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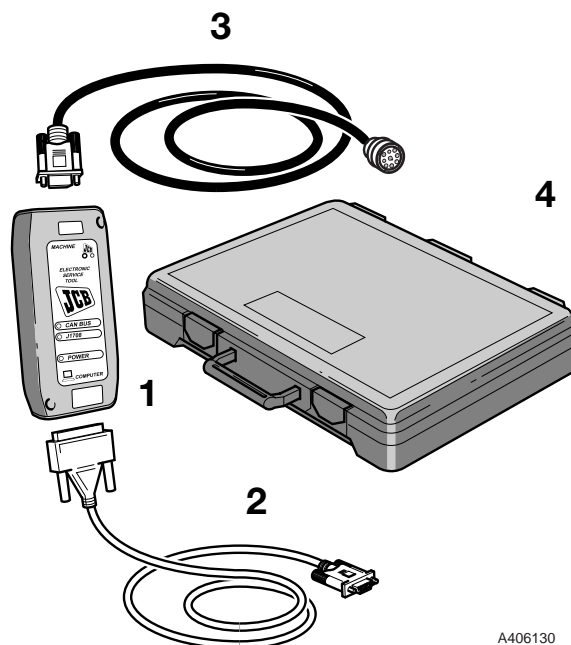
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## Service Tools

### Electronic Service Tool Kit

892/01033 Kit comprises:

- 1 Data Link Adaptor (DLA), enables data exchange between the machine ECU (Electronic Control Unit) and a laptop PC loaded with the applicable diagnostics software.
- 2 Interconnecting cable, DLA to laptop PC. Several cables are included to enable compatibility with different PC port types.
- 3 Interconnecting cable, DLA to machine ECU diagnostics socket.
- 4 Kit carrying case.



A406130

721/10885- Interconnecting cable, DLA to machine ECU diagnostics socket.  
(part of 892/01033 Kit above)



A408030

**System Type**

12V negative earth

**Battery - Std. JCB Round Pole**

Voltage

12V

Specific Gravity (fully charged)

Between 1.285 and 1.310 at 15 °C (59 °F)

**Starter Motor**

Direction of Rotation (viewed from pinion side)

Clockwise

**Alternator**

Direction of Rotation (viewed from pulley)

Clockwise

Nominal Output

12 volt 50 amp

Polarity

Negative Earth

**Tightening Torques - Alternator**

Mounting Bolt

**Nm****kgf m****lbf ft**

20.4 - 27.2

2.1 - 2.8

15.0 - 20.0

Adjusting Bolt

10.9 - 13.5

1.1 - 1.4

8.0 - 10.0

Shaft Nut

70 - 90

7.1 - 9.2

51.6 - 66.4

**Bulbs****Function****Rating**

Cab Lights, interior

10W

Working Lights, Boom &amp; Cab roof

55W

All Panel Warning Lamps

LED's

All Switch Illuminations

LED's

**CAUTION**

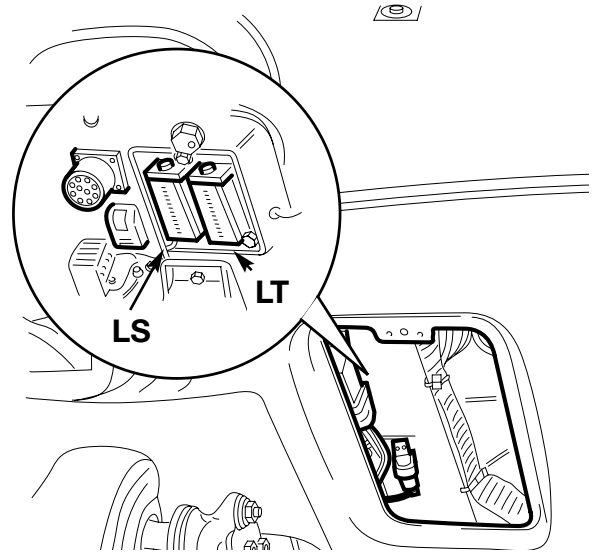
**Fuses**

Always replace fuses with ones of correct Ampere rating to avoid electrical system damage.

8-3-3-5

**Fuses**

The electrical circuits are protected by Primary Fuses and Secondary Fuses. The Primary Fuses **A** are located adjacent to the battery. The Secondary Fuses are located in fuse boxes LS and LT on the rear cab wall behind the seat. Remove the fuse box cover by releasing the top fastener. If a fuse blows, find out why before fitting a new one.



**LS Fuse Box**

Fuse	Circuit(s) Protected	Rating
LS1	Glow Plug Timer Air Cond. Relay Air Cond. Control Panel Radio Switch	5A
LS2	Redundancy Switch	5A
LS3	Redundancy Switch	5A
LS4	Travel Alarm Hi Flow ECU Input One Touch Idle ECU Input Travel Speed Select ECU Input	5A
LS5	Solenoid Outputs: Servo Isolator Solenoid Hi Flow Solenoids Slew Lock Solenoid	10A
LS6	Patch Planer Controls ISO/SAE Controls	7.5A
LS7/LS8	ECU Bank 1: Fuel Shut-Off Solenoid, Alternator Excitation, Throttle Solenoid, Quickhitch Solenoid, Front Work Lights	10A
LS9/LS10	ECU Bank 2: Horn, Slew Brake solenoid, Boom Light, Wiper Motor	10A

**LT Fuse Box**

Fuse	Circuit(s) Protected	Rating
LT11	EMS/ECU Battery +	5A
LT12	Refuel Pump Switch Input Horn Button Input	5A
LT13	Interior Light, Door Switch Input	5A
LT14	Engine Run Solenoid	5A
LT15	ECU Bank 3	10A
LT16	ECU Bank 3	10A
LT17	Refuel Pump Relay	25A
LT18	Cigarette Lighter/Accessory Socket	10A
LT19	Air Conditioning/Heater Blower	20A
LT20	Glow Plug Timer, Engine Crank Signal	5A

**LS**

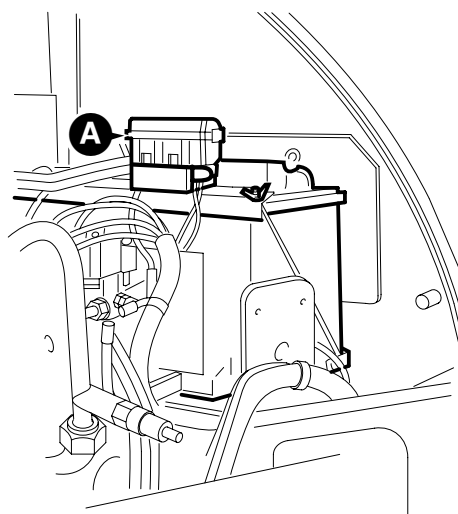
**LT**

5		5	
5		5	
5		5	
5		5	
10		10	
7.5		10	
10		25	
10		10	
10		20	
10		5	

**Fuses (cont'd)**

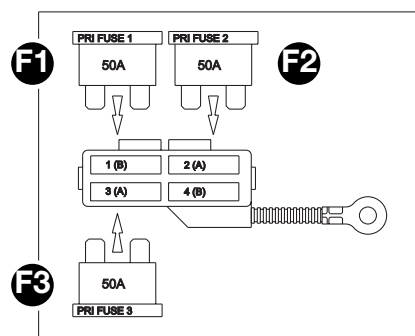
**Primary Fuses**

Fuse	Fuse Protected	Rating
F3	LT17, LT18, LT19	50 A
F2	LS7, LS8, LS9, LS10	50A
F1	LS1, LS2, LS3, LS4, LS5, LS6, LT11, LT12, LT13, LT14, LT15, LT16, LT20	50A



