Conductor length: l

Speed to cut magnetic flux at right angles: v

Rotating angle θ after t sec., $\theta = \omega t$ [rad]

$v = v' sin\omega t$

Electromotive force (e) induced to conductor,

Suppose $e = Blv = Blv' sin\omega t$

$Blv' = Em$,

it may be expressed as

$e = Em\ sin\omega t$[V]

As ωt increases, the magnitude and direction of (e) change into a sine wave shape, i.e. they turn into a sine wave electromotive force. If the load is connected to the force, a sine wave alternating current is generated.

1.2 Commutator

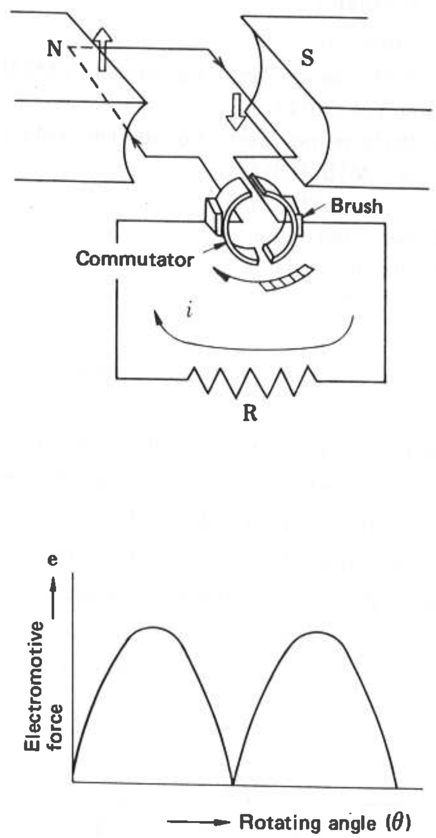


Fig. 1.3 Commutator Action

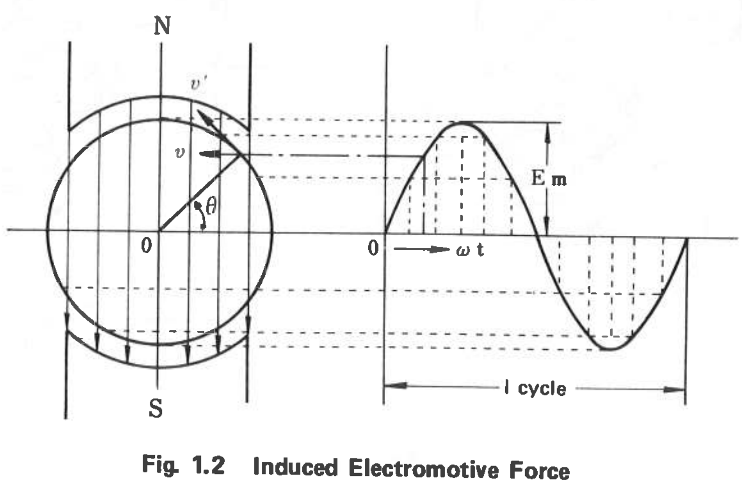


Fig. 1.2 Induced Electromotive Force

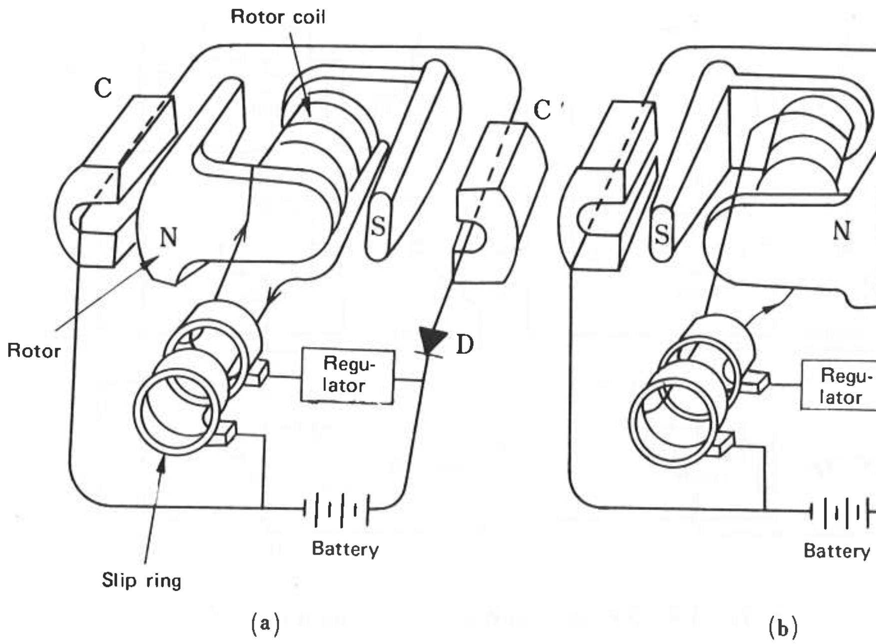


Fig. 1.4 The Principle of AC Generator

If the slip ring (Fig. 1.1) is split into 2 sections (Fig. 1.3), and if they are connected to the coils, the magnitude of the voltage changes; its direction, however, does not change, as can be seen in Fig. 1.1 This is called "commutator."

In Fig. 1.3, as there are 2 coils, the pulsating current is large. But if the numbers of the coils and commutators are increased, the pulsating current becomes gentler until it becomes DC.

1.3 Carbon Brush Type AC Generator

1.3.1

A.C. generators are generally of the rotating-field type. Fig. 1.4 illustrates the principle of AC generation. With field-revolving type generators, the generating coil is stationary and the field coil rotates. The field rotor is wound with a coil. If direct current is applied through the slip ring, the field rotor is magnetized and forms the magnetic poles (N, S).

The stators are wound with conductors (C, C') and generate alternating current by rotating the rotor.

The generated AC is rectified by the diode (D) into DC, which is then charged to the battery. If ordinary DC is rectified by the diode, it takes on various waveforms – depending upon the system as shown in Fig. 1.5. Tractor generators take on the waveform (C) since 3-phase AC undergoes full-wave rectification.

Fig. 1.6 illustrates the 3-phase full-wave rectifier circuit of an AC generator.

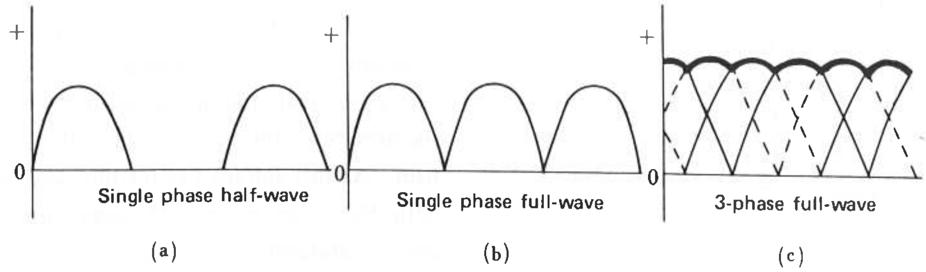


Fig. 1.5 Rectification Waveform

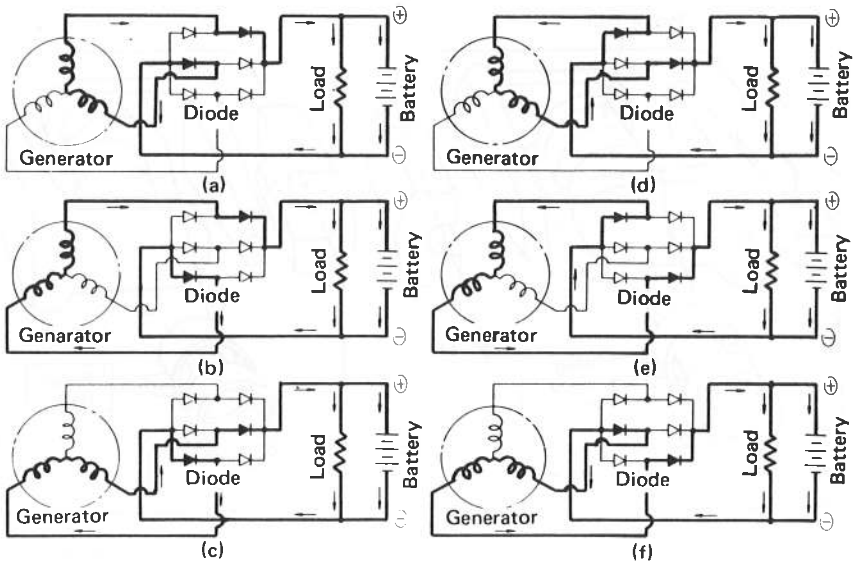


Fig. 1.6 3-Phase Full-Wave Rectification Circuit

1.4 Brushless AC Generator

Conventional AC generators have slip rings and brushes, but brushless AC generators have none of these. The generating principle is the same, however the structure is different. The brushless AC generator comes in 2 types; the belt-driven type and the engine direct-coupled type. Fig. 1.7 illustrates the structure of the latter. The magnetic circuit is indicated by the dotted line arrow.

Pole core (N) → Main gap → Stator → Main gap → Pole core (S) → Auxiliary gap (1) → Yoke → Auxiliary gap (2) → Rotor → Pole core (N)

Because the field coil is stationary, as is shown in Fig. 1.7, slip rings and brushes are unnecessary.

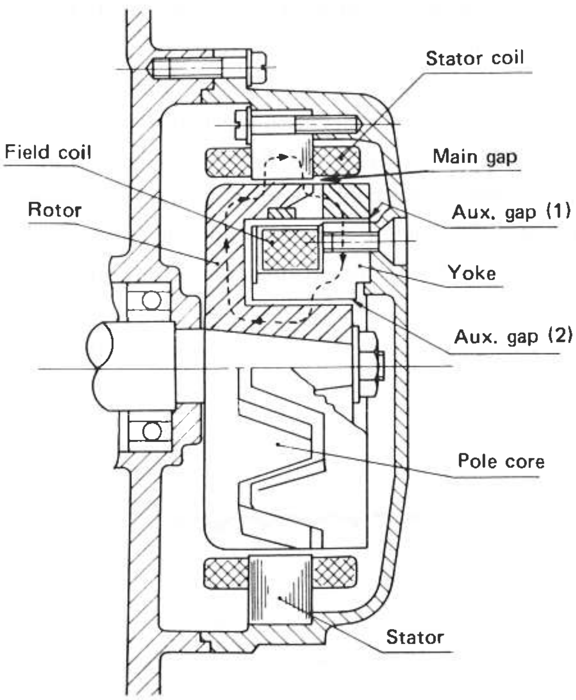
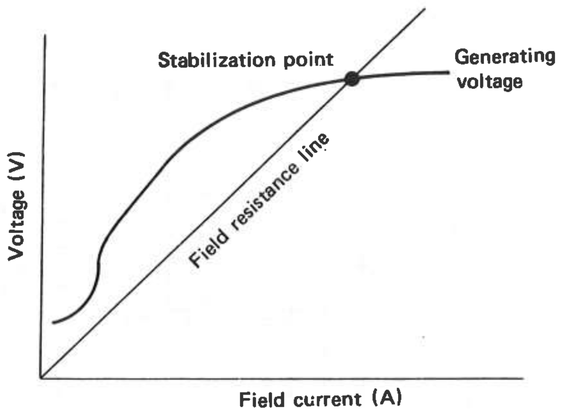


Fig. 1.7 The Structure of Brushless AC Generator

2. DC GENERATORS

DC generators are of a DC shunt type. The field coil is excited by the voltage generated by the generator, and it is connected to the armature coil by a shunt. The shunt excites the pole core through the battery, supplying the residual magnetism. If the armature is rotated, a small amount of voltage develops across the armature coil due to a slight flux residual magnetism. As this voltage excites the field coil, more magnetic flux is generated. The generating voltage rises and is stabilized at the intersecting point of the field resistance.



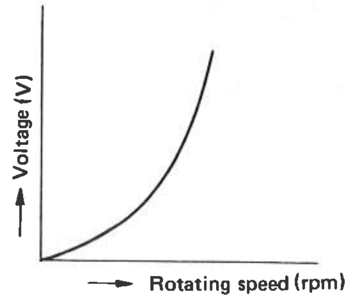


Fig. 2.2 Speed Characteristics of Shunt Generator

2.1 Generating Voltage

A DC generator is a shunt generator, and its generating voltage is expressed as

$$E = \frac{P}{a} Z\Phi \frac{N}{60} [V]$$

E: Generating voltage [V]
P: Number of magnetic poles
a: Total number of conductors
Φ: Number of magnetic fluxes [Wb]
N: Rotating speed [rpm]

Suppose $\frac{P}{a} Z \frac{1}{60} = K$, $E = K\Phi N [V]$

Because Φ is proportioante to the field current it is expressed as

$$E = K' I_f N [V]$$

Fig. 2.2 shows the relationship between the rotating speed and the voltage of the shunt generator.

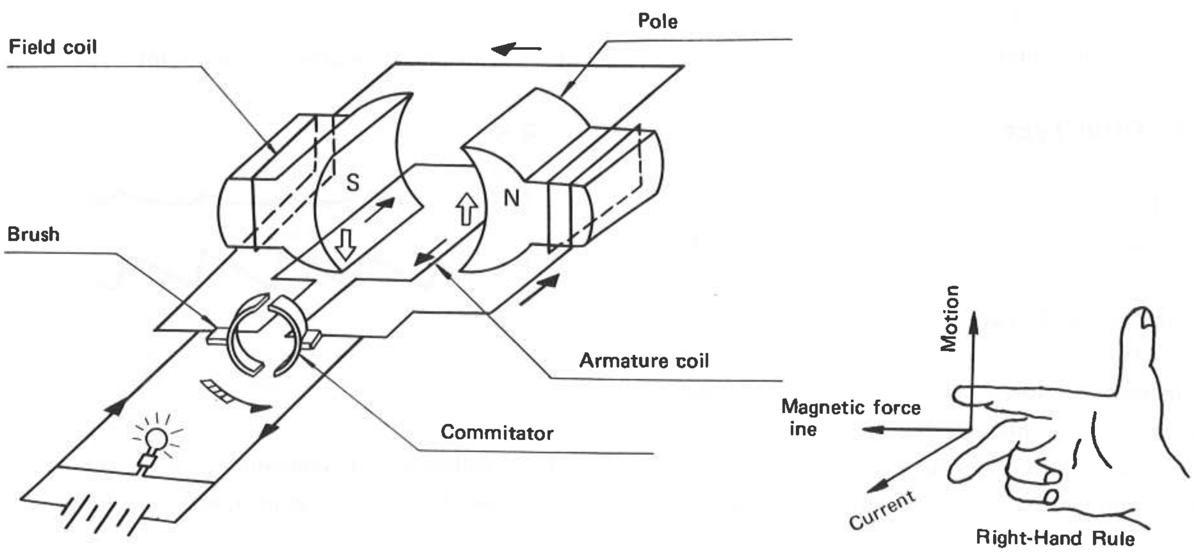


Fig. 2.1 Shunt Generator

3. REGULATOR

3.1 Type and Principle

Regulators can be classified, depending on the operational principle, as follows:

(1) Tirrill type (contact-point type)
 i) Single contact-point type
 ii) Double contact-point type
(2) Carbon pile type
(3) Transistor type
 i) Semi-transistor type
 ii) Full-transistor type
 iii) IC type

The generating voltage of the generator is expressed in the following equation:

$$E = K\Phi N = K'I_f N\,[V]$$

E: generating voltage of generator
K, K': constants
Φ: magnetic flux [Wb]
N: generator rotating speed [rpm]
If: field current (rotor or field current) [A]

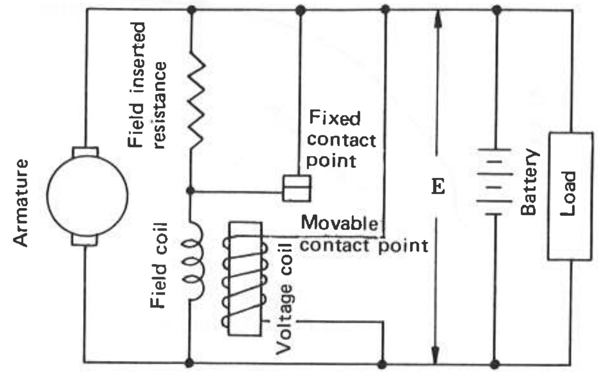
This indicates that the voltage rises if either the speed or the field current increases. Thus, to keep the current constant even when the rotating speed rises, it is only necessary to reduce the field current by the amount of the rise in speed.

