

HCR1500-EDII
HCR1500-D20II

Electrical Systems

Engine starting circuits

1500-EDII for sn1454xxx

1500-D20II for sn1414xxx



Contents

1. Electrical Equipment for Engine Starting Circuits

1-1	Power and Fuses	2
1-2	Starting Motor	3
1-3	Battery Relay	3
1-4	Air Heater Relay and Air Inlet Heater	3
1-5	Starting Switch	3
1-6	Starter Relay	4
1-7	Alternator	4
1-8	Power Off Delay Timer	4
1-9	Air Pressure Release Valve	4

2. Engine Starting Circuits

2-1	Starting Switch On	5
2-2	Starting Engine	6
2-3	After Starting Engine	7
2-4	Stopping Engine	8

3. Engine Control Circuits

3-1	Manual Throttle Control	9
3-2	Auto Throttle Control	11
3-3	Emergency Shutdown Control	15
3-4	Diagnostic Lamps	16

4. Accessory Circuits

4-1	Lights	17
4-2	Horns	17
4-3	Warning Lamps	18
4-4	Gauges	23

1. Electrical Equipment for Engine Starting Circuits

1-1 Power and Fuses

- | | |
|------------------|--|
| PC1 Line | Power for electrical system, starting switch, back-up power for engine ECM and radio. If the F7 fuse is blown, the engine is not able to start. |
| PS1 Line | Power for PLCs, throttle control, angle indicators (optional). |
| P1 Line | Power for engine ECM, lights, horns, warning lamps, gauges and drifter hourmeter (optional). If the F1 fuse is blown, lose those controls. If it is blown while the engine is running, the engine will shut off. |
| P2 Line | Power for solenoid valves, indicators and buzzers. If the F2 fuse is blown, lose those controls. |
| P3 Line
(P03) | Power for switches and solenoid valves of the rod changer. If the F3 fuse is blown, lose those controls. |
| P4 Line | Power for wiper motors, room light and radio. If the F4 fuse is blown, lose those controls. |
| P5 Line | Power for air conditioner. If the F5 fuse is blown, lose those controls. |
| P6 Line | Power for additional lights (optional) and 3-D angle indicators (optional). If the F6 fuse is blown, lose those controls. |

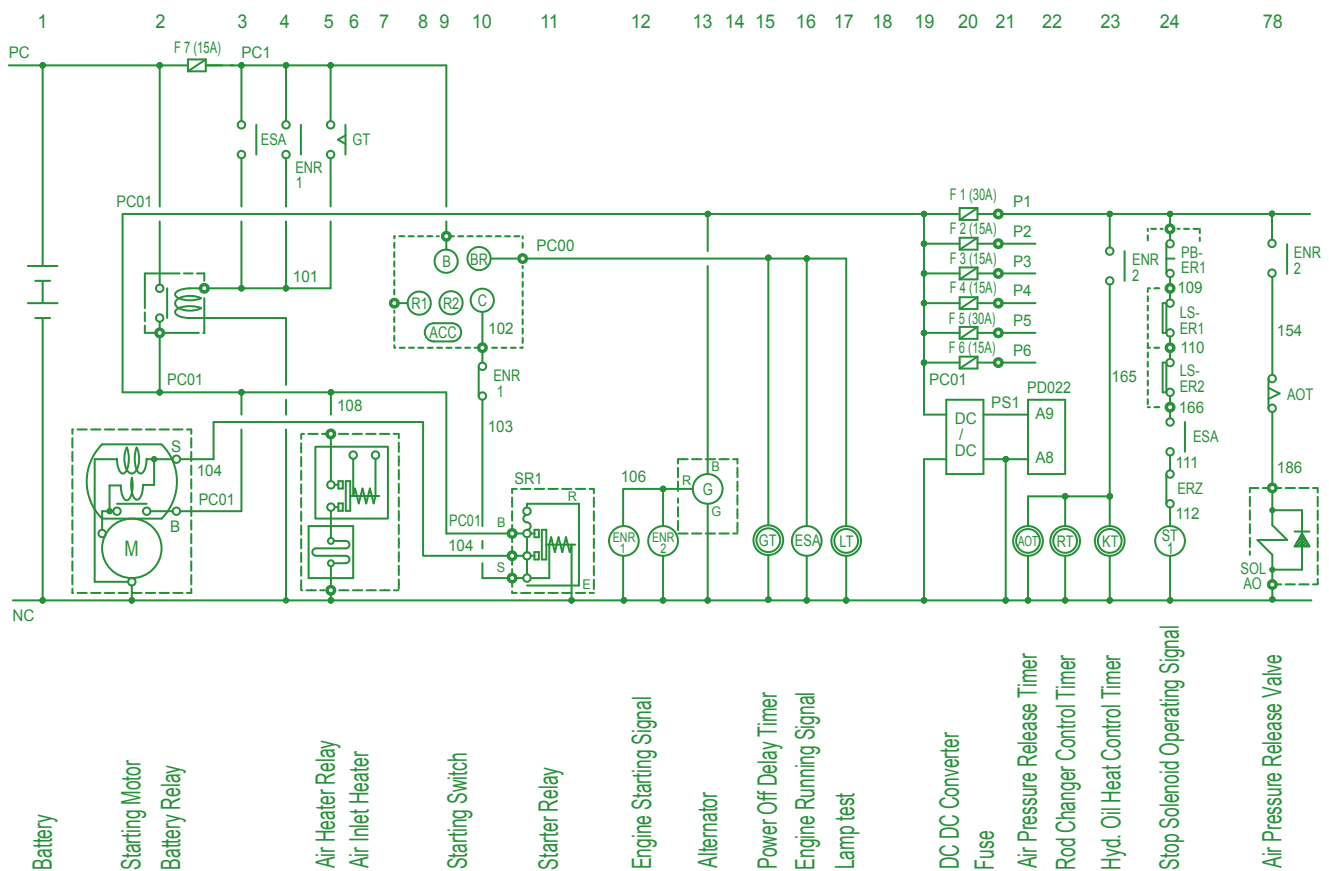


Fig.1

1-2 Starting Motor

The starting motor (address 2) drives the flywheel to crank the engine. It consists of starter solenoid and motor.

1-3 Battery Relay

The battery relay (address 2) is a main switch to provide power from the battery to the circuits.

1-4 Air Heater Relay and Air Inlet Heater

The air heater relay and air inlet heater (address 5) aid in start-up of the engine. It is controlled by signals of the engine ECM under the following conditions.

A) Starting switch is in "On" position

The heater will be activated for 30 seconds when the sum of the coolant temperature and inlet manifold air temperature is below 25° C [77° F].

B) Starting switch is in "Start" position

During engine craking, the heater will be activated for 30 seconds when the sum of the coolant temperature and inlet manifold air temperature is below 25° C [77° F].
If the engine fails to start, the ECM will activate the heater for another 30 seconds.

C) After starting engine

After the engine has started, the combination of coolant temperature and inlet manifold temperature will determine the state of the heater. The state has two strategies.

Continuous strategy : Activate the heater for a maximum of 7 minites.

Intermittent strategy : The heater is cycled for a maximum 13 minutes. It will be turned on for 10 seconds and turned off for 10 seconds.

The heater will shut off when the sum of the coolant temperature and inlet air temperature reaches 35° C [95° F].

1-5 Starting Switch

The starting switch (address 9) activates the circuits. The table below shows the contact capacity and conduction state of the terminals.

Contact capacity		2A	20A	10A	10A	10A
Terminal	B	BR	ACC	R1	R2	C
Switch position						
HEAT (H)	○	○	○	○		
OFF (O)	○					
ON (R)	○	○	○			
START (HS)	○	○	○		○	○

Table 1

1-6 Starter Relay

The starter relay (address 11) provides high current to the starter solenoid of the starting motor for starting engine. After starting engine, the relay will break the connection between batteries and the starter solenoid to prevent motor damage.

1-7 Alternator

The alternator (address 13) produces electrical power and supplies current to the circuits. The buildup of alternator voltage is used to control the hour meter and starter relay.

1-8 Power Off Delay Timer

The power off delay timer (address 15) is used to hold the battery current to the circuits for 5 seconds after the starting switch is turned off.

1-9 Air Pressure Release Valve

The air pressure release valve (address 78) is used to aid in start-up of the engine. It reduces the compressor load by releasing pressure in the receiver tank during engine starting.

2. Engine Starting Circuits

2-1 Starting Switch On

- 1) When the starting switch is turned to the ON position, switch contact connects B and BR terminal. The battery current flows through the starting switch contact to the coil of the timer GT (address 15) and relay ESA (address 16). When the relay coils are energized, NO contacts of the timer GT (address 5) and relay ESA (address 3, 24 and 5-90) will close.
- 2) With the relay contacts closed, current flows to the coil of the battery relay (address 2), causing its contact to close. This connects the battery and each circuit to supply power.
- 3) If the engine stop switches PB-ER1/LS-ER1/LS-ER2 (address 24) are not pressed and the relay ERZ is not activated, current flows to the coil of the relay ST1, causing its NC contacts (address 5-90) to open. With the contacts opened, the engine is ready to start.
- 4) When the sum of the coolant temperature and inlet air temperature is below 25° C [77° F], the ECM will activate the heater relay (address 5).