A439160

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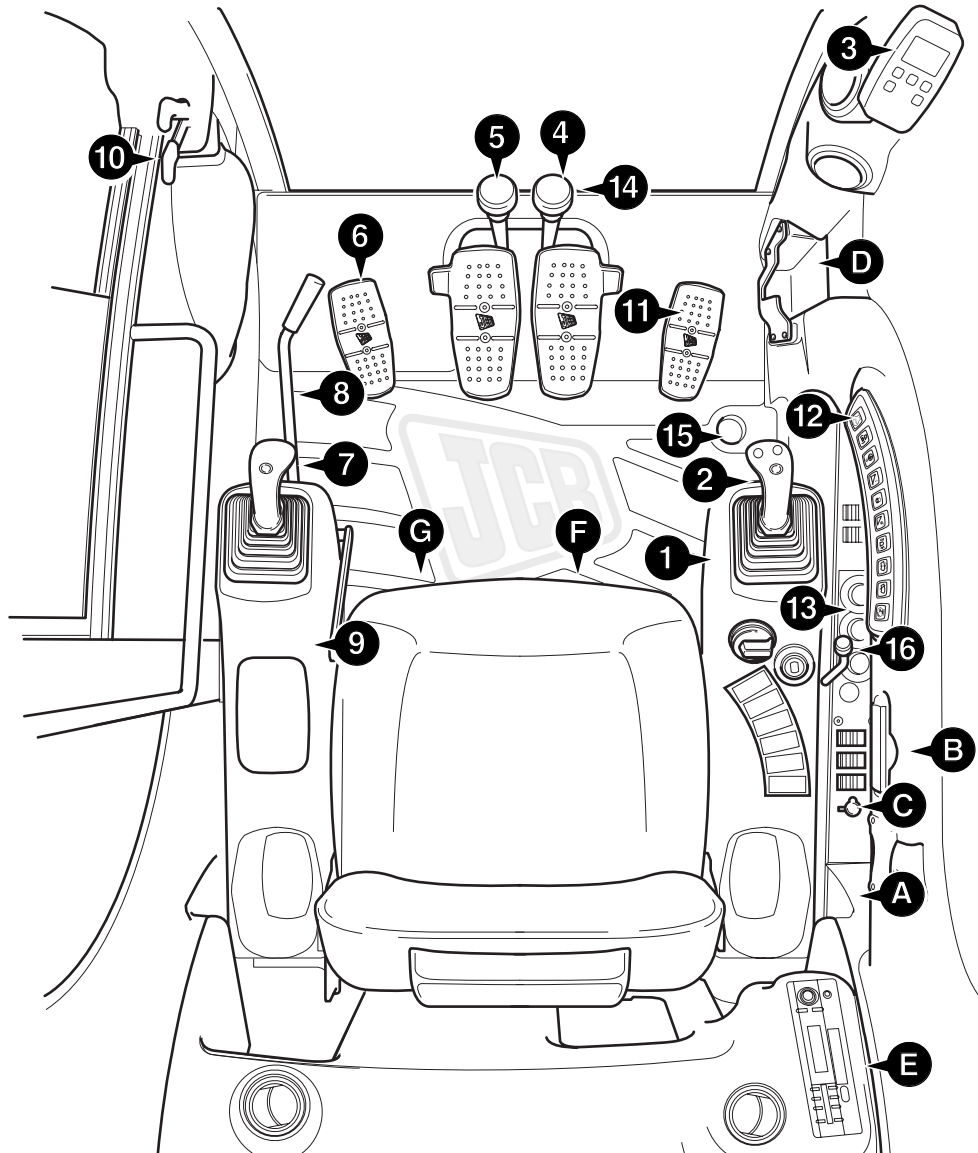


**Relays**

- LK Engine Run Relay
- LU Refuel Pump Relay
- LK Air Conditioning/Heater Relay

## Switches and Controls

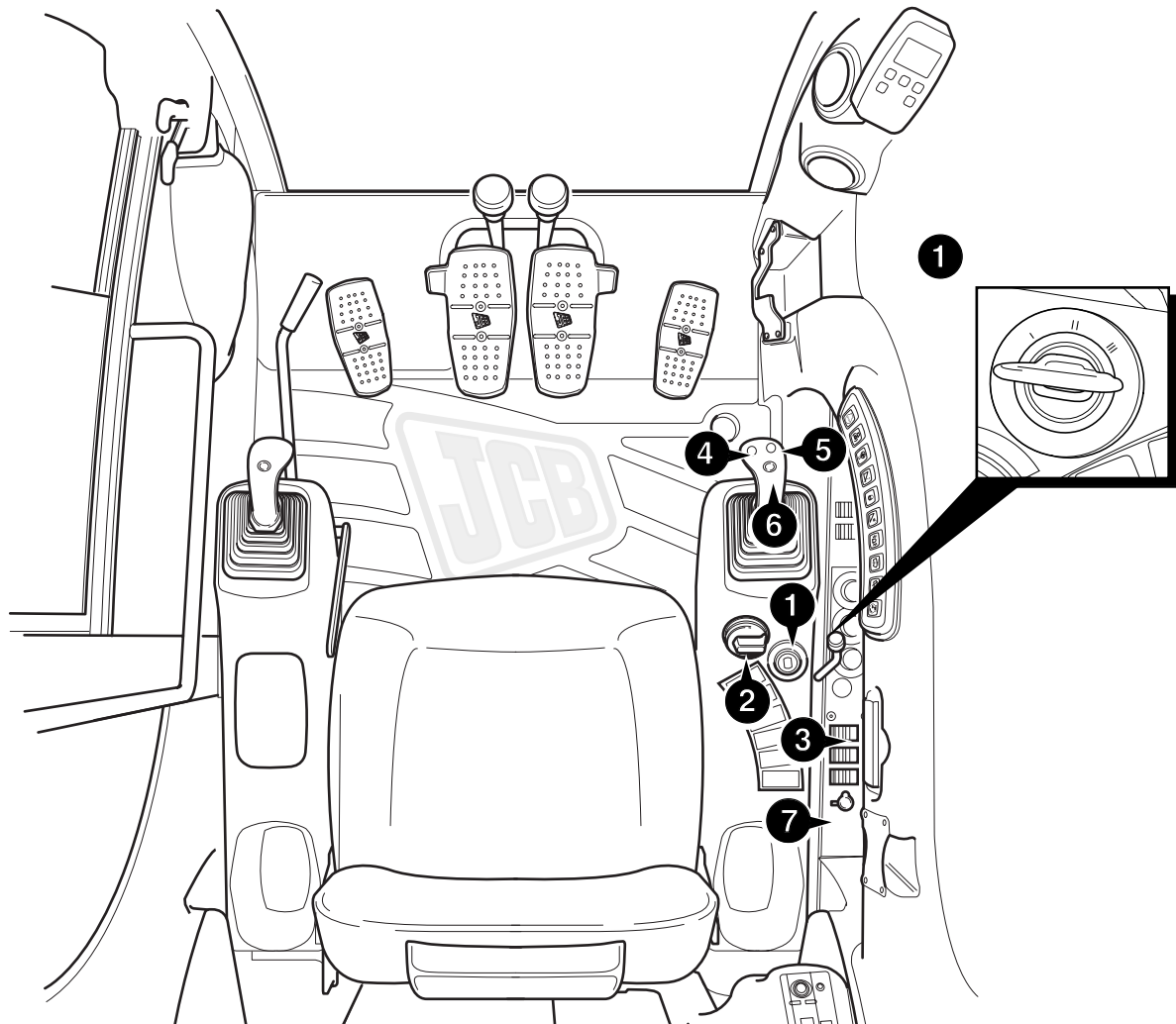
### Location of Controls and Components



- |                                      |  |  |
|--------------------------------------|--|--|
| 1 Right Console                      | 10 Door Lock Release Lever               | A Mobile Phone Holder                    |
| 2 Right Excavator Joystick Control   | 11 Optional Circuit Pedal (if fitted)    | B Ashtray                                |
| 3 Electronic Monitoring System (EMS) | OR Optional TAB Boom Control (if fitted) | C Cigarette Lighter/Mobile Phone Charger |
| 4 Right Hand Track Control           | 12 Facia Panel                           | D Cup Holder                             |
| 5 Left Hand Track Control            | 13 Air Cond./Heater Controls             | E Radio                                  |
| 6 Swing Control                      | 14 2-Speed Tracking Switch               | F Tool Box                               |
| 7 Left Excavator Joystick Control    | 15 High Flow Auxiliary Switch            | G Cool Box                               |
| 8 Control Lock Lever                 | 16 Dozer Operating Lever                 |  |
| 9 Left Console                       |  |  |

## Switches and Controls (cont'd)

## Right Console

**1 Starter Switch**

This is operated by the starter key. It has four positions. The key can only be removed when in the 'O' position.

**O Off/Stop Engine**

Turn the key to this position to stop the engine. Make sure the controls are in neutral and the excavator and dozer are lowered before stopping the engine.

**I On**

Turning the key in this position connects the battery to the electrical circuits. The key will spring back to this position when released from II.

**II Heat Position (Not Functional)**

Turning the switch to this position has no effect. The engine is pre-heated automatically if necessary.