The regulator is a device designed to control the voltage by adjusting the field current in accordance with changes in the rotating speed.

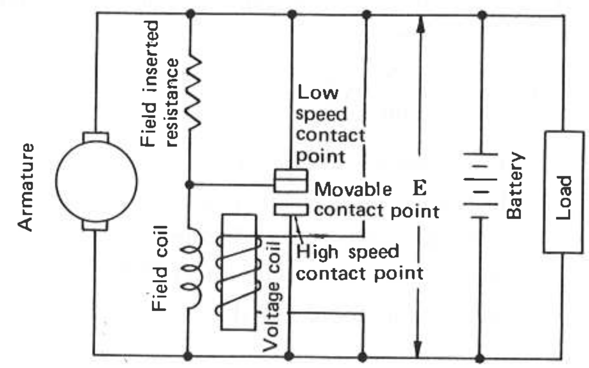
3.2 Tirrill Type

The Tirrill regulator controls the current by contact-point interruption, i.e. by the insertion of resistance or short-circuits. Fig. 3.1 illustrates the basic principle of the Tirrill type.

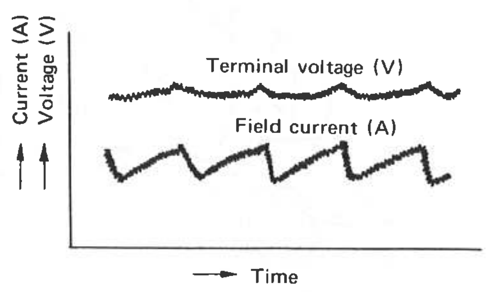
Fig. 3.1(a) shows the principle of the single contact-point type: As the rotating speed increases, the voltage increases, a large amount of the voltage coil current flows, and the sucking force is intensified to absorb the movable contact-point, which then opens. At that time, the field inserting resistance enters in series into the field coil; meanwhile, the field current decreases and the voltage drops. When the voltage drops to a specified value, the sucking force lessens



(a) Principle of Single Contact Point Type



(b) Principle of Double Contact Point Type



(c) Oscillograph of Generator Terminal Voltage and Field Current (Rotating Speed, Constant)

Fig. 3.1 Principle of Tirrill Regulator

and as a result the contact point closes; the resistor is shorted, the coild current increases, and the voltage increases. By a continuous reception of this process, voltage is kept constant.

Fig. 3.1(b) shows the double contact point type. When the speed is low and the load is heavy, the low-speed contact point and the movable contact point operate like the single contact point type. But if the rotating speed increases, the field current and voltage increase as the field inserting resistance is small. Then, the voltage coil current increases to absorb the movable contact point, which touches the high-speed contact point. As a result, the field coil is shorted and the voltage falls. In other words, in the case of high speeds or light loads, the movable contact point repeats a betwixt-and between status (neither low-speed nor high-speed) and adheres to high-speed contact point, thereby adjusting the voltage. The features of the double contact point type includes a wide range of rotating voltage regulation speeds and a prolonged service life. Fig. 3.1(c) shows an oscillograph of the terminal voltage and field current.

3.3 Carbon Pile Type

The carbon pile type regulator utilizes changes in the contact resistance of carbon pile. Fig. 3.2 shows the relation between electric resistance and the pressure exerted on a pile of thin carbon disks.

The carbon pile type utilizes this property. As shown in Fig. 3.3, a pile of carbon disks is connected in a

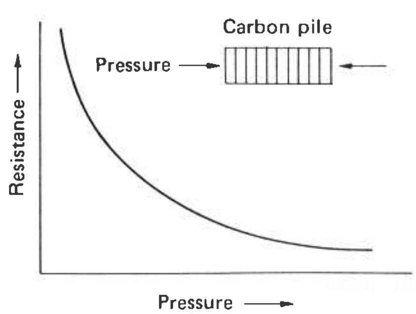
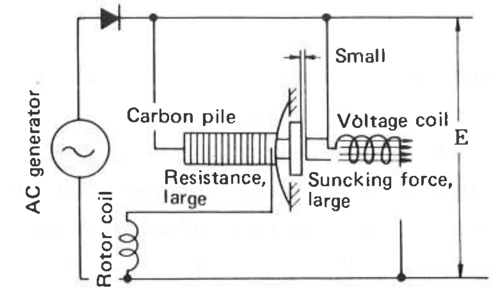


Fig. 3.2 Relations between Resistance and Pressure

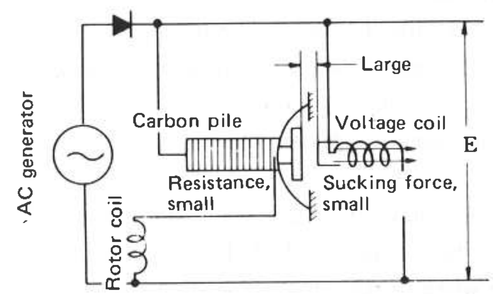
series to a rotor coil and is pressed by a plate spring. As the rotating speed increases, the generating voltage rises, the voltage coil current increases, and the sucking force is intensified to draw the movable iron pieces.

Then, as pile pressure decreases, resistance increases, rotor coil current is reduced and the generating voltage falls.

If the rotating speed is low, the phenomenon is operated inversely; thus the voltage is kept constant.



(a) In the Case of High Voltage



(b) In the Case of Low Voltage

Fig. 3.3 Principle of Carbon Pile Regulator

3.4 Transistor Type

The transistor regulator is designed for the intermittent control of current, utilizing the switching action of a transistor. Fig. 3.4 shows its basic principle.

The transistor type employes transistors and zener diodes. The base currents of transistors T_1 and T_2 are regulated by transistor T_2 and zener diode ZD, respectively.

If the key switch is turned on, the base current is

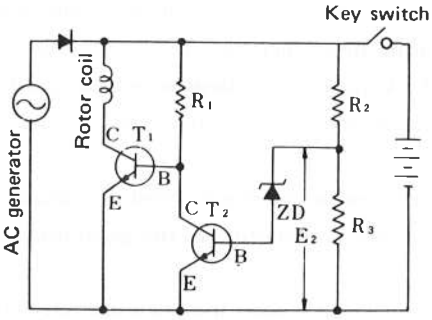


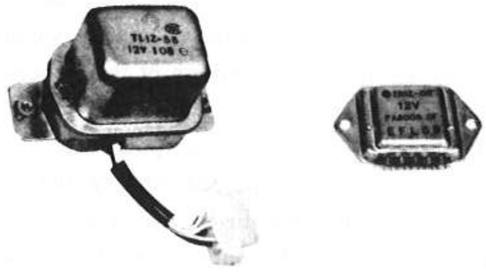
Fig. 3.4 Principle of Transistor Type

fed through R_1 to T_1 and the current flows from the collector through the rotor coil to the emitter. As the rotating speed increases and the generating voltage rises, the voltage across the zener diode also rises. When it equals the zener voltage, the zener diode becomes conductive and the base current of the transistor T_2 flows. At that point, current flows from the collector through R_1 to the transistor T_2. Then the base current of transistor T_1 is shut off, so that no current is fed to the rotor coil. However, when no current flows to the rotor coil, the generating voltage of the generator falls and the voltage across the zener diode also drops. As a result, the zener diode becomes non-conductive and the transistor T_1 becomes conductive again, and current is supplied to the rotor coil. If E_2 becomes the zener voltage when it exceeds the specified voltage, voltage can be regulated intermittently on the basis of this specified voltage.

3.5 IC Regulator

An integrated circuit (IC) is an electronic circuit which is an inseparable combination of circuit elements on a substrate. An IC is a genuine sample of micronization and has a host of features including super compactness, light weight, reliability and economy.

The IC regulator is an all-integrated-circuit version of the transistor regulator. Outstanding features include compactness, and reliability. In addition, ICs can be installed in generators.



(a) Tirrill Regulator (b) IC Regulator

Fig. 3.5 Outside Views of Tirrill and IC Regulators

Fig. 3.5 illustrates the outside views of the Tirrill and IC regulators.

The ICs come in 3 types:

(1) Semi-conductor IC

This is a typical IC which comprises circuit elements formed on or in a semi-conductor substrate and mutual connectors.

(2) Film IC

This comprises a thin or thick film covering circuit elements and all of the mutual conductors integrated on an insulated substrate.

(3) Hybrid IC

The passive elements and wiring of this type of IC are made of film IC. Its active elements are made of individual parts or semi-conductor ICs.

The IC regulator currently available is made of hybrid IC.

3.6 Charge Relay and Field Relay

(1) Charge relay

The charge relay turns charge lights on and off by utilizing the generating voltage of a generator. When the generator is not charging a battery, the charge relay switches the charge light on. When the generator voltage has reached the specified value, the voltage coil turns the charge light off, indicating that the generator is charging.

(2) Field relay

When the engine stops and the key switch is left on, this relay serves to reduce the current flowing in the field circuit. While the generator is not in operation, resistance is inserted into the rotor coil in a series; when the generator begins to turn, and reaches a specified voltage, the resistance is short-circuited. Both the charge relay and the field relay are similar to a voltage regulator in construction.

3.7 Current Limiter, Cut-out Relay

(1) Current limiter
When current flows exceeding a specified value, the point opens, resistance is inserted into the field coil, and the voltage drops, thus preventing the output voltage from exceeding the specified value.
(2) Cut-out relay
This relay is used for DC generator charging circuits. When the generator's rotating speed decreases, and the generating voltage drops, it serves to prevent the occurence of a reverse current from the battery and thereby prevents the occurence of the battery discharging and burning damage to the generator.

4. INSPECTION

4.1 Diode

To test the diode, first check the polarity.
If the polarity is correct, check the diode with the ohmmeter to see whether it is good or bad, as shown in Fig. 4.1.
When the diode is good, the following result should be given:

(1) Black dot marked diode

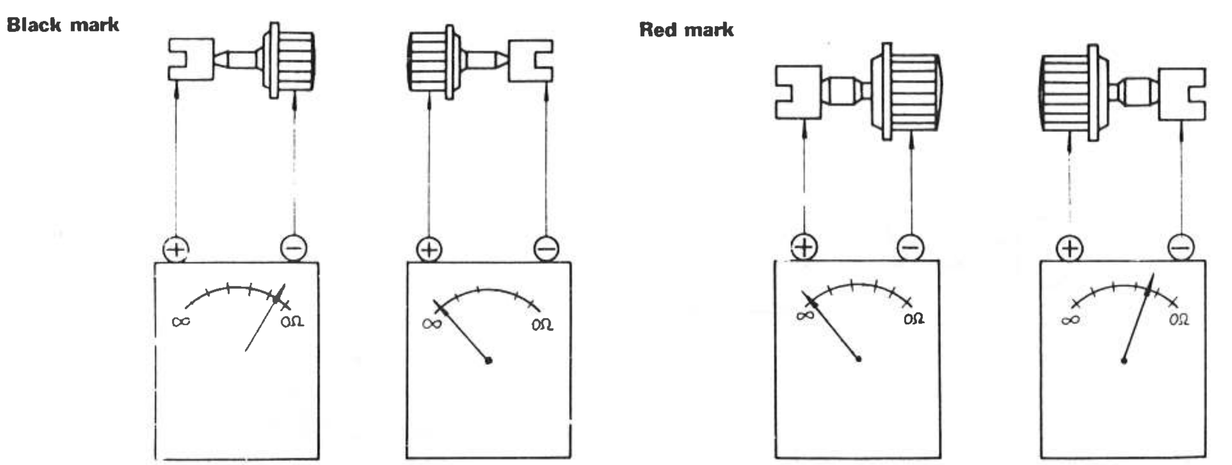
+Ve – terminal -Ve – case	The meter should read
+Ve – case -Ve – terminal	The meter should not read

(2) Red dot marked diode

+Ve – terminal -Ve – case	The meter should not read
+Ve – case -Ve – terminal	The meter should read

a)	Black marked on the case:	Negative base diode
b)	Red marked on the case:	Positive base diode

Continuity test: Between the diode terminals and the case



The meter should read. The meter should not read. The meter should not read. The meter should read.

Fig. 4.1 Testing Diode Continuity

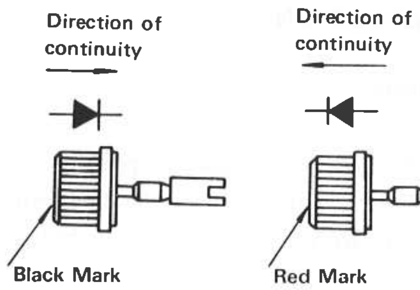


Fig. 4.2(a) Conductive Direction of Diode

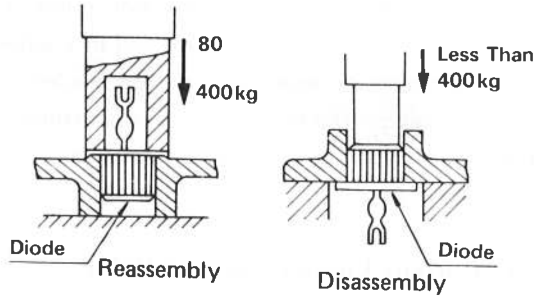


Fig. 4.2(c) Replacement of Diode

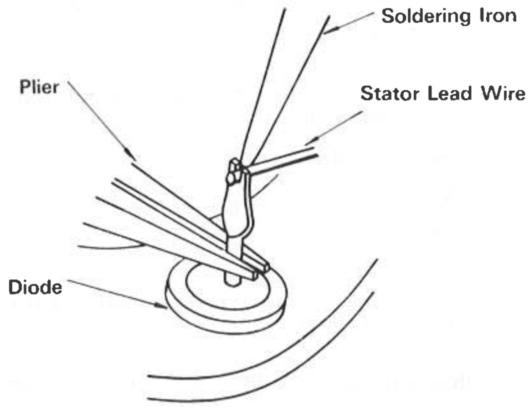


Fig. 4.2(b) Connecting & Disconnecting

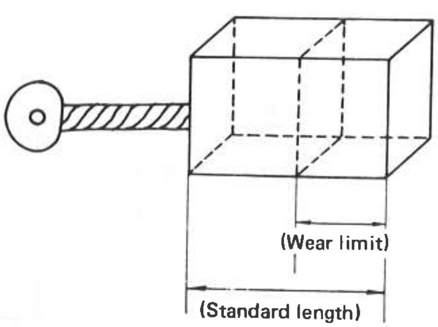
4.2 Brushes

Brush spring pressure and brush length

4.3 Rotor

Continuity test: Between the slip rings
Insulation test: Between the slip ring and the rotor coil

Apply one tester probe to each slip ring. Check the rotor coil for continuity and insulation. If the reading is lower than the specified meter specification, the coil is short-circuited. If the meter indication is higher than the meter specification the coil is open or has poor electrical connection.
Apply a tester probe to either the slip ring or the rotor as shown in Fig. 4.4. Check the rotor for insulation. If the meter pointer deflects, the rotor coil is grounded and should be replaced.