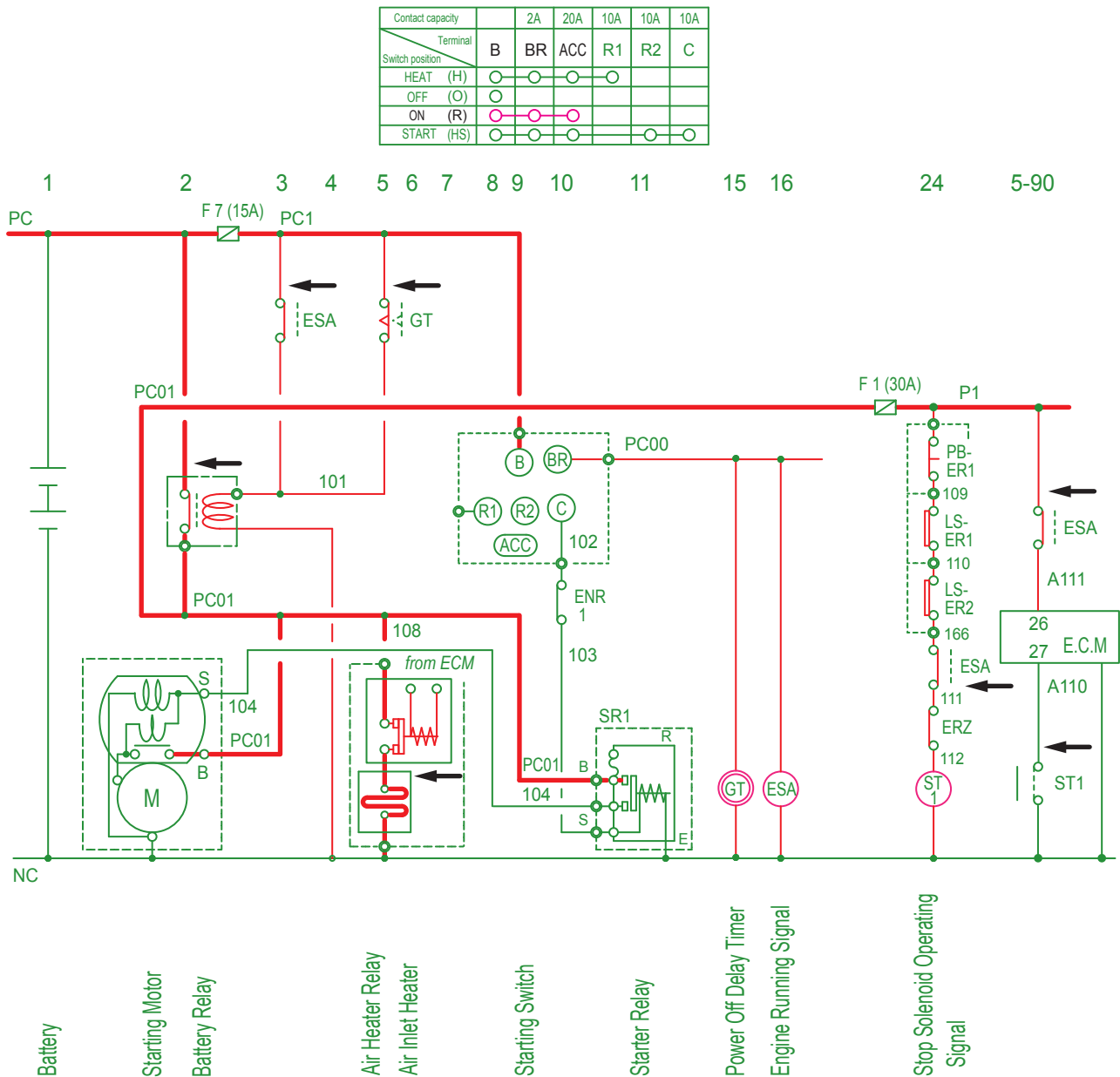


Fig.2

2-2 Starting Engine

When the starting switch is turned to the start position, switch contact connects B and C terminal. Current flows to the coil of the starter relay (address 11), causing its contacts to close. With the contacts closed, battery voltage is delivered to the starter solenoid and starter motor rotates to crank the engine.

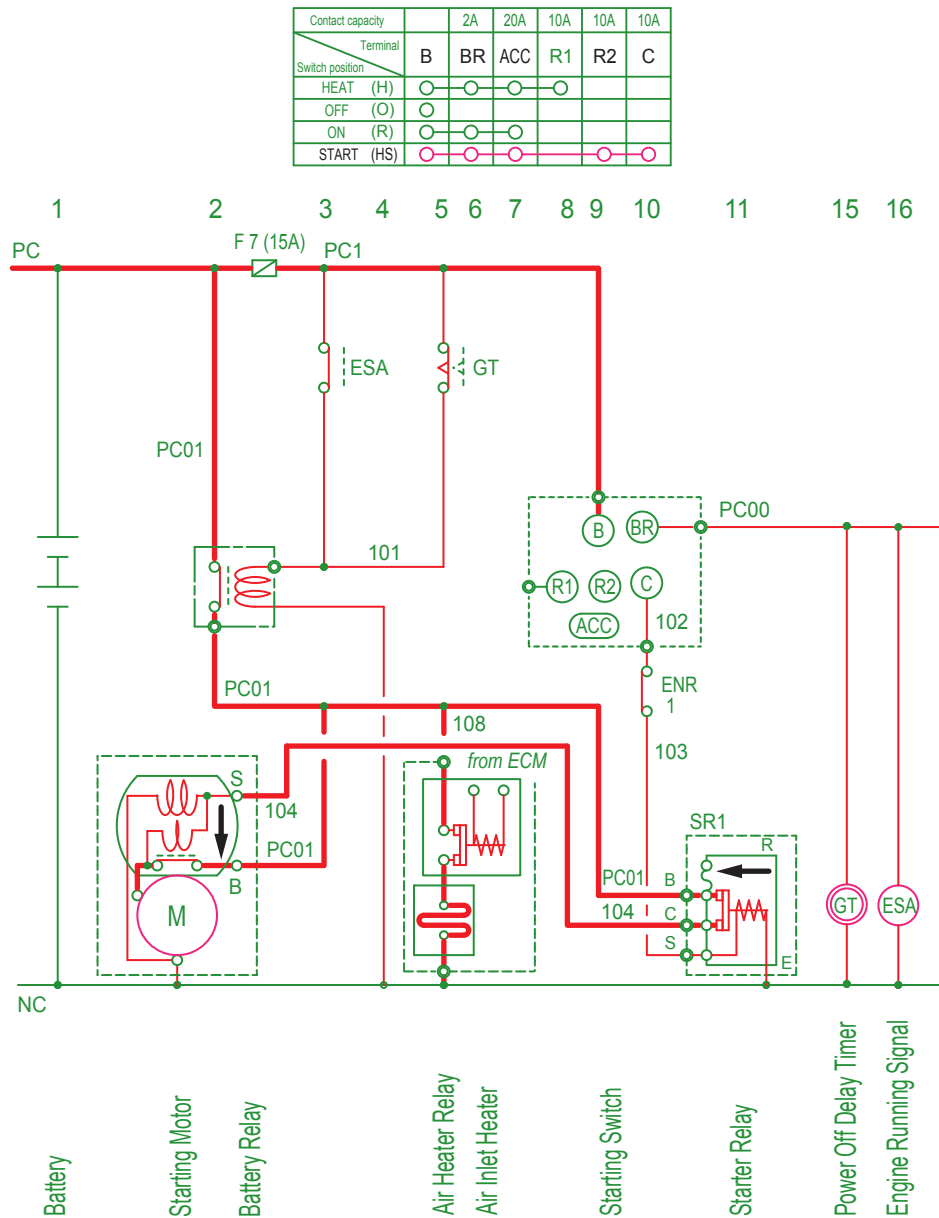


Fig.3

2-3 After Starting Engine

- 1) After the engine started, the alternator (address 13) generates electricity. When buildup of alternator voltage reaches 12V, the relay ENR1 and ENR2 (address 12) are energized.
- 2) When the relay ENR1 is energized, the NC contacts (address 10) open. Current stop flowing to the starter relay, causing its contact to open. Thus the starting motor stop operation. The starting motor will not operate while the engine is running.
- 3) When the relay ENR2 is energized, the NO contacts (address 23 and 78) close, causing the timer AOT, RT, KT and the solenoid valve AO to be energized.
- 4) The contacts of the timer AOT (address 78) open 30 seconds after the relay coil is energized. The NC contact of the relay AO (address 78) remains closed during timing, causing the solenoid valve AO to be activated, releasing pressure in the receiver tank.
- 5) When the hydraulic oil temperature is below 25° C [77° F], the hydraulic oil preheat control will automatically start after preset time of the timer KT (address 23) has passed (2 minutes).