**III Start**

Operates the starter motor to turn the engine.

**Note:** Do not operate the starter for more than 20 seconds at one time. If the engine does not start in this time, return the key to the 'O' position. Wait at least one minute before trying again. The switch mechanism prevents you from reselecting 'Start' without first returning to 'O'.

**2 Throttle Dial**

This rotary control provides progressive engine speed control over the full range.

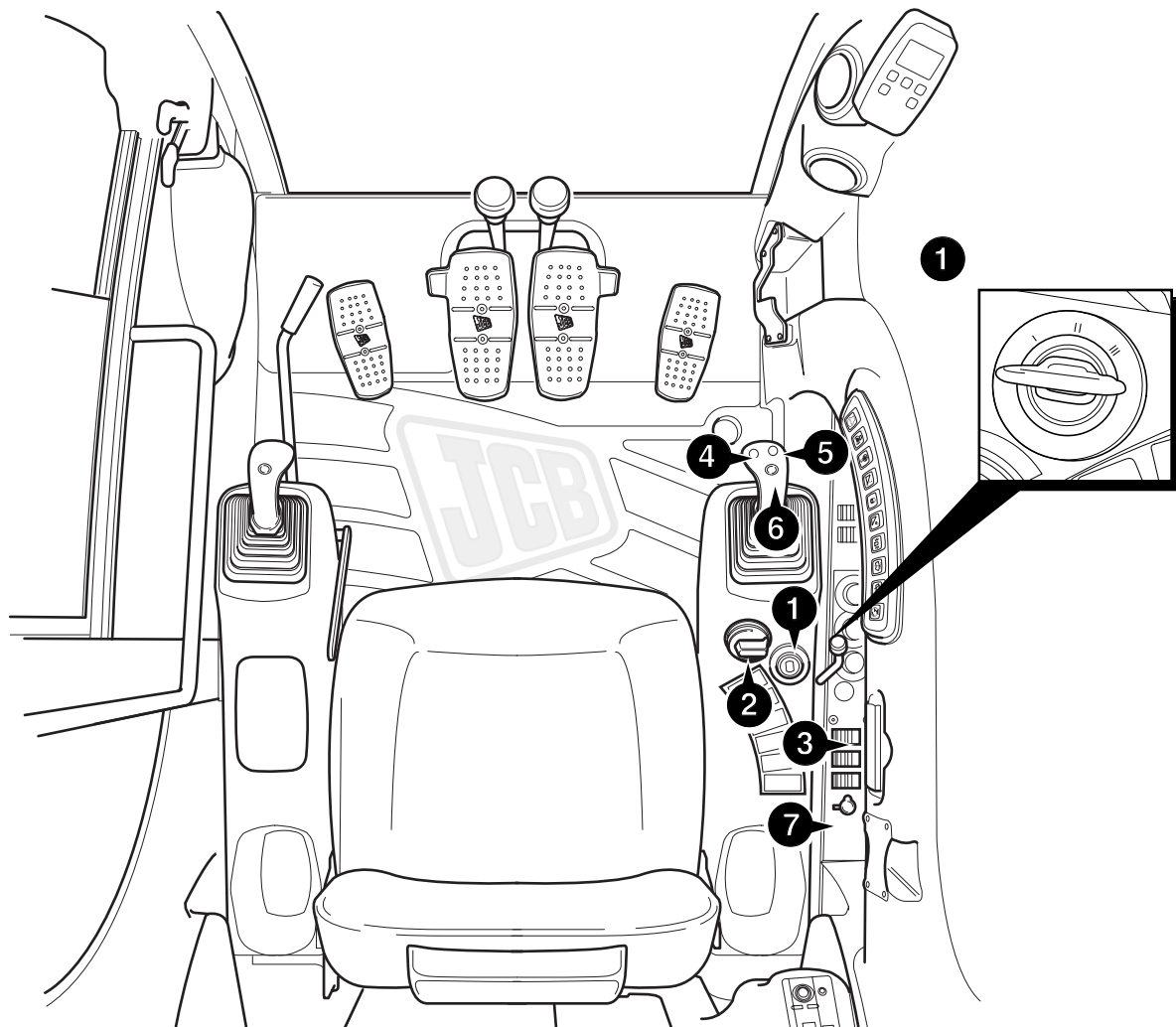
**Note:** If the engine speed does not change even after turning the throttle dial it may be because the idle switch **6** is ON. Push the idle switch to OFF to reactivate the throttle dial.

If the engine is started with the throttle dial not at the minimum position, no engine speed control will be possible until the dial is turned to the minimum position.



## Switches and Controls (cont'd)

### Right Console (cont'd)



#### 3 Radio Mute Switch

This switch is used to temporarily switch the sound from the radio OFF. When the mute switch is selected the indicator light will illuminate. When the switch is reselected the radio sound will resume and the indicator will extinguish.

#### 4, 5 High-Flow Auxiliary Switches

These switches operate high-flow hydraulic attachments, such as augers. Press and hold switch 4 to operate the attachment in the 'forward' direction. Press and hold switch 5 to operate the attachment in the 'reverse' direction.

**Note:** 'Forward' and 'reverse' directions will be determined by the hydraulic connections to the attachment.

Forward operation can also be activated by a foot-operated switch, see **Operating Attachments**.

**Note:** The EMS will prevent the high flow circuit operating if the hydraulic oil temperature is at or below 0 °C (32 °F), or if is at or higher than 98 °C (208 °F).

#### 6 One Touch Idle Switch

Pressing this switch instantly changes the engine speed back and forth between that selected for working and a 'low idling' speed. When 'low idling' has been selected the message "LOW IDLE" is displayed on the **EMS Panel**.

#### 7 Cigar Lighter/12 V Power Point

To operate the lighter **D**, press it fully into its socket. When it has heated up sufficiently it will spring forward a little way out of its socket. It can then be removed for use. **REMEMBER IT WILL BE HOT.** Return the lighter to its socket after use.

This machine is equipped with a 12 V system and can be used for mobile phone chargers or other 12 V powered devices (maximum current 10 A).

## Switches and Controls (cont'd)

### Heater/Air Conditioning Controls

Located on the **right console**, the heater/air conditioning controls are used in conjunction with the heater fan controls.

#### Air Conditioning On/Off

Press switch **X** to switch the air conditioning system on or off. The system will only operate if the cab temperature is above 0 °C (32 °F).

#### Fresh Air/Recirculated Air

Turn rotary switch **A** fully anti-clockwise for fresh air, turn it fully clockwise for recirculated air. (Intermediate positions give a mixture of fresh and recirculated air.)

#### Heater Fan

Turn rotary switch **B** clockwise to turn on the heater fan. Turn further clockwise for faster speeds. Functions only with the starter switch ON.

#### Temperature

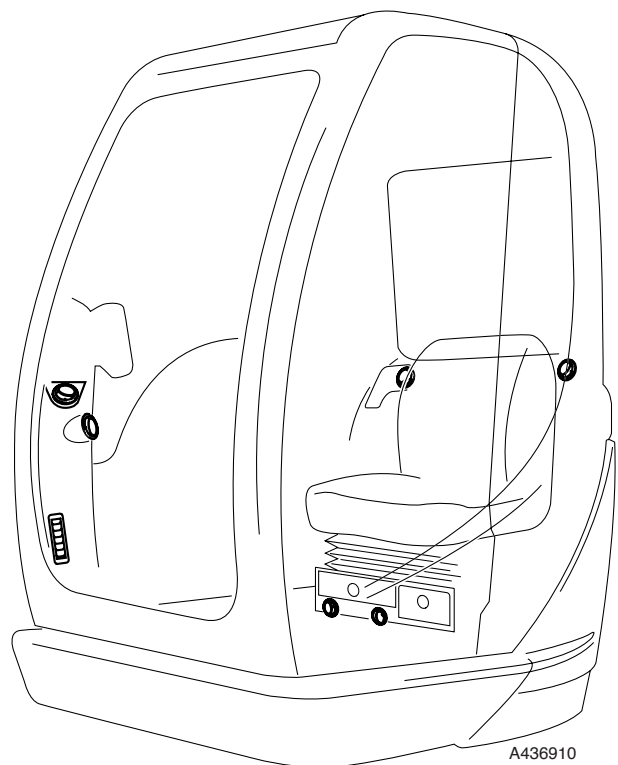
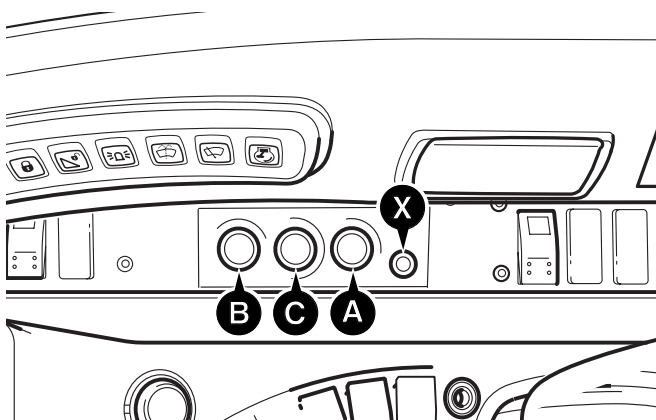
Turn rotary switch **C** clockwise to increase the heat.

