9. ELECTRICAL SYSTEM

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ELECTRICAL SYSTEM

1. GENERAL

A typical electrical system is shown in Fig.9-1.

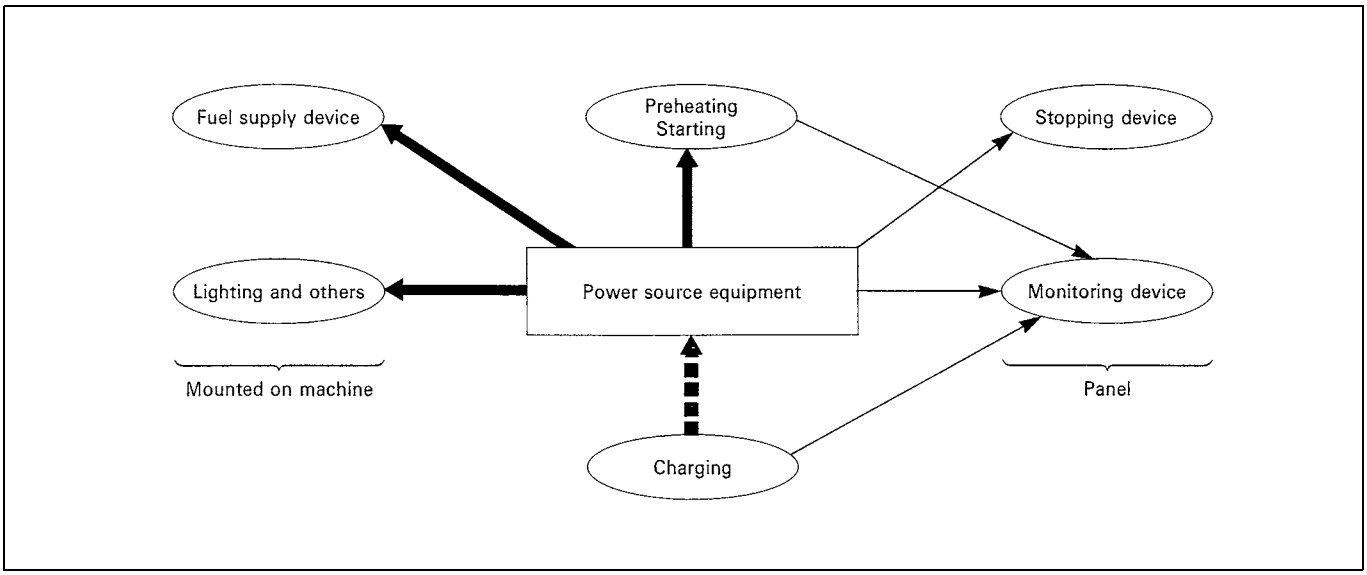


Fig. 9-1

An electrical system consists of starting equipment, such as a starter and glow plug ; charging devices, such as an alternator, regulator, and battery ; and indication and control equipment, such as an oil switch, water temperature switch, glow plug indicator, timer and starter switch.

2. STARTING DEVICE

[1] GENERAL

The starting device is composed of the starter, starter switch, glow plug, slow blow fuse, battery, glow lamp timer, safety relay for starter, etc., and the outline of the basic operation is as the followings ;

1) Voltage from battery is added to the B terminal of starter switch through the slow blow fuse.
2) If the starter switch is turned on, B terminal will be connected to AC, and the electrical current will flow to each load.
3) If the starter switch is turned to preheating, B terminal will be connected to AC and 19, making the glow plug heat, and at the same time lighting the glow lamp, and the lamp will be turned off by activation of the lamp timer after 5 seconds.
   Even if glow lamp is turned off, when the starter switch is either in the preheating position or starting position, the glow plugs will remain heating.
4) If the starter switch is turned to the starting position, B terminal will be connected to AC, 19, and 50 will be connected to the ST terminal of starter (in case of the type with safety relay, it shall be connected via relay) to start the engine.
5) After the engine is started, if you have let your hand off the starter switch, it automatically returns to ON position.

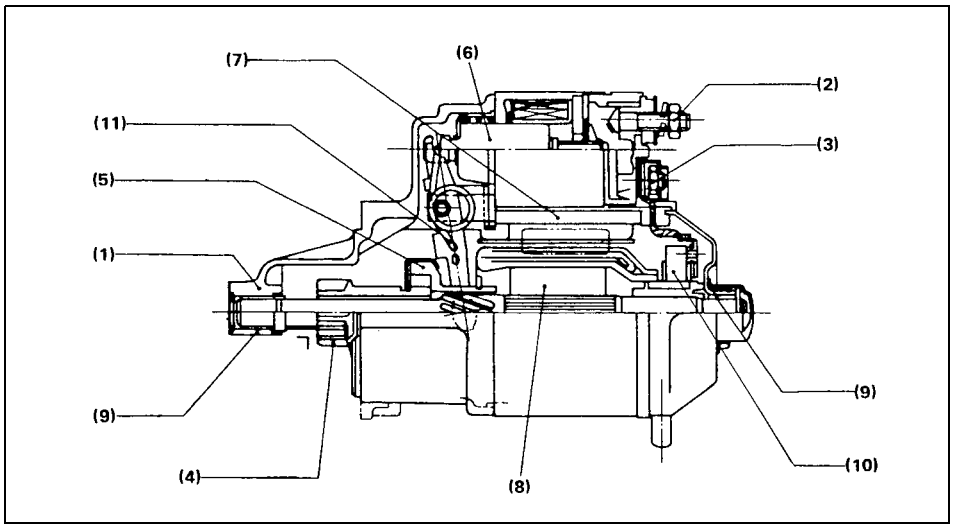
[2] STARTER

The function of starter is to rotate the engine with the speed higher than the minimum rotation speed required to start the engine.
Particularly in the diesel engine of which compression ratio is high, small-sized and powerful starters are required, and for this purpose, the direct-current / direct-winding type, which can produce powerful rotation force when the rotation speed is still low, is suitable.
However, compared with other electric motors the size of this type is small and the weight is light, in proportion to its large output resulting in a short usage time (rated time : 31 sec.).

(1) Types of starter

1) Conventional type

This type is provided with the magnet switch with terminal, and the pinion made of carburized materials and the overrunning clutch (roller clutch) to prevent overrun of the armature after starting.



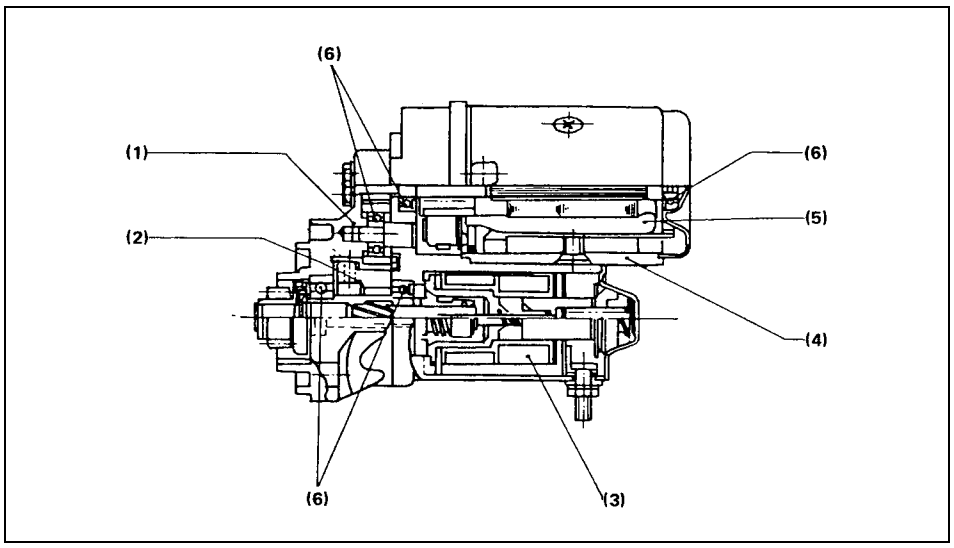
(1) Drive side housing
(2) B terminal
(3) S terminal
(4) Pinion
(5) Overrunning clutch
(6) Solenoid
(7) Yoke
(8) Armature
(9) Bearing
(10) Brush
(11) Drive lever

Fig. 9-2 Conventional type

2) Reduction type

This type drives the pinion reducing the speed of the small-sized high-speed large-output motor by 1/3 to 1/5, so that the motor can be made smaller and lighter.

The starter is made lighter by using aluminum die cast metal, and in addition, there is no exposure of the pinion sliding surface and waterproofing is improved.



(1) Drive side housing
(2) Overrunning clutch
(3) Solenoid
(4) Yoke
(5) Armature
(6) Bearing

Fig. 9-3 Reduction type

(2) Circuit of the starter

1) When the starter switch is turned to start position:

a) If the starter switch is turned to start position, electrical current will flow to holding coil (H.C) and pulling coil (P.C), and it will excite the 3 coils, and suck the plunger.
Consequently, the pinion gear will move out to the fly wheel side, and the ring gear and pinion gear will be intermeshed.

b) Electrical current will also flow to the armature from P.C, and it will remove the load in the initial stage of armature rotation.
(If the armature is slightly rotated, it will facilitate intermesh of the pinion gear and ring gear.)

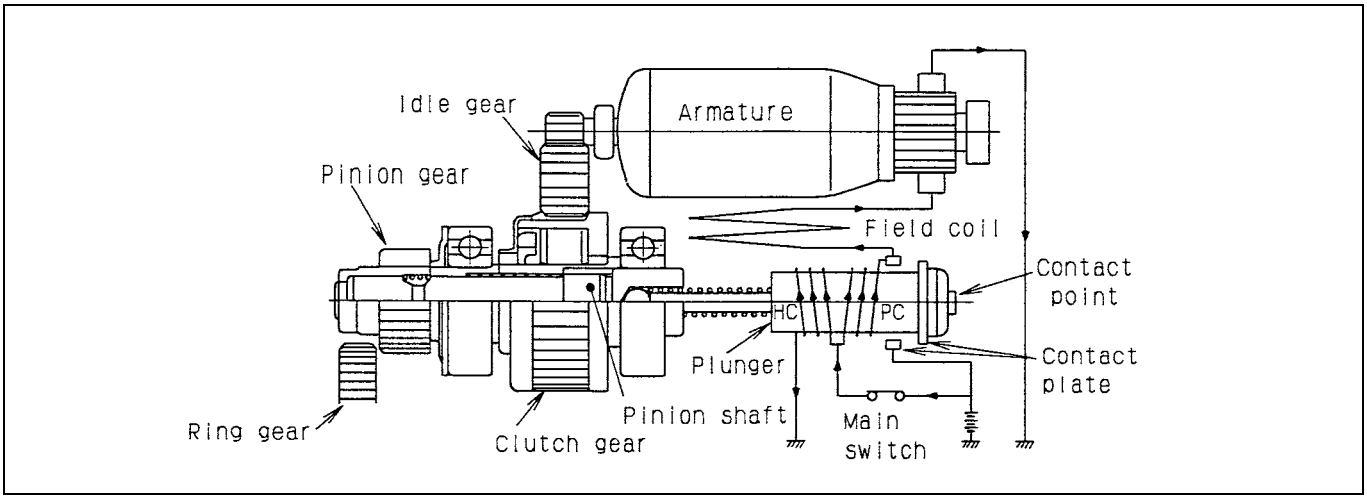


Fig. 9-4

2) During cranking of the engine :

a) If the pinion gear and ring gear are fully intermeshed, the main contact point will be closed, and the field coil and armature coil will be directly connected from the battery so that a large amount of electrical current flows and the pinion gear rotates.

b) Potential difference of P.C will become zero by the voltage from the main switch and the voltage from the main contact point, making the magnetic force nonexistent.

c) Therefore, the plunger is supported by H.C alone while the pinion is intermeshed with the ring gear.

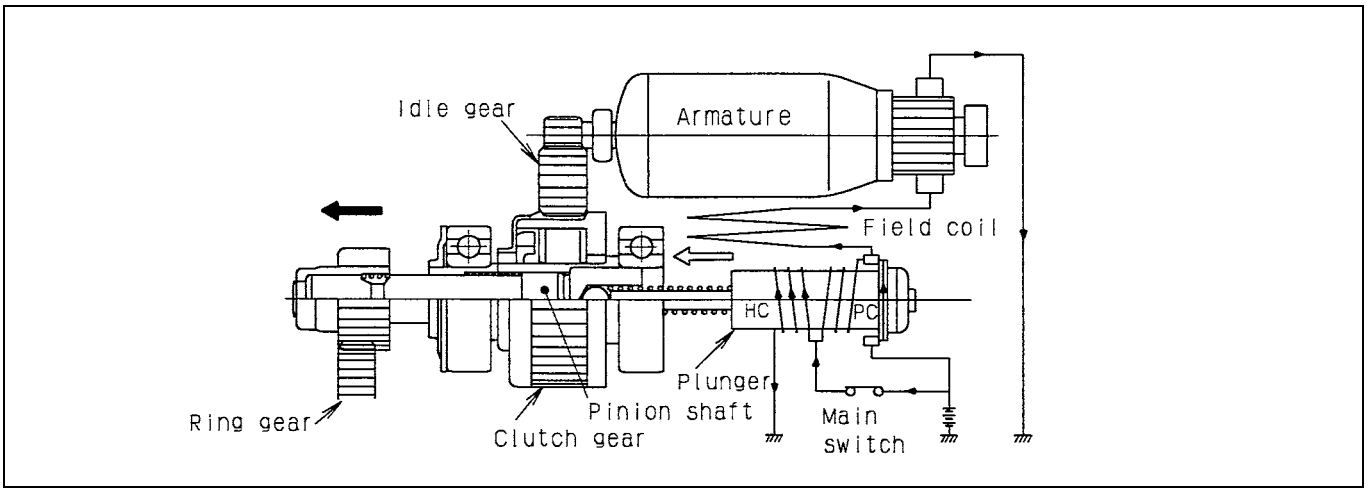


Fig. 9-5

3) When the engine is started :

a) When the engine is started, rotation of the gear will become faster than rotation of the pinion gear. (If such a state is left as it is, rotation of the engine will be driven directly into the armature, and may damage it.)

b) In case that rotation faster than that of the armature is transmitted to the pinion gear, the overrunning clutch will begin to race, and will protect the armature from abnormal rotation.

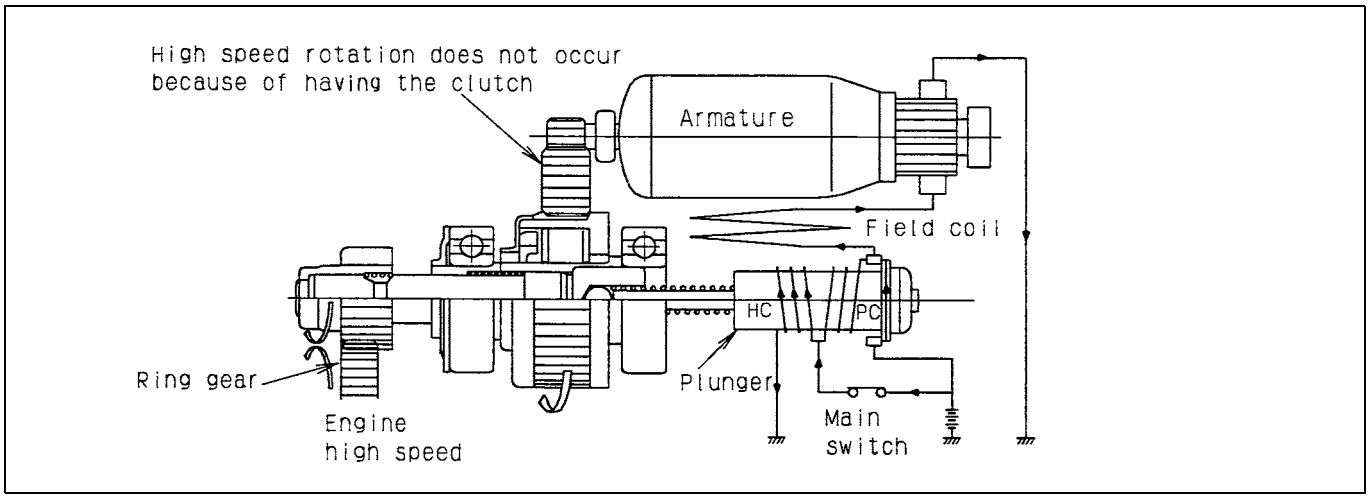


Fig. 9-6

4) When the starter switch is returned to AC :

a) If the starter switch is returned to AC, energizing to H.C will be shut off.

b) The force on the plunger will cease and the pinion gear will be returned by the return spring. At the same time, the main contact point will be opened as well, and rotation of the armature will be stopped. Braking of the armature is performed by abrasion force of the brush and commutator.

* For an instance, potential difference of the C terminal becomes higher than that of the S terminal, and electrical current flows from the main contact point to the direction of P.C and H.C so that engaging force of the plunger will be offset each other, and the plunger will be returned quickly.

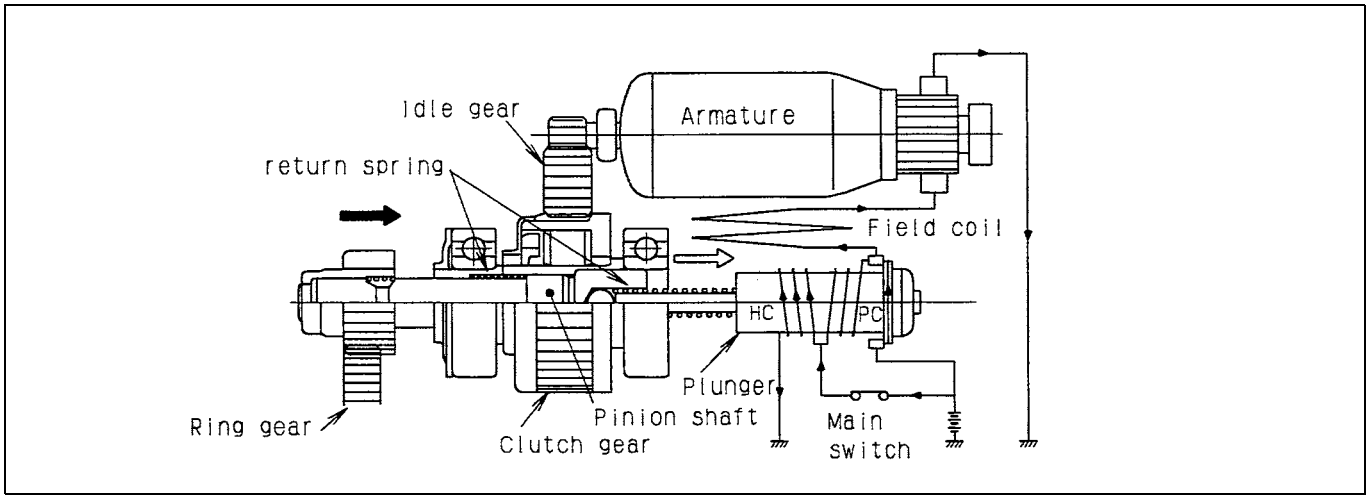


Fig. 9-7

5) The check method for the starter wiring connection

Terminal	The measuring method	The judging standard and countermeasure
S terminal	1. Remove the wiring to the starter B terminal and connect the S terminal wiring alone. 2. Remove the wiring connection of other parts connected to the battery (+) terminal. 3. Connect a voltmeter to the battery (+) terminal and starter S terminal. 4. Connect an ammeter to the S terminal wiring. 5. Connect a voltmeter to the battery (-) terminal and the starter body. 6. Turn the key switch to the starting position, wait 3 seconds, and measure each value of the ammeter and voltmeters. 7. Calculate the wiring resistances from the measured current and voltages and sum up them.	The total sum of resistance shall satisfy the following standard. KBT Standard Starter for; NSM, 07, V3 : 50 to 70 mΩ or lower 05, 03M : 90 mΩ or lower When the above standard is not satisfied, the wiring diameter shall be increased.
B terminal	1. By the stop solenoid and stop lever, keep the engine in the condition where start up is not possible. 2. Connect the S terminal wiring. 3. Connect the starter B terminal wiring. 4. Remove the wiring connection of other parts connected to the battery (+) terminal. 5. Connect a voltmeter to the battery (+) terminal and starter B terminal. 6. Connect a voltmeter to the battery (-) terminal and starter body. 7. Connect a clamp-on ammeter to the starter B terminal wiring. 8. Turn the key switch to the starting position, wait 3 seconds, and measure each value of the ammeter and voltmeters. 9. Calculate the wiring resistances from the measured current and voltages and sum up them.	The total sum of resistance shall satisfy the following standard. KBT Standard Starter for; NSM, 07, V3 : 50 to 70 mΩ or lower 05, 03M : 90 mΩ or lower When the above standard is not satisfied, the wiring diameter shall be increased.