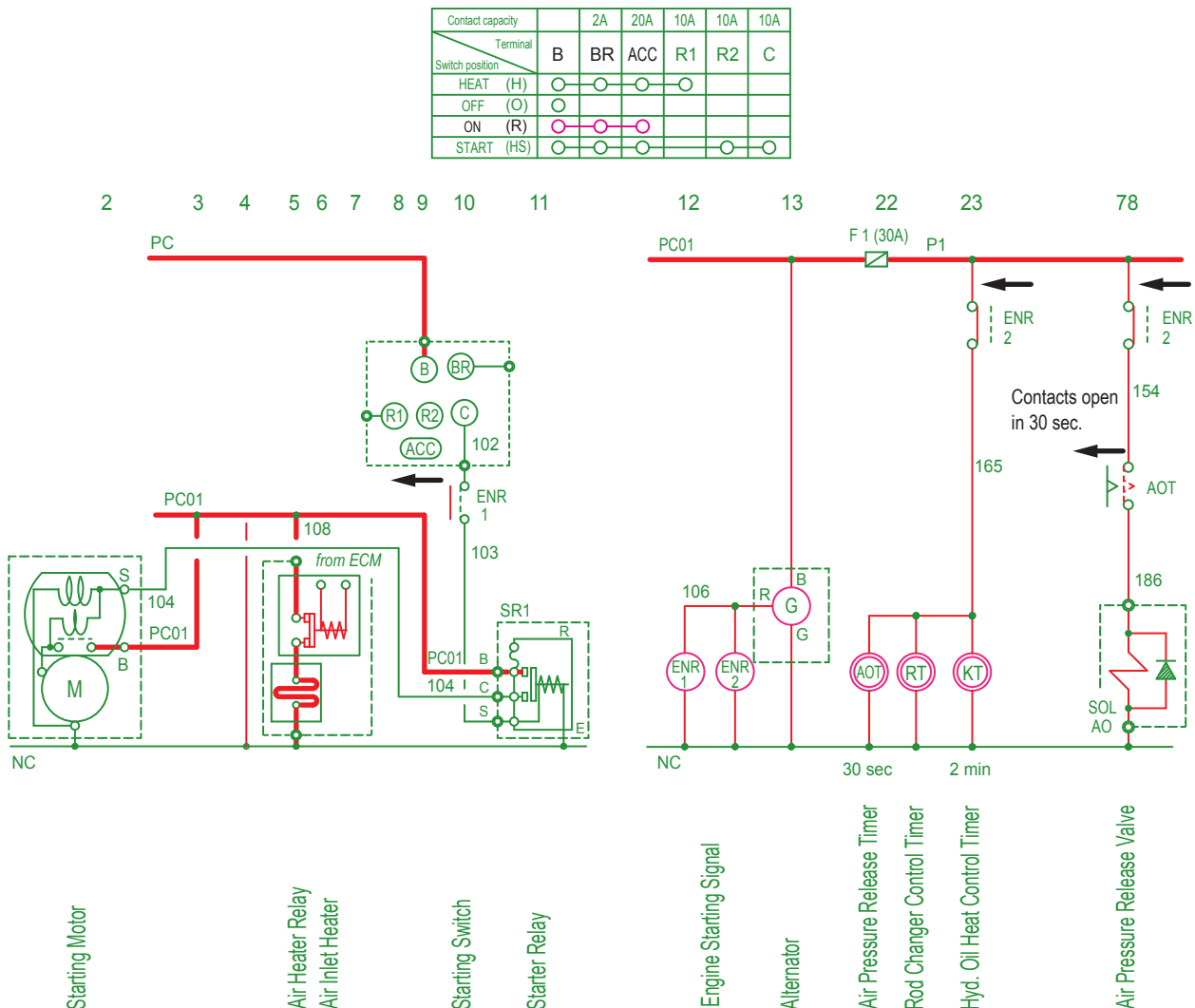


Fig.4

2-4 Stopping Engine

- 1) When the starting switch is turned off, switch contact disconnect B and BR terminal. The relay ESA (address 16) is de-energized, causing the contacts (address 1-3, 1-24 and 5-90) to open. With the contacts opened, current to the engine ECM is cut off, causing engine to stop.
- 2) The NO contact of the timer GT (address 5) remains closed for 5 seconds, leave the battery relay energized and continue supplying power to the circuits.

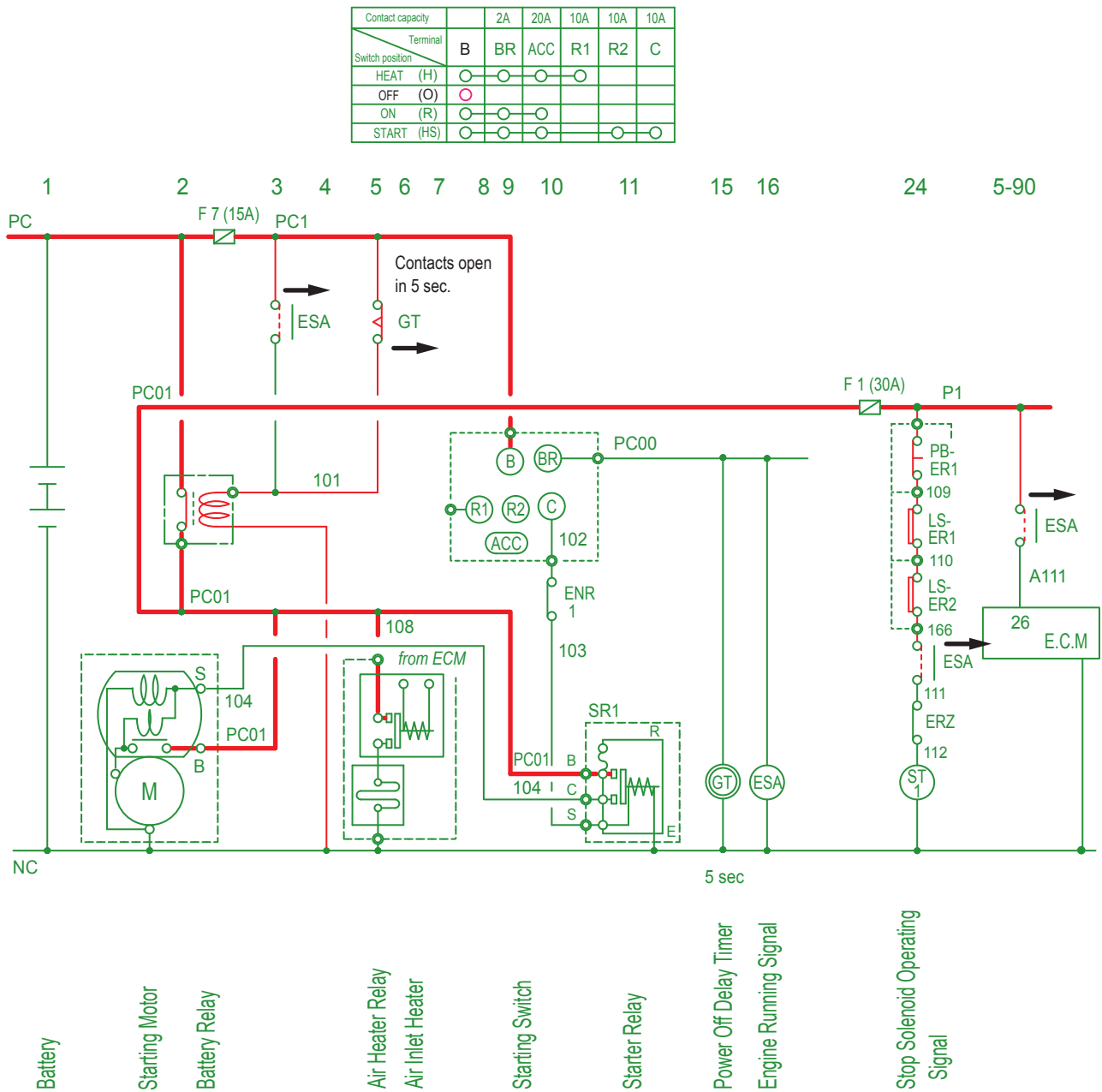


Fig.5

3. Engine Control Circuits

3-1 Manual Throttle Control

The engine speed changes as below table by turning the throttle switch (address 76-80).