#### Vents

Air can be distributed as required using the vents shown in the illustration opposite. The vents can be adjusted for both direction and flow.

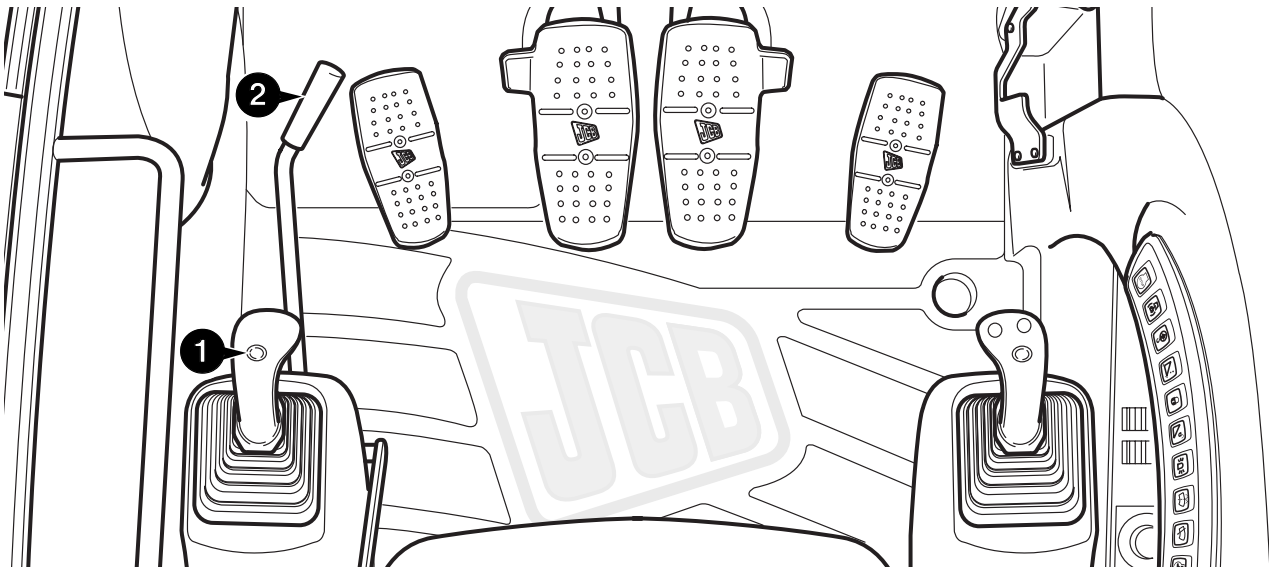
### Using the Air Conditioning

- 1 In hot weather to produce comfortable working conditions.
  - a Close the door and windows. Turn on the air conditioning switch **X**.
  - b Set control **A** fully anti-clockwise to avoid drawing hot air in from outside the cab.
  - c Set control **B** to the required fan speed. (The system will begin operating as soon as the fan starts.)
  - d Set control **C** as required to achieve the required temperature.
- 2 In cold/damp weather, to minimise misting.
  - a Close the door and windows. Turn off the air conditioning switch **X**.
  - b Set control **A** fully clockwise to avoid drawing damp air in from outside the cab.
  - c Set control **B** to the required fan speed. Adjust the vents as required to direct maximum air to the windows.
  - d Set control **C** as required to achieve the required temperature.



## Switches and Controls (cont'd)

### Left Console



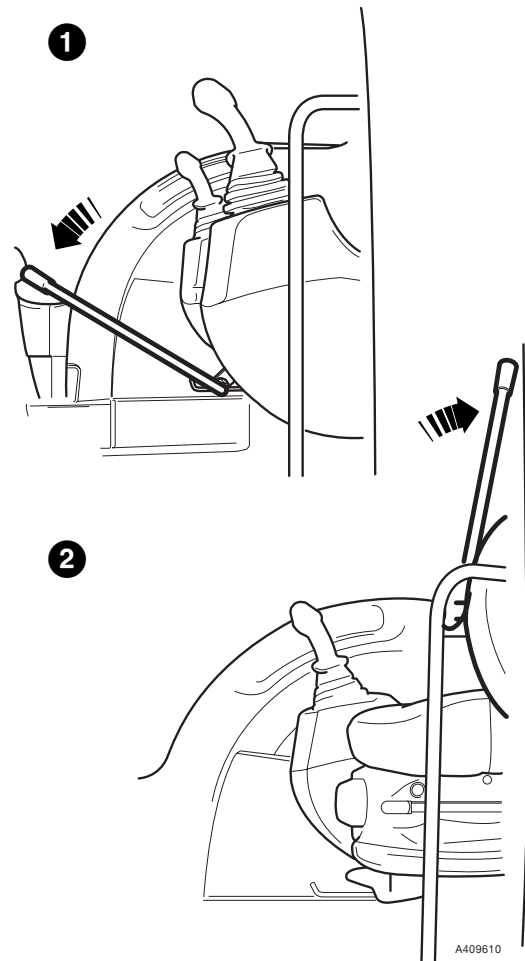
#### 1 Horn Button

When the horn button is pressed the horn will sound.

**Note:** Always press the switch and sound the horn to give signals, when the machine is started or you engage travel or slew.

#### 2 Control Lock Lever

When the Control Lock Lever **A** is at its lowest position **1** the hydraulic controls are unlocked and therefore usable. Raising the lever to position **2** lifts the left console clear of the doorway and isolates the hydraulic controls for entering/leaving the cab. The controls remain locked until both the lever **and** the console are returned to position **1**. (The controls can also be isolated by pressing the servo isolator switch, see **Facia Panel**.)



A409610

## Switches and Controls (cont'd)

### EMS Panel

The EMS (Electronic Monitoring System) provides a sophisticated means of controlling and monitoring various aspects of the machine's engine and hydraulic systems. The EMS panel, in conjunction with the Facia Panel, provides the operator interface to the EMS, using an LCD display and a series of indication lamps to display warnings and messages. Five pushbutton switches allow the operator to access the functions of the EMS. An integral buzzer sounds to attract the operator's attention to any warning messages.

#### 1 LCD Display

The LCD has 20-segment bar graph gauges for fuel, hydraulic and water temperatures. There are also indicators for time, travel speed (Hare/Tortoise type), power mode and hours run. The panel also has an eleven character message area to display warning and operational messages. If a machine error occurs then the normal Engine Hours/Clock display is replaced by a warning message. If the error persists, the display will alternate between the warning message and the Engine Hours/Clock display. If there are multiple warning messages to be displayed, the display will cycle the messages through the display. The normal clock and engine hours display is also overwritten by one-time status messages which indicate machine operational changes. These will automatically be cleared after a short period of time.

#### 2 Mode Button

Press to select working mode. The machine will be in **S** mode when started. Pressing the button cycles through the modes as follows:

**S** ➔ **H** ➔ **L** ➔ **S** ➔ **H** ➔ **L** etc.

Select the appropriate work mode suitable for the work to be carried out:

#### S - STANDARD MODE

For general digging and loading work.

#### H - HEAVY MODE

For harder digging work.

#### L - LIGHT MODE

For precise or light duty work.