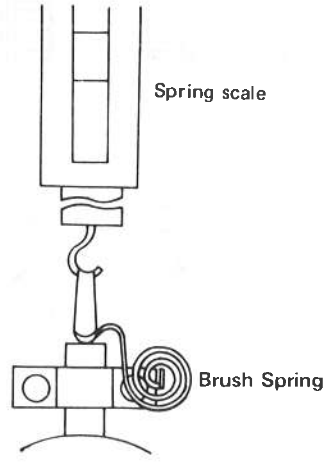


Fig. 4.3 Checking Brush Spring Strength

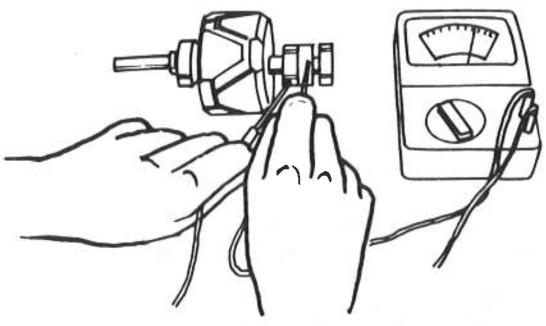


Fig. 4.4 Testing Rotor Coil Continuity

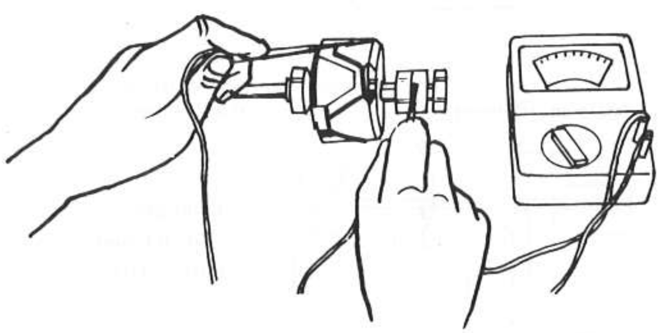


Fig. 4.5 Testing Rotor Coil Insulation

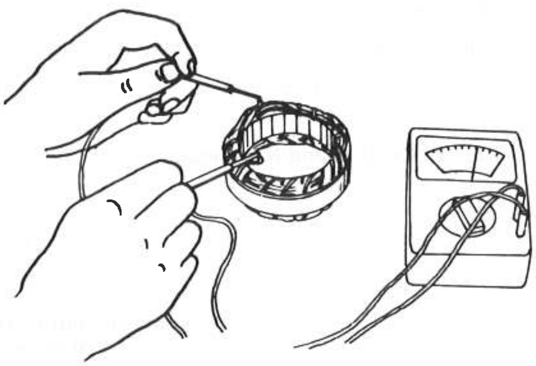


Fig. 4.6 Testing Stator Coil Continuity

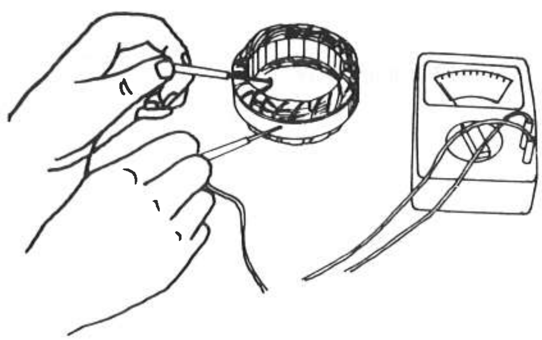


Fig. 4.7 Testing Stator Coil Insulation

4.4 Stator

Continuity test: Between the stator coil terminals (Fig. 4.6)

Insulation test: Between the stator coil terminals and stator core (Fig. 4.7)

To check for continuity, connect the circuit tester probes to two terminals in turn on the stator as shown in Fig. 4.6. If the meter reading is considerably higher than the standard specification, there is a short circuit in the stator winding.
To check the stator coil for insulation, connect one probe to each stator winding and other to the stator frame, as shown in Fig. 4.7. If the pointer deflects, the stator winding is grounded and should be replaced.

4.5 Voltage Regulator

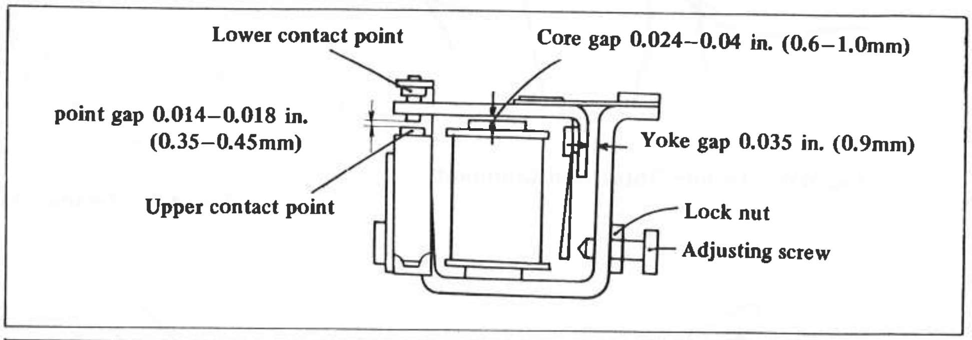
4.5.1 Description of the Voltage Regulator

The voltage regulator regulates the output voltage generated by the A.C. generator at a constant level at all times, regardless of the RPMs of the engine. If it is not adjusted correctly it will result in overcharging or undercharging, which will cause a battery malfunction or malfunction of other components of the electrical system.
The voltage regulator used in this tractor is a Tirrill regulation type unit [except models YM135(D)(T) & YM155(D)(T)]. A Tirrill voltage regulator shorts out or cuts in a registor that is connected in series with the rotor coil through the opening and closing of the

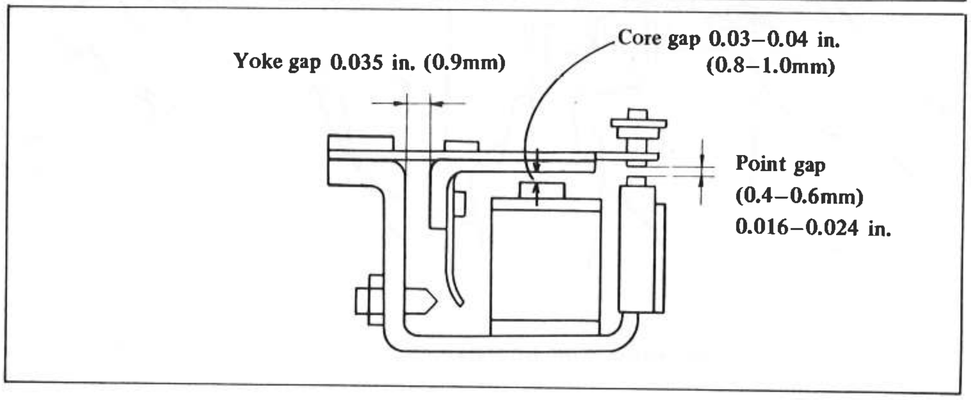
contact points, to regulate the current flow of the rotor coil and maintain the voltage generated by the A.C. generator at a constant level.

4.5.2 Inspection and Maintenance

(1) Voltage Regulator



(2) Charging Relay



After conducting a non-load voltage test, adjust the gaps in the sequence described below.

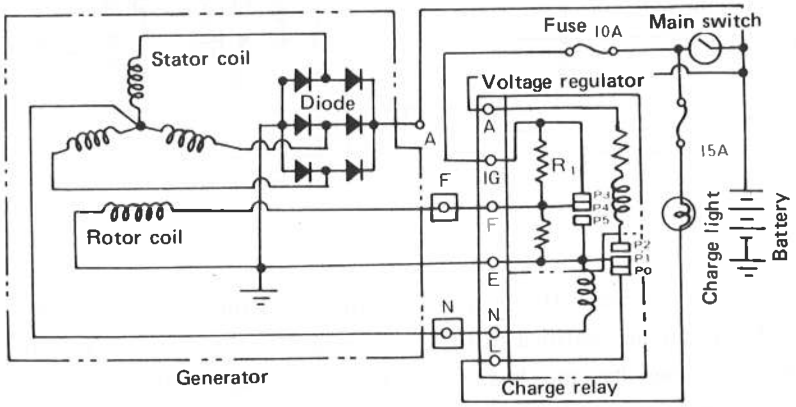
(1) Yoke gap
(2) Core gap
(3) Point gap

Inspect the contact points, and if they are burned or or pitted, polish them gently with an extremely fine grade of sandpaper – #500 to #600.

5. PERFORMANCE TEST [FOR MODELS YM240(T) & YM330(T)]

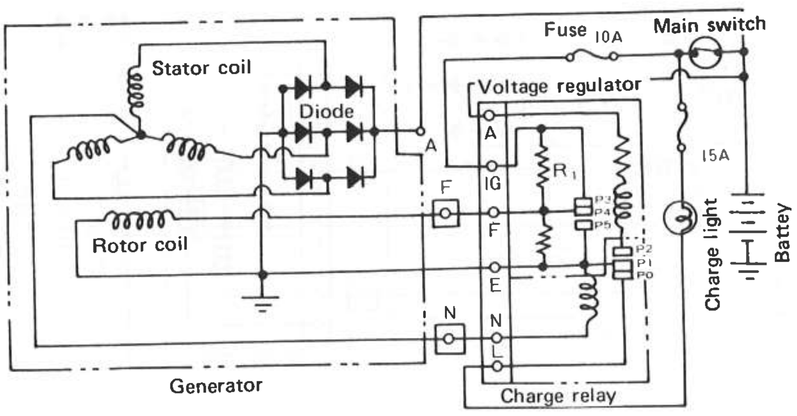
5.1 Description of Motion

5.1.1 Connection Diagram (Generator & Regulator)



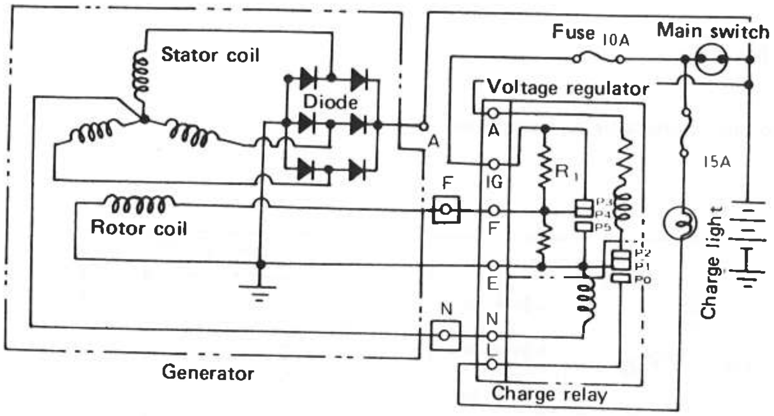
5.1.2 Description of Motion

(1) Main Switch Turned On



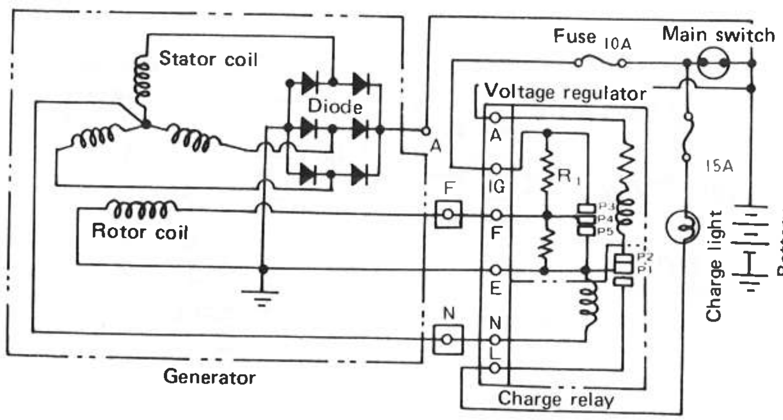
Current from the main switch is shunted into two routes. One is to the regulator IG, voltage regulator contacts P3 and P4 and terminal F and to the rotor coil to magnetize the rotor core. It is then grounded via terminal E. The other flows to the charge light, charge relay terminal L and contacts P0 and P1 to operate the light, and to the ground.

(2) Operation at Low Speed



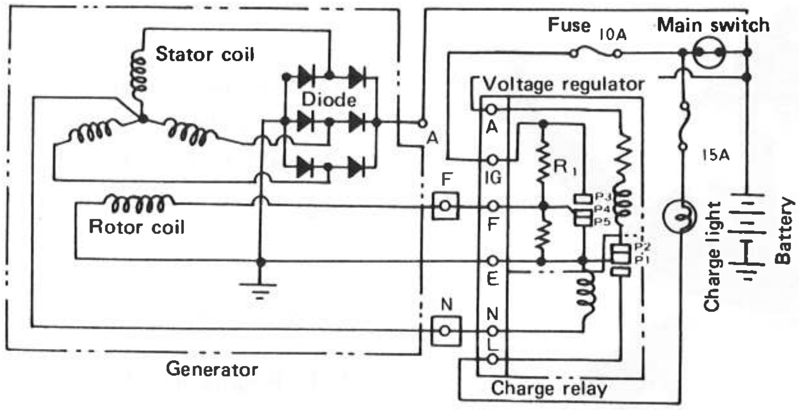
When the engine starts operation, 3-phase AC electricity is generated in the stator coil and rectified to DC electricity diodes. When the voltage becomes higher than the battery voltage, current flows through the terminal A into the battery, i.e., charging is performed. At the same time, of terminal N voltage is applied to the charge relay coil. When it reaches working voltage, contact P1 is attracted to contact P2 and the charge light goes out.

(3) Operation at Medium Speed



When engine speed increases, the voltage coil is excited and contact P4 is attracted to P5, i.e., it is set to the mid-position. At this point, the rotor coil is connected in series to resistor R_1. The current which now flows into the rotor coil decreases and the magnetic force of the rotor is weakend to prevent an increase of generated voltage and to maintain it at a constant level.

(4) Operation at High Speed



When the engine reaches high speed, the attracting force of the voltage coil increases, contact P4 comes in contact with P5 and current flows through resistor R_1 directly into the ground E. As a result, current flowing into the rotor decreases more than in medium-speed operation and the voltage is maintained at a constant level.

5.2 AC Generator Test

When testing the performance of the generator, connect the circuit as shown in Fig. 5.1. Perform the following two tests; cut-in speed and output current.

5.2.1 Cut-in Speed

(1) Turn SW1 ON, (SW2 OFF), bring the generator up to approximately 800 rpm, and turn SW 1 OFF.

(2) Bring the rpm up to the non-load voltage level (14V) and stabilize. The rpm level should exceed the minimum level when in use.