Throttle position	Revolution (min ⁻¹)
I	1250
II	1600
III	1800
IV	2000
V	2200

Table 2

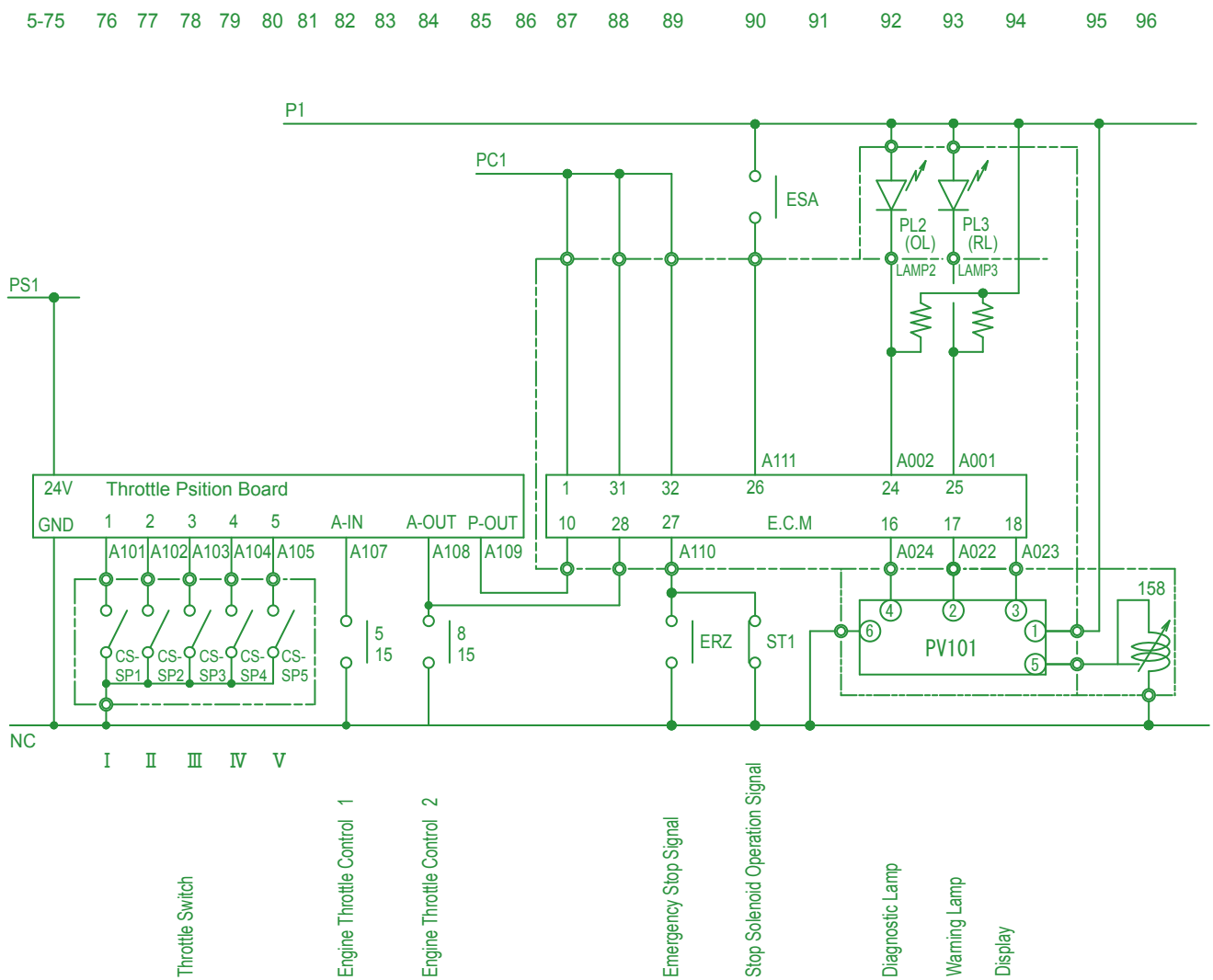


Fig.6

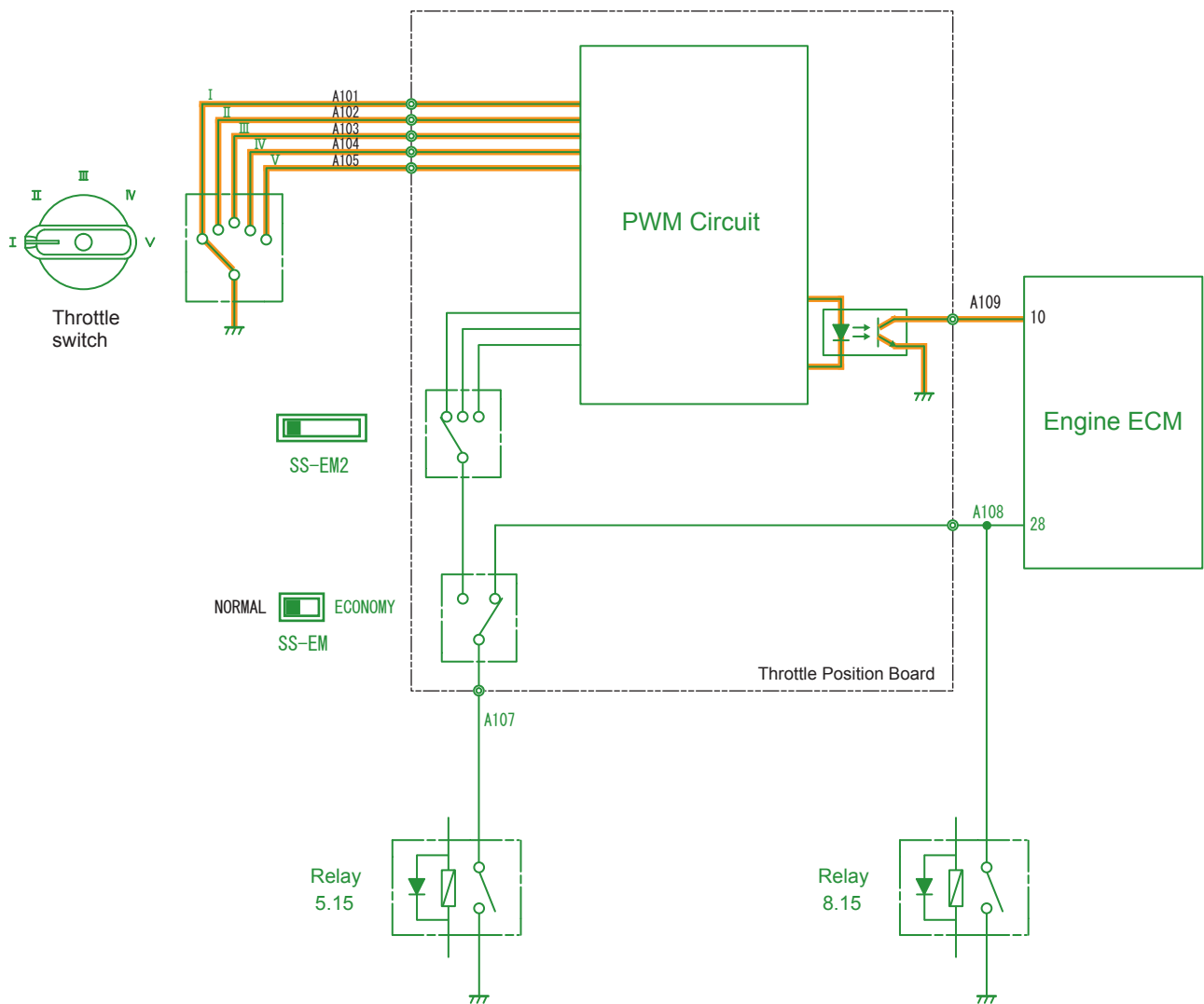


Fig.7

3-2 Auto Throttle Control

The engine speed rises automatically by the following conditions.

- Impact switch SW-PH(0.09) is on if the interlock system is not working.
- Flow switch SN-BF(3.05) is off.

The engine speed in auto throttle can be selected from 1600, 1800, 2000 and 2200 min⁻¹ by changing switch SS-EM and SS-EM2 on the throttle position board.

SS-EM position	SS-EM2 position	Revolution (min ⁻¹)
NORMAL		2200
ECONOMY	L 	1600
	C 	1800
	R 	2000

Table 3

A) Normal Operation

When throttle signals are received, current flows to the coil of the output relay 8.15, causing current from engine ECM (#A108) to be grounded. This increases the engine speed.