Note :
The starter type must be checked before application review.

(3) Overrunning clutch

1) Function

In case that the pinion gear and ring gear are still intermeshed even when the engine is started, the motor will be forced to run in abnormal rotation, and the armature, brush, etc. will be damaged.

In order to prevent such an error, the overrunning clutch will function as the device to let the pinion race against the armature shaft when the engine is started, and to shut off transmission of rotation of the engine to the motor.

2) Action

a) When starting :

If the outer is rotated in the arrow mark direction receiving rotation of the armature, the clutch roller will be pushed toward the narrower side of clearance between the outer concave side and the inner so that the outer and inner will be locked. The roller will function as a wedge between the inner and outer, and will transmit the rotation of the outer to the inner, and both will rotate in the same speed.

b) After the engine is started :

When the pinion is forced to rotate by the ring gear, rotation of the inner (rotation of engine x gear ratio) will become faster than that of the outer (a number of rotation of armature), and the clutch roller will move toward the direction that compresses the spring.

Consequently, clearance between the outer concave side and the inner becomes wide to prevent overrunning of the armature.

(It is required to decrease the contact pressure of the pinion gear and ring gear to realize smooth separation of the pinion gear, and for the sake of this, the pinion gear must be in the state of racing.)

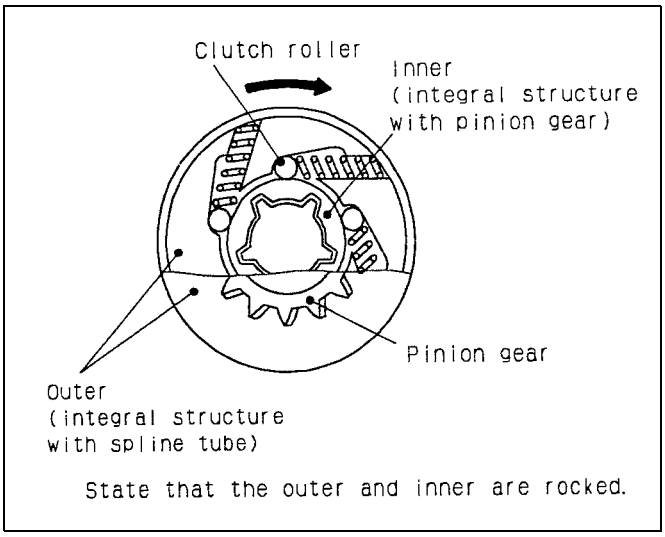


Fig. 9-8

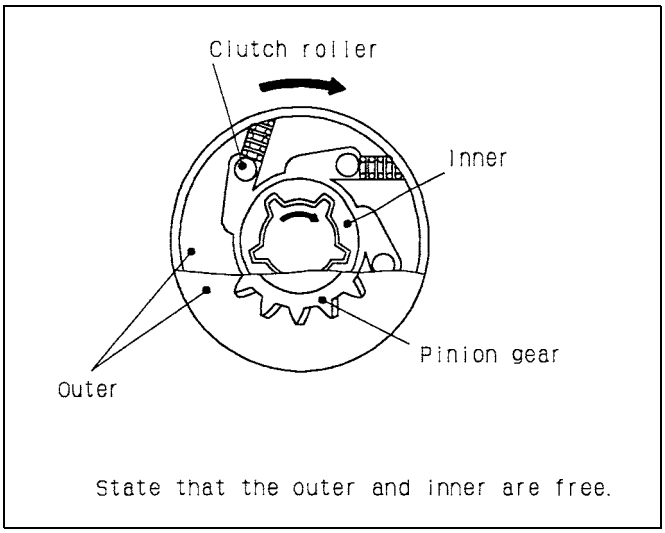


Fig. 9-9

[3] STARTER SWITCH

Starter switch is an important part comprising of the starting device of engine. Particularly, as seizing of the starter and solenoid may be incurred due to failure of the starter switch, careful consideration is required for the installation position, place, and direction, so that rain or cleaning water should not directly splash on the starter switch.

As the standard part of KUBOTA engine, the starter switch in below figure is recommended.

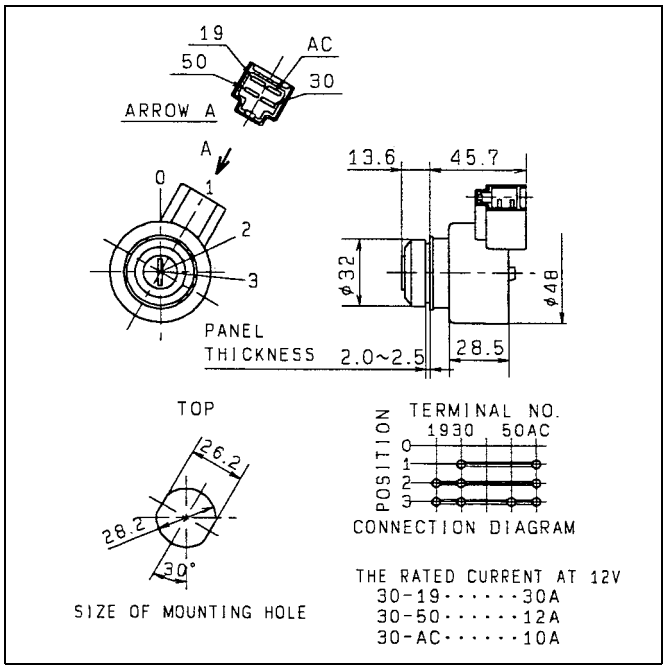


Fig. 9-10 - (1) Starter switch

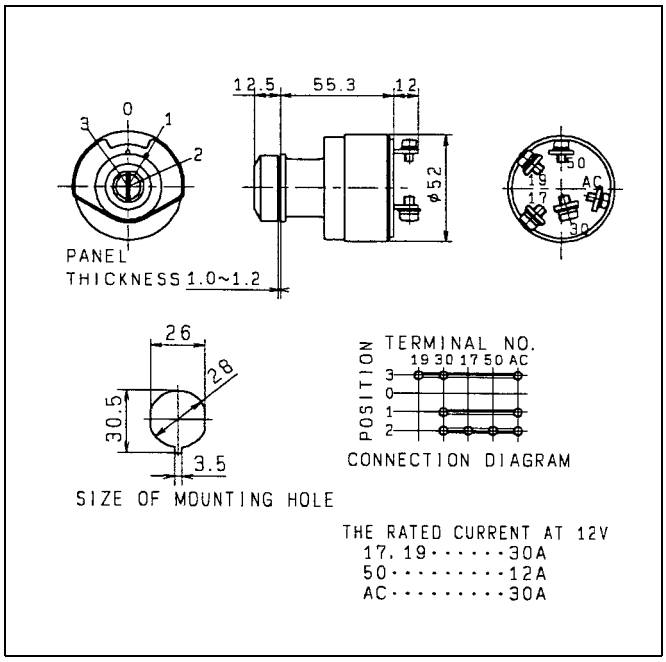


Fig. 9-10 - (2) Starter switch

[4] GLOW PLUG

(1) General

Pressed heat of air, and if the cylinder and head is cold when the engine is to be started, the glow plug will be used to supplement this compressed heat.
On the S.M., 05, 03-M, 07 and V3 series of KUBOTA diesel engine, the QGS type plug of double-material type and high reliability, of which temperature is increase is fast, is employed. The outline specifications are as shown in the next page. (Q.G.S : Quick Glow System)

(2) Structure and function

In case of the conventional sheathed-type glow plug, the heating element is only incorporated in the sheathed tube, however, in case of this quick glow type, the heating element that combines a heating element and resistive element is connected in series.
As for the temperature increase property, when the temperature at the initial stage of power supply is low due to activation of the resistive element, resistance is small and enough electrical current flows into the heating element so that the temperature will increase quickly.
If power supply is continued, the amount of electrical current decreases and overheating is prevented, this is because temperature of the resistive element will increase and the resistance will become large (about 10 times).

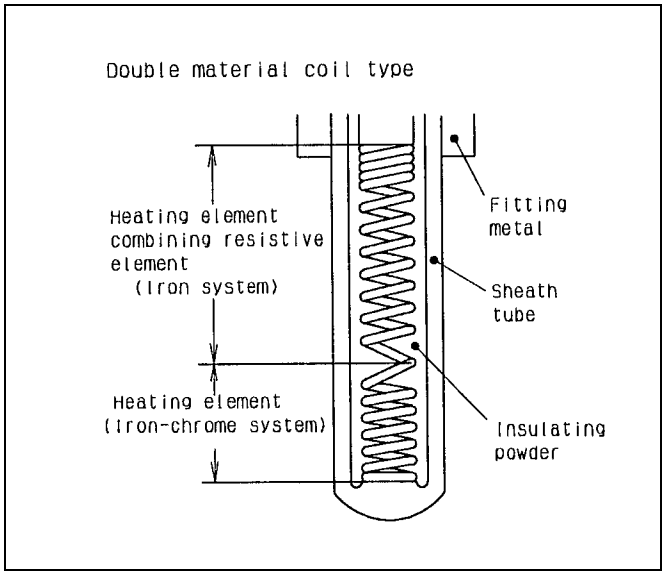


Fig. 9-11 Structure of glow plug

Further, the heat point is at 2 to 3 mm (0.08 to 0.12 in.) from the tip, and protrusion into the combustion chamber is short.

KUBOTA's standard starter switch has the function that the glow plug will be energized as well when energizing the starter.
In case that starter switch is prepared by an OEM, it should also be designed so that the glow plug will also be energized when energizing to the starter.

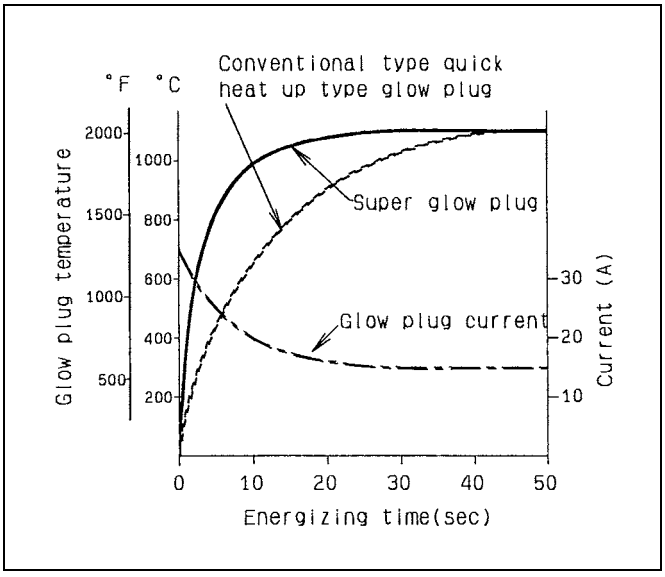
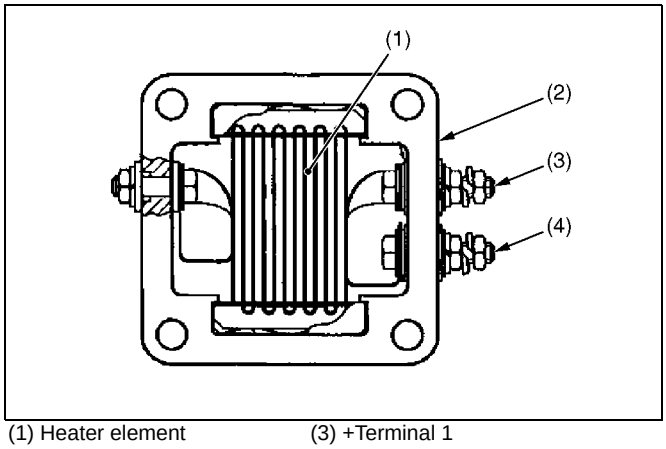


Fig. 9-12 Comparison of the temperature increase

[5] INTAKE AIR HEATER

(1) General

The intake air heater is introduced in order to further improve the starting performance and to reduce the white smoke at cold starting.
The intake air heater is mounted on the intake manifold. In this new construction, there is no need to arrange any glow plug on the cylinder head.
This means that a multi-valve design can be implemented and that the starting performance and serviceability are enhanced.



(1) Heater element
(2) Intake air heater body
(3) +Terminal 1
(4) +Terminal 2

Fig. 9-13 Heater element type

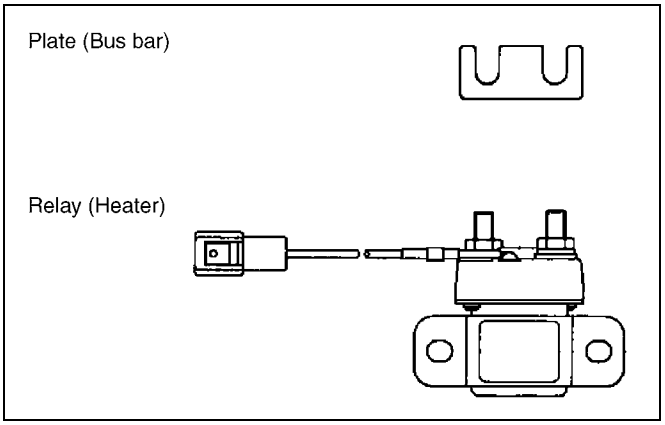


Fig. 9-14 Option parts

[6] GLOW LAMP AND LAMP TIMER

(1) General

The purpose of glow lamp is to time the activating conditions of the glow plug located in the combustion chamber of engine.
When the starter switch is turned to preheating position, the lamp timer will activate the glow plug lamp, and when the timer has activated after 5 seconds, the lamp will be turned off.
Even if the lamp is turned off by the lamp timer, the glow plug will still be kept turned ON, if the starter switch is in preheating position, or the starter is in the state of being turned ON.

(2) Activation circuit

a) If the starter switch is turned to preheating, energizing will be made to No.6 terminal of the lamp timer from No.19 terminal through the glow lamp.
Then, the lamp timer is grounded, and it will light the glow lamp for 5 seconds.
At the same time, energizing will also be made to the glow plug directly from No.19 terminal, and the glow plug will be heated.

b) If the starter switch is turned to starting, energizing will be made to No.5 terminal of the lamp timer so that electrical power of the glow lamp cannot be grounded, and the glow lamp will not be on. Energizing will be made to the glow plug directly from No.19 terminal of the starter switch, and the glow plug will be heated.

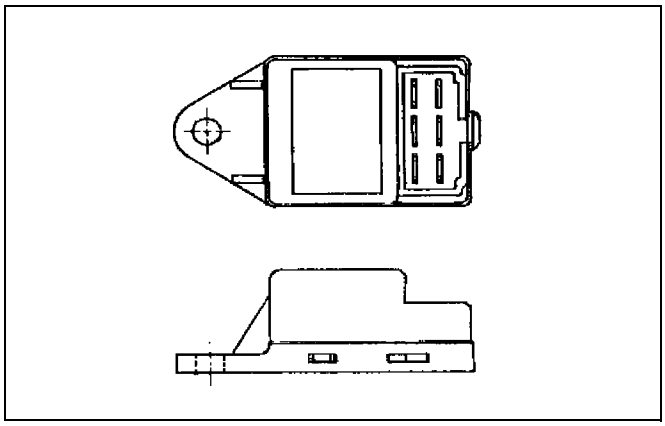


Fig. 9-15 Glow lamp timer

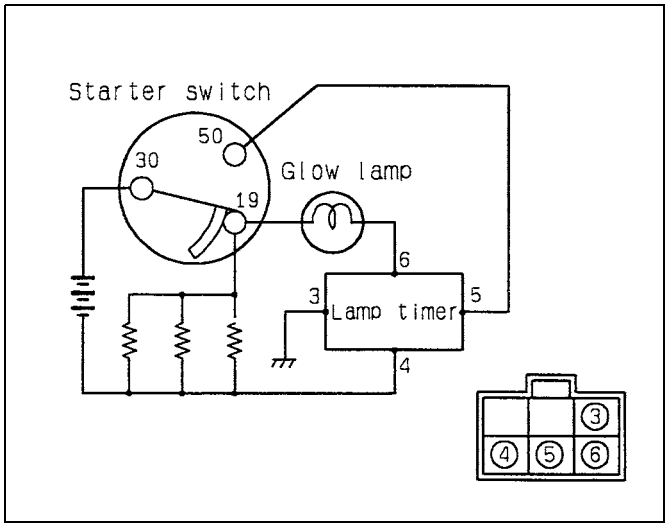


Fig. 9-16

[7] GLOW SYSTEM WITH THE SENSOR

(1) General

The purpose of this system is to control energizing time to the glow plug by means of water temperature of the engine, and this system makes it easy for the operator to start the engine even when it is in cold season, because starting preparation can be completed if it is confirmed that the glow lamp is turned off.
This system consist of starter switch, glow lamp, glow relay, glow controller, water temperature sensor and glow plug.

(2) Glow controller

If the starter switch is turned on, water temperature will be detected by water temperature sensor of engine, and energizing time to the glow plug and glow lamp will be controlled by rise and fall of the water temperature.
When the glow plug has reached start-temperature, the controller will turn off the glow lamp.
When the starter switch is the starting position, the glow plug will be energized directly from the starter switch so that starting ability is improved. When the starter switch is in this position, the glow lamp will be turned off.