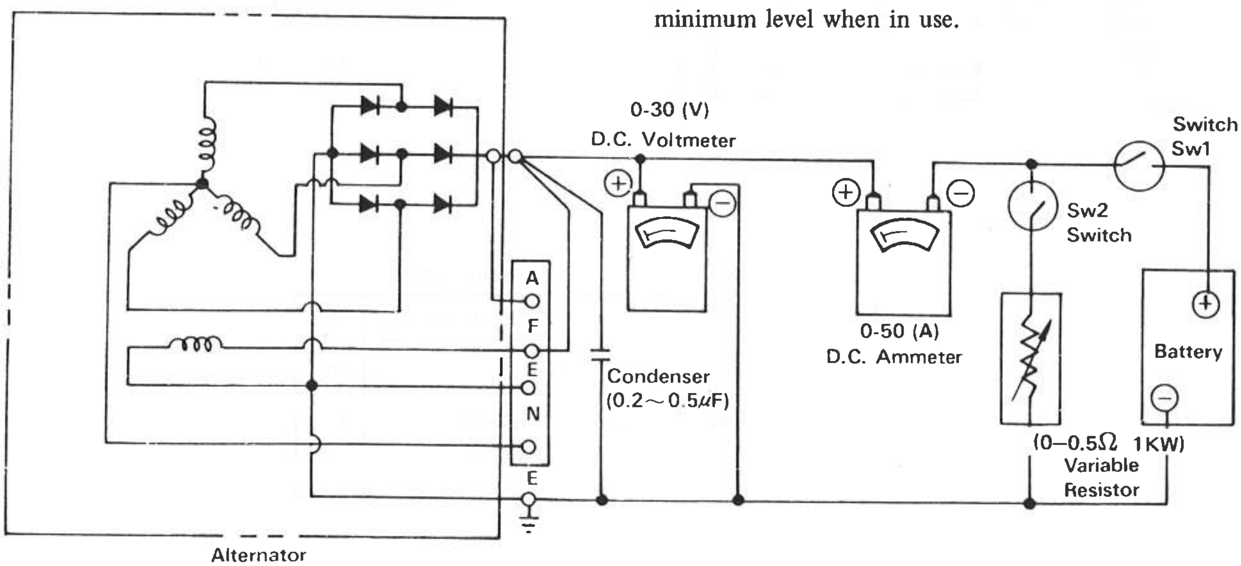
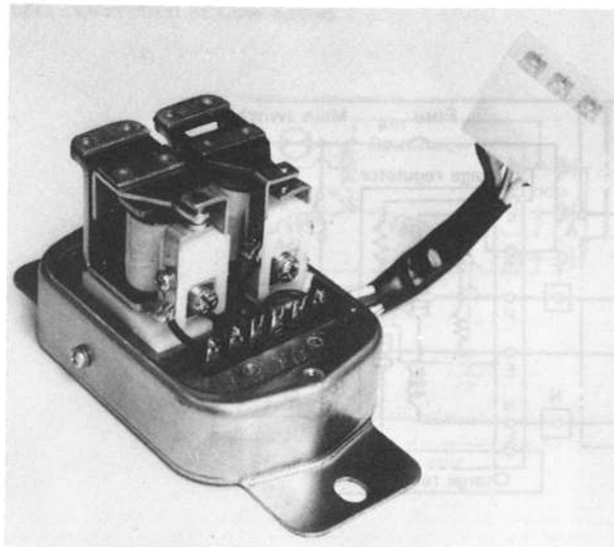


Fig. 5.1 Measuring Circuit for Performance of AC Generator



level when in use.
This is the cut-in speed which should correspond to the specifications.

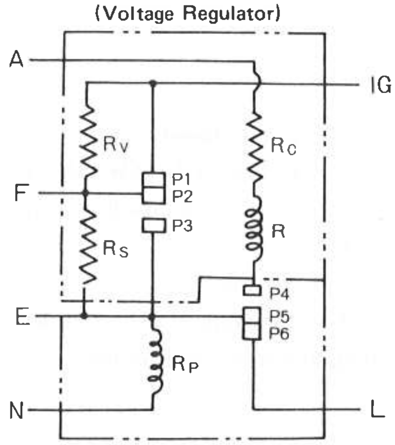
5.2.2 Output Current

Employing the same connections, Sw. 1 is set to the ON position, Sw. 2 to OFF, the rpms of the A.C. generator are increased to the measurement rpm (7,000 rpm), and the variable resistance is set to the maximum resistance. The current flow reading should be 15A or more.

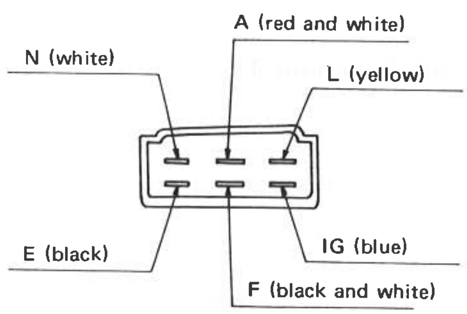
5.3 Regulation Test

5.3.1 Internal Connection and Major Values (Ω) at 20°C (model TLIZ-86)

(Voltage Regulator)



(Charge Relay)



(Connector Arrangement)

Unit: (Ω)

Variable resistor	RV: Resistor inserted into the rotor	10
	RS: Steady resistor	40
	RC: Compensation resistor	31
	R: Potential coil resistor	10.3

Unit: (Ω)

Charge relay	RP: Potential coil resistor	31.9

5.3.2 Measurement of Resistance across Terminals

Measuring Terminal	Status of Charge Relay	Status of Voltage regulator	Resistance in Normal Condition	Indication and Possible Cause in Abnormal Condition
IG-F		At rest	0 Ω	Indication of more than 0 Ω shows contact failure of low-speed points P1 and P2 of the RV.
		Attracted	Approx. 10 Ω	Indefinite indication shows opening of the resistor inserted into the rotor.
L-E	At rest		0 Ω	Indication of more than 0 Ω shows contact failure of low-speed points P1 and P2 of the voltage regulator.
	Attracted		∞ Ω	Any indication other than ∞ shows deposition between P6 and P5.
N-E			Approx. 31.9 Ω	Indication of 0 shows that the potential coil of the charge relay is short-circuited. Indefinite indication shows that the potential coil (RP) of the charge relay opens.
A-E	At rest		∞ Ω	Any indication other than ∞ shows the P4 and P5 of the charge relay are deposited.
F-E	At rest	Attracted	0 Ω	Indication of more than 0 Ω shows contact failure across high-speed points P2 and P3 of the voltage regulator.

5.3.3 Non-Load Voltage Measurement (Voltage the voltage regulator.

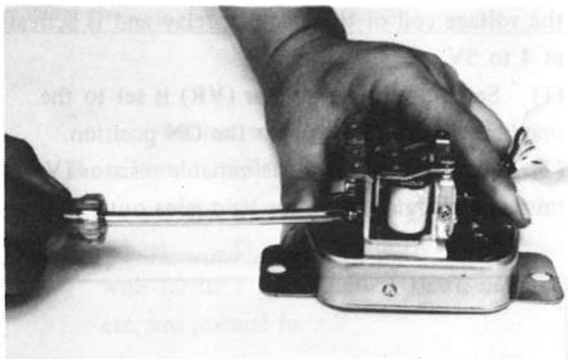
When carrying out a performance test, check to ensure that the regulator is connected to the correct generator. The connection diagram between the generator and regulator is shown in Fig. 5.2.

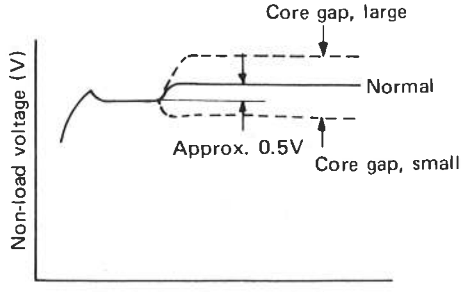
(1) Set the switch to the ON position, apply an exciting current to the rotor coil of the AC generator, and raise the rpm of the AC generator.

(2) As soon as the AC generator reaches the lower limit (800 rpm) of its usable range, shut off the switch.

(3) Raise the rpm of the AC generator to the rated rpm (6,000 rpm), and measure the non-load voltage. It should be anywhere between 13.5 and 14.5V.

If it is more or less than this range, the voltage can be increased by tightening the adjusting screw or reduced by loosening the screw.





Speed-Voltage Characteristics Curve

Model	TL1Z-86
Too much voltage	Loosen the adjusting screw
Too little voltage	Tighten the adjusting screw

When the engine changes operation from low to high speed, the voltage increases approx. 0.5V. When voltage varies by more than 0.5V, the core gap is out of order and needs to be readjusted.

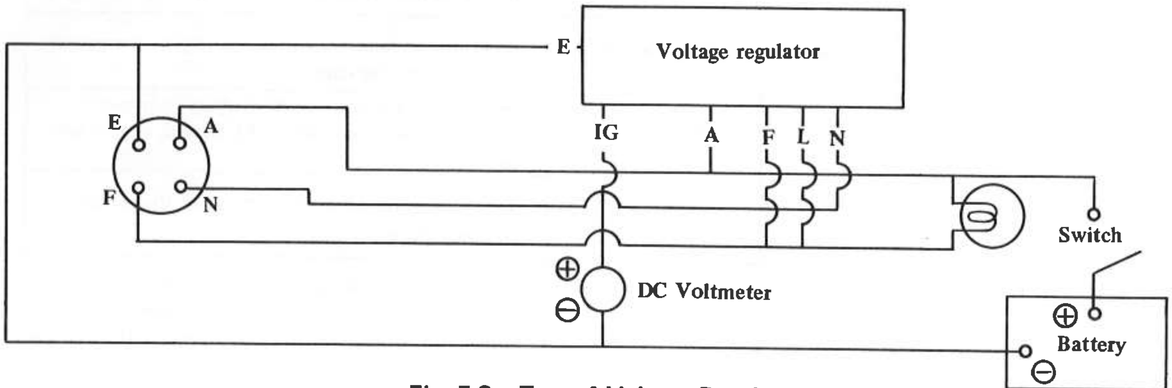


Fig. 5.2 Test of Voltage Regulator

5.3.4 Charge Relay

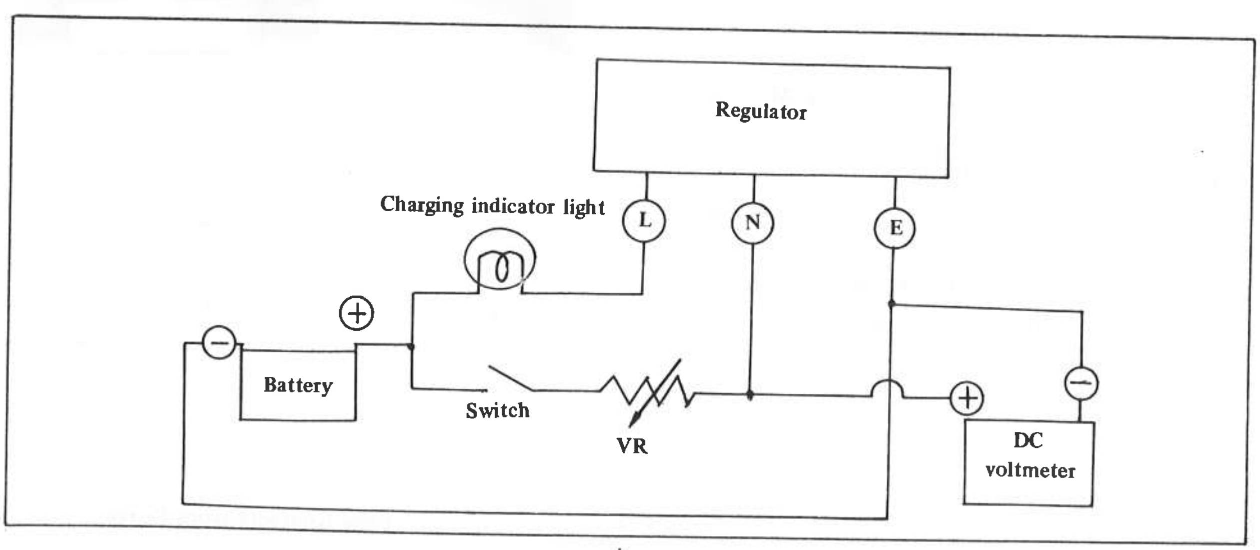
The voltage at terminal A of the AC generator is 8 to 10V. The voltage at terminal N, approximately one-half of the voltage at terminal A, is applied to the voltage coil of the charging relay and is activated at 4 to 5V.

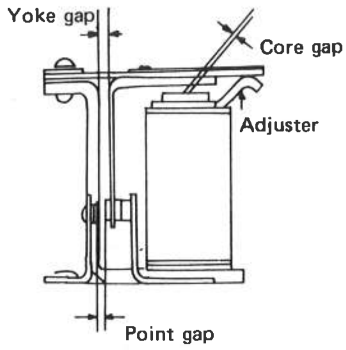
(1) Set the variable resistor (VR) is set to the maximum and the switch to the ON position.

(2) Slowly turn down the variable resistor (VR) until the charging indicator light goes out,and stop there.

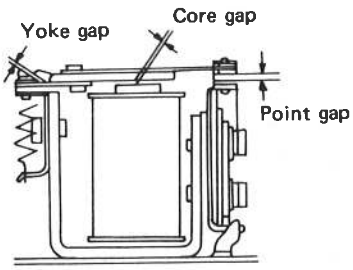
(3) Measure the voltage. It is in good condition if it reads 4 to 5V.

If it is more or less, readjust the yoke gap, core gap, and point gap using the same procedures as those used for the voltage regulator as shown below. The voltage will increase if the voltage adjusting screw is tightened, and will decrease if it is loosened.





(Voltage Regulator)



(Charge Relay)

6. PERFORMANCE TEST [FOR MODELS YM135(D)(T) and YM155(D)(T)

6.1 Specifications

Generator : GP8108 (KOKUSAN)
Current limiter : RS 2130 (KOKUSAN)

1. Rotating direction	Clockwise (viewed from the flywheel side)
2. Operational rotation	1000 rpm – 5000 rpm
3. Allowable rotation	12,000 rpm
4. Charging performance	More than 8.5A/14V at 4000 rpm
5. Rotation for initial charging	Less than 1500 rpm

6.2 Structure

Name : 8-8 pole magneto revolving type generator
Components : For details, refer to Fig. 6.4 and 6.5.

(1) Stator
   A. Armature coil .... Wiring is provided to an 8-pole armature core. Each coil is connected in series.
   B. Plate complete .... Aluminum die cast plate attached with rectifying diodes.

(2) Flywheel .... Throttled plate flywheel attached with ferrite magnet; pulley, shaft, bearing, etc. are pressed in.