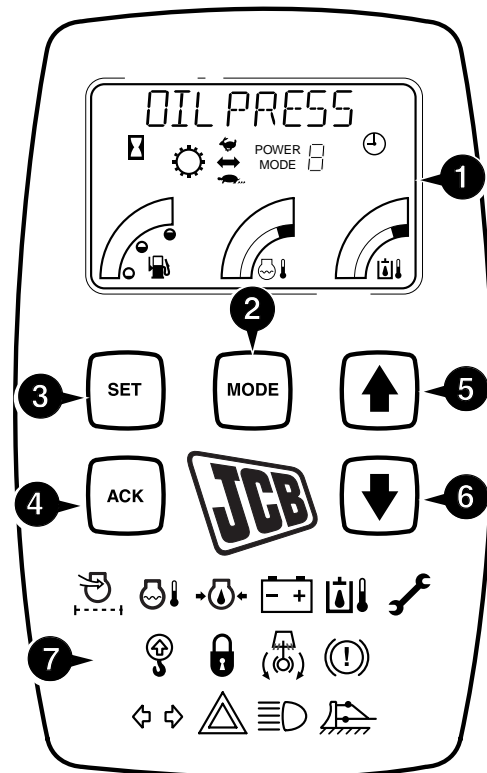
#### 3 Set Button

Press the SET button to access the monitor Set Up menu. The menu can be scrolled through using the Scroll Up and Scroll Down buttons **5**, **6**. The SET button can also be used to exit from EMS menus.

#### 4 ACK Button

Press to acknowledge warnings shown on the display. This will clear the message and silence the buzzer but will not extinguish the warning lamps. It is also used when navigating the menu system and to acknowledge any changes to EMS settings.

#### 5 Scroll Up Button



A410580

#### 6 Scroll Down Button

#### 7 Indication Lamps

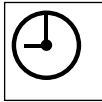
Fourteen indication lamps are included on the monitor. (See next page.)

## Switches and Controls (cont'd)

### LCD Display Icons



Indicates that machine hours are displayed top left of the display. This icon flashes while the engine is running.



Indicates the time.

### CAUTION

All the warning lights should go out when the engine is started. Rectify any faults immediately.

4-2-1-4

### Indication Lamps



#### Engine Air Filter Blocked (WARNING LAMP)

Illuminates if the engine air filter is blocked.



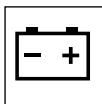
#### High Engine Coolant Temperature (WARNING LAMP)

Illuminates if the engine coolant temperature rises too high.



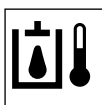
#### Low Engine Oil Pressure (WARNING LAMP)

Illuminates if the engine oil pressure drops too far. The light should go out when the engine is started.



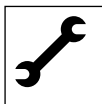
#### Charging System Fault (WARNING LAMP)

Illuminates when the battery voltage is low.



#### High Hydraulic Oil Temperature (WARNING LAMP)

Illuminates if the hydraulic fluid temperature rises too high.



#### Service Required (Status Lamp)

If illuminated contact your JCB dealer. Note that this will first light at 20 hours before the next service interval is due and will be accompanied by the 'SERVICE RQD' message on the monitor. Pressing 'ACK' will cancel the message but the LED will stay illuminated. If the service is not carried out within 20 hours of the specified interval, you can still cancel the message but the LED will flash until the service has been performed.



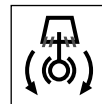
#### Lifting Overload (Optional) (Status Lamp)

Illuminates if the safe working load of the machine is exceeded (if this feature is activated on the Facia Panel by means of the **Overload Caution** button). This feature is only available when Hose Burst Check Valves are installed.



#### Servo Isolator ON (Status Lamp)

Illuminates when the machine's servo isolator is engaged. Lower the lock lever or press the isolator switch to disengage the isolator.



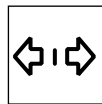
#### Slew Lock ON (Status Lamp)

Illuminates when the machine slew lock is engaged. Press the slew lock switch to disengage the slew lock.



#### Brake Pressure Low (WARNING LAMP)

Not used.



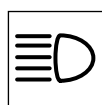
#### Direction Indicator (Status Lamp)

Not used.



#### Hazard Warning Lamps Indicator (Status Lamp)

Not used.



#### Main Beam Indicator (Status Lamp)

Not used.

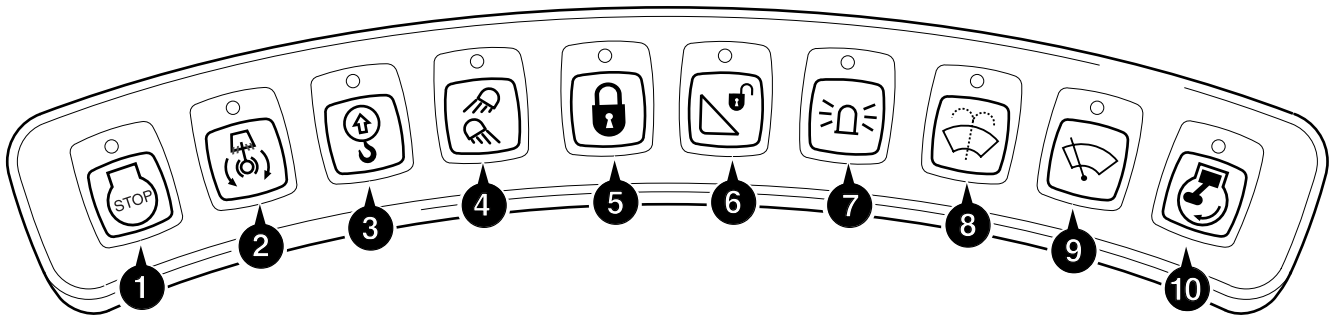


#### Dozer Mode Indicator (Status Lamp)

Not used.

## Switches and Controls (cont'd)

### Facia Panel



#### 1 Emergency Stop

Press to stop the engine. The EMS panel will display “EMER STOP”. Press again to allow the engine to be restarted.

#### 2 Slew Lock

Press to enable the slew lock. The monitor will display “SLEW LOCK”. This message will flash until the Slew Lock engages, at which point the message will stop flashing. Press again to release the slew lock. (The EMS will prevent the Slew Lock from engaging until the machine has stopped slewing and the slew brake has engaged.)

#### 3 Overload Caution (Option)

Use this to switch the Overload Caution system on and off. When the system is ON, if a load exceeding the lift capacity of the machine is lifted the monitor will display “OVERLOAD” warning message and a buzzer will sound. (This feature is only available when Hose Burst Check Valves are installed.)

#### 4 Work Lights

Press once to switch on the boom and front worklights. Press a second time to switch on the rear worklight (the boom and front worklights will remain lit). Press a third time to switch all these lights off.

#### 5 Servo Isolator

Press to isolate the servo system. The monitor will display “ISOLATOR”. When pressed the controls are isolated and no machine movement is possible. Press again to de-isolate the system.

#### 6 Quickhitch (option) - Position bucket on floor

When a quickhitch system is fitted, press to release the hitch. The monitor will display “Q/H DISCON?” and the alarm will sound, press ACK switch on the monitor within 5 seconds. The monitor will display “Q/H DISCON”. Press again to re-apply the quickhitch.

#### 7 Beacon (option)

When a beacon is fitted, press to activate the beacon. The monitor will display “BEACON ON”. The switch gives power to the jack socket into which the rotating beacon or the service inspection lamp is plugged.

#### 8 Windscreen Washer

Press to operate the windscreen washer. The washer will stop when the button is released. The windscreen wiper will operate for approximately four wipes once the button is released. The button’s LED will flash during intermittent operation and remain lit during continuous operation.

#### 9 Wiper

Press once to operate the wiper in intermittent mode. The monitor will display “WIPER INT”. The frequency of wipe can be adjusted using the EMS menu. Press a second time to operate the wiper continuously. The monitor will display “WIPER ON”.