☆ When the atmospheric temperature is more than +5 °C (41 °F), the engine can be started without heating of glow plug.

Water temperature	Energizing time to the timer
20 °C (68 °F)	3.3 sec
0 °C (32 °F)	5.0 sec
-15 °C (5 °F)	10 sec

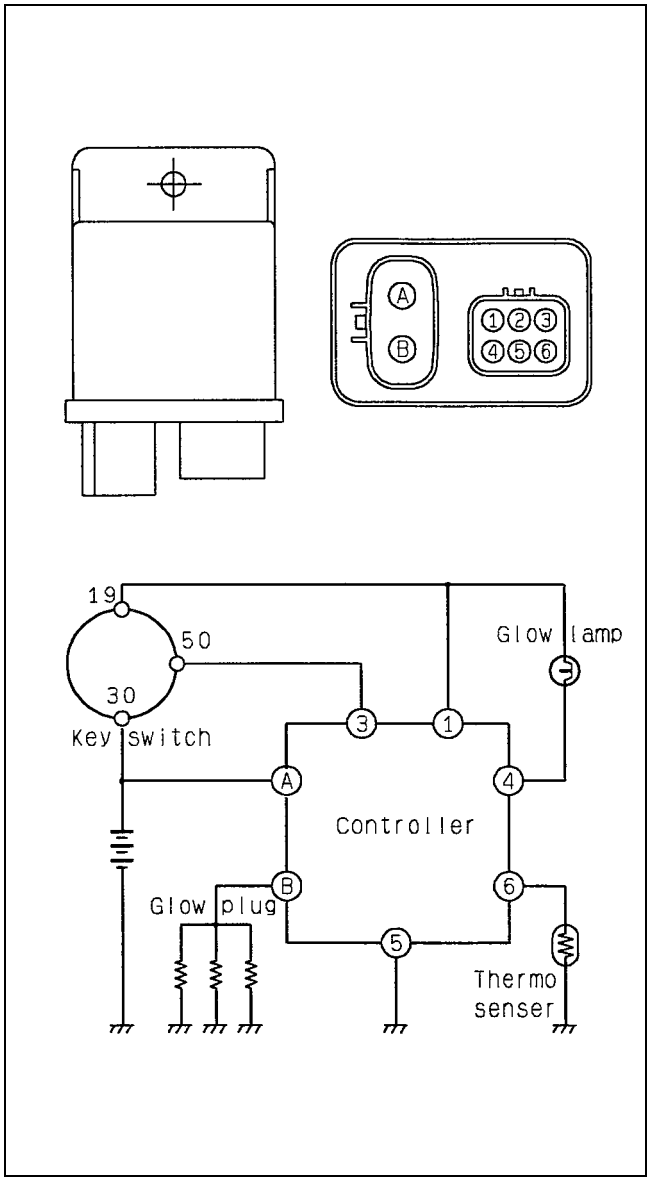


Fig. 9-17 Glow controller

(3) Water temperature sensor
(Only use for glow plug)

The water temperature sensor for glow plug is installed to near the thermostat.
When the water temperature is decreased, the electrical resistance will become small, and when the water temperature is increased, will become large.

Temperature	Resistance value (Ω)
-20 °C (-4 °F)	16.2
0 °C (32 °F)	3.88
20 °C (68 °F)	2.45
40 °C (104 °F)	1.14
60 °C (140 °F)	0.58
80 °C (176 °F)	0.32

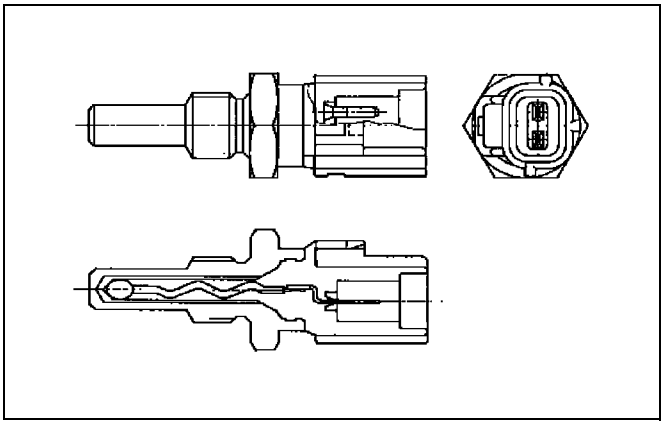


Fig. 9-18 Sensor (water temperature)

[8] HEATER SYSTEM

(1) General

This system is intended for the prevention of burnout caused by oversupply of current to the intake heater.

(2) Heater controller

Turn the key switch on to make conduction between terminals A and B for 25 seconds.

The output is cut off when 25 seconds have passed.
Turn the key switch to the start position (50) to make conduction between terminals A and B for the duration while the position of the switch is maintained.
The timer period after the key switch is turned off from on and turned on again varies based on the following re-energization characteristics.

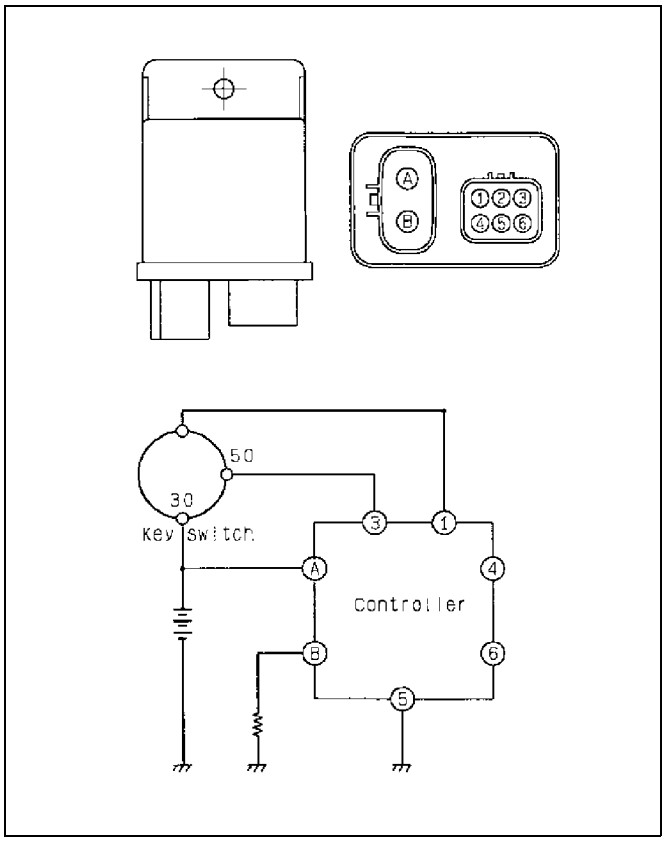


Fig. 9-19 Controller

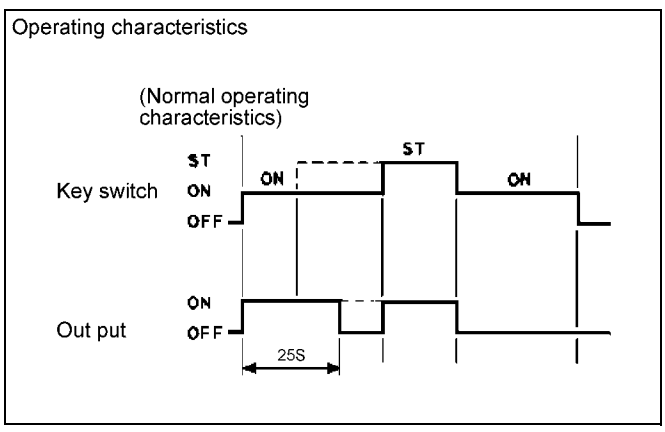


Fig. 9-20 Operating characteristic

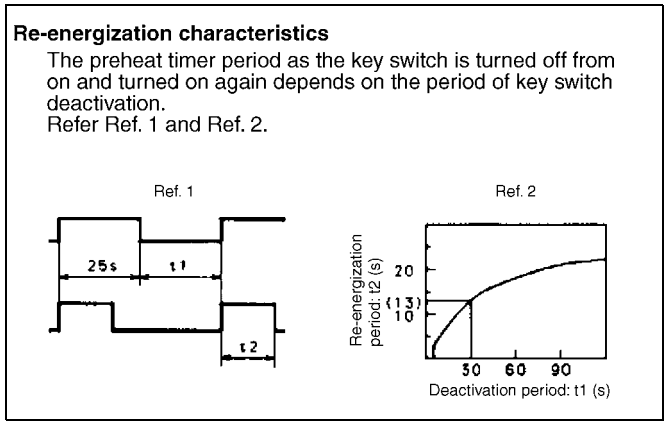


Fig. 9-21 Re-energization characteristics

[9] STARTER SAFETY SYSTEM

The purpose of this system is to prevent accidental starting of the starter during rotating of the engine.
The No.50 terminal of the starter switch will be connected to the ST terminal of the starter through the safety relay, and when the engine is started and the alternator begins charging, this relay will automatically shut off the starting circuit by detecting the generated voltage of the alternator.

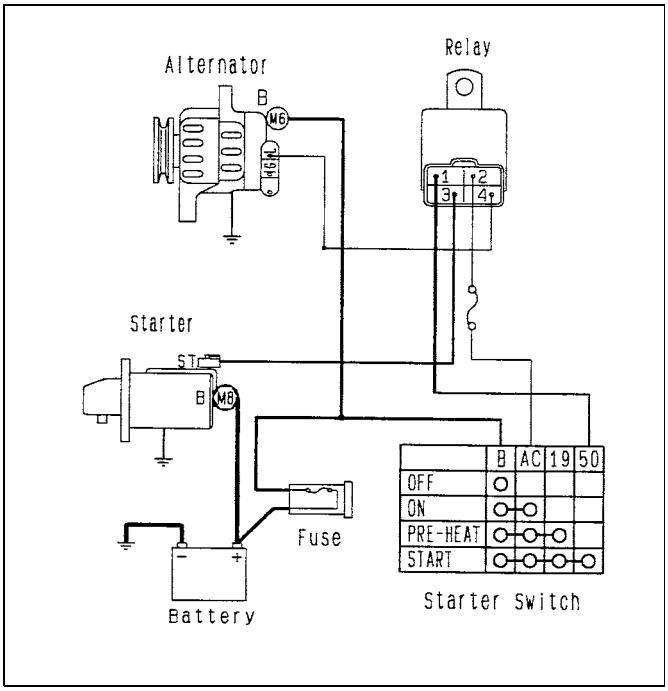


Fig. 9-22 Safety system circuit

Note :
The abobe is only avairable when the combination of the alternator and fan driving pulley is either of the following :
(1) 1K574-64010(40A) : fan driving pulley diameter 112 mm
(2) 1G882-64010(40A) : fan driving pulley diameter 122 mm

3. CHARGING DEVICE

[1] GENERAL

The function of the charging device is to charge batteries. There are various types depending on the size of the engine, and in case of KUBOTA engines, it can be broadly divided into the two types, i.e., the separate regulator type and the built-in type.

[2] IC REGULATOR BUILT-IN TYPE ALTERNATOR

The alternator is the incorporated with an IC regulator, this has been made small size and light weight by the semiconductor technique of the IC regulator.
The cooling property and safety is improved by incorporating the cooling fan and roller that is an integral structure.
Further, the serviceability is also improved by facilitating mounting and removal of the rectifier and IC regulator.

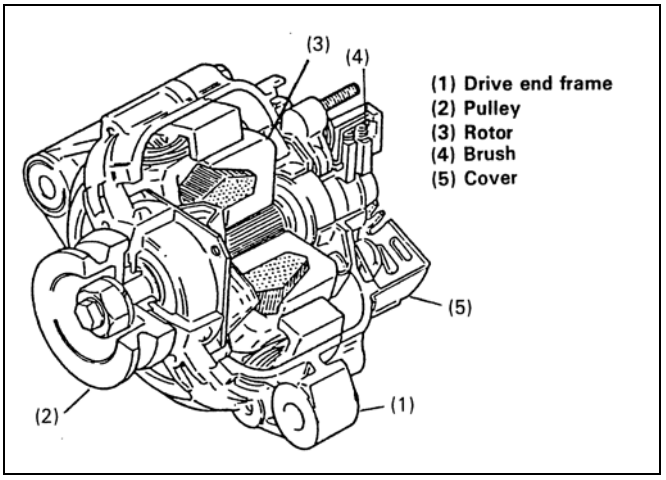


Fig. 9-23 IC regulator built-in type alternator

(1) D2 Type regulator

IC regulator has a special feature that makes it possible to interrupt field current by using the transistor or IC instead of the contact-point-type regulator.

IC regulator has the special features as follows :

1) Readjustment for this regulator is unnecessary because the control voltage does not change over time. Further, vibration-proof property and durability is excellent because IC regulator has no moving parts.

2) Since IC regulator has over-temperature compensation property, which makes the control voltage low if the temperature is increased, it makes it possible to properly charge the batteries.

The circuit inside IC regulator is as shown in the following figure.

It is composed of the monolithic IC-incorporated hybrid IC. (Since the inside circuit of the monolithic IC is extremely complex, it is described as M.IC circuit.)

Tr1 has the function as the contact point to control field electrical current, and as the charging lamp relay to light the charging lamp.

M.IC controls Tr1 and Tr2 by detecting decrease of the output voltage of alternator, decrease of the L-terminal voltage, disconnection of the rotor coil, etc.

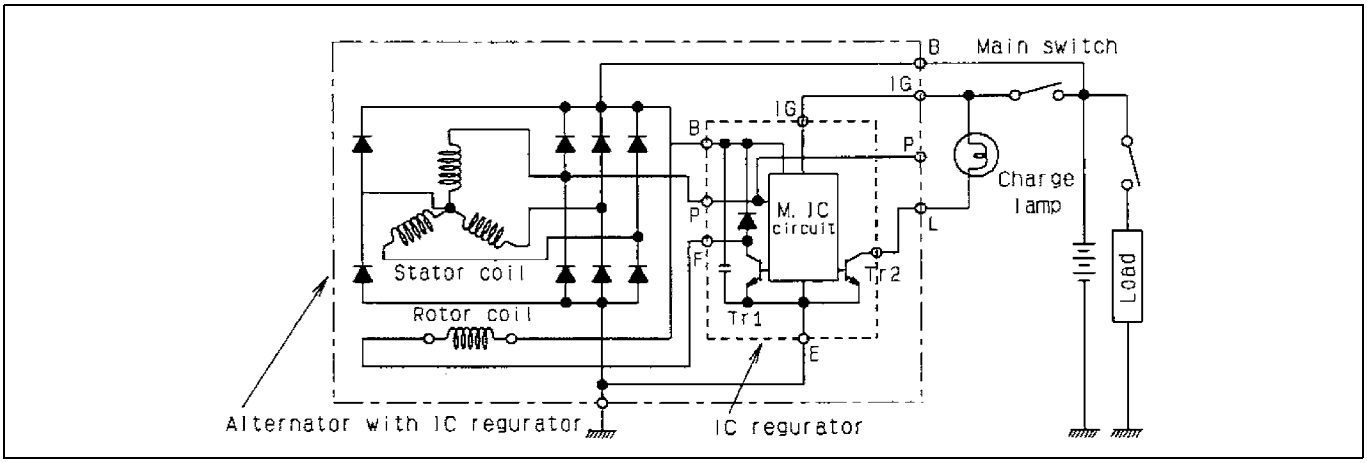


Fig. 9-24 D2 Type regulator circuit

Application example (1)

D1 Type

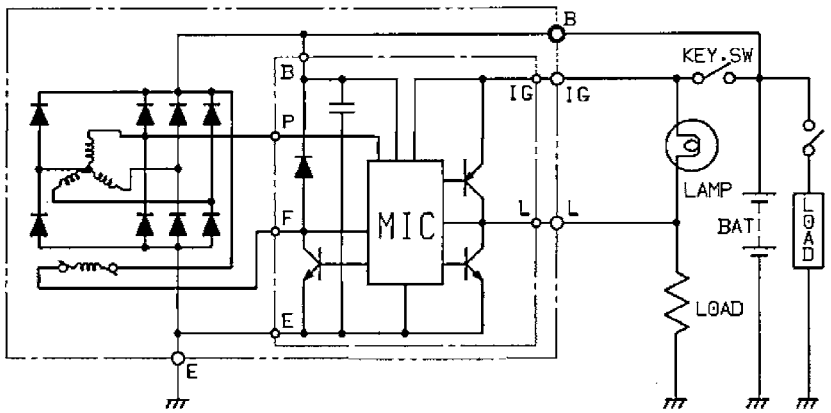


Fig. 9-25 D1 Type regulator circuit

Application example (2)

M Type

Mitsubishi regulator (single-function)

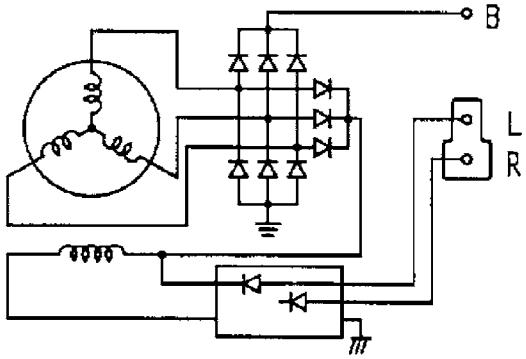


Fig. 9-26 M Type regulator circuit

● **Specification of alternator with IC (incorporated with) regulator**

Norminal voltage	12 V	
Maximum output	S.M.	20 A, 40 A
	05	20 A, 30 A, 40 A, 60 A
	03-M	20 A, 30 A, 40 A, 45 A, 70 A
	07	60 A
	V3	45 A, 60 A, 90A
Rotational direction	Right as seen from pulley side	
Armature wiring	3 phase, Y wiring	
Rectifying system	Total wave rectification ☆	
min^{-1} (rpm) at no load (when cold)	14 V at 0 A 1050 ~ 1350 min^{-1} (rpm)	
min^{-1} (rpm) at max. output (when cold)	14 V at maximum output below 4000 min^{-1} (rpm)	

Generating capacity will be determined by rpm of engine and pulley ratio.

● **Standard pulley dimensions**

Pulley / Engine	Crank pulley mm (in.)	Alternator pulley mm (in.)
S.M. series	100 (3.94)	58.5 (2.30)
05 series	105 (4.13)	58.5 (2.30)
03-M series	130 (5.12)	65 (2.56)
07 series	131 (5.16)	65 (2.56)
V3 series	143 (5.63)	70 (2.76)

The variation of generating capacity according to the min^{-1} (rpm) of engine is shown as the figure in next page.

☆ **Total wave rectification**

In case of the generator for mobile equipment of which purpose is to charge the batteries, alternating current cannot be used as it is. Because of this, it is required to conduct the action called rectification so that the alternating current can be changed to direct current. Alternator conducts rectification by means of diode.