6.3 Connecting Diagram

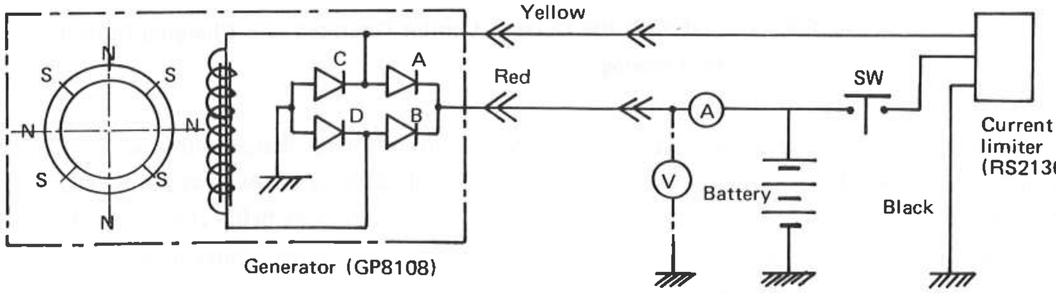


Fig. 6.1 Connecting Diagram (GP8108, RS2130)

6.4 Description of Motions

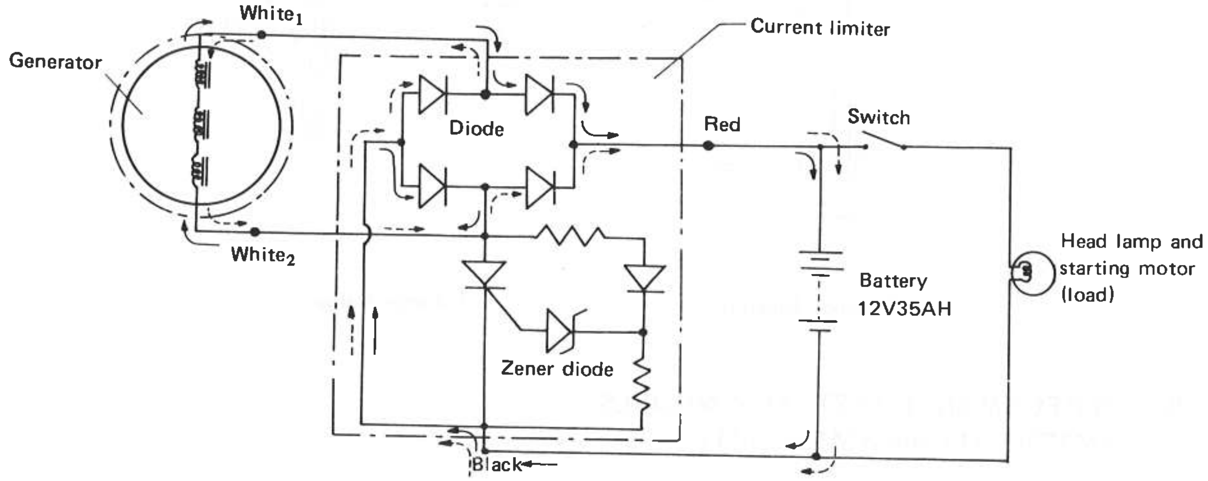


Fig. 6.2 Circuit without the Current Limiter Operated and Charging Current Much Flowing

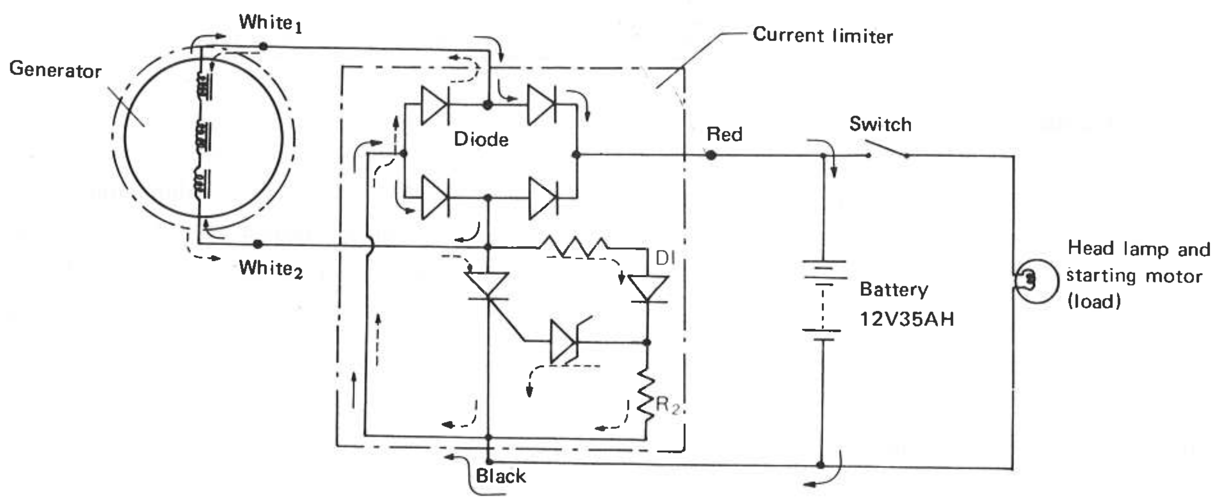


Fig. 6.3 Circuit with the Current Limiter Operated and Charging Current Little Flowing

AC electricity, generated by the generator, is rectified in a full wave to DC electricity [red cord: positive (+) and black cord: negative (-)] through four diodes. When it becomes higher than the battery voltage, it is charged into the battery. When the current being charged increases with the high speed applied, ½ of an AC waveform generated is cut to adjust the current being charged by the action of resistors and zener diodes in the current limiter.

6.5 Inspection and Characteristics

(1) Performance inspection of the generator coupling with the current limiter at the condition shown in Fig. 6.1.

Condition between charge current voltage of battery terminal	Normal	Abnormal	Causes
	1) More than 7A at 14V (without current limiter 2) 7~2A at 14~15.5V (with current limiter)	1) Current: more than 7A Volatge: more than 15.5V	Bad condition of current limiter
		2) No charging current	Bad condition of current limiter and generator
		3) Charging current noted but voltage of battery terminal is low	Bad condition of battery

(2) Separate inspection of generator (Refer to Fig. 6.5)

On Performance

		Normal	Abnormal	Causes
1	Tester indication at: non-load voltage [between lead (+) (red) and generator body unit] Operated (N≒ 4000 rpm)	Approx. more than 28V, DC	Approx. less than 28V, DC	1) Diode is bad 2) Open circuit in armature coil
2	Continuity check by tester [between lead (red) and grounding]	Continuity / No continuity	Continuity / Continuity	Diode is bad
			No continuity / No continuity	Diode is bad Break of lead
	[Diode check]			
	Diode A—lead (red)	No continuity / Continuity	Continuity (no continuity) / Continuity (no continuity)	Diode is bad (break or short circuit)
	Diode B—lead (red)	No continuity / Continuity	Continuity (no continuity) / Continuity (no continuity)	
	Diode C—grounding	Continuity / No continuity	Continuity (no continuity) / Continuity (no continuity)	
	Diode D—grounding	Continuity / No continuity	Continuity (no continuity) / Continuity (no continuity)	

	[Armature coil] Diode terminal A–B	Continuity	No continuity	Break of circuit
3	[Insulation resistance] at: 500V Mega tester Lead (red)–grounding	More than 3MΩ	Less than 3MΩ	Bad insulation at armature coil

On Rotating Condition of Flywheel

	Normal	Abnormal	Causes
When flywheel rotated manually	Magnetic stress felt 8 times per one rotation. Rotates comparatively smooth	Noise accompanies with rotation	Bearing is bad. Distortion of flywheel
		No magnetic stress is felt. Light rotation	Lowering, or failure of magnetic energy of of flywheel

6.6 Cautions for Handling and Assembly

	Cautions	Resulting failures
1	Do not improperly wire to the battery. Confirm (+) & (-), and coloring of leads	Short-circuit of battery 1) Burning of generator diode 2) Burning of generator coil 3) Burning of current limiter
2	Do not operate at less than the specified speed	Burning of the generator coil Failure of the current limiter
3	Do not tighten the belt excessively	Broken pulley & generator bearing
4	Avoid shocks and large stress to the peripheral of the flywheel	Distortion of the flywheel
5	Do not hang the lead wire	Break of the lead wire
6	Do not operate out of the specified assembly condition (the cooling fan must always be operating properly).	Burning of the current limiter & the generator
7	Do not pour water in the generator unit	Short-circuits of the generator Damage to bearing
8	During disassembly and reassembly, tighten the shaft to the required torque – 25 kg-cm to 300 kg-cm.	Damage to the flywheel by the loosening of screws
9	Use rated or genuine parts for the replacement of bearings	To prevent damage to the bearings
10	Use genuine parts for the replacement of generator diodes	To prevent the diodes from bearing

6.7 Instructions for Disassembly and Reassembly

(Disassembly)

1) Remove the hexagon nut (C) .....
   (When adjusting the top of shaft (*side); do not put any stress on the flywheel)
2) Dismantle flywheel (a) .....
   (Tap lightly the top of the shaft with a wooden hammer)
3) Separate the lead wire from each diode terminal (A, B, C, D) with a soldering iron .....
   (do not apply the soldering iron to the terminals for a long time because it may damage the diodes)
4) Remove set screws (h), and proceed to diodes.
5) First remove set screw (d), and remove armature coil.

(Reassembly)

Follow the above instruction in reverse order.

6.8 Maintenance and Inspection

1) Do not keep the unit in storage where it is dusty, damp, and a high temperature condition is present.
2) In case dust, dirt, water, oil, etc. are deposited on the generator and lead connections, clean the generator before use.
3) Keep the appropriate belt tension, and avoid belt slippage.

[Current Limiter]

This is coupled with the generator. Refer to each section of the generator, for the specifications, diagram, and handling instructions.
The current limiter forms one unit in a resin mold. In the case of the failure, replace the limiter as a unit.

[Inspection of Current Limiter]

Refer to the circuit diagram of Figs. 6.1 and 6.4

1) Check the continuity between the red lead and the black lead with tester.

Normal	Continuity noted / No continuity	
Abnormal	Continuity noted / Continuity noted	No continuity / No continuity

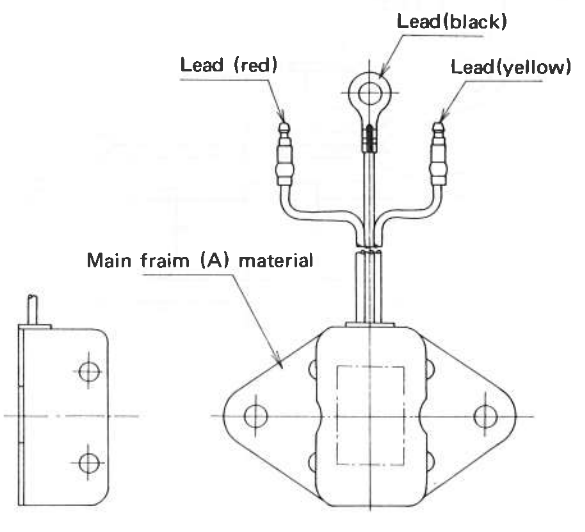


Fig. 6.4 Current limiter

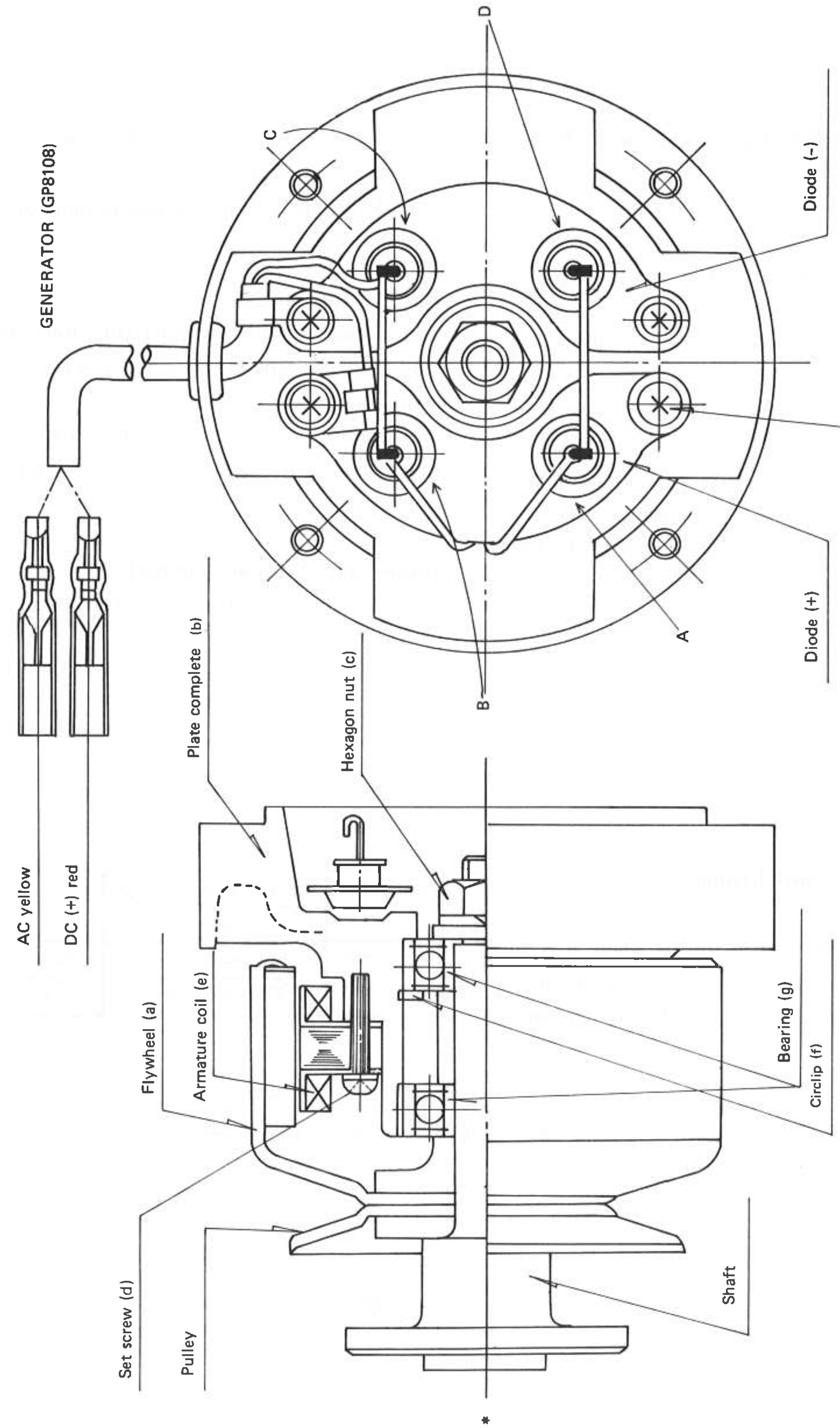

GENERATOR (GP8108)
AC yellow
DC (+) red
Plate complete (b)
Hexagon nut (c)
Flywheel (a)
Armature coil (e)
Set screw (d)
Pulley
Shaft
Bearing (g)
Circlip (f)
Diode (-)
Set screw (h)
Diode (+)
A
B
C
D

Fig. 6.5

7. TROUBLE SHOOTING

7.1 No Charging

Defective Point	Cause	Remedy
Wiring and ammeter	Opening, short-circuit or connection failure of the connector	Repair or replace.
Generator	Opening, grounding or short of each coil Insulation failure of terminals Silicon diode faulty	Replace. Repair. Replace.
Regulator	Short or opening of leads Regulating voltage is lower than the specified voltage	Repair or replace. Re-regulate the voltage.

7.2 Battery tends to discharge due to deficient charging

Defective Point	Cause	Remedy
Wiring	Early status of opening or short, or connector is loose	Repair or retighten.
Generator	Blowing or contact failure of the fuse Opening or contact failure between the ignition switch and regulator terminal IG Layer short (internal short) of the rotor coil Layer short of the stator coil Single-phase wire opening of the stator coil Slip ring fouled V belt is slipping Improper brush contact Punctured diode	Repair. Repair. Replace. Replace. Replace. Clean or regrind if required. Re-adjust tension. Repair. Replace.
Regulator	Regulating voltage is lower than the specified voltage. Point fouled or high-speed point deposited (low-speed point) Internal short of coil resistor	Re-adjust the voltage. Replace or repolish. Replace.
Battery	Insufficient electrolyte or of improper quality Plate faulty	Add distilled water or re-adjust specific gravity. Replace.