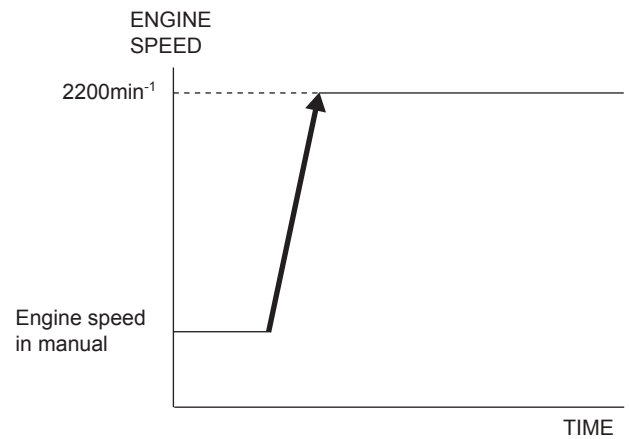


Fig.8

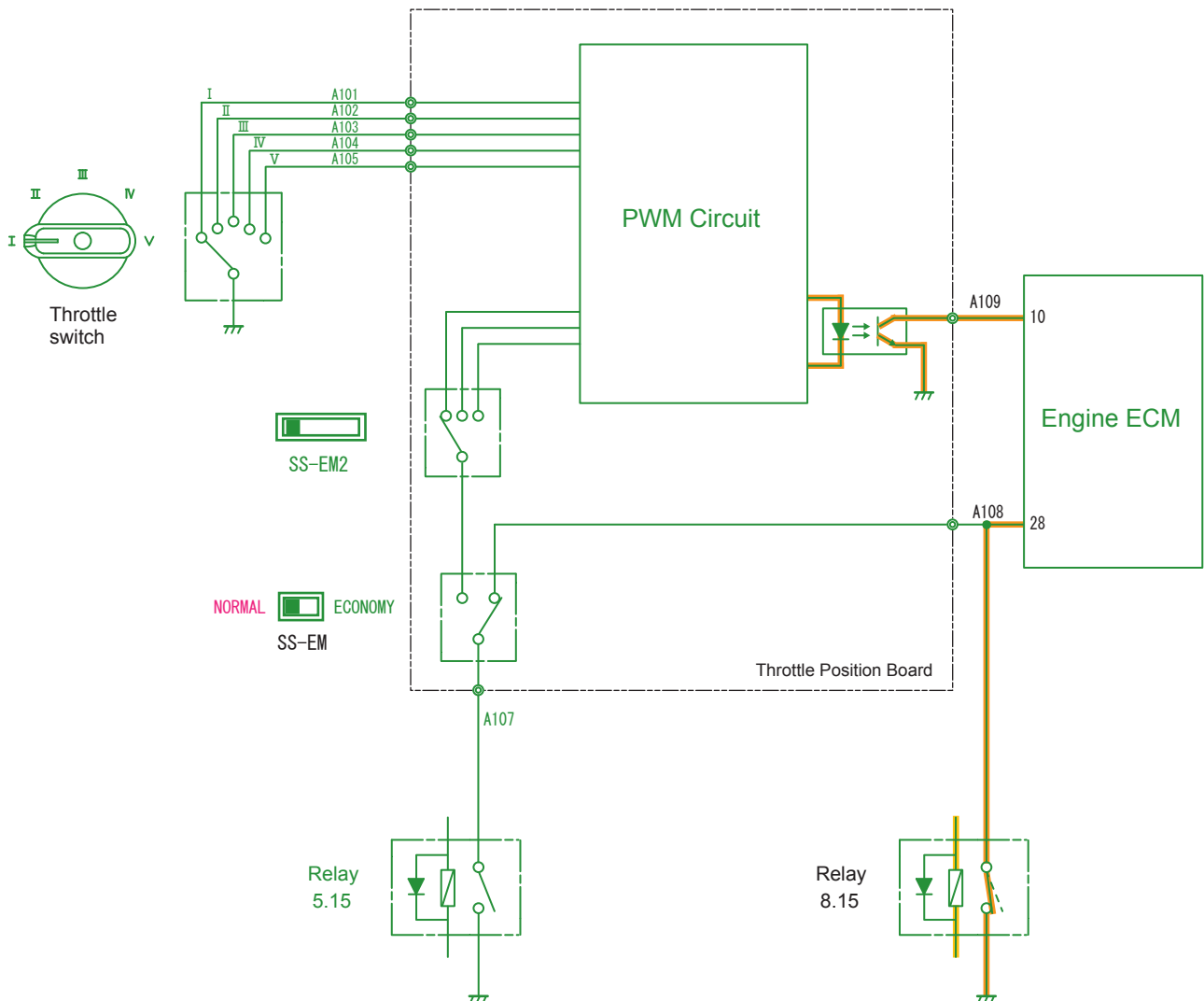


Fig.9

B) Economy Operation

At the following conditions, the engine speed can be selected from 1600, 1800, 2000 min^{-1} by changing switch SS-EM2.

Switch SS-EM: ECONOMY position

Impact: ON

When the throttle signals are received, current flows to the coil of the output relay 5.15, causing the PWM circuits that is selected by SS-EM2 to be grounded through the relay contact. This increases the engine speed.

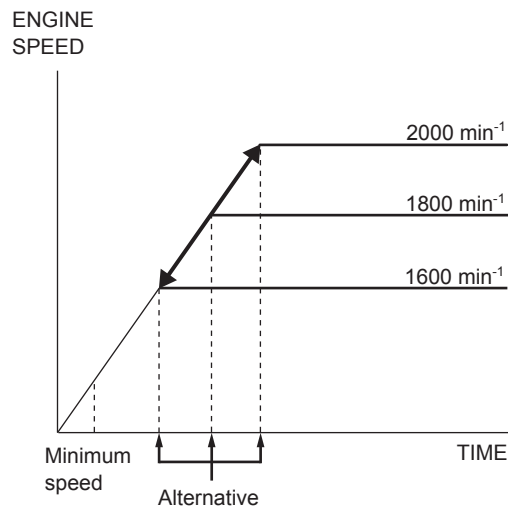


Fig.10

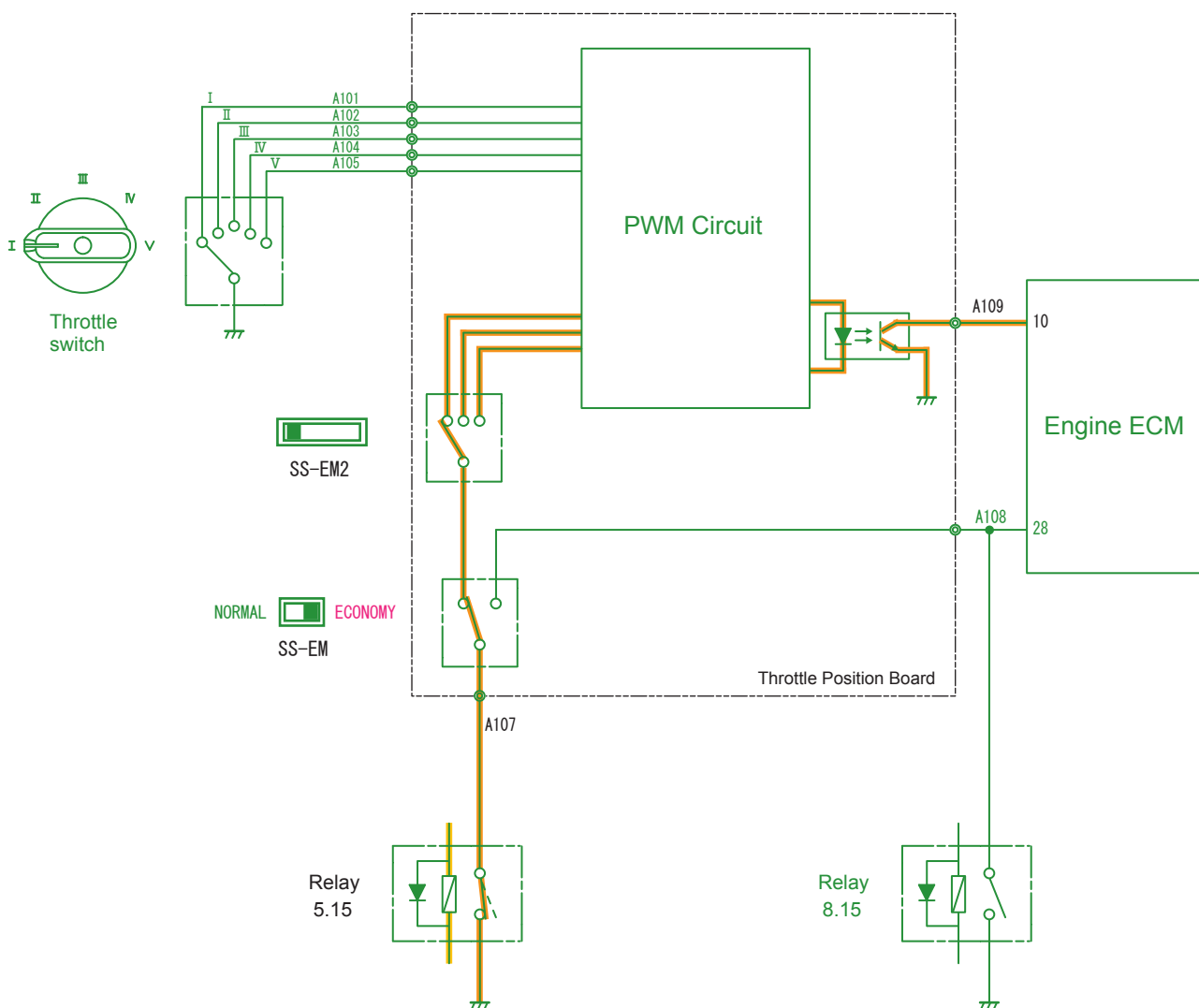


Fig.11

C) Super Economy Operation

In economy operation, when the impact is off, the engine speed rises to the maximum to increase air volume regardless of the position of the switch SS-EM2.

When the throttle signals are received, current stops flowing to the coil of the output relay 5.15, causing the relay 5.15 to stop. On the other hand, current flows to the coil of the output relay 8.15, causing current from engine ECM (#A108) to be grounded. This increases the engine speed to the maximum.