If the voltage is applied to diode in the normal direction, enough electrical current can flow even by small voltage, however if applied in the reverse direction, it inhibits the reserve flow of electrical current.

Using this property, alternate current generated in the stator coil is changed to the direct current.

As for the rectification using diode, there are two methods, i.e., 'half-wave rectification' that takes out only positive portion of alternate current, and 'total-wave rectification' that rectifies both positive and negative current and change to the direct current.

【Half-wave rectification】

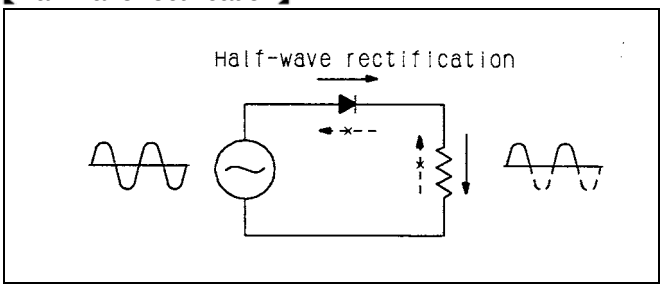


Fig. 9-27

【Total-wave rectification】

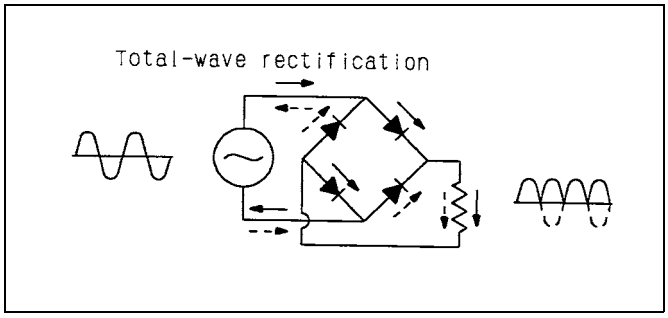


Fig. 9-28

● **Alternator P Terminal**

(1) P terminal waveform: The alternator P terminal outputs rotation signals required by a tachometer, etc.

The P terminal corresponds with one phase of the alternator stator and the output waveform during power generation is a waveform equivalent to the rectangular wave with a frequency in proportion to the number of revolutions of the alternator.

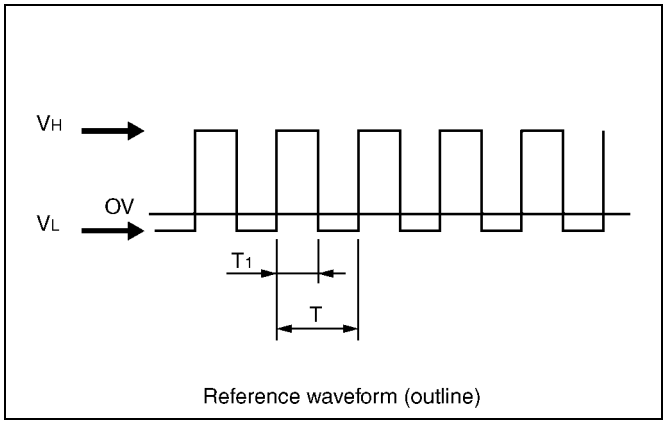


Fig. 9-29

Frequency (1/T) : Number of revolutions of alternator [rpm] / 10 [Hz]
Duty (Ti/T) : approx. 50%
VH (average) : about +0 to 2 V with reference to the alternator B terminal voltage (average)
VL : about -2 to 0 V

Note :

1) As with the B terminal waveform, the P terminal waveform includes noise, which varies depending on the number of revolutions, output and wiring (see the waveform in a separate material).
2) Surge voltage may be generated by any charging cable disconnection (especially with high number of revolutions/high output), etc.

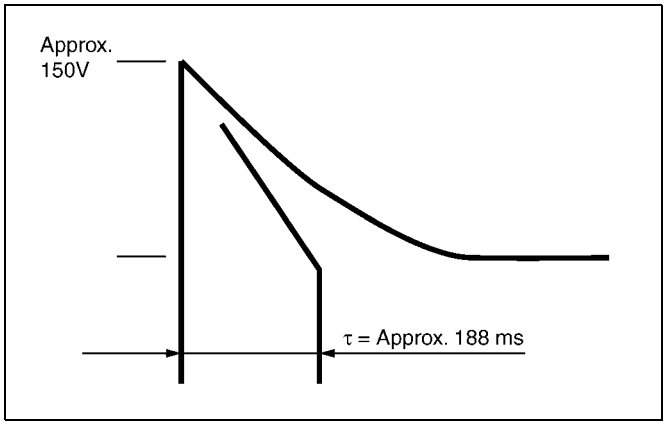


Fig. 9-30

Surge voltage waveform with any charging cable disconnection. (Alternator : F3A-H, 40 A 15000 rpm, max output)

3) May be VHmin = 6.5 V in high electric load shedding or unloaded condition with the battery fully charged.

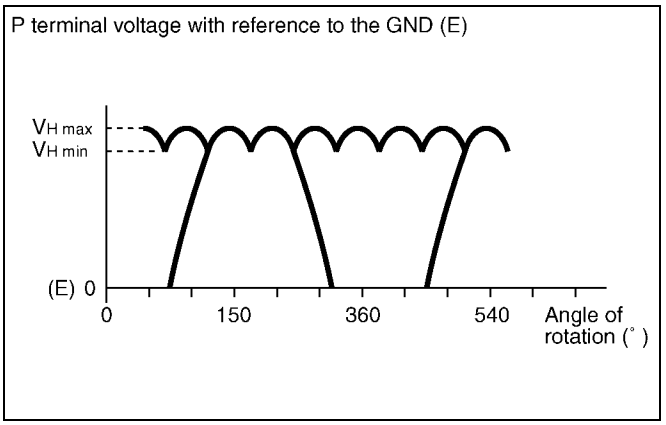


Fig. 9-31

(2) Load connected to the P terminal

P terminal output current: 0.5 A max (average current)

Note :

1) Ensure that there is no load short circuit or wrong wiring.
2) Do not connect inductive or capacitive load (connection of such load subject to discussion of the specification).
3) When detecting a waveform, take the noise and VHmin into consideration.
4) Take the surge voltage into consideration for the input of the load.
5) Use the actual equipment for sufficient check of the operation of the load.

Generating Current

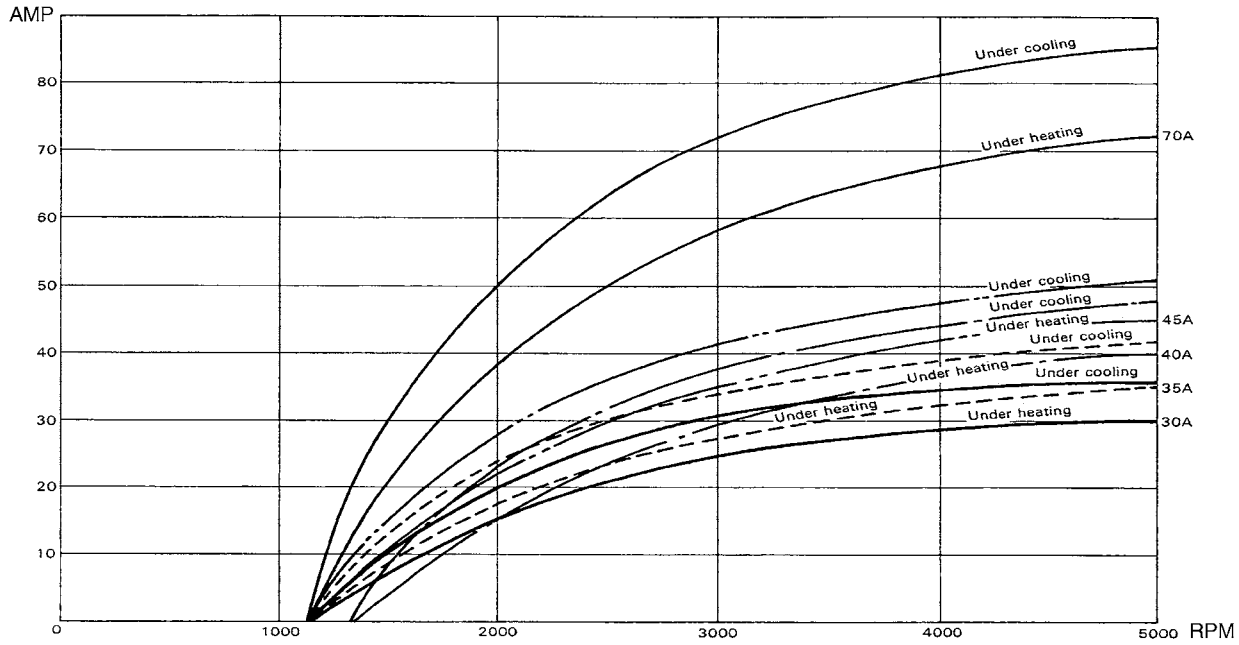


Fig. 9-32 Alternator output characteristics (at 14V constant)

[3] AC DYNAMO AND REGULATOR

(1) AC dynamo

The structure of AC dynamo is simple, and it is composed of the stator and rotor as its main component parts. As for the stator, 6 generating coils are wound, and the rotor has 6 permanent magnets around the circumference, and it rotates on the center of the stator coil.

Specification of AC dynamo

Normal voltage	12 V
Normal output	150 W
Rotational direction	Right as seen from the pulley side
Output min^{-1} (rpm)	4250 min^{-1} (rpm)
Charge starting min^{-1} (rpm)	1800 min^{-1} (rpm)

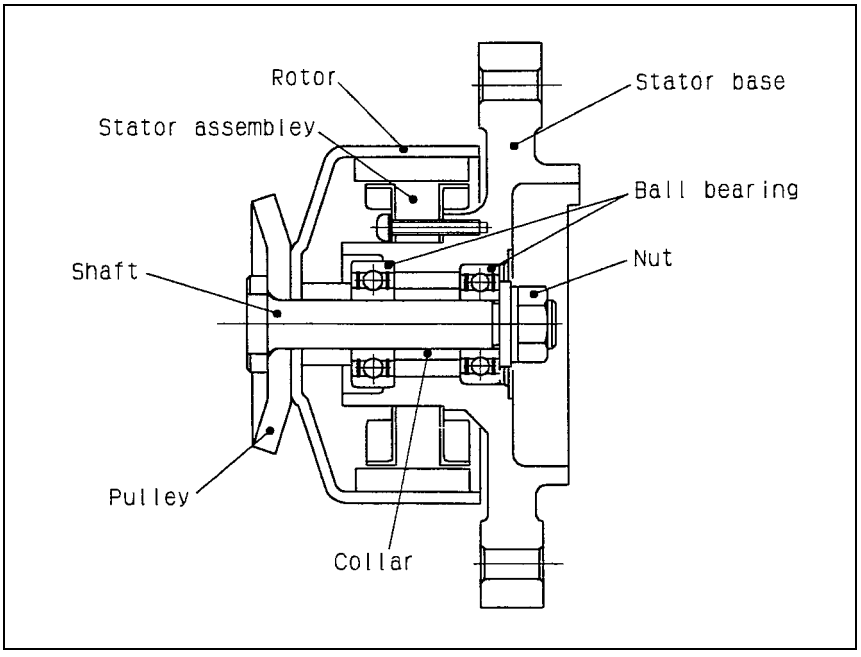


Fig. 9-33 AC dynamo

(2) Thyristor type regulator

Thyristor-type regulator is composed of the diode, resistor, thyristor, zener diode, and transistor.

When the battery voltage is low, the thyristor will be turned on, and complete the charging circuit to the battery.

Further, if the battery voltage is increased to be more than the specified value of the zener diode (14.5 ± 0.5 V), thyristor will be turned off, and the charging circuit to battery is shut off.

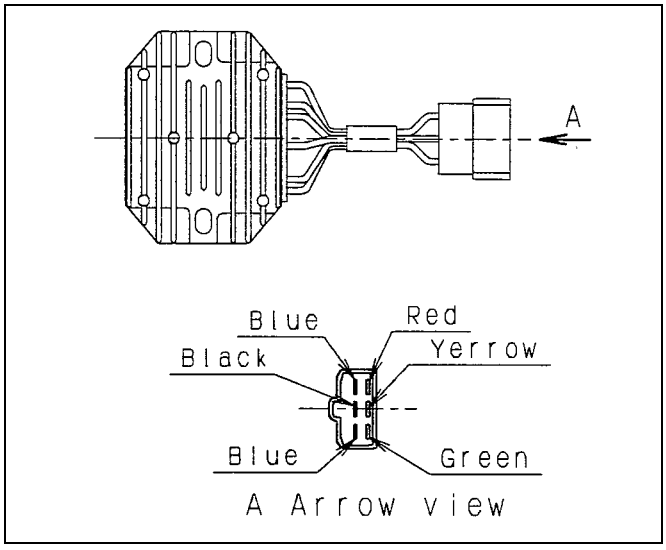


Fig. 9-34 Regulator (Kubota Standard Type)

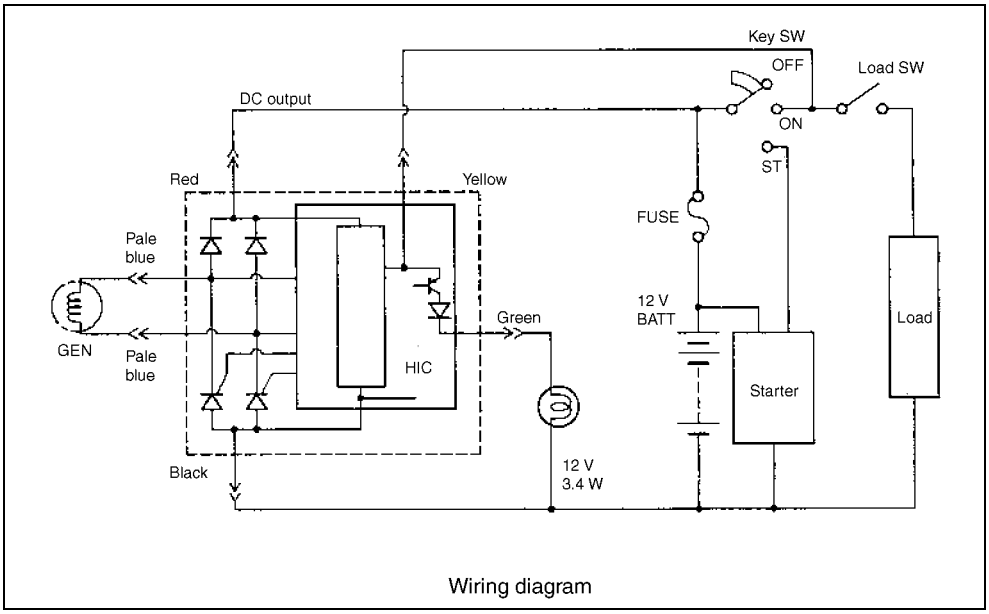


Fig. 9-35 Inside circuit of regulator

4. STOPPING DEVICE

[1] GENERAL

To stop diesel engine, normally, the operator will operate the stop lever, and reduce the injection amount of fuel to zero.
However, this operation of stopping the engine can be performed in such a way that the engine solenoid is excited by turning starter switch to the off position, and the stop solenoid plunger is pulled in to stop the fuel and the engine.
This system uses the engine key to operate the stop device, and facilitates easy operation, in addition, manual operation is also possible.

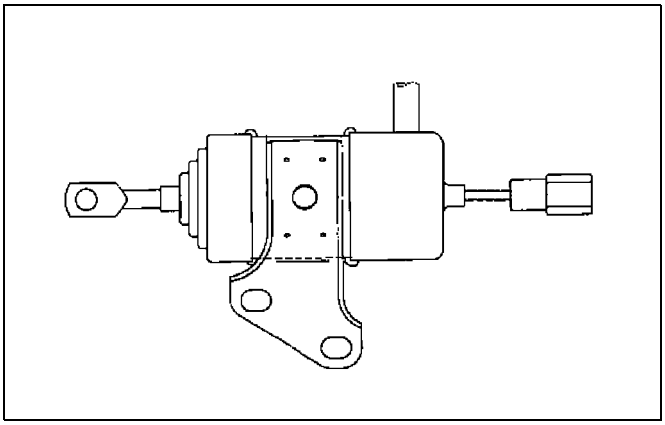
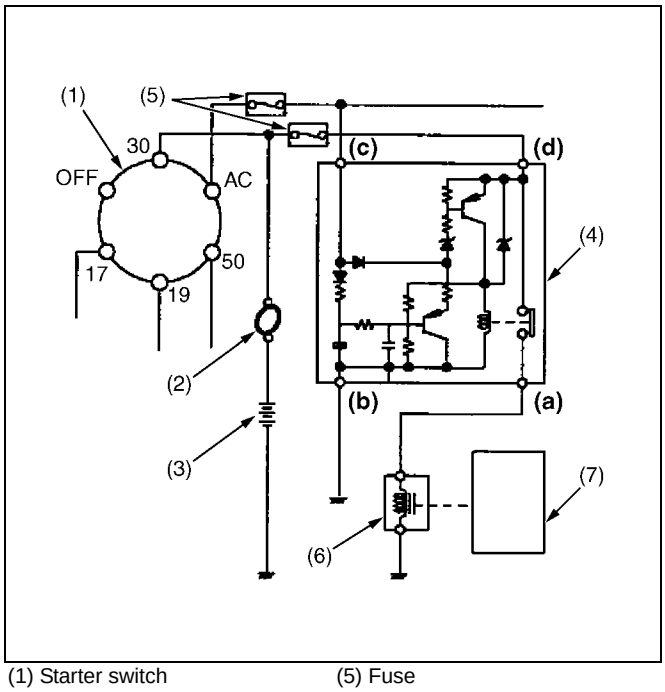


Fig. 9-37 Energize to stop device

[2] SOLENOID

(1) Energize to stop type solenoid

This stopping device is composed of the solenoid and timer relay, and will keep activating the solenoid for about 10 seconds after the starter switch is turned to off position so that the control rack is pushed to the non-injection position, and the engine is stopped.