#### 10 Auto Idle

Press the switch to activate the automatic engine idle system. The monitor will display “AUTO IDLE”. The engine speed will drop to idle when the machine hydraulics have remained unused for 5 seconds; the monitor will display “LOW IDLE”. The time delay can be adjusted by the monitor menu. (See **EMS panel, Set Mode.**)

**Note:** Regardless of the state of this switch, you can manually switch to and from LOW IDLE using the One Touch Idle Switch, see **Right Console.**



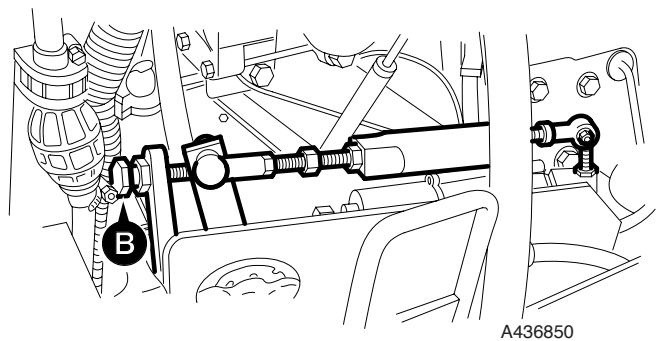
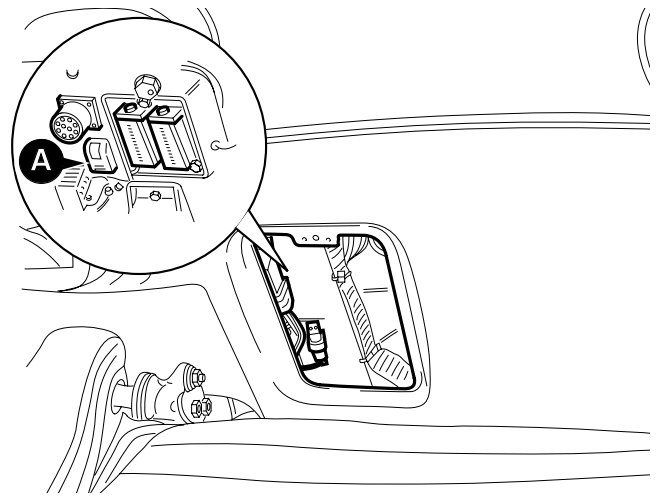
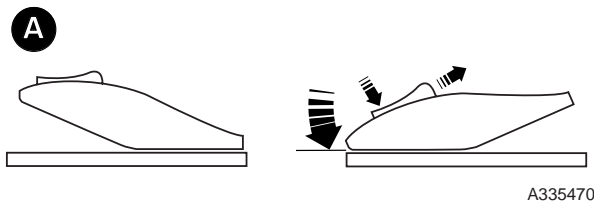
## Switches and Controls (cont'd)

### Redundancy Switch

The Redundancy Switch allows you to start and operate the machine with the EMS system switched off. This may be necessary in the event of system failure or when jump-starting the machine. The switch is located in the fuse box behind the seat.

Under normal conditions the switch **A** is OFF. The switch has a lock in the cap which must be slid towards the centre of the switch when pressing.

By switching the Redundancy Switch the engine can be started, the hydraulic functions are operable and the engine will run at idle speed. The monitor will display "LIMP MODE". The machine should be operated in this mode only to allow the machine to be moved to a safe position (See below for a method of raising engine speed while in this mode.)



### Mechanical Engine Speed Override

To use the machine in redundancy (LIMP) mode, adjust the mechanical engine speed override screw **B**. Increase the rev/min to an intermediate speed which is adequate for the machine to operate.

### Servo Controls Immobilisation

There are two means of immobilising the machine servo controls:

- 1 Raising the **Control Lock Lever** (see **Left Console**).
- 2 Pressing the **Servo Isolator Switch** (see **Facia Panel**).

**Note:** If you use the Control Lock Lever to isolate the controls, then only that lever can reactivate the controls. Similarly, if the Servo Isolator Switch has been used to isolate the controls, only that switch will reactivate them.

### **!** WARNING

#### Servo Isolator Switch

Use the servo isolator switch when you are not operating the machine, to avoid accidentally operating the controls and causing a dangerous movement of the machine.

**Before adjusting the cab environment, e.g. opening the windows or adjusting the seat, you must always isolate the controls using the servo isolator switch.**

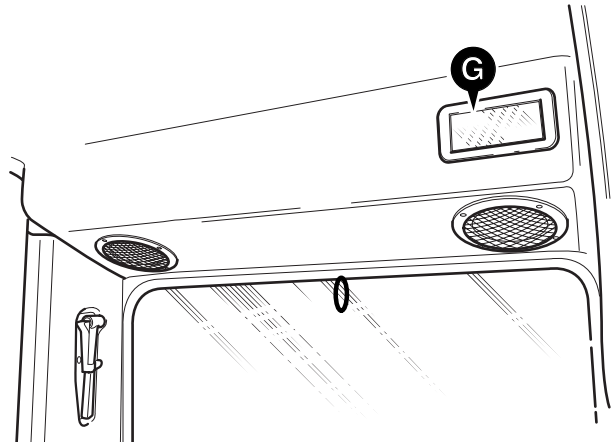
8-1-2-7

## Switches and Controls (cont'd)

### Cab Interior Light

The interior light **G** is located on the left of the cab back wall. To turn it on, press the right hand side of the light.

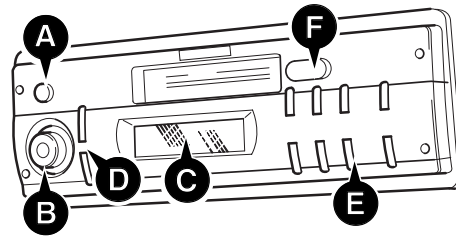
To extinguish press the side of the light to return it to the centre position. The lamp is also switched ON by a door operated switch. The light will remain lit for a period of time after the door has closed, then it will dim down until it is fully extinguished.



### Radio (Optional)

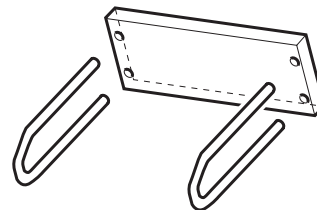
The radio, located on the right hand side of the rear panel, operates only with the Starter Switch ON and the Mute Switch OFF. It has the following controls:

- A Tone control
- B On/off switch and volume control
- C Tuning display (waveband, memory number, frequency)
- D Waveband/frequency select buttons
- E Pre-set memory store/select buttons
- F Cassette loading/control features



### Removal

Insert the bows as shown, lock the bows in, and press outward to release the retaining catches. Remove the radio.



### Replacement

Push in the radio until it engages with the retaining catches.

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### Radio Mute Switch

A radio mute switch is located on the right hand console.

Pressing this switch silences the radio's speakers without switching off the radio.



### Travel Levers

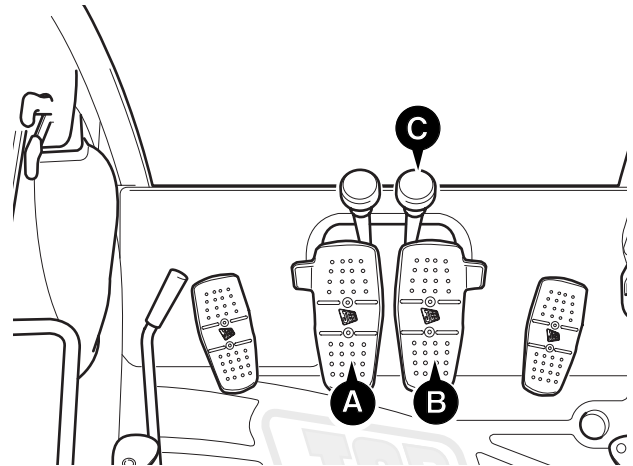
Travel is controlled by the two levers/foot pedals **A** and **B** at the front of the cab. Each lever controls the track on the same side, i.e. the left lever controls the left track, when the cab is facing forwards, that is towards the dozer blade. Before operating the travel lever, confirm whether the undercarriage is facing forwards or backwards.

**Note:** When not travelling, do not place your feet on the travel pedals.

#### **⚠️ WARNING**



**When the cab is swung around so that it is facing the track motor end of the undercarriage, the action of the tracking controls is reversed. Take extra care!**

8-2-8-1



### Travel Speed Change Button

The travel speed of the machine can be changed between high and low by pressing button **C**. (The travel speed is recorded at engine shutdown and is re-applied at the next engine start up). Each time the button is pressed, the speed is changed.