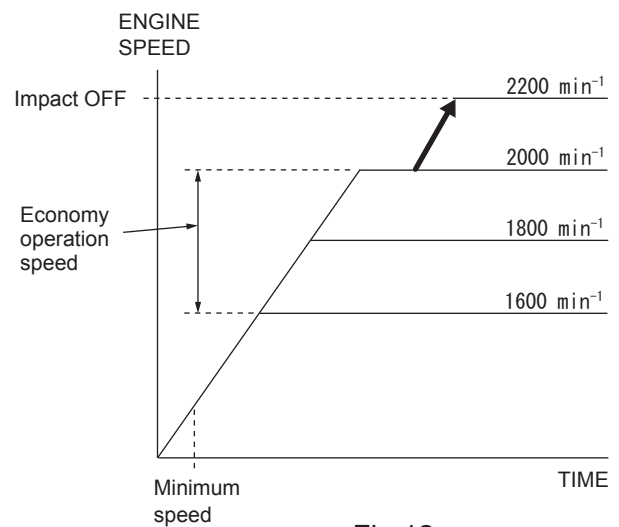


Fig.12

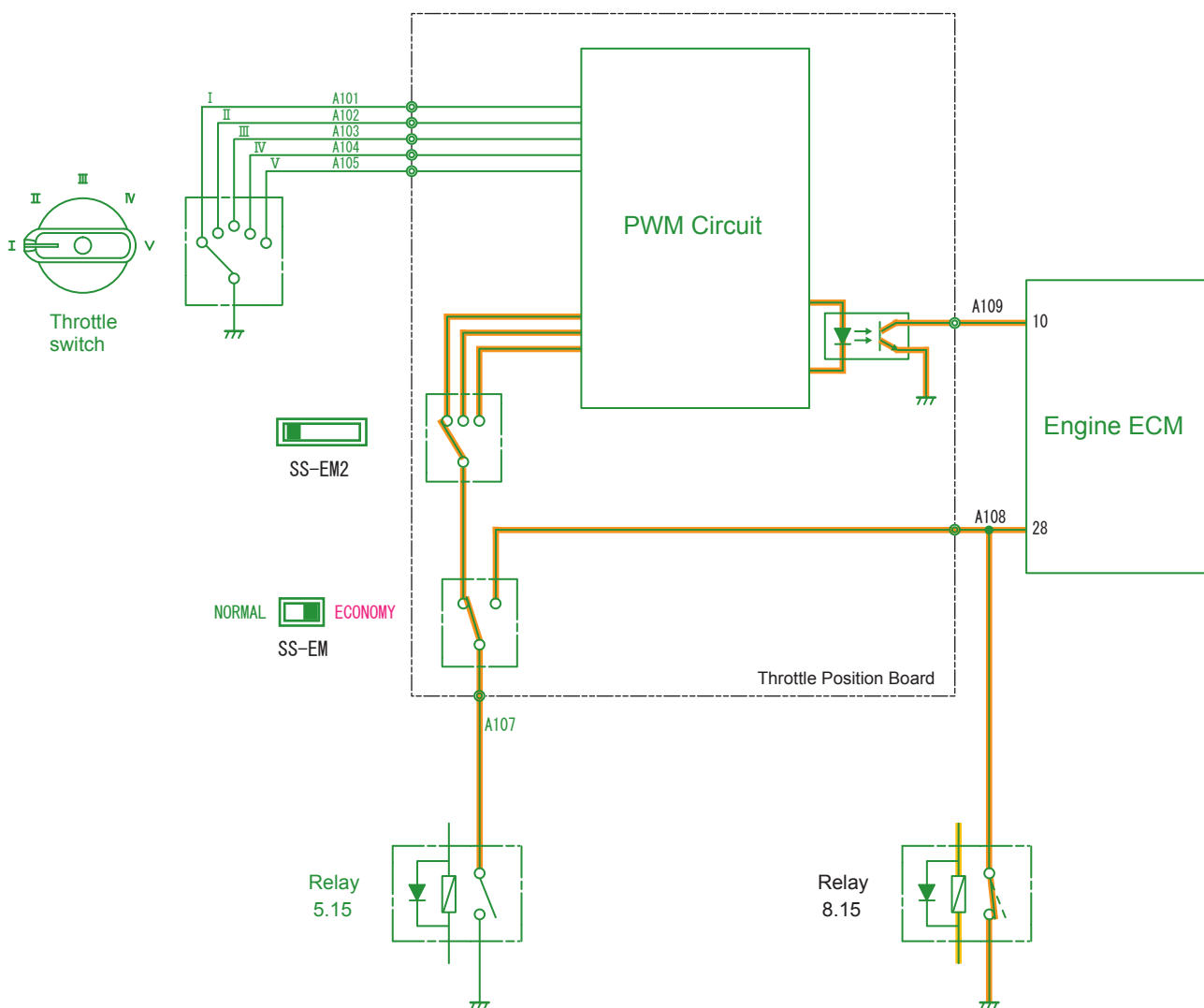


Fig.13

3-3 Emergency Shutdown Control

If abnormal conditions exist, the system automatically shuts off the engine. There are six conditions that would cause the engine to be shut off;

- When the emergency push buttons are pressed.
(NC contacts of the relay ST1 will close, address 90)
- When the hydraulic oil volume is below 145 liters [38.3 gal.].
(Hyd. oil tank capacity : 240 liters [63.4 gal.], NC contacts of the relay ERZ at address 89 will close.)
- When the compressor discharged air temperature reaches $120 \pm 2^{\circ} \text{ C}$ [$248 \pm 3.6^{\circ} \text{ F}$].
(NC contacts of the relay ERZ at address 89 will close.)
- When the engine oil pressure is low.
(Approx. less than 104kPa : according to the engine speed, by ECM control)
- When the coolant temperature reaches 111° C [231.8° F]. (by ECM control)
- When the engine speed reaches 2800 min^{-1} . (By ECM control)

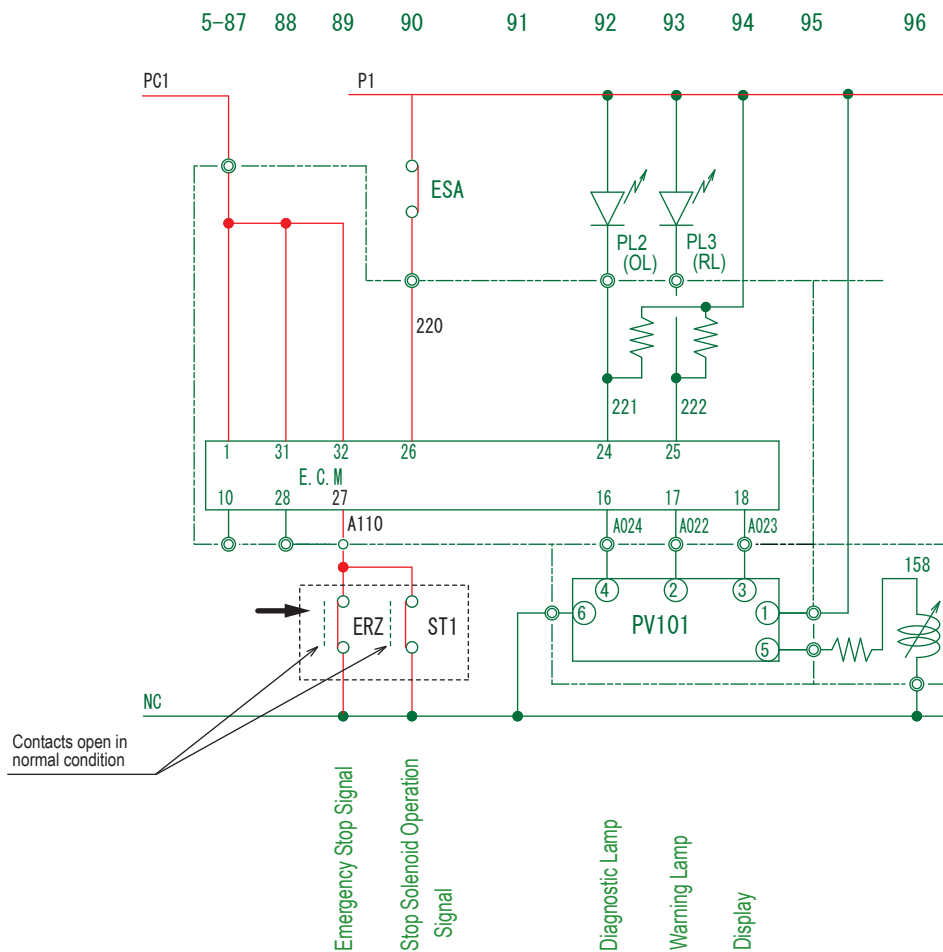


Fig.14

3-4 Engine Diagnostic Lamps

1. Warning Lamp (red)

If the problems exist in the engine, the operator will be alerted by the warning lamp (address 93).

2. Diagnostic Lamp (yellow)

The diagnostic lamp is used to indicate the existence of an active fault by flashing codes. If the active fault codes exist, the diagnostic lamp (address 92) will come on and flash codes. For flash codes, refer the engine operation and maintenance manual.