(1) Starter switch
(2) Fusible ring
(3) Battery
(4) Timer relay
(5) Fuse
(6) Solenoid
(7) Injection pump

Fig. 9-36 Energize to stop device

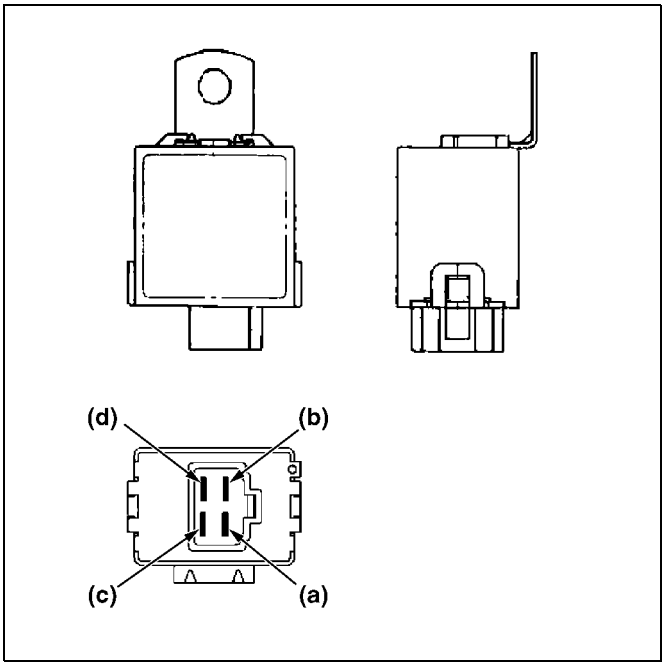


Fig. 9-38 Timer relay

(2) Energize to run type solenoid

In case that electrical trouble (equipment damage, disconnection of wire, and short circuiting) has occurred, the energized to stop type solenoid can stop the engine only by manual operation, and on the other hand, in case of energize to run type, engine can be stopped forcibly (automatically).

The energize to run type is an effective system in view of safety, however the engine cannot be started if electrical trouble has occurred.

1) Activation circuit

a) When the starter switch is turned to 'start' :

If the starter switch is turned on, electrical current will flow from AC of the starter switch to Hold Coil (H.C), and excite H.C.

If the main contact point of the starter is closed, electrical current will flow from C terminal of the starter to Pull Coil (P.C), and excite P.C.

With above procedure, the plunger will then be pulled in.

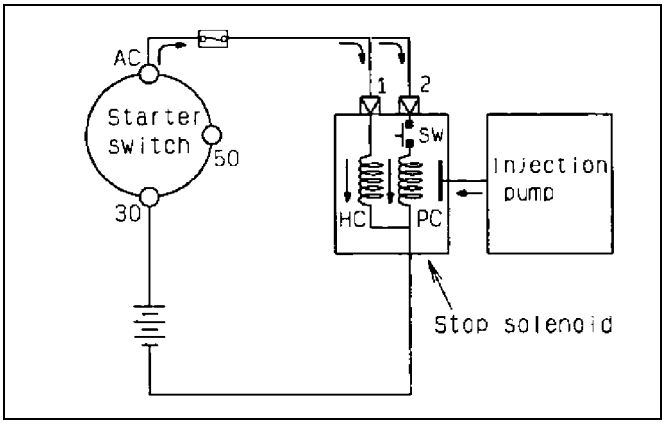


Fig. 9-39

b) When the starter switch is turned on :

The plunger is attracted by the magnetic force of the attraction coil and completely drawn, when the solenoid internal contact is opened to cut off the current to the attraction coil. However, the holding coil maintains the plunger at the drawn position.

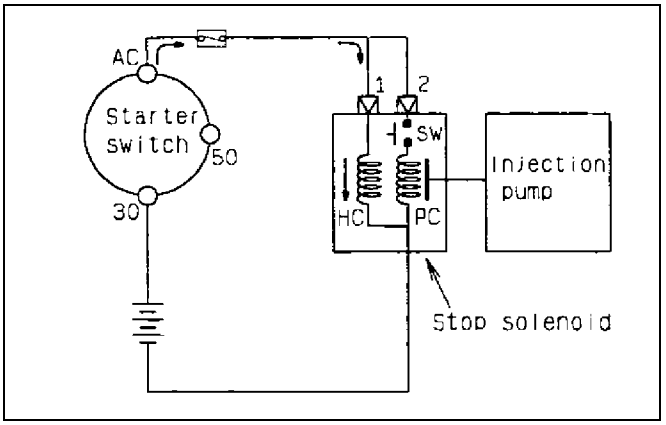


Fig. 9-40

c) When the starter switch is turned off :

When the key switch is turned off, the current to the holding coil is cut off and the plunger returns to the initial position by the return ring in the solenoid, which brings the injection pump fuel injection quantity to 0.

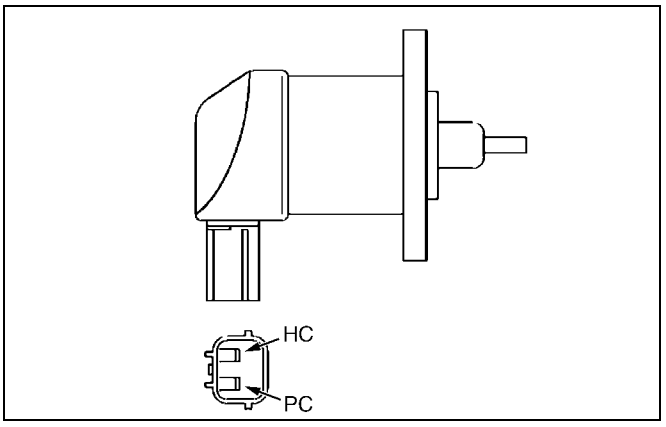


Fig. 9-41 Energize to run solenoid

5. MONITORING AND CONTROLLING DEVICE

[1] MONITORING DEVICE

(1) General

Minimum limit monitoring is required to maintain the normal operation of the engine.
Operating and monitoring devices include parts and instruments as follows

a) Glow lamp
b) Oil pressure lamp
c) Water temperature lamp
d) Charging lamp
e) Water temperature meter
f) Hour meter

g) Oil pressure gauge
h) Fuel gauge
i) Pilot lamp

Which equipment is employed shall be determined by taking into consideration the factors such as the types of engines, use condition (temperature, time, load, etc.), and design.

(2) Lamps

There are lamps which indicate abnormality of oil pressure, coolant temperature, and one which indicates heated condition of the glow plug.
The pilot lamp combines the four lamps, i.e., glow lamp, oil pressure lamp, coolant temperature lamp, and charging lamp into one unit, and is convenient when planning the control box and when operating.

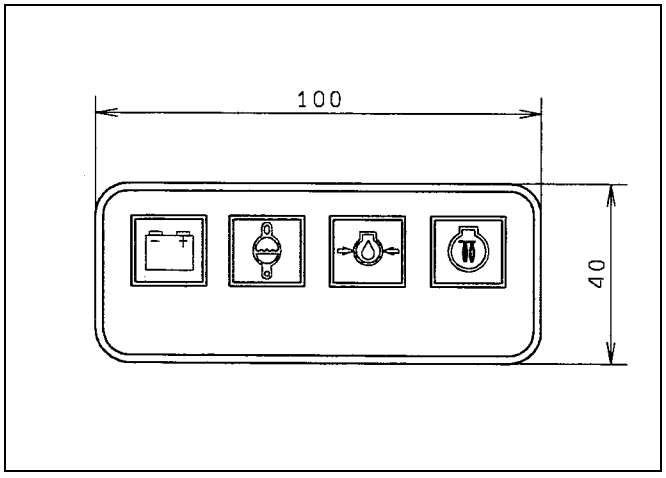


Fig. 9-42 Pilot lamp (Kubota option)

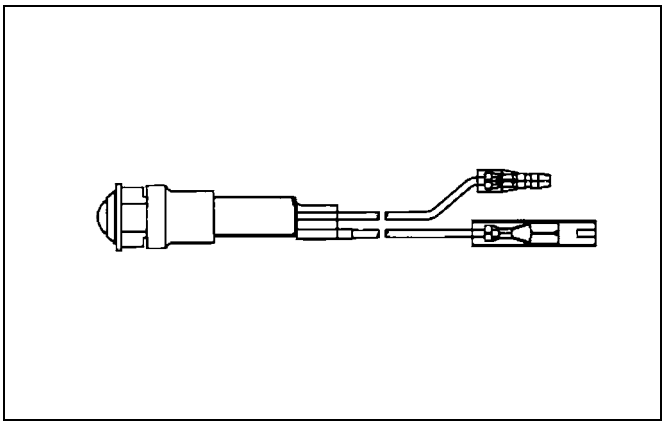


Fig. 9-43 Indicator lamp (Kubota standard)

(3) Water temperature and oil pressure gauge (Kubota option)

The gauge indicates cooling water temperature and lubricating oil pressure during the operation of the engine.
Generally, the lamp-indication type is often employed, however other indication types are also available depending on the request, and several types are available as optional parts from KUBOTA.
When employing these gauges, it is required to install the relevant sensors on the engine.

(4) Hour meter (Kubota option)

There are two types, i.e., the mechanical type and electrical type.
In case of the mechanical type, the cable length is predetermined since the engine and the hour meter are connected by cable, and the maximum length is restricted depending on the drive resistance. Installation of mechanical type is comparatively easy. However, in case of the electrical type, design and preparation of the parts, as well as adjustment for installation are necessary for the sake of installing the sensor.

[2] CONTROLLING DEVICE

(1) General

This section describes the electronic governor system, which is mounted mainly on the BG type.

(2) ECU (Engine Control Unit)

ECU also has an actuator function that is necessary for the control of electronic governors; therefore, it is used in such engines like the BG-type engines of generator specification.

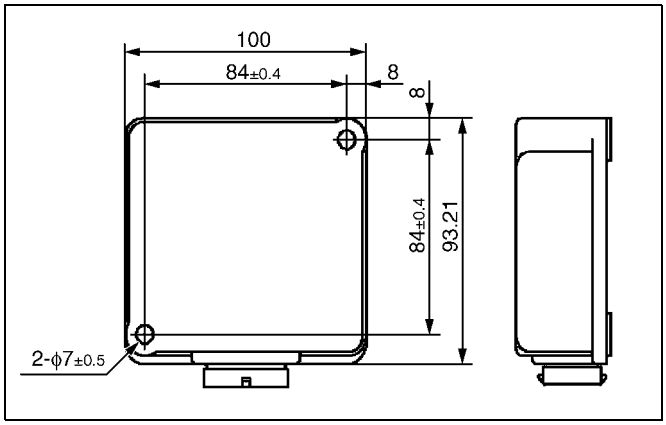


Fig. 9-44

(3) Proportional solenoids

The proportional solenoid is able to control the plunger position instantaneously by changing the driving current of the solenoid in addition to the functions of the conventional Stop solenoid.

The proportional solenoid is used in the electronic governors to reduce the revolution fluctuation by linearly controlling the control rack of the fuel pump of the engine. Such electronic governors are widely used for various applications including power generators and refrigerators.

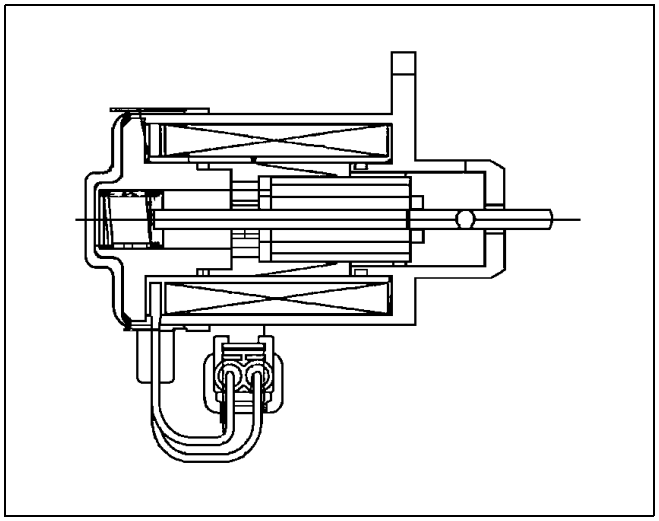


Fig. 9-45

(4) Engine speed sensor

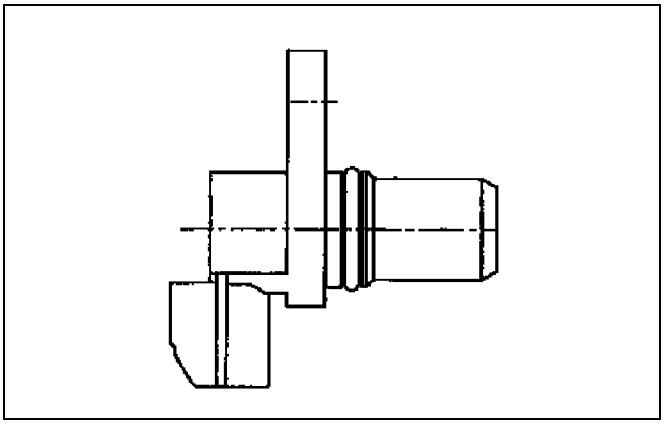


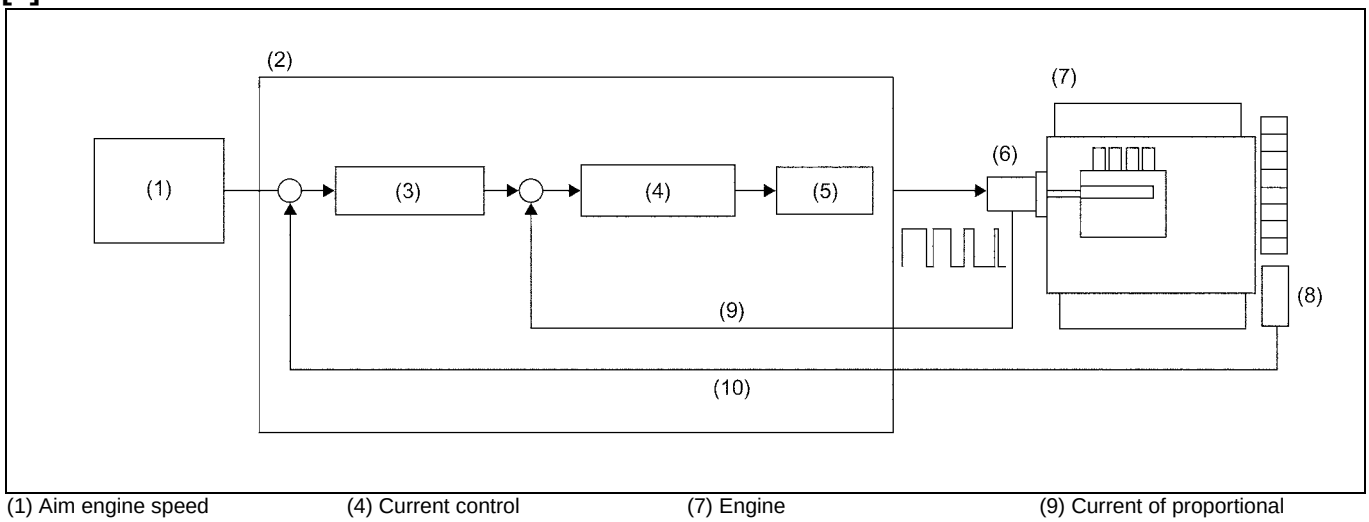
Fig. 9-46

6. ELECTRONIC GOVERNOR

[1] GENERAL

BG series uses an electronic governor in conjunction with a mechanical governor. The function of the electronic governor is, by isochronous control, to maintain constant engine speed the prescribed level, even if the load changes, by controlling the fuel.

[2] SOFTWARE BLOCK DIAGRAM

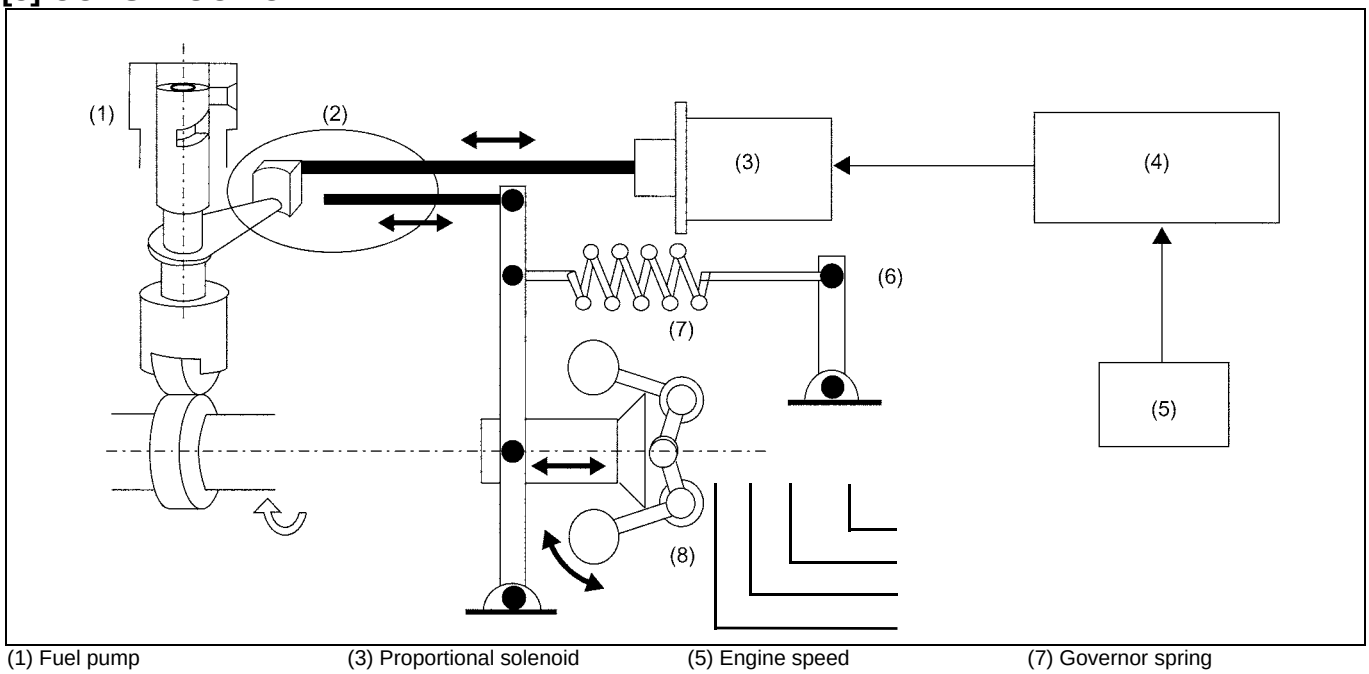


(1) Aim engine speed
(2) ECU
(3) Speed control
(4) Current control
(5) PWM
(6) Proportional solenoid
(7) Engine
(8) Engine speed sensor
(9) Current of proportional solenoid
(10) Engine speed

Fig. 9-47

Note :
Feedback Signal : Equivalent fuel injection quantity substituted from the current of engine speed and proportional solenoid.