7.3 Overcharging due to excess of charge

Defective Point	Cause	Remedy
Wiring	Shunt generator is formed due to short circuit across terminals A and B circuits	Repair.
Battery	Internal short circuit	Replace.
Regulator	Regulating voltage is too high Regulator improperly grounded Coil lead opens Charge relay is not cleared. Low-speed point deposited High-speed point fouled	Re-adjust it. Completely ground it. Repair or replace. Re-adjust. Replace. Re-polish.

7.4 Charge current unstable

Defective Point	Cause	Remedy
Wiring	Short circuit occurs at broken sheath due to vibration of tractor or opening part is held by sheath and occasionally comes in contact	Repair or replace.
Generator	Early layer short Brush spring damaged Slip ring fouled Early coil opening	Replace. Replace. Clean. Repair or replace.
Regulator	Regulating voltage is out of specification Key switch faulty Points fouled	Re-adjust. Replace. Clean.

7.5 Charge light does not come on

Defective Point	Cause	Remedy
Charge relay	Charge relay has contact failure or opens Points fouled	Repair or replace. Re-polish.

Note: Before deciding a charge fault using an ammeter, check to be sure that the ammeter is correct.

8. SERVICING VALUE

AC Generator

Applicable engine models		YM240(T)		YM330(T)
		OLD	NEW	
Manufacturer		Hitachi	⇐	⇐
Manufacturer's code		• LT110-04	LT115-52	⇐
Yanmar code		124560-77200	124756-77200	⇐
Combinated regulator	Manufacturer's code	TL1Z-86	⇐	⇐
	Yanmar code	124550-77710	⇐	⇐
Output (V/A)		12V 10A	12V 15A	⇐
Usable speed (rmp)		2000-10000	1500-13500	⇐
Rated speed (rpm)		7000	7000	⇐
Output current (A)/Voltage (V) at speed (rpm)		9/14-5000 10/14-7000	8/14•2500 15/14•7000	⇐
No load voltage (V)/Speed (rpm)		14/less than 2000	14/less than 1500	⇐
Direction of rotation (from pulley side)		Clockwise	Clockwise	⇐
Ground polarity/Weight (kg)		Negative/3.2	Negative/3.4	⇐
Pulley	Belt/Pulley outer dia. (mm)	A single/63	A single/69	⇐
	Pulley ratio	2.31	1.81	⇐
Resistance at 20°C	Rotor coil (Ω)	13.5	9.8	⇐
	Stator coil (1-phase) (Ω)	0.19	0.14	⇐
Brushes	Spring strength (kg)	0.3±15%	⇐	⇐
	Standard length/Wear limits (mm)	14.5/7	⇐	⇐
Slip-ring	Standard outer dia./Wear limits (mm)	31/1	⇐	⇐
	Correct limits/Correct accuracy (MM)	0.3/0.05	⇐	⇐
Shaft	Drive end Outer dia. (mm)/Bearing	15/6202SD	15/6202B	⇐
	Rear end Outer dia. (mm)/Bearing	12/6201SD	⇐	⇐

Regulator

Applicable engine models		YM240(T)	YM330(T)
Manufacturer		Hitachi	⇐
Manufacturer's code		TLIZ-86	⇐
Yanmar code		124550-27710	⇐
Battery terminal voltage (V)		12	⇐
Control system		Tirrill	⇐
Ground system		Negative	⇐
Ground polarity/Weigth (kg)		Negative/0.39	⇐
Voltage regulator	Adjusting voltage	14.0±0.5	⇐
	Yoke gap (mm)	0.9	⇐
	Core gap (mm)	0.6~1.0	⇐
	Point gap (mm)	0.35~0.45	⇐
Relay	Operating voltage (V)	8~10 (CR. GN. A terminal)	⇐
	Yoke gap (mm)	0.9	⇐
	Core gap (mm)	0.8~1.0	⇐
	Point gap (mm)	0.4~0.6	⇐
Temperature grade V/°C		–	⇐
Model of interchangeable		–	⇐
Condition of adjustment		Charging current less than 5A	

Generator & Regulator

Applicable tractor models		YM135(D)(T) *	YM155(D)(T)
		OLD	NEW
Manufacturer		KOKUSAN	
Generator	Manufacturer's code	GP8106	GP8108
	Yanmar code	124064-77200	124660-77201
Combinated regulator	Mfg. code	RS2133	RS2130
	Yanmer code	124064-77710	124660-77710
Output (V-A)		12-8	12-8.5
Usable speed (rpm)		1000–5000	←
Rated speed (rpm)		4000	←
Output current (A)/Voltage (V) at speed (rpm)		8/14-4000	8.5/14-4000
No load voltage (V)/Speed (rpm)		–	–
Direction of rotation (from pulley side)		Clockwise	←
Ground polarity		Negative	←
Pulley	Belt/pulley outer dia. (mm)		
	Pulley ratio		

9. STARTER DYNAMO (Reference)

9.1 Composition

The starter dynamo is composed of a starter motor for starting and a generator to charge the battery. It operates in combination with a voltage regulator and a magnetic switch.

9.2 Operation

Operation of the starter dynamo is explained in the following paragraphs.

9.2.1 Motor

(1) When the main switch is turned to the START position, current flows through the magnetic switch coil, which activates the magnetic switch to ON.

(2) When high current flows through the series field coil, the shunt field coil will be excited by current flowing through the lower contacts of the voltage regulator.

In this manner, the motor operates as a compound motor, generating high torque.

(3) If the main switch is turned OFF after the engine has started (the main switch is in the ON position), the series coil will no longer receive excitation voltage

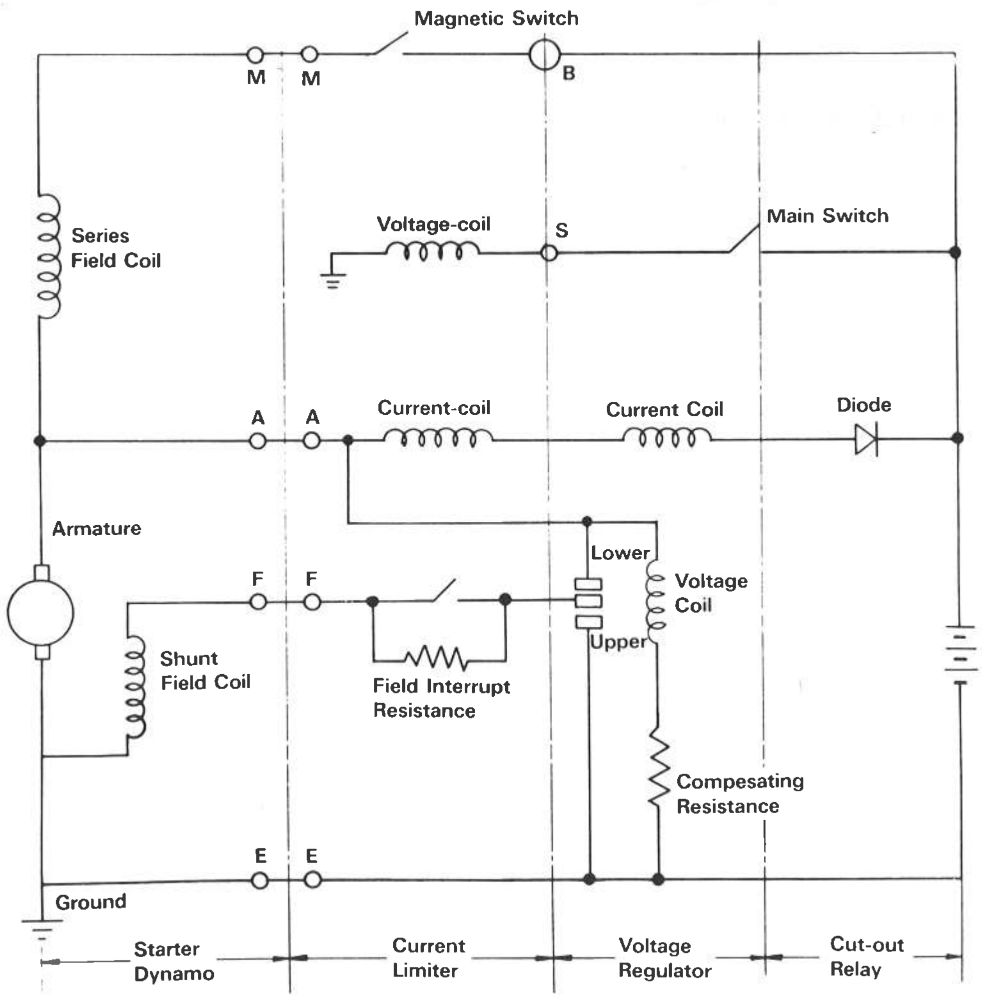


Fig. 9.1 Schematic Lyaout of Starter Dynamo Electrical Circuit

and the motor will operate as a shunt dynamo.

9.2.2 Regulator

The same as previously mentioned (Chapter III 4.5).

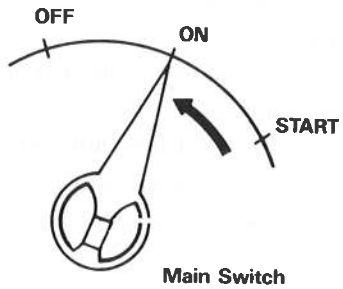


Fig. 9.2 Main Switch

IV. OTHER EQUIPMENT

IV. OTHER EQUIPMENT

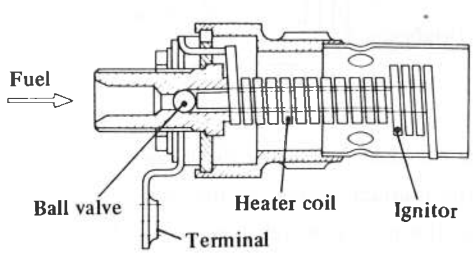
1. Thermostart
2. Water Temperature Indicator Light
3. Charging Indicator Light
4. Engine Lube Oil Pressure Indicator Light
5. Turn Signal Light
6. Horn
7. Lights
8. Safety Switch
9. Main Switch
10. Fuse
11. Bulb Capacity
12. Electric Wiring Diagram

1. THERMOSTART

Item	Specifications
Type	SH100-02 (Hitachi) Magnetic valve type
Voltage	12V
Current flow	13A

1.1 Description of the Thermostart

The thermostart is a starting aid for use in low ambient temperatures. It ignites and burns fuel in the intake manifold to warm the air intake and improve starting qualities. The thermostart, unlike glow plugs, is not exposed to the combustion heat of the engine during operation and therefore provides outstanding durability, and since its consumption of electricity is lower than that of glow plugs, the load on the



battery is reduced.

(1) Thermostart switch is set to the ON position.
This activates the heater coil.

(2) Valve stem moves.
This opens the ball valve.

(3) Fuel flows through the ball valve, and volatilizes because of heat from the heater coil.

(4) Volatilized fuel is ignited by the ignitor.

(5) Set the thermostart switch to the OFF position to switch off the electricity and the heater will cool off.
This will close the ball valve.

(6) Fuel will cease to flow
Fuel is stored in the header tank, and is fed to the thermostart plug by gravity.

1.2 Operation

(1) Throttle lever is set to the STOP position.

(2) Decompression lever is operated.

(3) Clutch pedal is depressed, and the starter motor is operated for five seconds (until lube oil indicating light goes out.)

(4) Restore decompression lever to position providing compression.

(5) Open the throttle above halfway.

(6) Press the thermostart switch for 5 to 10 seconds (in the ON position) and turn the starter motor.

Note: In the case of model YM330(T), turn the starter key switch for 5 to 10 seconds to the "TS" position.

(7) As soon as the engine start up, switch off the thermostart, and remove your hand from the starter key switch (the main switch will automatically revert from the START to the ON position).
tion).

Note: Model YM330(T), remove your hand from the starter key switch, and turn the key switch to the "START" position immediately.

2. WATER TEMPERATURE INDICATOR LIGHT

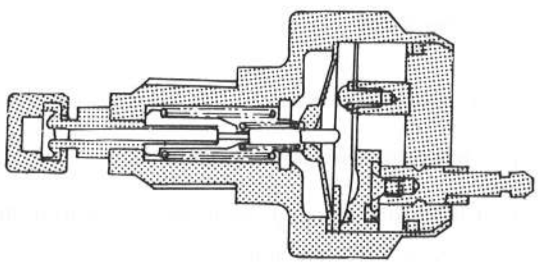
2.1 Specifications

Water temperature unit

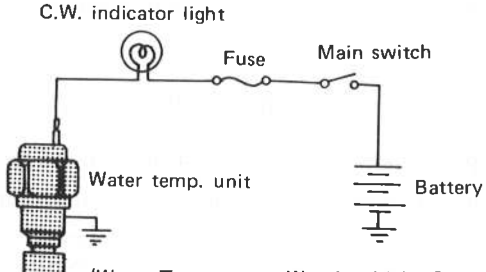
		YM135(D)(T) YM155(D)(T)	YM240(T) YM330(T)
Working temp.	ON	120±3°C	110±3°C
	OFF	112±3°C	102±3°C
Current capacity		DC12V, 7A	DC12V, 7A
Unit Identification color		black	gray

C.W. indicator light

Bulb	12V–3.4W



(Water Temperature Unit)



(Water Temperature Warning Light Circuit)

3. CHARGING INDICATOR LIGHT

The functioning of the charging indicator light has already been explained in Chapter III in the section on the voltage regulator.

(1) The light goes on when the starting switch is turned to the ON position.

(2) When the engine starts up, electricity is generated by the AC generator; and when the prescribed voltage is reached, the charging relay is activated to extinguish the charging indicator light.

4. ENGINE LUBE OIL PRESSURE INDICATOR LIGHT

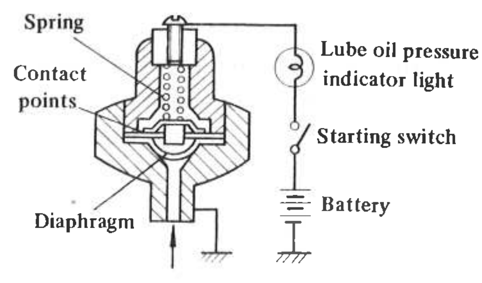
4.1 Specifications

Item	Specifications
Oil pressure switch	Activating pressure ($1 kg/cm^2$)
Lube oil pressure indicator light	12V – 3.4W

4.2 Description of Lube Oil Pressure Indicator Light

The lube oil pressure regulating valve fitted inside the lube oil filter (cartridge type) is adjusted to specified value, while the relief valve is set to activate at a pressure of specified value.

The lube oil switch is fitted at the lower part of the cylinder block, to the left of the lube pipe. It is activated when the lube oil pressure drops, at which time the indicator light goes on.



The oil pressure forces the diaphragm upwards to open the contact points, so that when pressure is normal, the indicator light turns off. When the oil pressure drops and the diaphragm is being forced up

Even when the main switch is turned ON, the light does not goes on.	1. Fusing	* change the fuse.
	2. Ground the terminal of the oil pressure switch 2.1 lights up	* change the oil pressure switch (Note) Check the engine oil level.
	2.2 does not light up	* repair the light and wiring.
The light does not go out when the engine is in operation	3. The oil pressure is low	* check up the oil pressure, repair
	4. The engine oil is low	* Supply oil.
	5. The oil pressure switch malfunctioning	* change the switch.
	6. Ground between the light and the pressure switch	* repair the wire harness.

to keep the contact points open, the points close to allow electricity to flow so that the indicator light will turn on.
Thus, when the starting switch is moved to the ON position, the indicator light goes on since there is no oil pressure, but once the engine starts up and oil pressure rises, the light will go off. This is the normal, correct condition.