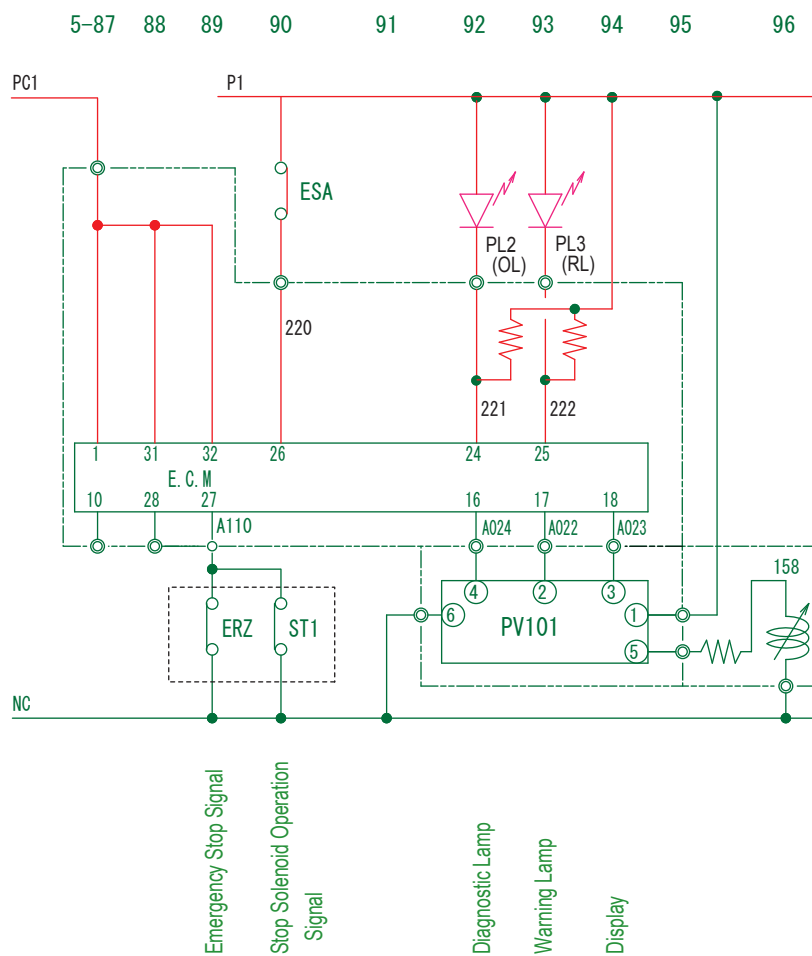


Fig.15

4. Accessory Circuits

4-1 Lights

When the switch SS-WL1 (address 28) is turned on, two head lights (for ED), or four head lights (for EW) will come on.

When the switch SS-WL2 (address 32) is turned on, two tail lights will come on.

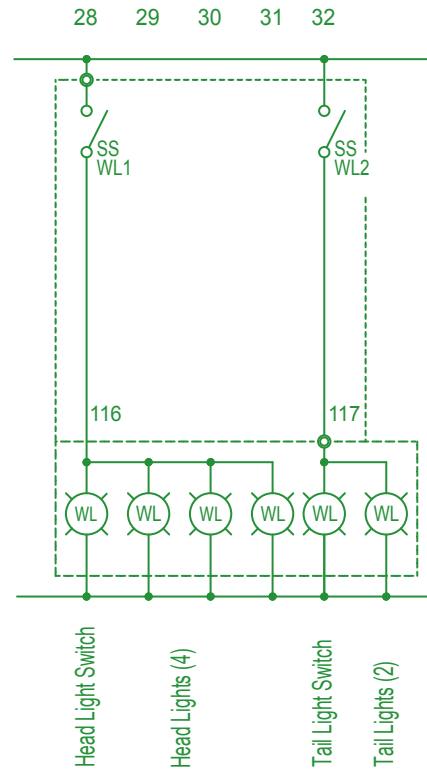


Fig.16

4-2 Horns

When the push button PB-HR (address 38) is pressed, two horns will sound.

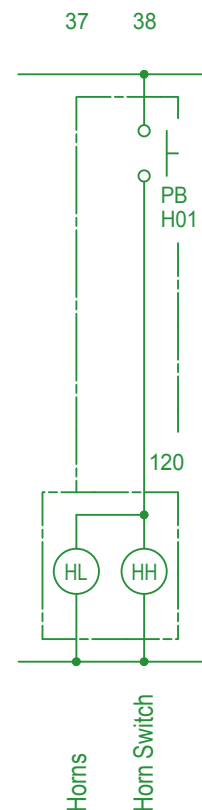


Fig.17

Fig.18

• Lamp Test

When the starting switch is turned to the on position, current from P1 line flows to ground through diodes and the NC contacts of the timer LT (address 63 and 71). The warning lamps will come on to check the operation of lamps. Since battery current flows through the starting switch to the coil of the timer LT (address 17), the timer contacts will open in 5 seconds to turn off the warning lamps.

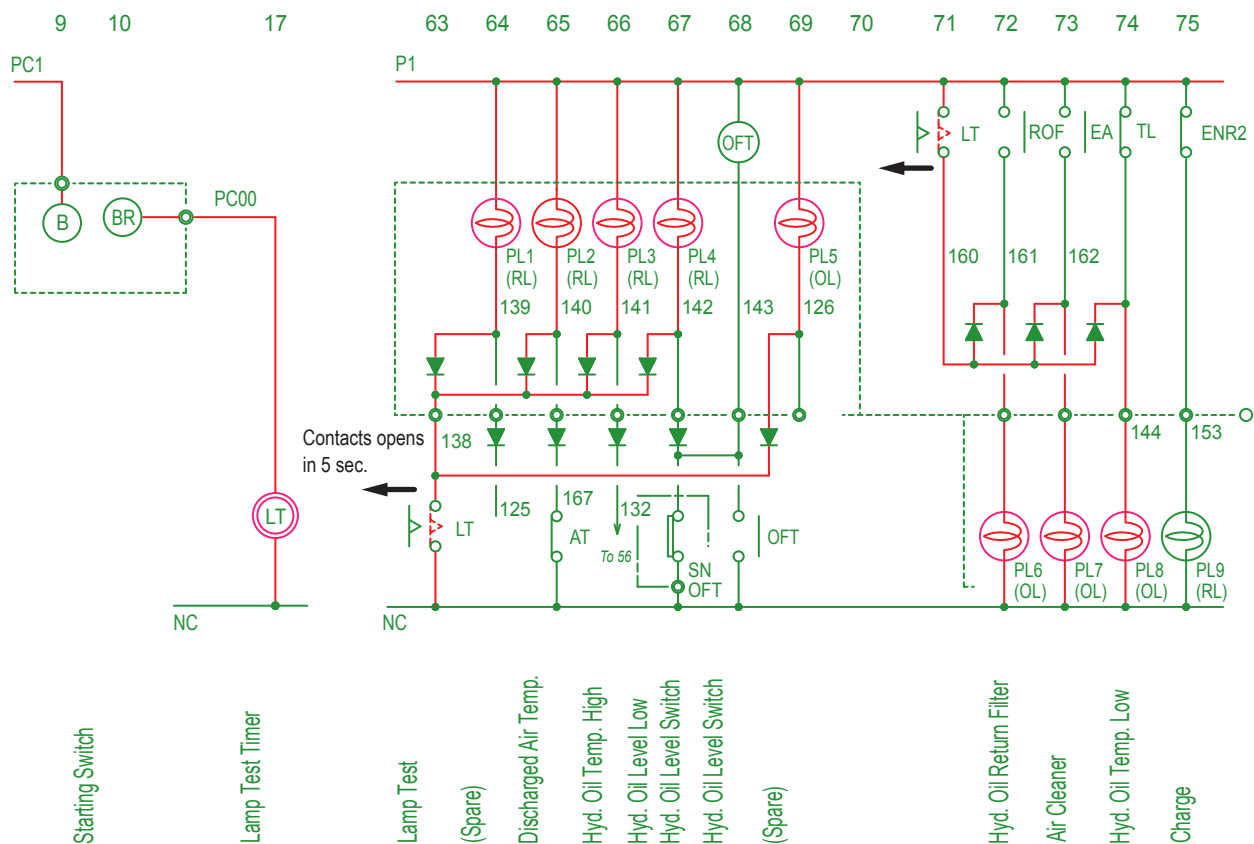


Fig.19

When the differential pressure between inlet and outlet of the oil filter reaches 275 ± 27 kPa, the indicator switch SN-ROF (address 52) is turned on and make its contact. The relay ROF is energized, causing the NO contacts (address 72) to close. Current flows to the warning lamp PL6 and it comes on.



When the airflow resistance (Pressure drop) of the air cleaner reaches 6.23 ± 0.57 kPa (for engine), 7.47 ± 0.57 kPa (for compressor), the indicator switch SN-EA (address 53) is turned on and make its contact. The relay EA is energized, causing the NO contacts (address 73) to close. Current flows to the warning lamp PL7 and it comes on.



• Discharged Air Temperature High

When the compressor discharged air temperature reaches $120 \pm 2^{\circ} \text{ C}$ [$248 \pm 3.6^{\circ} \text{ F}$], the temperature switch SN-AT (address 54) is turned off and opens its contact. The relay AT is de-energized, causing the NC contacts (address 65) to close. Current flows to the warning lamp PL2 and it comes on.

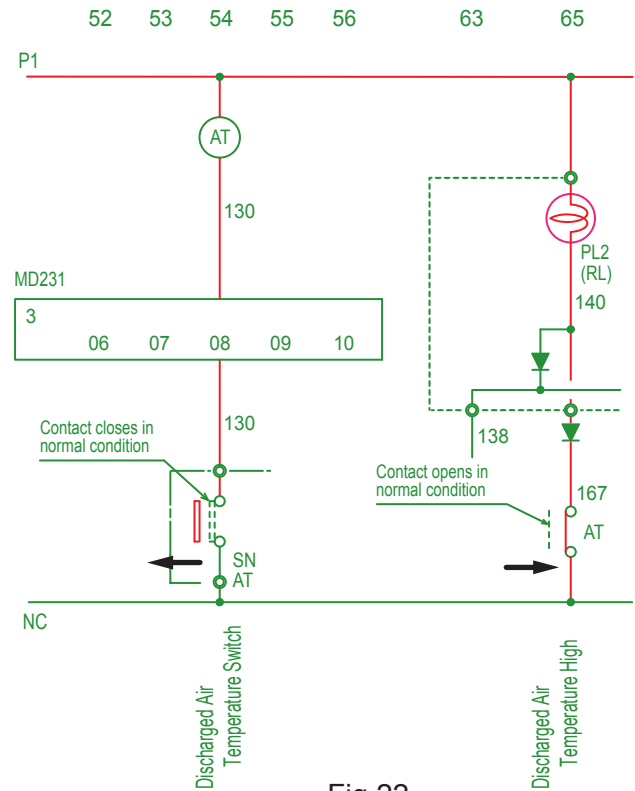


Fig.22

• Hydraulic Oil Temperature Low

If hydraulic oil temperature is below $25 \pm 3^{\circ} \text{ C}$ [$77 \pm 5.4^{\circ} \text{ F}$], the contact of the thermo switch L (address 55) is open. Since the NC contact of the relay TL (address 74) remains closed, current flows to the warning lamp PL8 and it comes on.