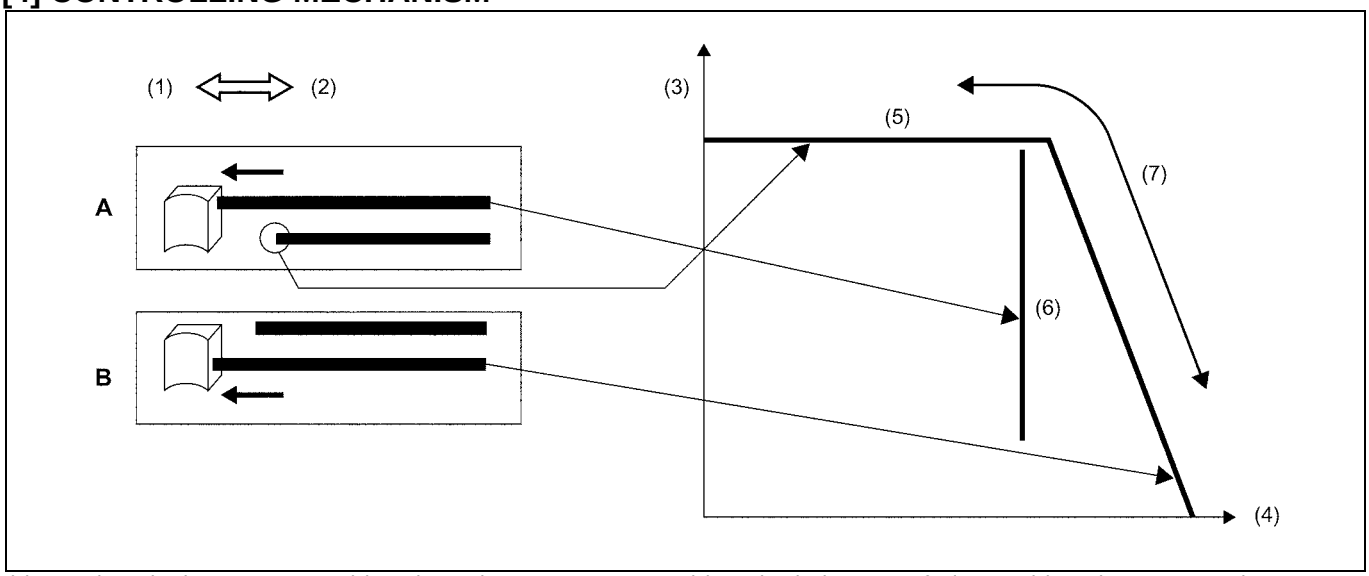
[3] CONSTRUCTION



(1) Fuel pump
(2) Control rack
(3) Proportional solenoid
(4) ECU
(5) Engine speed
(6) Accelerate lever (fixed at maximum speed)
(7) Governor spring
(8) Governor weight

Fig. 9-48

[4] CONTROLLING MECHANISM



(1) Quantity reduction
(2) Quantity increase
(3) Fuel quantity
(4) Engine speed
(5) Mechanical governor fuel control
(6) Isochronous control
(7) Mechanical governor operating curve

A : Within the range of the mechanical governor free speed control occurs.
B : If the engine rotational speed increases priority is given to the mechanical governor control function.

Fig. 9-49

7. WIRING

[1] STANDARD WIRING (KUBOTA Recommendation)

The two types of the wiring, i.e.,
Starter with safety device / Energize to stop type solenoid for S.M., 05, 03-M series
and Starter with safety device / Energize to run type solenoid for S.M., 05, 03-M, 07, V3 series, respectively, as follows.
In case that a particular request is not presented, the KUBOTA standard specification or similar wiring to the specifications are recommended.

[2] CAUTIONARY ITEMS FOR WIRING

1) Equipment should be grounded securely.
When the grounding is not properly done, necessary amount of electrical current will not flow, and function of electrical equipment will not be exhibited fully. For example, it is possible that insufficient grounding of the starter will cause failure to start, and in addition, after repeating the starting many times, the starter will seize.
Therefore, select a clean metal surface for the grounding wire attachment (on the main machine side as well as engine side), and completely remove the paint to make the contact resistance as low as possible.

2) The wire diameter of wiring and the electrical current capacity of each fuse are shown in the wiring diagram.
However, these are only recommended values, and therefore when applying to the actual case, be careful to use the correct sites taking into consideration the length of wiring and the connection form.
Note that the wire diameters not specified in the wiring diagram shall be 0.8 to 1.25 mm^2.

3) Wiring should be routed and secured, be careful so that the insulation will not be worn off due to contact with other parts during operation, and short circuiting will not occur.
Further, it recommended to protect wiring with corrugated protective covers.

4) In case that wiring is made mistaking the polarity, wiring materials may be burned and damaged, or it may result in personal injury.
It is important that any mistaken wiring never be made, and in addition, attention and care (by changing the colors and length of wire) should be taken not to let workers perform incorrect wiring.

5) Use low-voltage wires for automobile (AV SS wire, etc.) for wiring. However, in case that the ambient temperature is more than 75 °C (167 °F), use heat-resistant wires (AVX wire, etc.).
Example :
A V 0.5 RW

A : Color code
V : Sectional area
0.5 : Insulation material : Vinyl
RW : Low-voltage wire for automobile

6) To protect wiring, use a fuse or slow-blow fuse. Note that slow-blow fuses should be located near to the battery, and fuse box to the starter switch.

7) As for the load that may incur when unexpected current comes into the circuit, such as the case of motors, be careful not to directly connect to ACC and any wires connected directly to battery '+'.

8) Attach covers to the terminal on the terminal on the positive side of the battery to prevent sparks due to accidental contact.

[3] SIZE OF WIRING

(1) General

a) The size of wiring shall be determined taking into consideration the various factors such as the length of cable, electrical current value, allowable voltage drop, etc.

b) When electrical current 'A' (Amperes) flows in the circuit, the resistance 'ohms' always exists as the result of electrical power loss in the cable, and the voltage will be decreased.
The difference between the voltage of electrical power source and the voltage at the connection end of the cable of each equipment is the voltage drop leading to poor performance.

c) Excessive electrical power loss in the cable will cause overheating of the cable and drastic voltage drop.
To resolve such a problem, it is important to take into consideration that the cable resistance is the accumulated value of complete circuit and to correctly use the specified cables.

d) The rated value of the cable shall be determined according to the allowable electrical current value.
Electrical resistance depends on the total sectional area of the conductive material (wire).
It is possible to minimize the electrical power loss and voltage drop by using correct cables.
It is important to restrain the temperature increase of the cable for the cables that are used together in a harness.

e) All of the voltage drop in the circuit should not exceed 10% of the regular voltage. (For example, 1.2 V in case of 12 V circuit.)
The voltage drop expected to occur in the circuit can be measured by using the simple formula as shown below :

Voltage drop = Current value × Total cable resistance

f) For the cables in which electrical current will flow continuously for a long period of time, attention and care must be taken for both the temperature increase and voltage drop, and on the other hand, as for the circuit to be used for a short time (for example, preheating circuit), care must be taken for the voltage drop.
Voltage drop of the glow plug circuit, is should be minimized so that necessary level to heat the glow plug can be maintained.

(2) Connector and terminal

After selecting the correct cables, it is required to select the connectors and terminals that can match each electrical part.
The connectors and terminals of major electrical parts that are employed in KUBOTA engines are shown in the SOS.

(3) Battery cable

The battery cable is the first 'connection' in the electric system of engine. Attention and care should be taken so that this cable should be of the sufficient size matching the electrical current required, and the length should be as short as possible.
Take care to securely install the battery terminals, and tightly clamp the cables.

Voltage drop against each battery cable should not exceed 0.6 V DC – 0.8 V DC.

Recommended minimum battery cable :

Engine	Cable size (mm^2)	AWG size
S.M. series	20	4
05 series	20	4
03-M series	30	3
07 series	60	2/0
V3 series	60	2/0

8. BATTERY

The battery makes it possible to store electric energy as chemical energy, and to take it out as electric energy as needed.
Further, a battery is the device that can repeatedly charge and discharge.

(1) Formula of discharging amount
Discharging amount (Ah) = Rated capacity (Ah) × (S.G. when fully charged - S.G. when measuring) / (S.G. when fully charged - S.G. when fully discharged)

In general case :
S.G. when fully charged : 1.26 {20 °C (68 °F)}
S.G. when fully discharged : 1.06 {20 °C (68 °F)}

S.G. : Specific Gravity

Battery capacity is indicated by the electricity amount that can be taken out before the voltage reaches the discharging end voltage, after the fully charged battery is continuously discharged with a electrical current.

Capacity (Ah) = Discharging currenct (A) × Time until discharging end voltage (Hr)

[Meaning of 45 Ah / 20 Hr]
45 Ah / 20 Hr = 2.25 A ··· 20 hour rate current

Capacity is determined when the battery voltage becomes the discharging end voltage, when the battery is discharged for 20 hours at 2.25 A.

(2) Temperature rectification
Temperature compensation should be made for the specific gravity measured by a gravimeter.
This specific gravity value will indicate that “it is low when the temperature is high”, and “it becomes high when the temperature becomes low”.
Generally, the specific gravity of the electrolyte of battery shall be taken using the temperature of 20 °C (68 °F) as the standard, and as for the rate of the change, the specific gravity decreases by 0.0007 against a temperature increase of 1 °C (34 °F), and the specific gravity increases by 0.0007 against the temperature of 1 °C (34 °F).

It is convenient to use the following formula to convert the specific gravity measured at a certain temperature into the standard temperature of 20 °C (68 °F).

S20 = St + 0.0007 (t - 20)
S20 : S.G. at the temperature of 20 °C (68 °F)
St : S.G. at the temperature of t °C

[Example : In case of electrolyte temperature of 40 °C (104 °F)]
Reading of gravimeter : 1.240
S20 = 1.240 + 0.0007 (40 - 20) = 1.254

Consequently, the S.G. converted into 20 °C (68 °F) is 1.254. If looked at on the gravimeter, it appears that it is discharged by about 10%, however, if converted into the standard temperature, it is practically near to the state of full charge.
The charged or discharged state of battery can be known by measuring the S.G. of the electrolyte.
When measuring S.G., it can easily be performed comparatively by using a suction gravimeter.

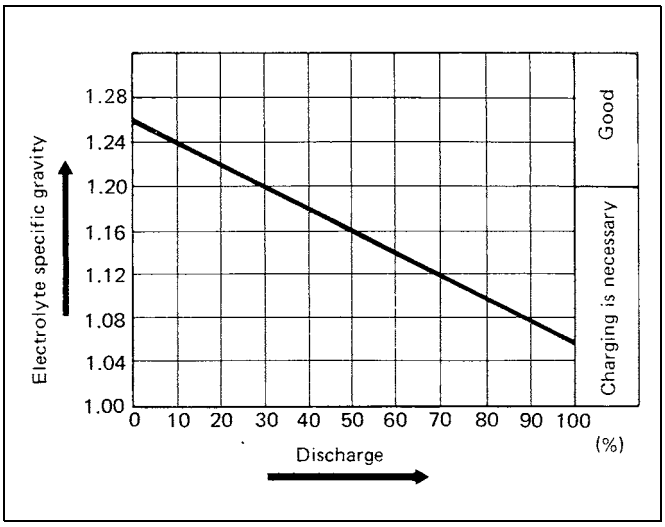


Fig. 9-50 Relation between specific gravity of electrolyte and discharging amount

Gravity of electrolyte 20 °C (68 °F)	State of discharging
1.260	100
1.210	75
1.160	50
1.110	25
1.060	Totally discharged

Fig. 9-51 Specific gravity indication varies with discharging amount

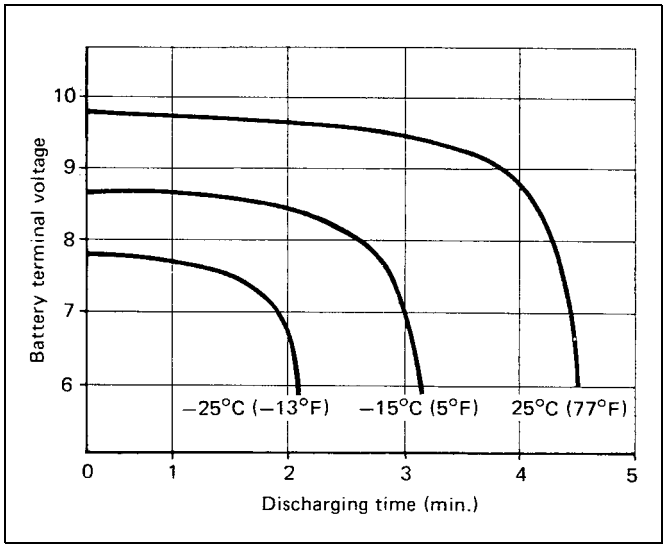
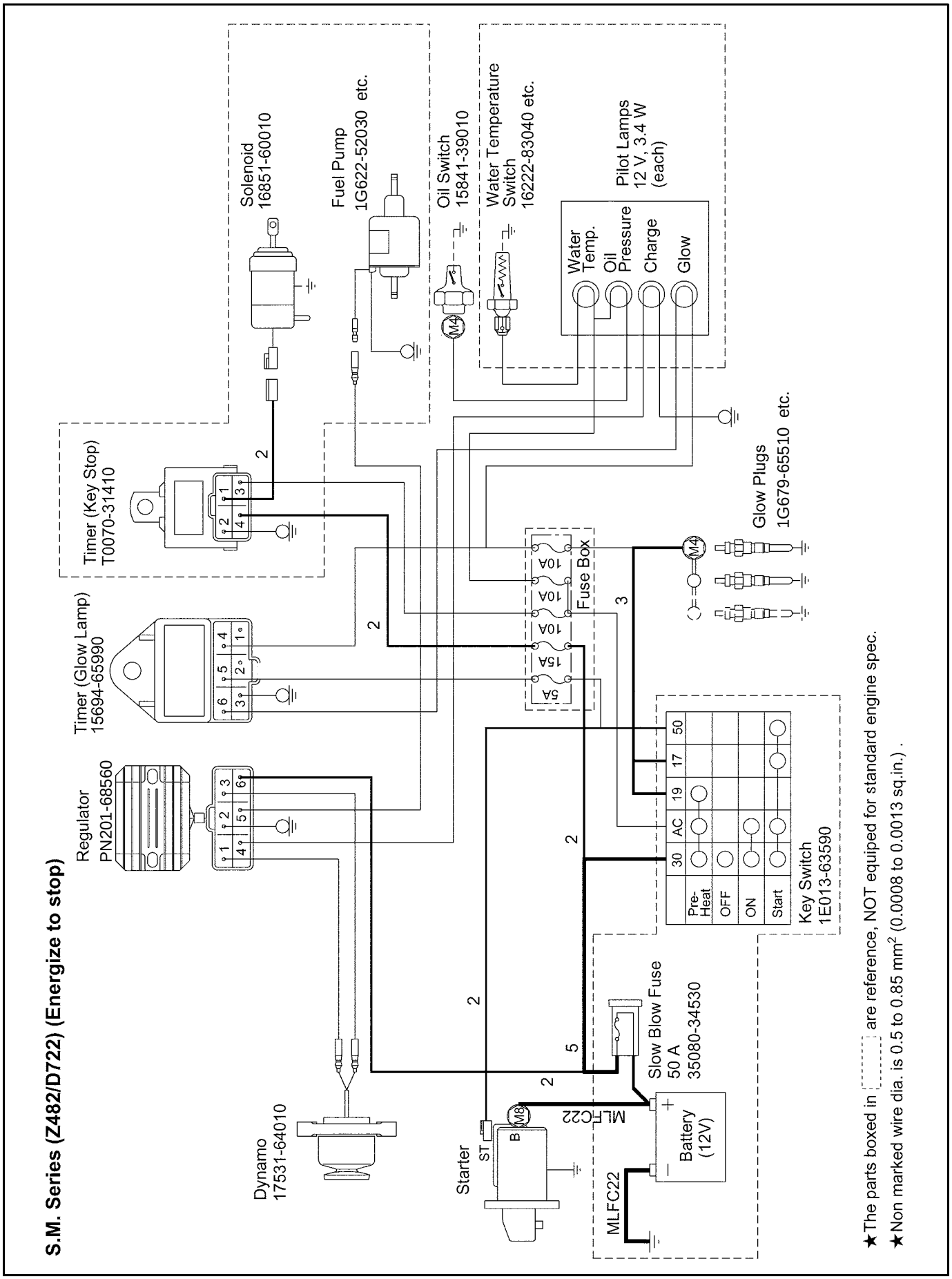
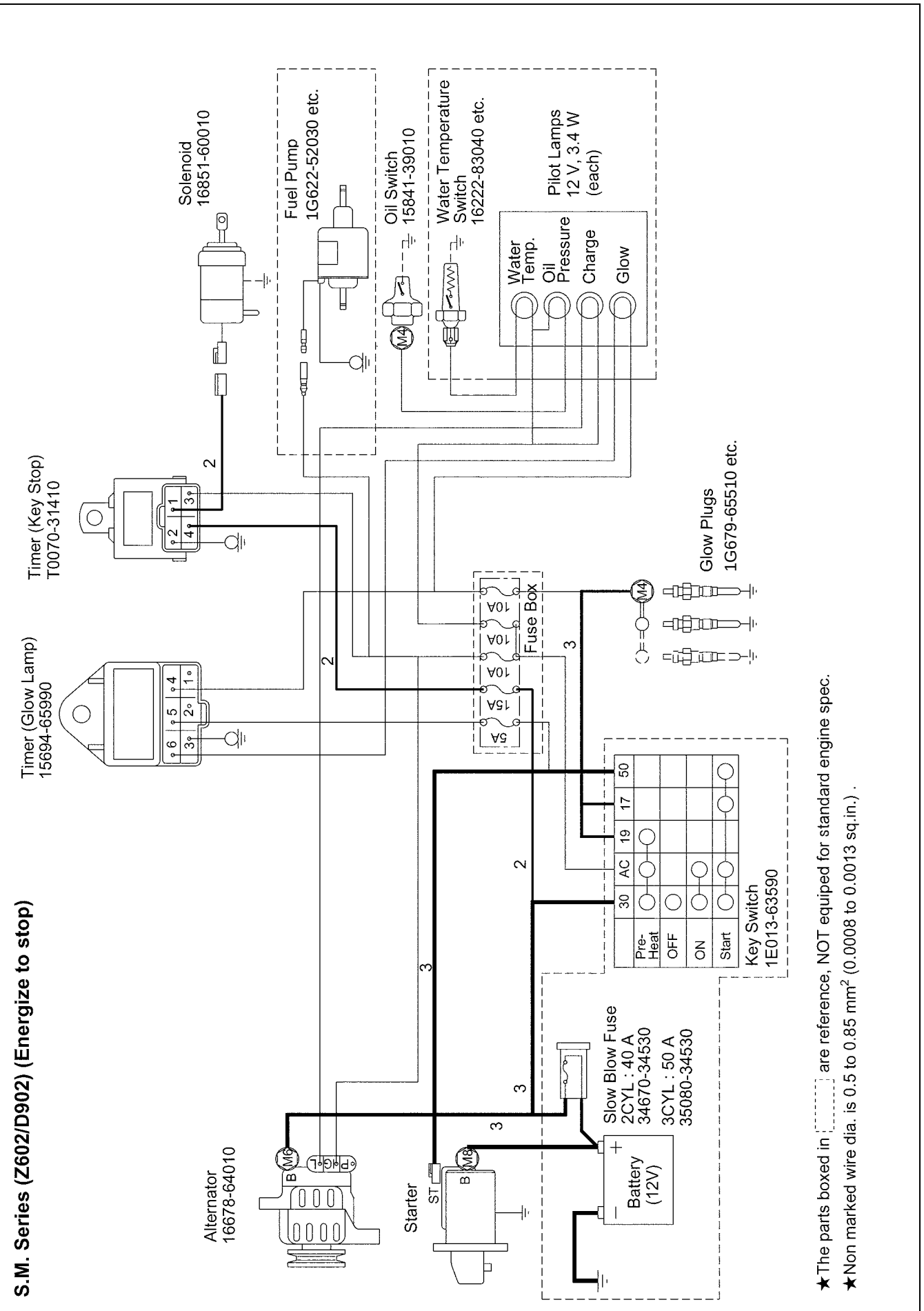
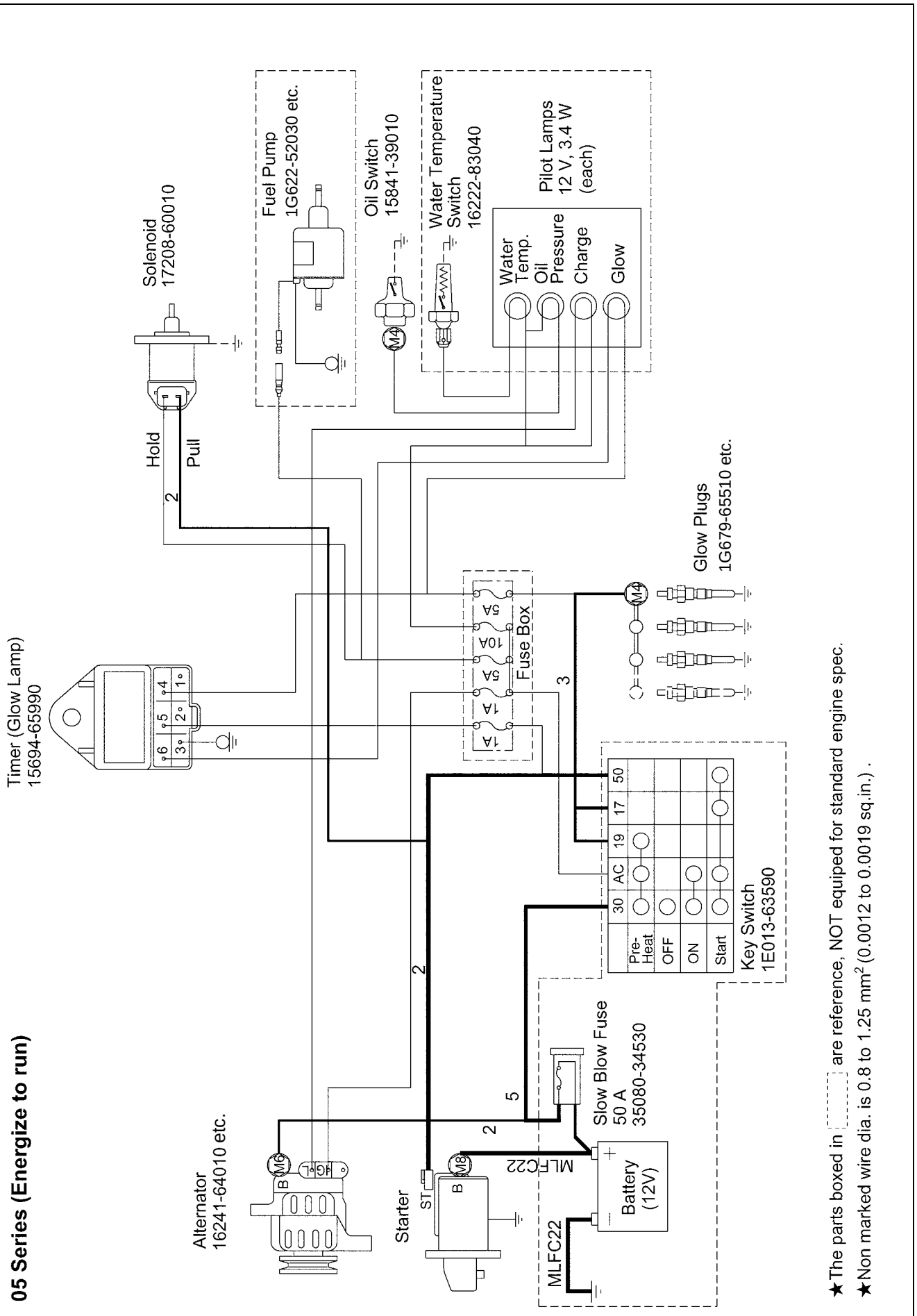