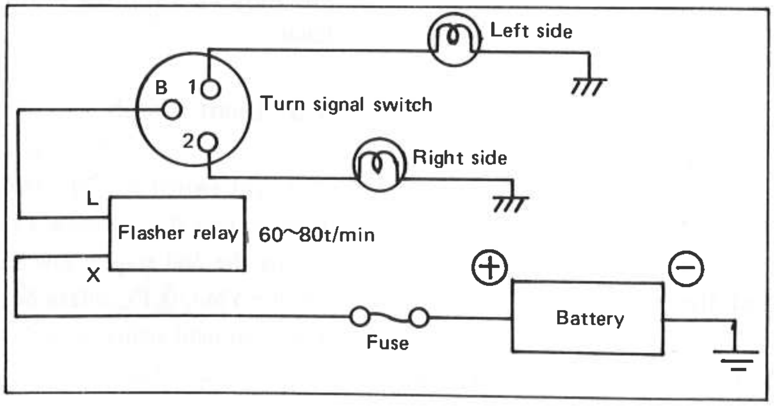
5. TURN SIGNAL LIGHTS

5.1 Specifications

Item	Specifications
Flasher relay	12V–23W heat band snap type
Signal lights	12V–20W
Counting	70 ± 10 t/min
Counting ratio	30 ~ 75% at 11 ~ 13V
Starting time	less than 1.7 second at 12.8V

5.2 Description of Turn Signal Lights

The turn signal lights comprise the turn signal switch, the flasher relay, and the signal lights.
The flasher relay is a heat band snap type; it opens and closes a pair of contact points through expansion



resulting from a rise in the temperature of the heat band.

5.3 Turn Signal Switch

Inspect the turn signal switch in the following manner, after removing the lead wire connected to the terminals (B)-(1) and -(2).

(1) Place the SW in the neutral position.
Measure the insulation between
B-2
B-1
1-2
With a tester, and confirm the insulation among the three; the switch is normal if continuity is not found.

(2) Turn the SW on the (1) side (left) . If there is continuity in the B-1 interval, and there is no continuity in the B-2 and 2-1 intervals, the switch is normal.

(3) Turn the SW on the (2) side (right).
If there is continuity in the B-2 interval, and there is no continuity in the B-1 and 1-2 intervals, the switch is normal.

When using a light with a larger than standard capacity, the frequency of the on/off switchings increases; when a light with a small capacity is used, the frequency decreases. When using a light whose right and left capacities differ from each other, the right and left frequencies will not coincide.

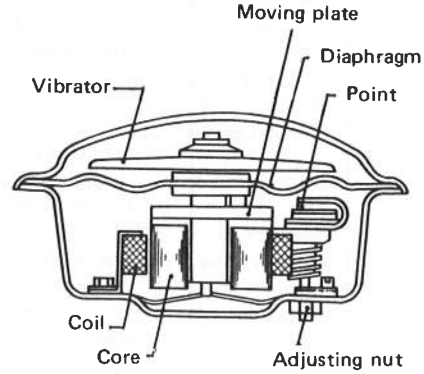
6. HORN

6.1 Specifications

Voltage	12V
Current flow	less than 1.2A
Sound level	100dB ± 2
Frequency	440 Hz ± 20

6.2 Description of the horn

When the horn button is depressed, electricity flows



through the coil of the horn, the core of the coil is magnetized, the moving plate is drawn towards the core, and causes the diapharagm that is coupled to the plate to move and open the contact points. The flow of current therefore is cut off. Through a repetition of this cycle, the vibrator vibrates to generate sound.

7. LIGHTS

7.1 Headlights

The headlights consist of low-high beam dual filament bulbs. Switching between low and high beams is accomplished by the lighting switch.

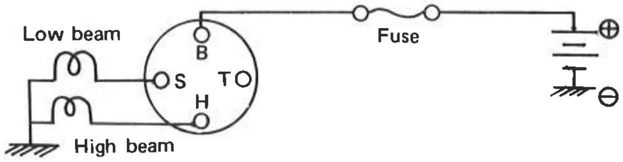
7.2 Work light

The work light is fitted to the rear part of the right fender.

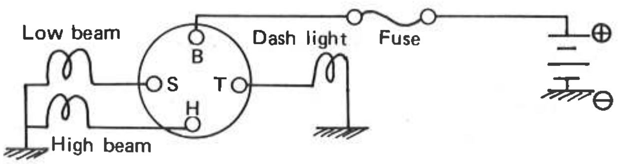
7.3 Light switch

The light switch is of the two-stage, change-over type; during the 1st stage a high beam lights up, and during the 2nd stage a low beam lights up.
On the YM330(T), a dash-board light is incorporated. The dash light lights up while the light is at either at the 1st or 2nd stage.

(1) YM135(D)(T), YM155(D)(T), YM240(T)



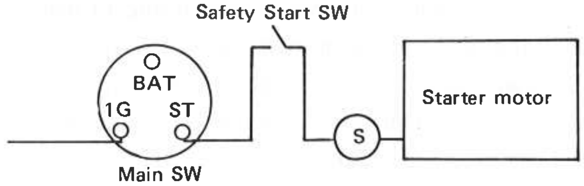
(2) YM330(T)



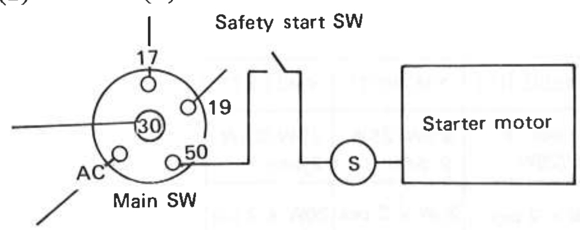
8. SAFETY START SWITCH

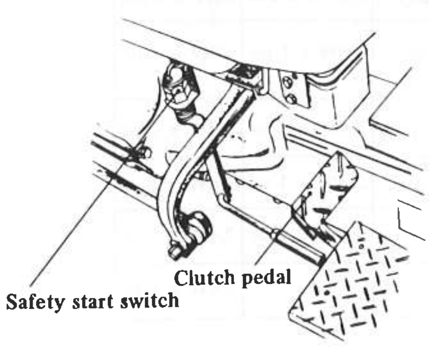
The safety start switch is provided for added safety of the tractor and prevention of accidents. When the clutch pedal is depressed (when the clutch is disengaged), the safety switch incorporated in the starter motor system circuitry closes to facilitate starting of the tractor.

(1) YM135(D)(T), 155(D)(T), 240(T)



(2) YM330(T)

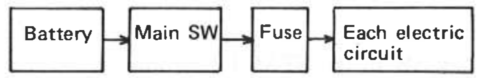




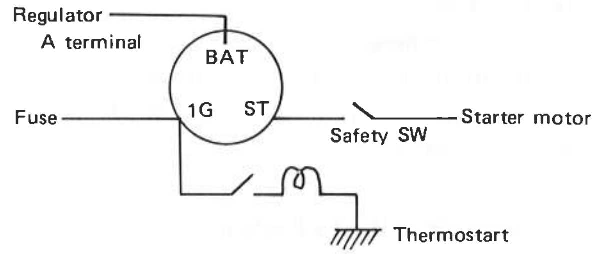
9. MAIN SWITCH

9.1. Construction

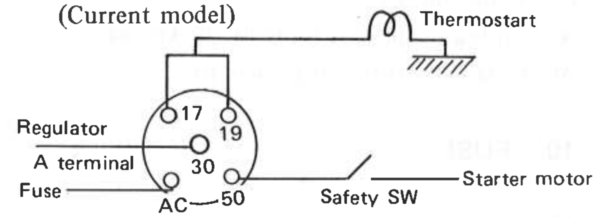
In forming the electric circuits, the main switch should be incorporated as follows:



(1) YM135(D)(T), YM155(D)(T), YM240(T) (Former model)



(2) YM135(D)(T), YM155(D)(T), YM240(T) & YM330(T) (Current model)



9.2 Inspection

Inspect the main switch in the following manner: After removing each terminals. Measure each terminal interval by using a tester. If the following results are obtained, the main switch is functioning normally.

(1) Key SW in the OFF position

(a) for 3 terminals

No continuity in any of the following:

BAT-1G

BAT-ST

ST-1G

(b) for 5 terminals

On 3 terminals, no continuity should be found in any of the 2-terminal intervals.

(2) Key SW in the ON Position

(a) for 3 terminals

Continuity for the BAT-1G interval. No continuity for the BAT-ST and 1G-ST intervals.

(b) for 5 terminals

Continuity for the 30-AC interval. No continuity for the 30-17, 30-19, 30-50, 17-19 and 19-50 intervals.

(3) Key SW in the START Position

(a) for 3 terminals

Continuity for any of the BAT-ST, BAT-1G and 1G-ST intervals.

(b) for 5 terminals

Continuity for the 30-50 and 30-AC intervals. No continuity for the 30-19, 30-17, 50-19, 50-17, AC-17 and AC-19 intervals.

(4) Key SW in the TS Position (YM330 (T) only)

Continuity for 30-19

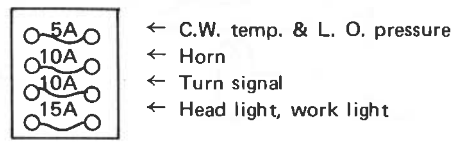
No continuity for 30-17, 30-50, 30-AC, AC-50, AC-A, AC-17, 50-19, 50-17 and 19-17

10. FUSE

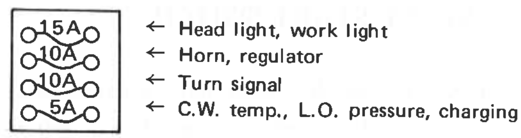
The fuse is provided in order to protect the circuit, i.e., the electrical equipment cannot be damaged directly during periods of trouble, as in the case of a short-circuit.

If a fuse with a specified capacity is not used, the fuse will often be subjected to fusing, thus damaging the electrical equipment directly.

If a fuse with a specified capacity is used and fusing occurs, the fuse must be changed, either the fuse must be changed or the causes behind the fusing must be investigated.



[YM135(D)(T), YM155(D)(T)]



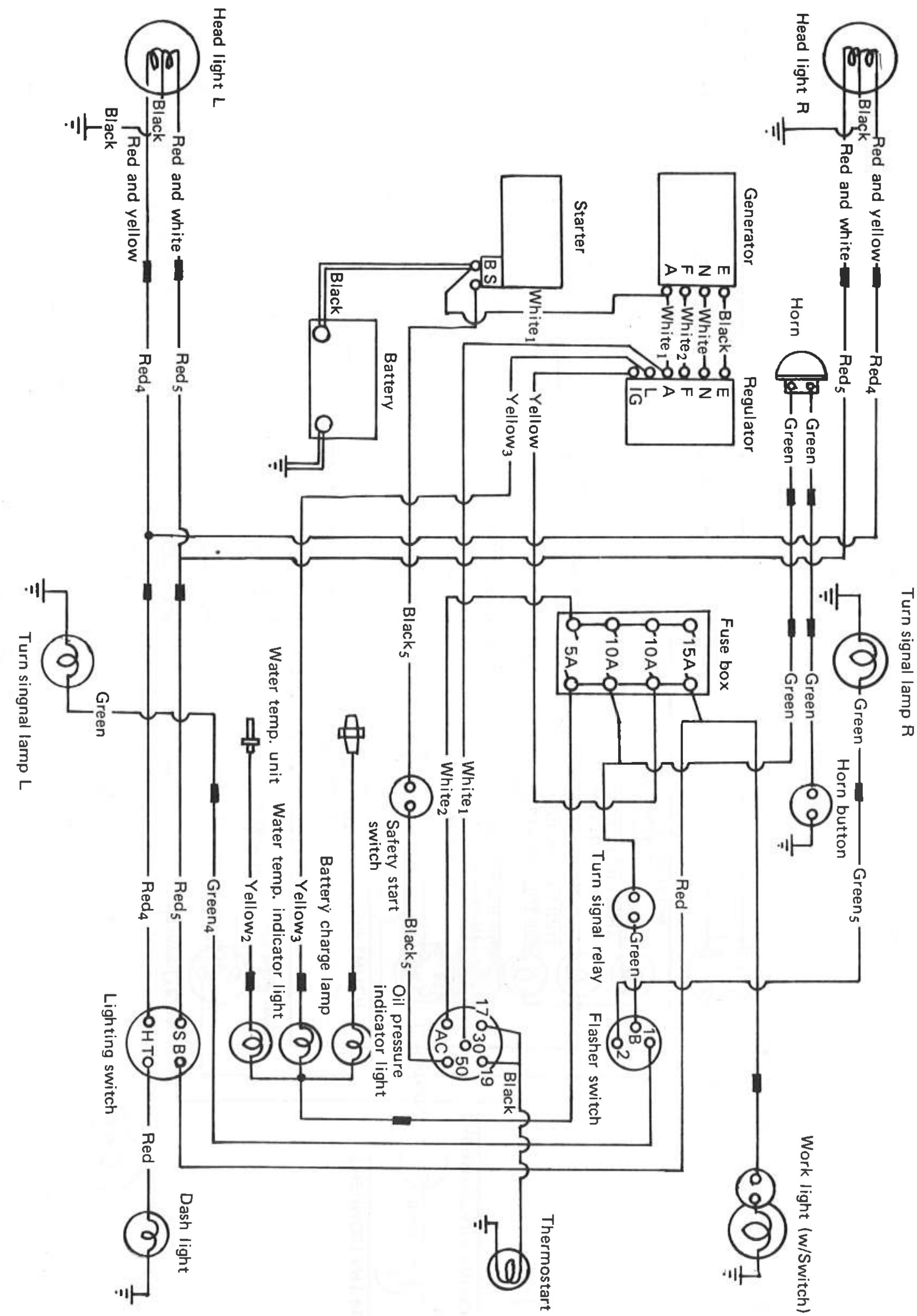
[YM240(T), YM330(T)]

11. BULB CAPACITY

As explained above, it is necessary to use lights with a specified capacity; otherwise, either fusing, or increases/decreases in the going-on/off frequency of the turn signal will occur. These troubles violate traffic regulations and hinder efficient service or operation and can even cause serious problems. The table below indicates the specified capacities.