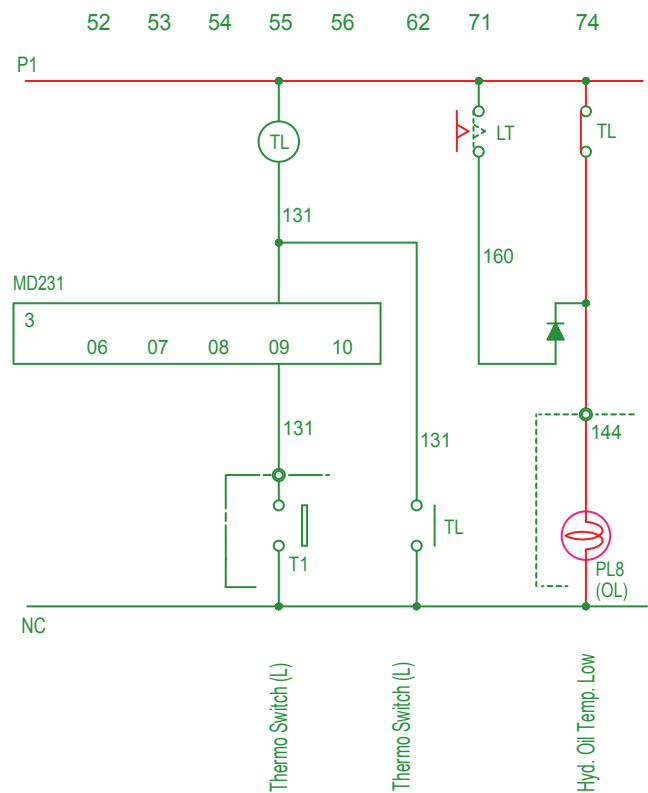


Fig.23

• Hydraulic Oil Temperature High

When the hydraulic oil temperature reaches $87\pm 3^{\circ}\text{C}$ [$188\pm 5.4^{\circ}\text{F}$], the thermo switch H (address 56) is turned on and make its contact. Current flows to the warning lamp PL3 (address 66) and it comes on.

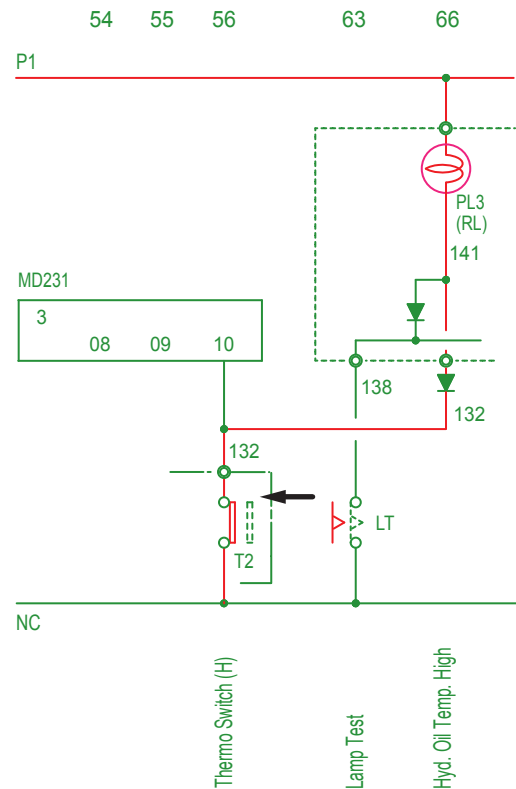


Fig.24

• Hydraulic Oil Level Low

When the hydraulic oil in the hydraulic tank decreases below 130 L [34.3 gal.] , the hydraulic oil level switch SN-OFT (address 67) is turned on and make its contact. Current flows to the warning lamp PL4 and it comes on. At the same time, the relay OFT (address 68) is energized, causing the NO contacts to close. Once the relay contacts closed, current always flows to ground through the relay contacts regardless of the state of the switch contact. Therefore, the warning lamp PL4 keeps lighting unless the starting switch is turned off.

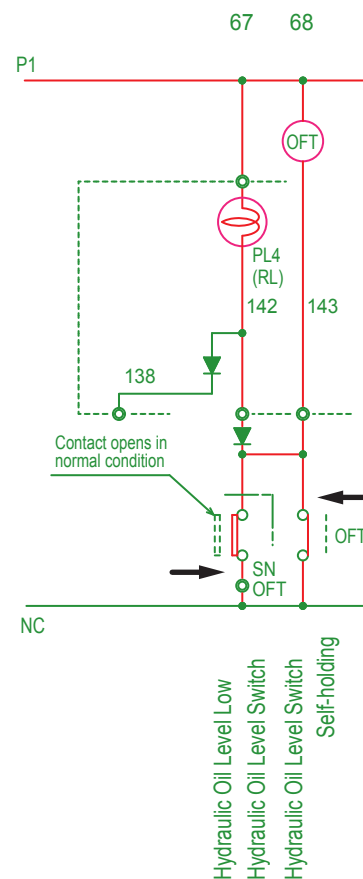


Fig.25

• Alternator Voltage Low

When the starting switch is turned on, current flows through the contacts of the relay ENR2 (address 75) to ground, causing the warning lamp PL9 to come on. After engine started, build up voltage of the alternator energizes the coil of the relay ENR2 (address 12), causing the NC contacts to open. Thus the lamp goes out.

NOTE : The relay ENR1 and ENR2 are 12V specification.

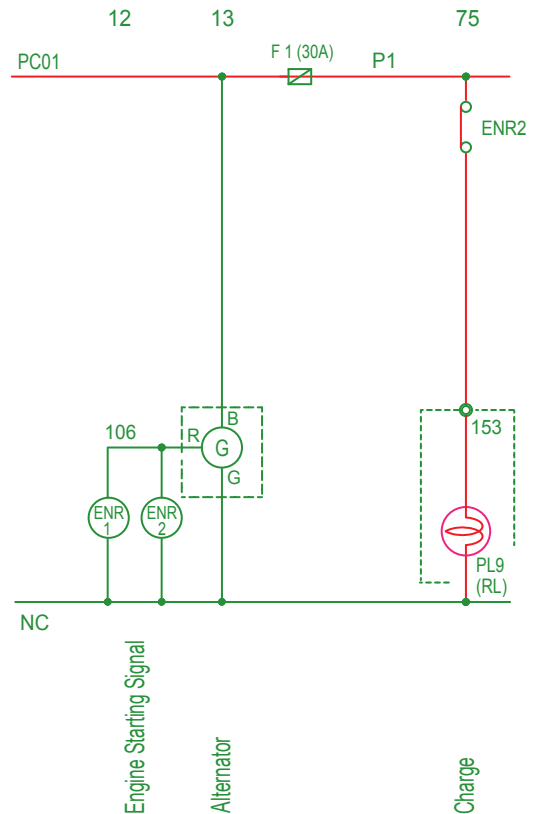


Fig.26

4-4 Gauges

The temperature gauges indicate the hydraulic oil and compressor discharged air temperature in an analog. The gauges read electrical resistance of the sensor or sending unit with changing temperature.

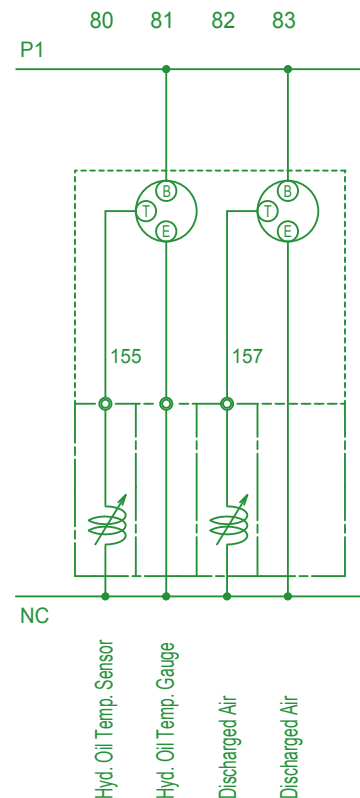


Fig.27

Hydraulic Crawler Drill
HCR1500-EDII, 1500-D20II
Electrical System
Engine Starting Circuits

Published : Sep. 2008

Revised : Dec. 2010

May 2013

Furukawa Rock Drill Co, Ltd.
All rights reserved



Address: 5- 3, 1-chome, Nihonbashimuromachi, Chuoku,
Tokyo, 103-0027, Japan.

Phone: 81-3-3231-6982

Fax: 81-3-3231-6993