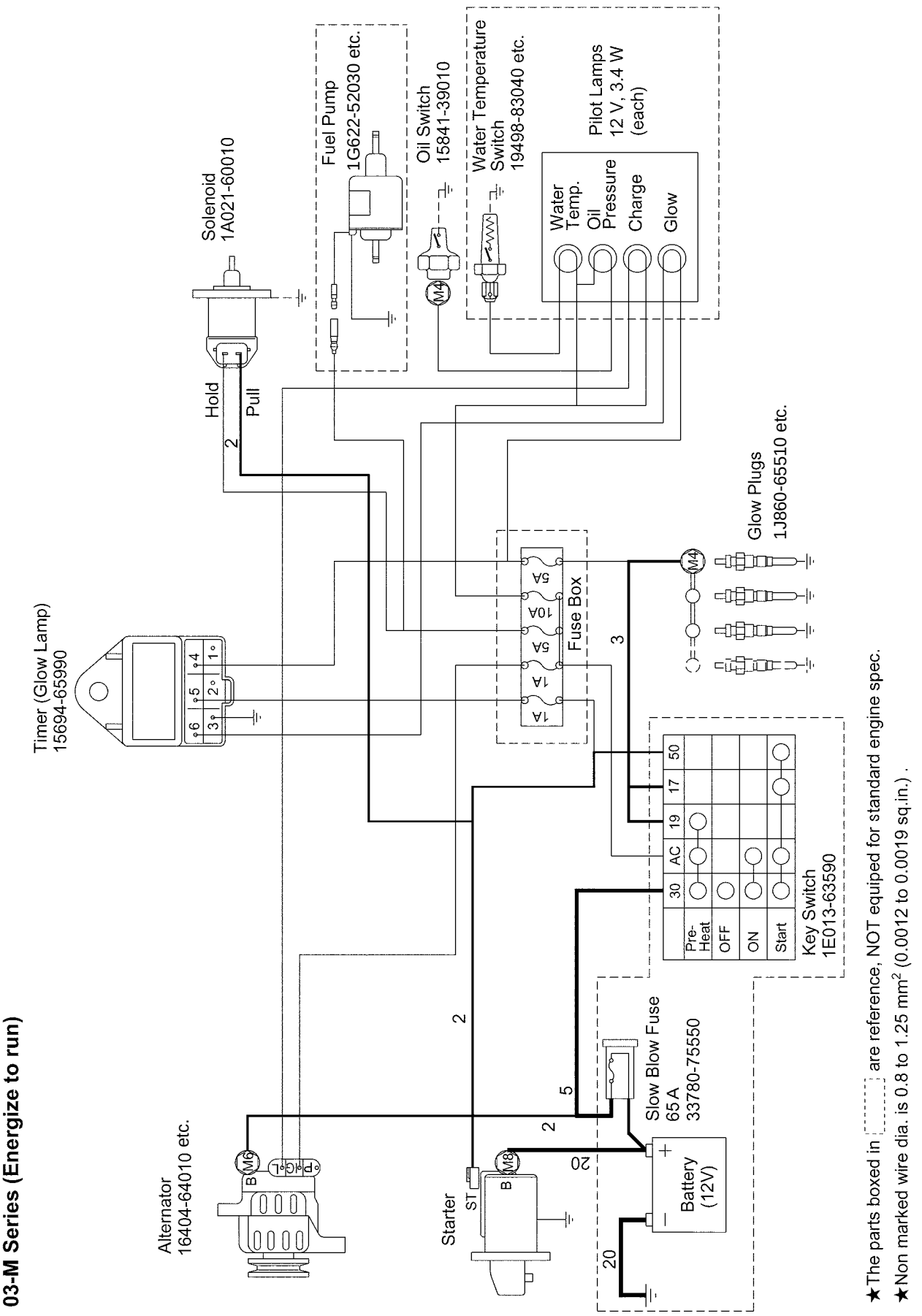
Fig. 9-52 Battery temperature and discharge ability (Example of N70 : 12 V, 70 A)

9. WIRING DIAGRAM

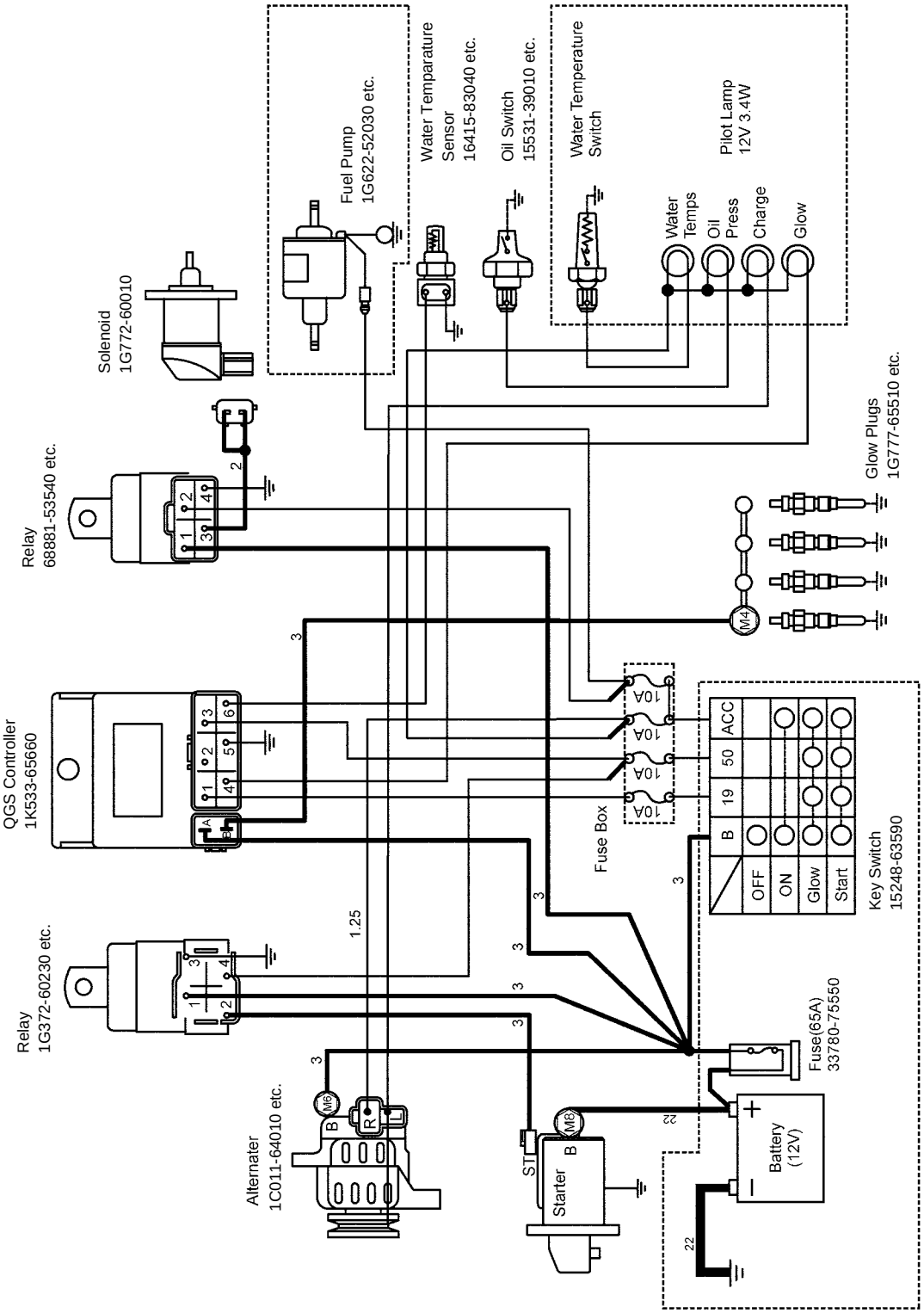


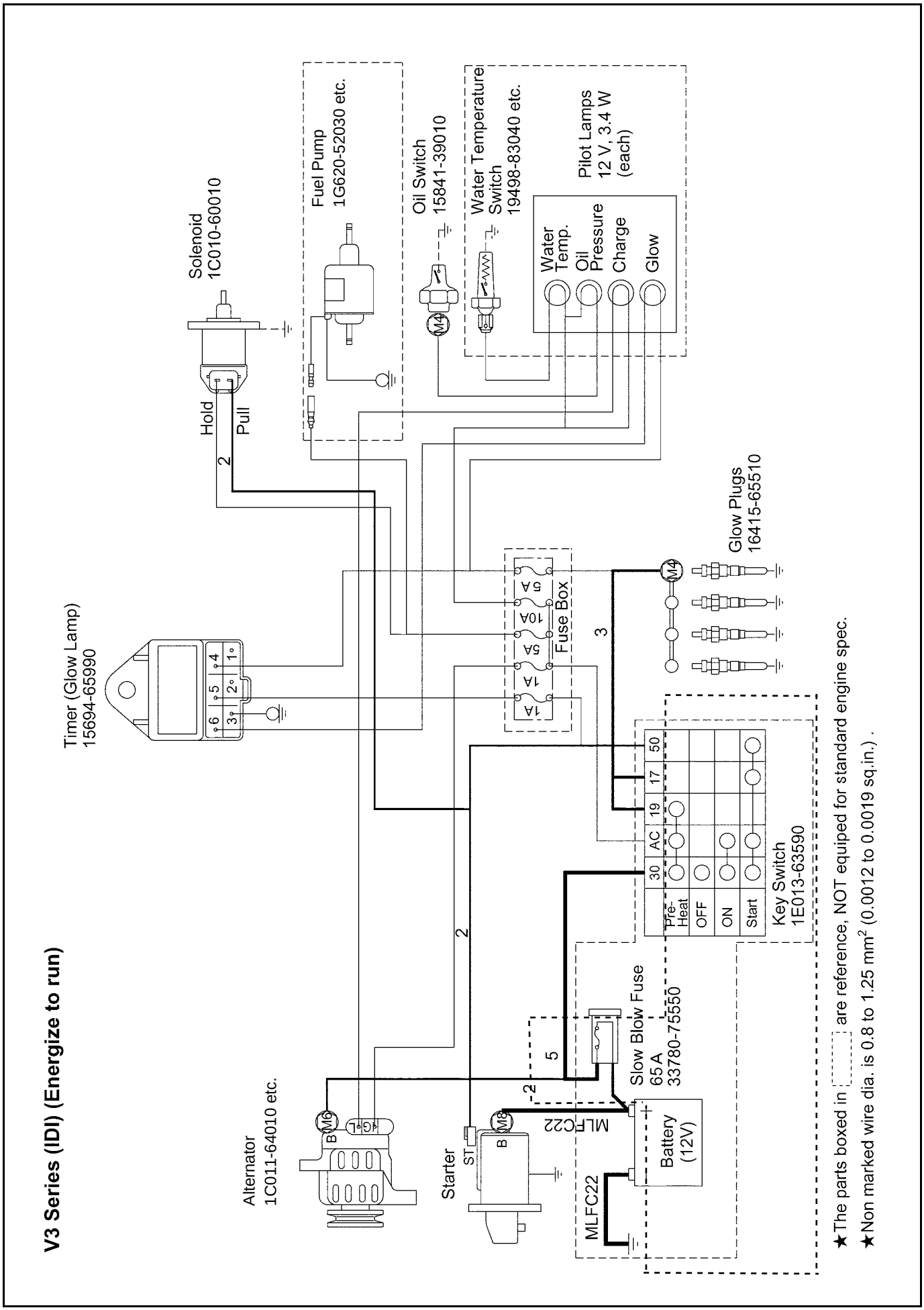

S.M. Series (Z602/D902) (Energize to stop)
Solenoid
16851-60010
Fuel Pump
1G622-52030 etc.
Oil Switch
15841-39010
Water Temperature
Switch
16222-83040 etc.
Pilot Lamps
12 V, 3.4 W
(each)
Water
Temp.
Oil
Pressure
Charge
Glow
Timer (Key Stop)
T0070-31410
Timer (Glow Lamp)
15694-65990
Fuse Box
10A
10A
10A
15A
5A
Glow Plugs
1G679-65510 etc.
Key Switch
1E013-63590
Pre-
Heat
OFF
ON
Start
30
AC
19
17
50
Slow Blow Fuse
2CYL : 40 A
34670-34530
3CYL : 50 A
35080-34530
Battery
(12V)
Alternator
16678-64010
Starter
B
L
P
ST
M6
M4
2
3
★The parts boxed in [ ] are reference, NOT equiped for standard engine spec.
★Non marked wire dia. is 0.5 to 0.85 mm² (0.0008 to 0.0013 sq.in.) .