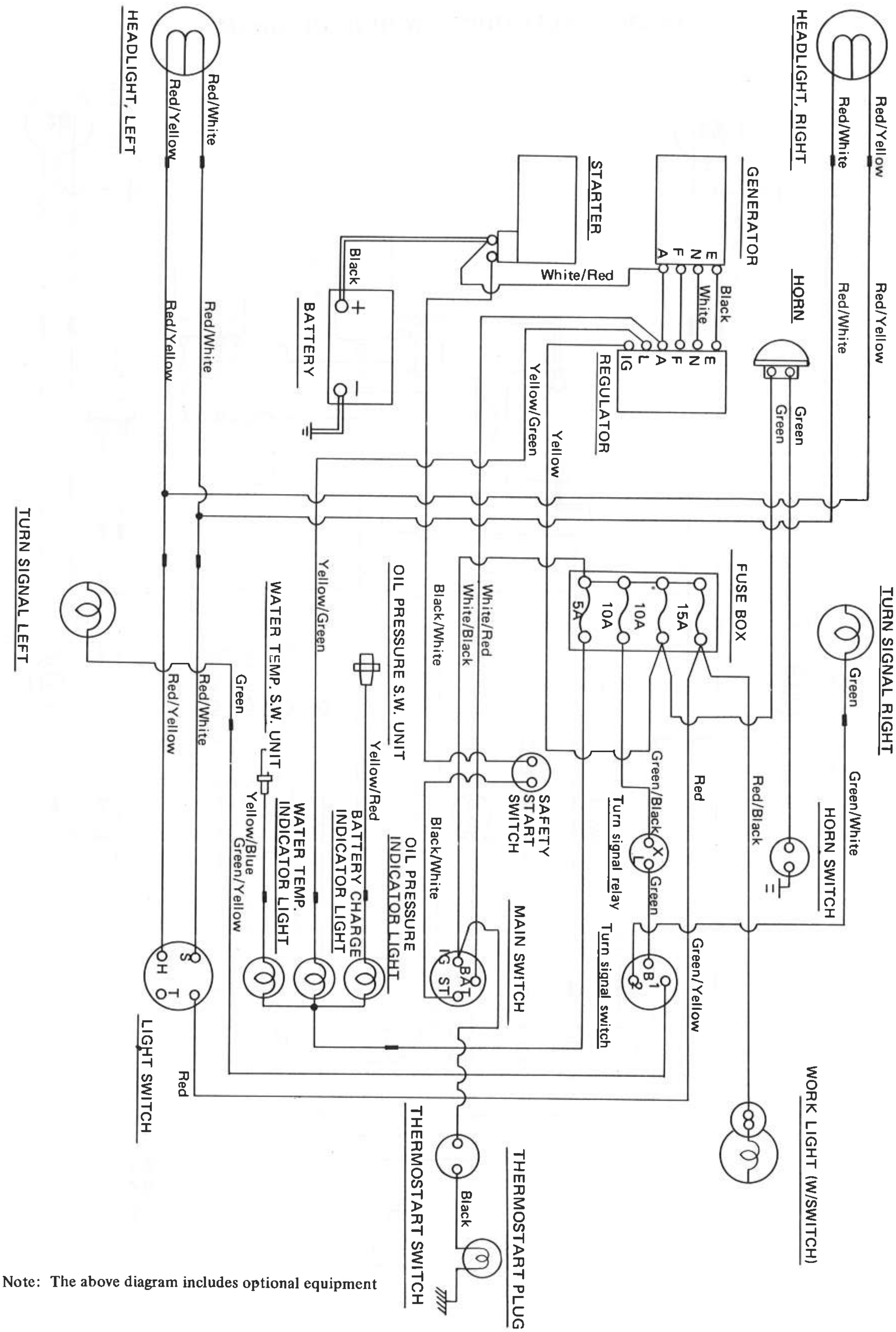
For 12V	YM135(D)(T)	YM155(D)(T)	YM240(T)	YM330(T)
Head light	2 pcs 25W/25W	2 pcs 25W/25W	25W/25W 2 pcs	25W/25W 2 pcs
Turn signal light	20W x 2 pcs	20W x 2 pcs	20W x 2 pcs	20W x 2 pcs
Work light	20W x 1 pcs	20W x 1 pc	20W x 1 pc	20W x 1 pc
C.W. temp.	3.4W x 1 pc	3.4W x 1 pc	3.4W x 1 pc	3.4W x 1 pc
L.O. pressure	3.4W x 1 pc	3.4W x 1 pc	3.4W x 1 pc	3.4W x 1 pc
Charging light	—	—	3.4W x 1 pc	3.4W x 1 pc
Dash board light	—	—	—	3.4W x 1 pc

(1) YM330(T) ELECTRICAL WIRING DIAGRAM



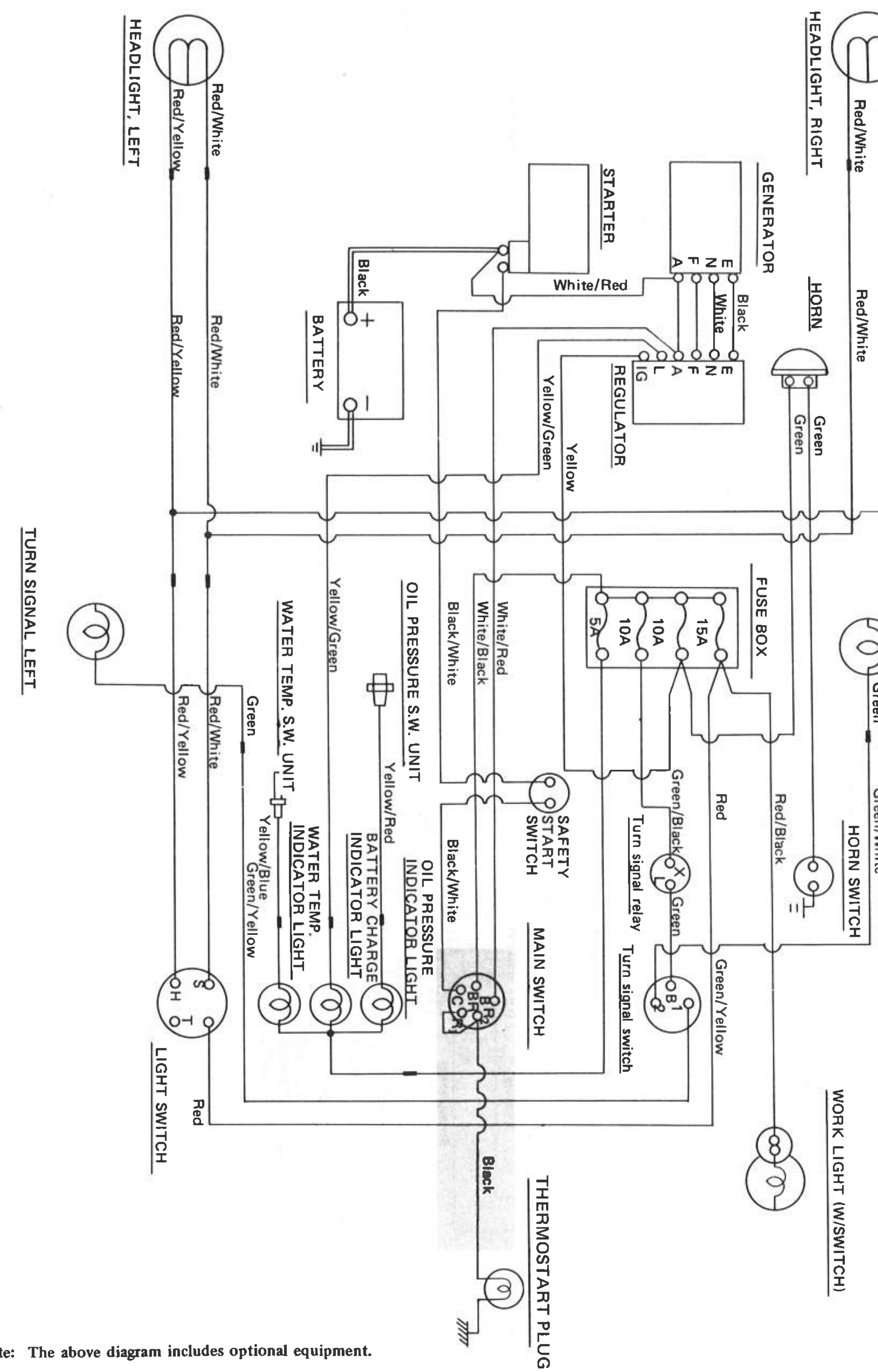
Note: The above diagram includes optional equipment

(2) YM240(T)ELECTRICAL WIRING DIAGRAM (FORMER)



Note: The above diagram includes optional equipment

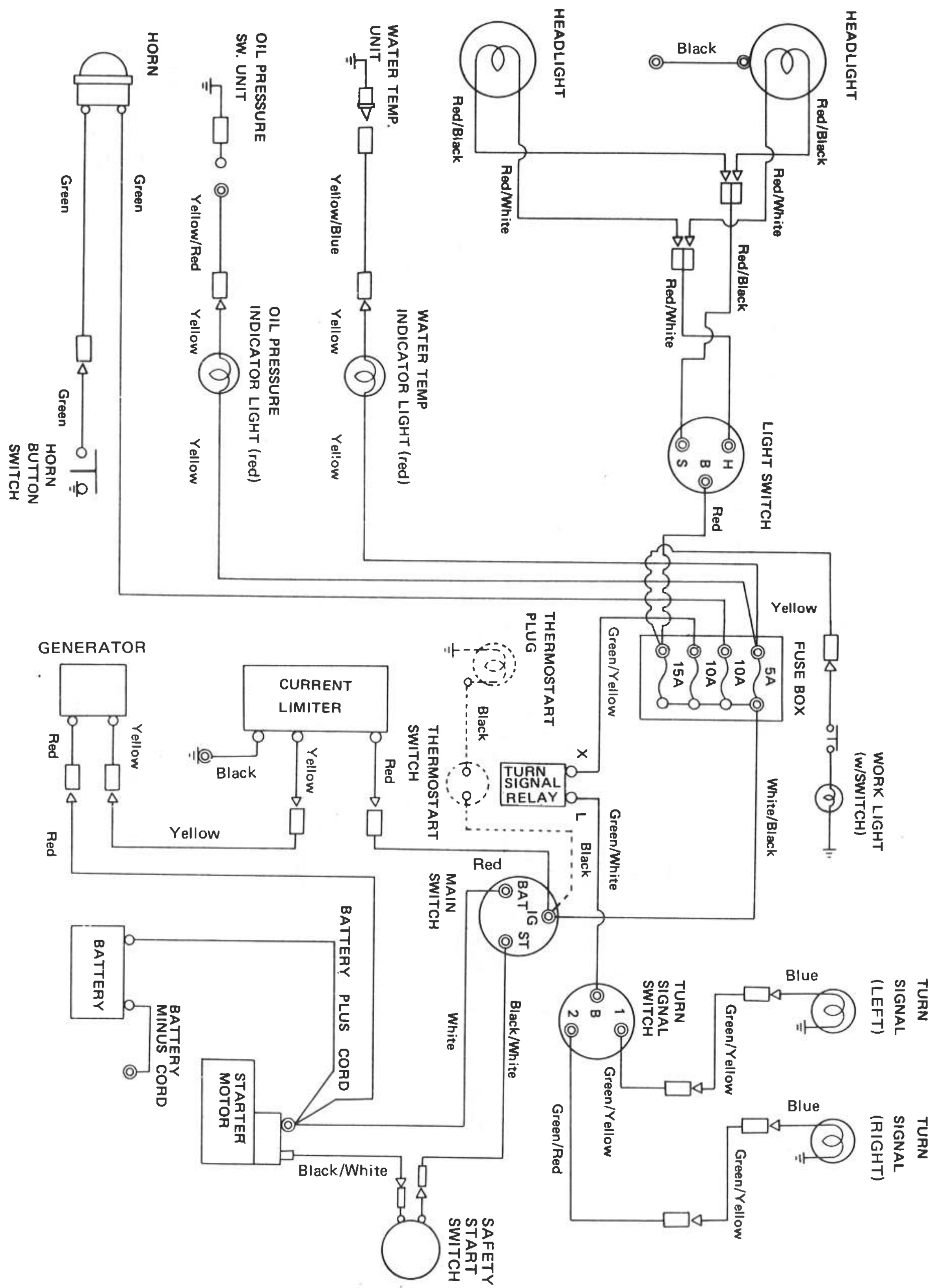
YM240(T)ERECTRICAL WIRING DIAGRAM (NEW MODEL)



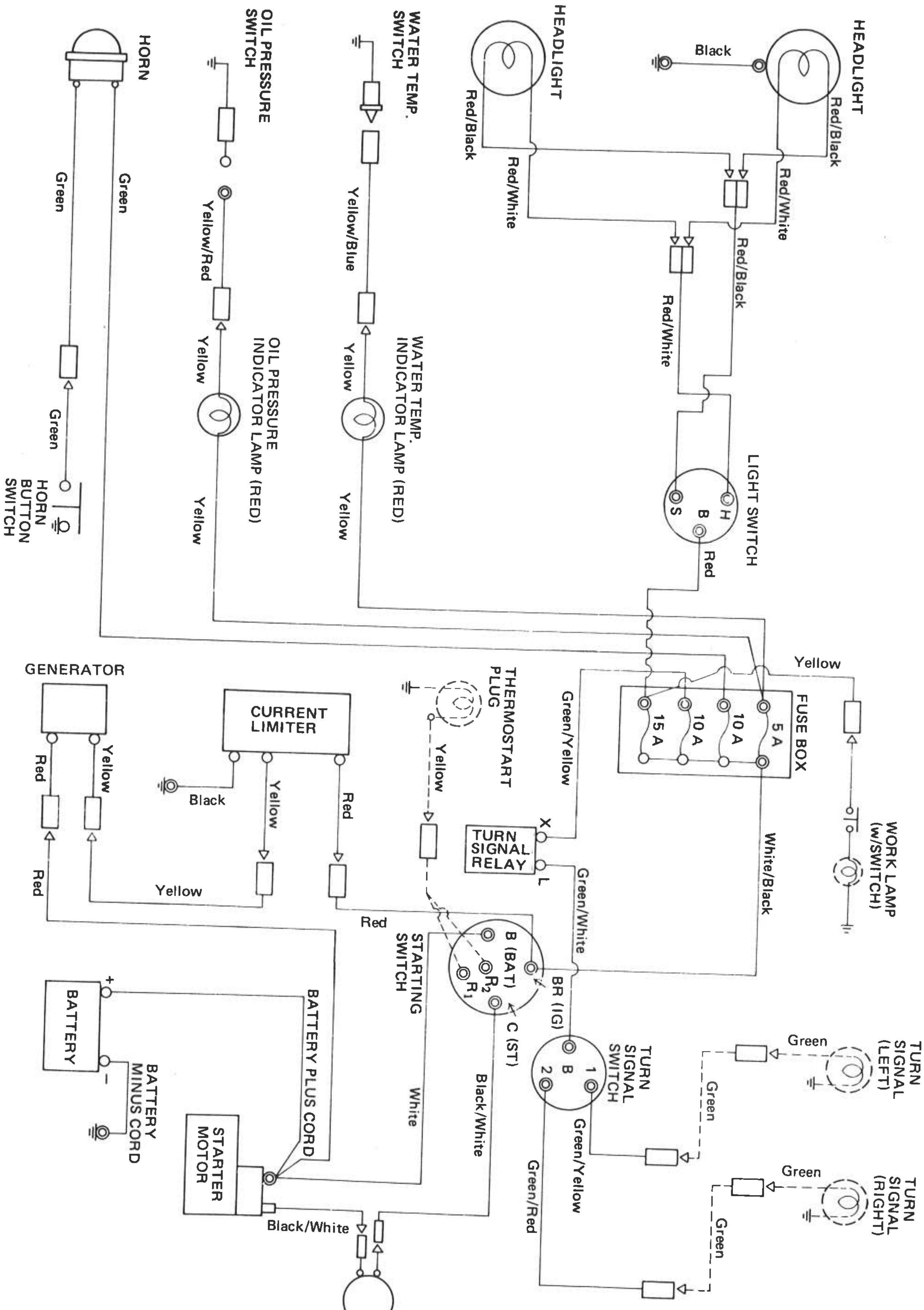
Note: The above diagram includes optional equipment.

(3) YM135(D)(T) & YM155(D)(T) ELECTRICAL WIRING DIAGRAM (FORMER)

(Before Serial No. 5100)



YM135(D)(T) & YM155(D)(T) ELECTRICAL WIRING DIAGRAM (NEW MODEL)



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