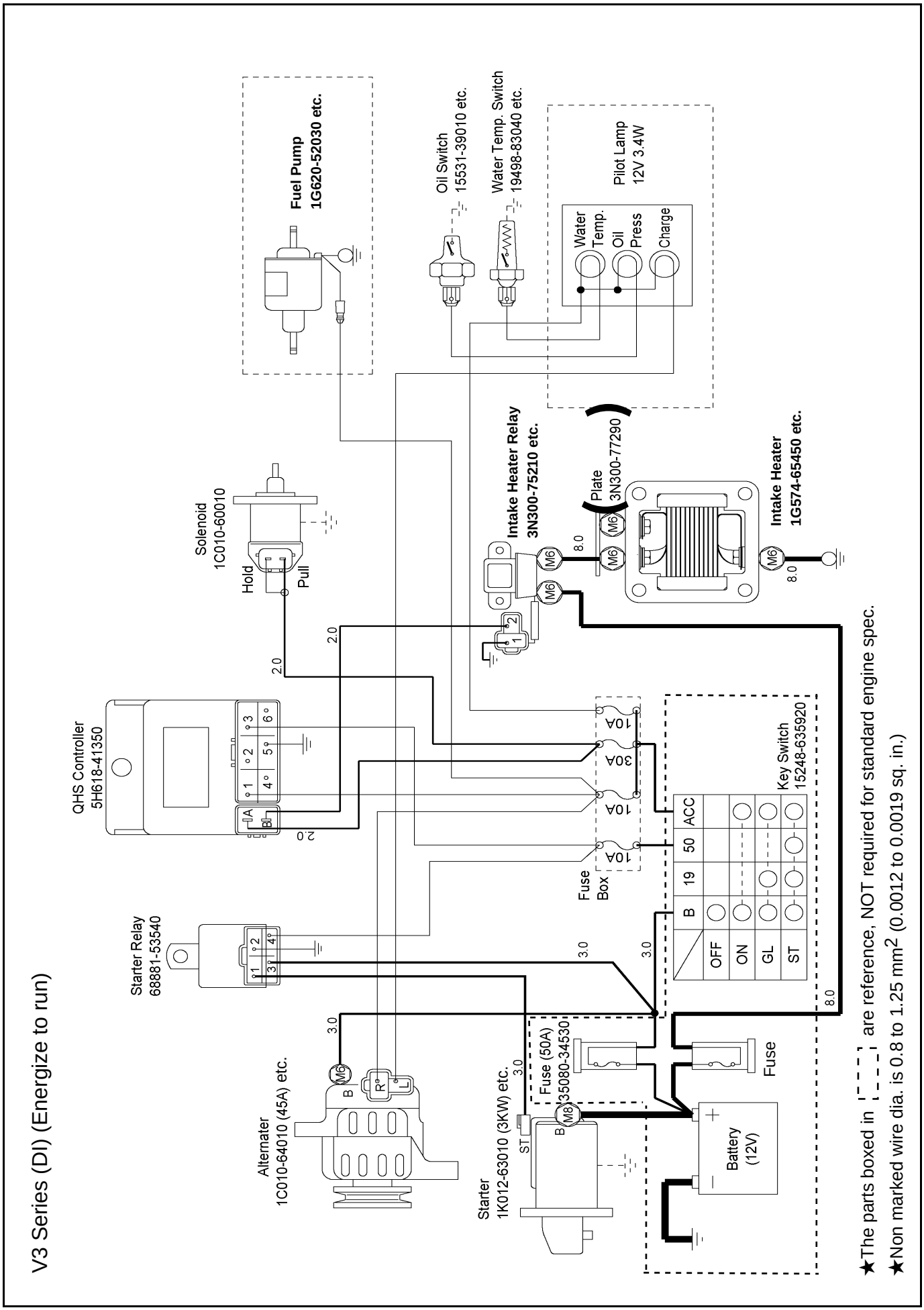

05 Series (Energize to run)
Solenoid
17208-60010
Hold
Pull
Fuel Pump
1G622-52030 etc.
Oil Switch
15841-39010
Water Temperature
Switch
16222-83040
Pilot Lamps
12 V, 3.4 W
(each)
Water
Temp.
Oil
Pressure
Charge
Glow
Glow Plugs
1G679-65510 etc.
Timer (Glow Lamp)
15694-65990
Fuse Box
5A
10A
5A
1A
1A
Key Switch
1E013-63590
Pre-
Heat
OFF
ON
Start
30
AC
19
17
50
Alternator
16241-64010 etc.
Starter
Slow Blow Fuse
50 A
35080-34530
MLFC22
Battery
(12V)
2
3
5
M4
M6
M8
B
IG
L
ST
★The parts boxed in [ ] are reference, NOT equiped for standard engine spec.
★Non marked wire dia. is 0.8 to 1.25 mm² (0.0012 to 0.0019 sq.in.) .


03-M Series (Energize to run)
Solenoid
1A021-60010
Hold
Pull
2
Fuel Pump
1G622-52030 etc.
Oil Switch
15841-39010
Water Temperature
Switch
19498-83040 etc.
Pilot Lamps
12 V, 3.4 W
(each)
Water
Temp.
Oil
Pressure
Charge
Glow
Glow Plugs
1J860-65510 etc.
Timer (Glow Lamp)
15694-65990
Fuse Box
5A
10A
5A
1A
1A
3
Key Switch
1E013-63590
Pre-
Heat
OFF
ON
Start
30
AC
19
17
50
Slow Blow Fuse
65 A
33780-75550
Battery
(12V)
Alternator
16404-64010 etc.
B
M6
L
R
Starter
ST
B
M8
2
5
20
★The parts boxed in [ ] are reference, NOT equiped for standard engine spec.
★Non marked wire dia. is 0.8 to 1.25 mm² (0.0012 to 0.0019 sq.in.) .

07 Series (V2607/V3307) (Energize to run)

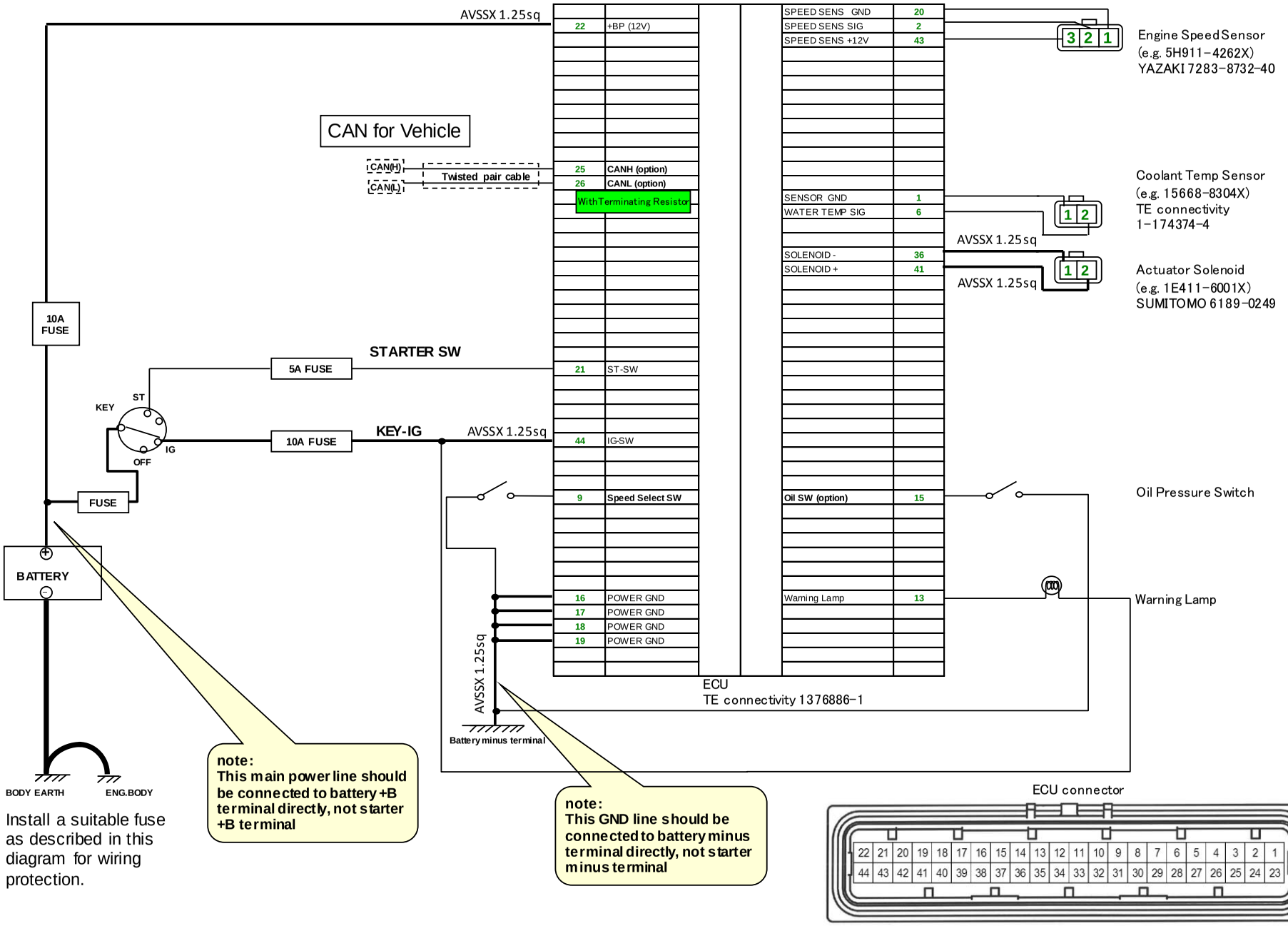



V3 Series (IDI) (Energize to run)
Solenoid
1C010-60010
Hold
Pull
2
Fuel Pump
1G620-52030 etc.
Oil Switch
15841-39010
M4
Water Temperature
Switch
19498-83040 etc.
Pilot Lamps
12 V, 3.4 W
(each)
Water
Temp.
Oil
Pressure
Charge
Glow
Glow Plugs
16415-65510
Timer (Glow Lamp)
15694-65990
Fuse Box
5A
10A
5A
1A
1A
3
2
Key Switch
1E013-63590
Pre-
Heat
OFF
ON
Start
30
AC
19
17
50
Slow Blow Fuse
65A
33780-75550
5
2
MLFC22
Battery
(12V)
Alternator
1C011-64010 etc.
M6
B
L
G
Starter
M8
ST
B
★The parts boxed in [ ] are reference, NOT equiped for standard engine spec.
★Non marked wire dia. is 0.8 to 1.25 mm² (0.0012 to 0.0019 sq.in.) .


V3 Series (DI) (Energize to run)
Fuel Pump
1G620-52030 etc.
Oil Switch
15531-39010 etc.
Water Temp. Switch
19498-83040 etc.
Pilot Lamp
12V 3.4W
Water Temp.
Oil Press
Charge
Solenoid
1C010-60010
Hold
Pull
Intake Heater Relay
3N300-75210 etc.
Plate
3N300-77290
Intake Heater
1G574-65450 etc.
QHS Controller
5H618-41350
Starter Relay
68881-53540
Fuse Box
10A
30A
10A
10A
Key Switch
15248-635920
OFF
ON
GL
ST
B
19
50
ACC
Alternater
1C010-64010 (45A) etc.
Starter
1K012-63010 (3KW) etc.
Fuse (50A)
35080-34530
Fuse
Battery
(12V)
★The parts boxed in [ ] are reference, NOT required for standard engine spec.
★Non marked wire dia. is 0.8 to 1.25 mm2 (0.0012 to 0.0019 sq. in.)

Z482 (Electronic governor): ECU System shematics

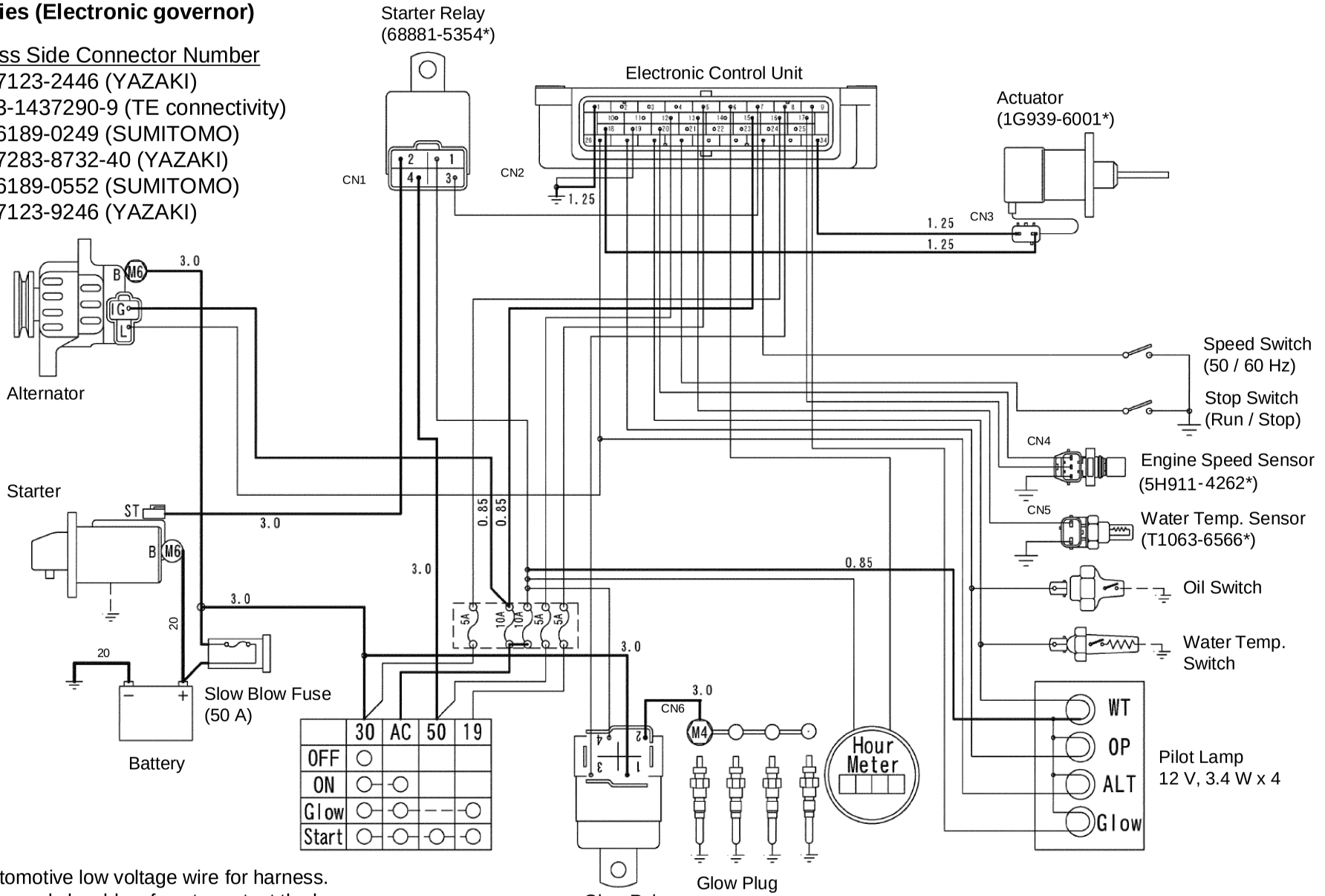
<Note> The picture shows the pin arrangement of the connector housing viewed from the harness connector mating side.



Install a suitable fuse as described in this diagram for wiring protection.

03-M series (Electronic governor)

Harness Side Connector Number
CN1: 7123-2446 (YAZAKI)
CN2: 3-1437290-9 (TE connectivity)
CN3: 6189-0249 (SUMITOMO)
CN4: 7283-8732-40 (YAZAKI)
CN5: 6189-0552 (SUMITOMO)
CN6: 7123-9246 (YAZAKI)



1. Use automotive low voltage wire for harness.
2. Use fuse and slow-blow fuse to protect the harness.
3. The wire and fuse size shown in this drawing are our recommendation, consider wire length and condition for actual production.
4. Allocate slow-blow fuse close to battery, fuse box close to key switch.
5. Do not directly connect induction device, such as motor, to AC line.
6. Use more than 0.5 mm^2 wire for unspecified wires in this drawing.

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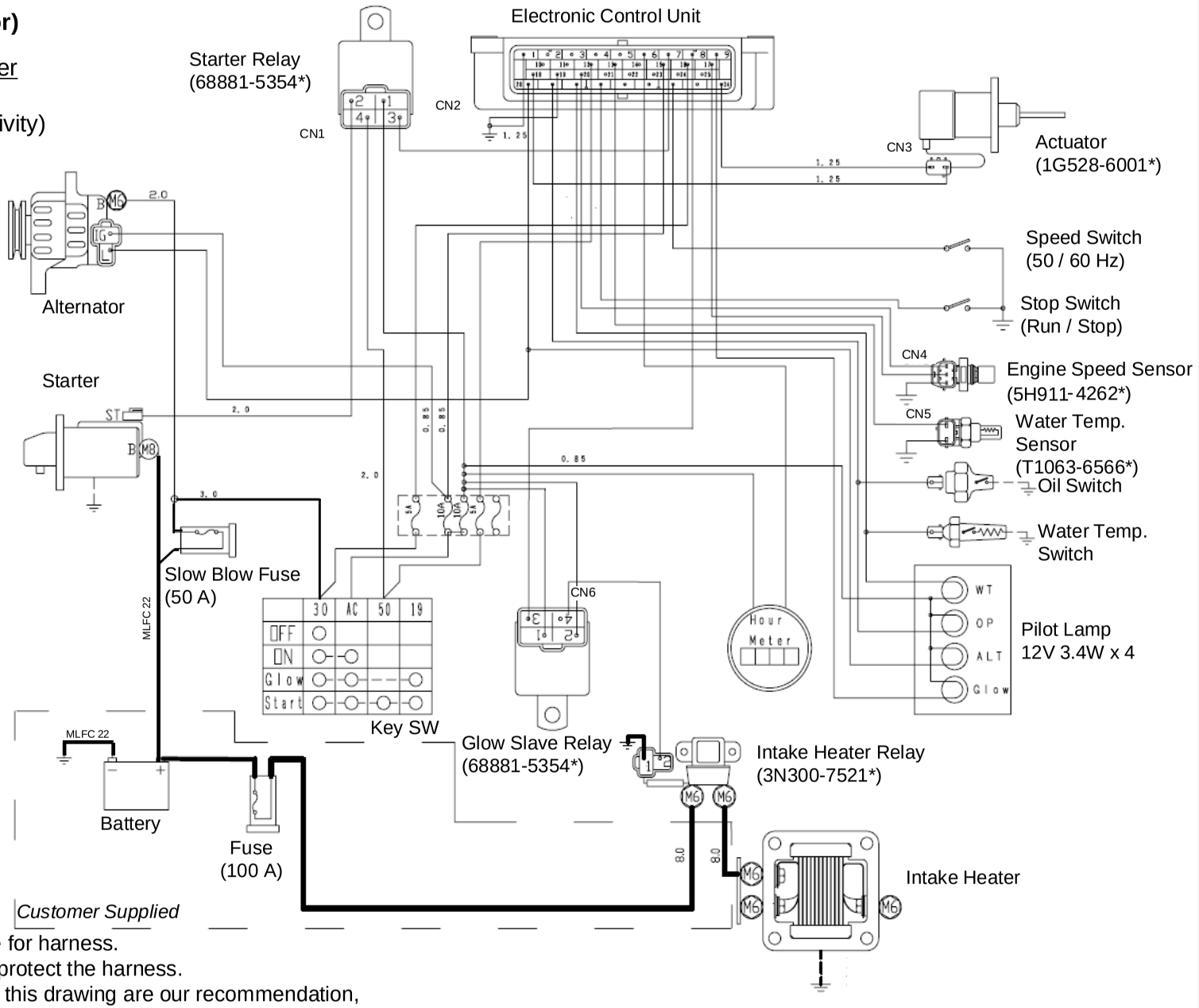
V3 series (Electronic governor)

Harness Side Connector Number
CN1: 7123-2446 (YAZAKI)
CN2: 3-1437290-9 (TE connectivity)
CN3: 6189-0249 (SUMITOMO)
CN4: 7283-8732-40 (YAZAKI)
CN5: 6189-0552 (SUMITOMO)
CN6: 7123-9246 (YAZAKI)



1. Use automotive low voltage wire for harness.
2. Use fuse and slow-blow fuse to protect the harness.
3. The wire and fuse size shown in this drawing are our recommendation, consider wire length and condition for actual production.
4. Allocate slow-blow fuse close to battery, fuse box close to key switch.
5. Do not directly connect induction device, such as motor, to AC line.
6. Use more than 0.5 mm^2 wire for unspecified wires in this drawing.

KiSS issued 05, 2010 A