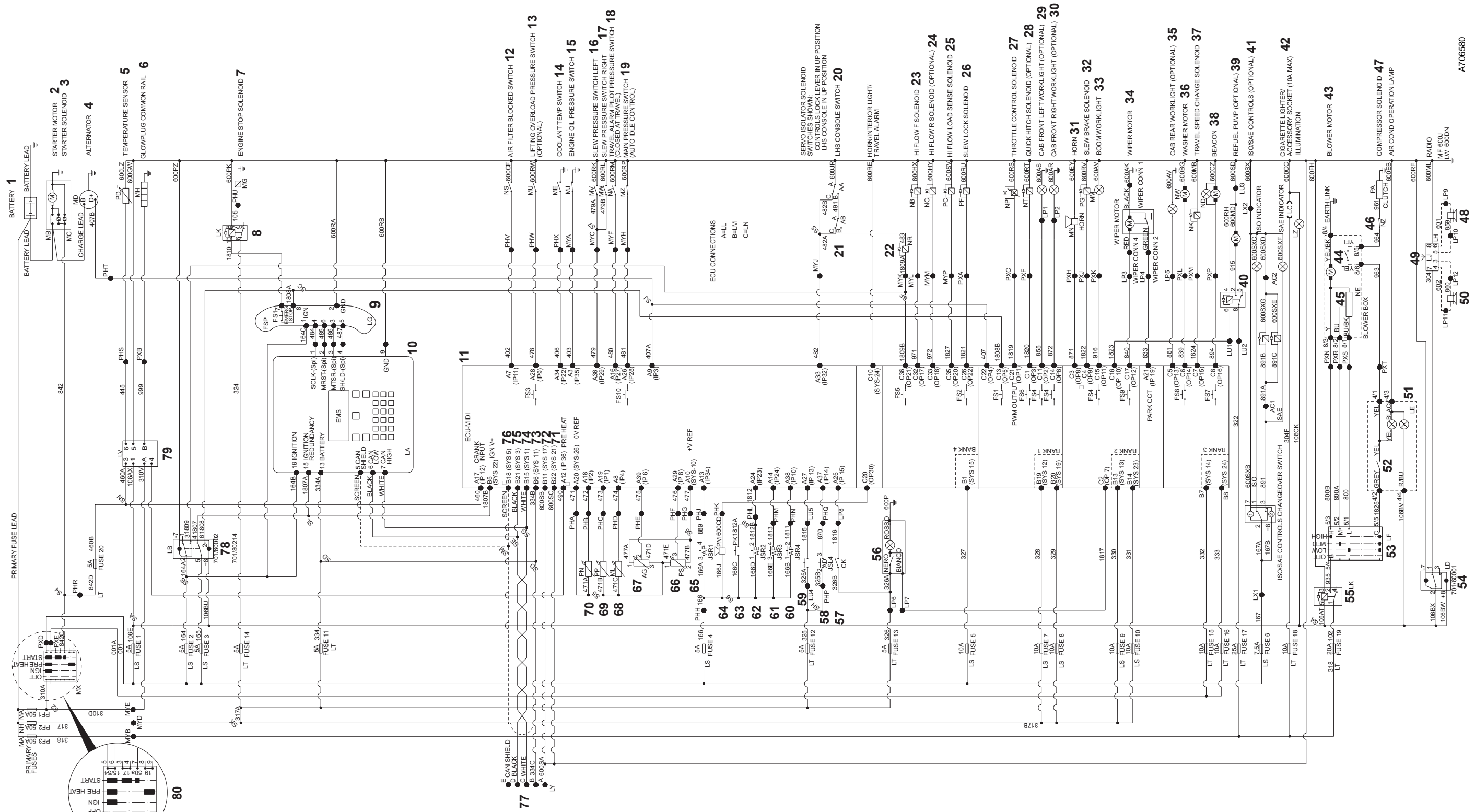
Travel Mode	Choice Selected
High Speed 	Use when the ground is level. When the load on the track motors increases, eg when travelling up a slope or dozing, speed automatically changes to Low. When the load reduces, speed returns automatically to High.
Low Speed 	Use when climbing or descending a slope or when the ground is rough. It does not change automatically.

**Note:** Do not change the mode when travelling. Stop the machine to select different speeds.

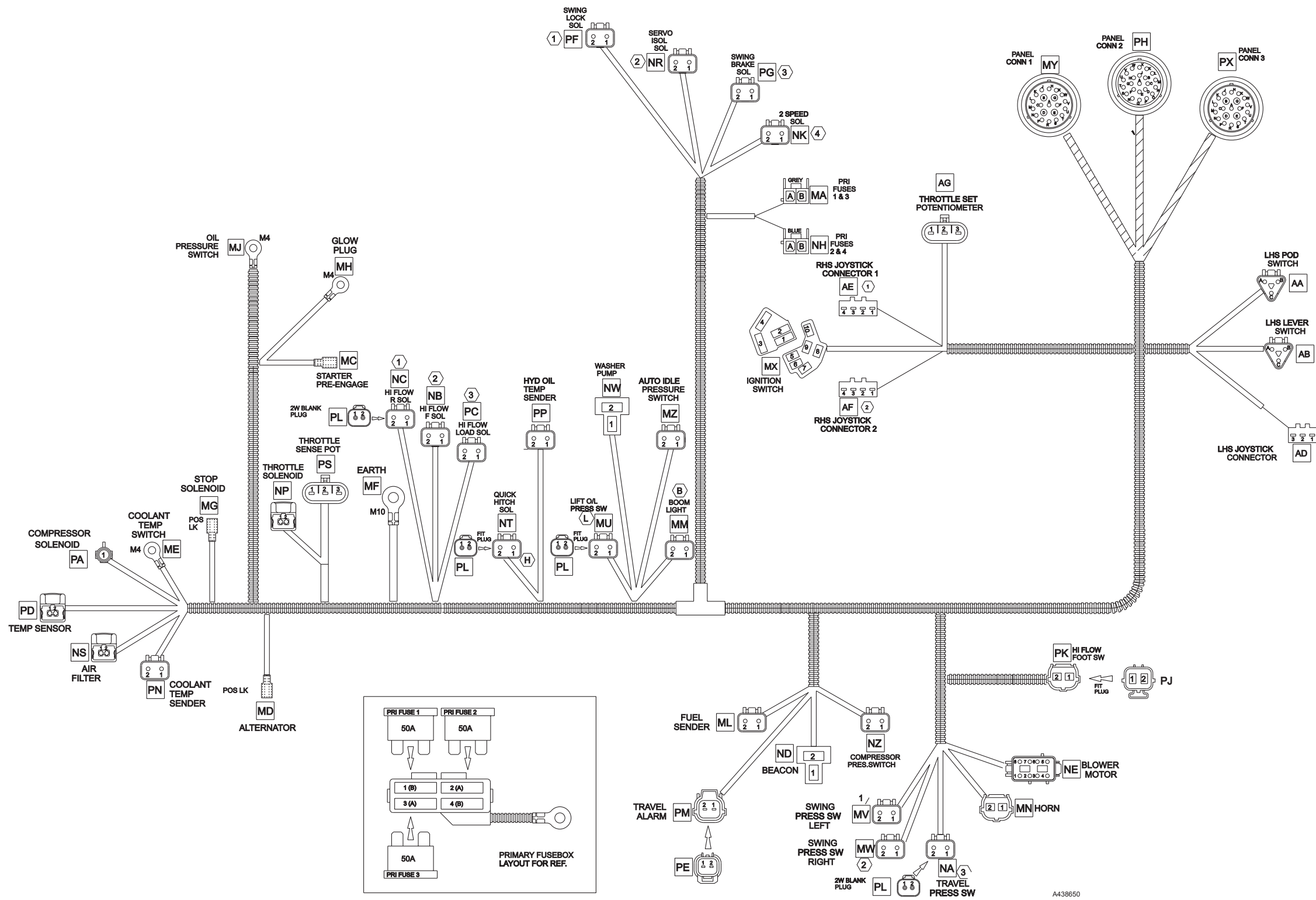
## Component Identification

The following item numbers are identified on the wiring schematics in this section:

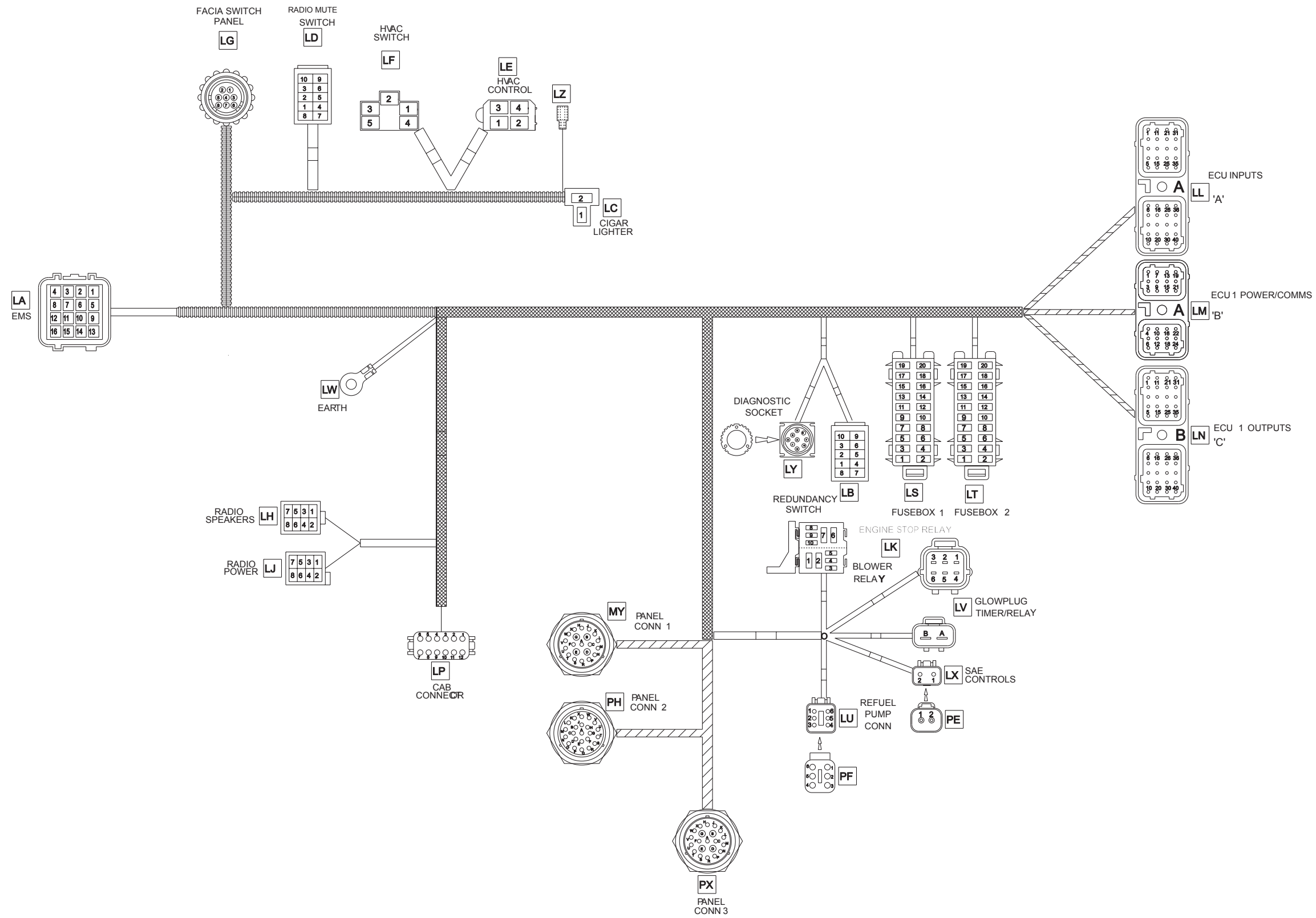
Item	Description	Item	Description
1	Battery	53	Heater/AC Switch
2	Starter Motor	54	Radio Switch
3	Starter Solenoid	55	Air Conditioning/Heater Relay
4	Alternator	56	Interior Light
5	Temperature Sensor	57	Interior Light Door Switch (shown door closed)
6	Glow Plug Common Rail	58	Horn Button
7	Engine Stop Solenoid	59	Refuel Pump Switch
8	Engine Run Relay	60	One Touch Engine Idle
9	FSP (Facia Switch Panel)	61	Hi Flow R Switch (Optional)
10	EMS (Electronic Monitoring System)	62	Hi Flow F Switch
11	ECU (Electronic Control Unit)	63	Hi Flow F Switch (Foot)
12	Air Filter Blocked Switch	64	Travel Alarm (Optional)
13	Lifting Overload Pressure Switch (Optional)	65	Travel Speed Change Button
14	Coolant Temperature Switch	66	Throttle Sense Potentiometer (Engine)
15	Engine Oil Pressure Switch	67	Throttle Set Potentiometer (Cab)
16	Slew Pressure Switch Left	68	Fuel Sender
17	Slew Pressure Switch Right	69	Hydraulic Oil Temperature Sensor
18	Travel Alarm Pilot Pressure Switch	70	Coolant Temperature Sensor
19	Main Pressure Switch (Auto Idle Control)	71	Battery 0 V Power Supply
20	Servo Isolator Solenoid Switch, LHS Console	72	Battery 0 V Power Supply
21	Servo Isolator Solenoid Switch, Controls Lock Lever	73	Battery 12 V Power Supply
22	Servo Isolator Solenoid	74	CAN High
23	Hi Flow F Solenoid	75	CAN Low
24	Hi Flow R Solenoid (Optional)	76	CAN Shield
25	Hi Flow Load Sense Solenoid	77	Programming/Diagnostic Port
26	Slew Lock Solenoid	78	Redundancy Switch
27	Throttle Control Solenoid	79	Glow Plug Timer
28	Quick Hitch Solenoid (Optional)	80	Ignition Switch
29	Cab Front Left Worklight (Optional)		
30	Cab Front Right Worklight (Optional)		
31	Horn		
32	Slew Brake Solenoid		
33	Boom Worklight		
34	Wiper Motor		
35	Cab Rear Worklight (Optional)		
36	Washer Motor		
37	Travel Speed Change Solenoid		
38	Beacon		
39	Refuelling Pump (Optional)		
40	Refuel Pump Relay		
41	Patch Planer/ISO-SAE Controls (Optional)		
42	Accessory Socket (5 A max)		
43	Blower Motor		
44	Blower Freeze Switch		
45	Blower Resistor		
46	AC Hi-Low Pressure Switch		
47	Compressor Solenoid		
48	LH Speaker		
49	Radio		
50	RH Speaker		
51	AC Control Panel (inc. lights)		
52	AC On/Off Switch		



Slewpan Harness



Main Cab Harness



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## System Overview

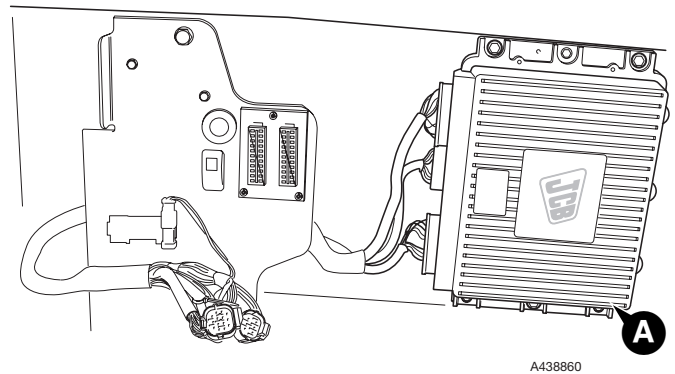
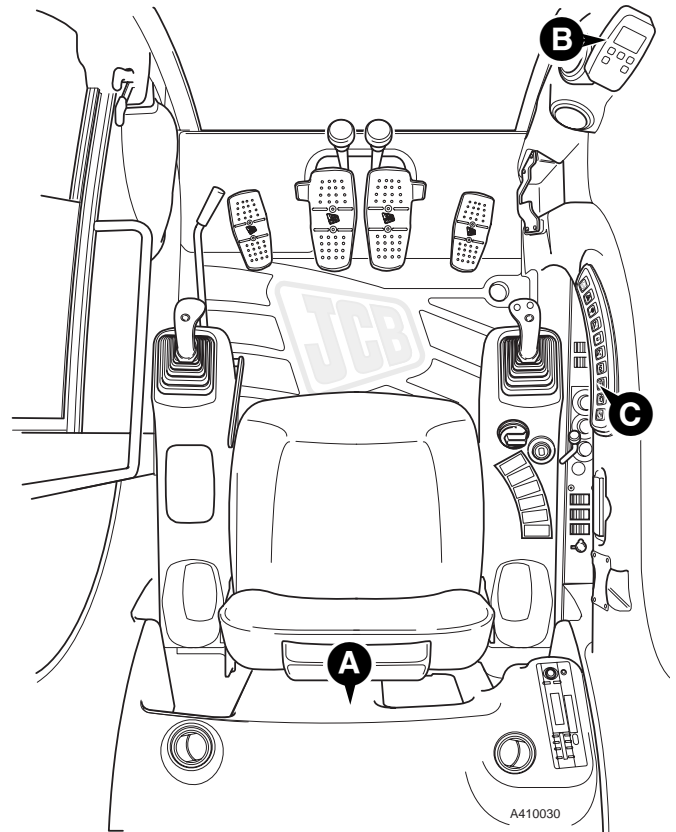
### Operation

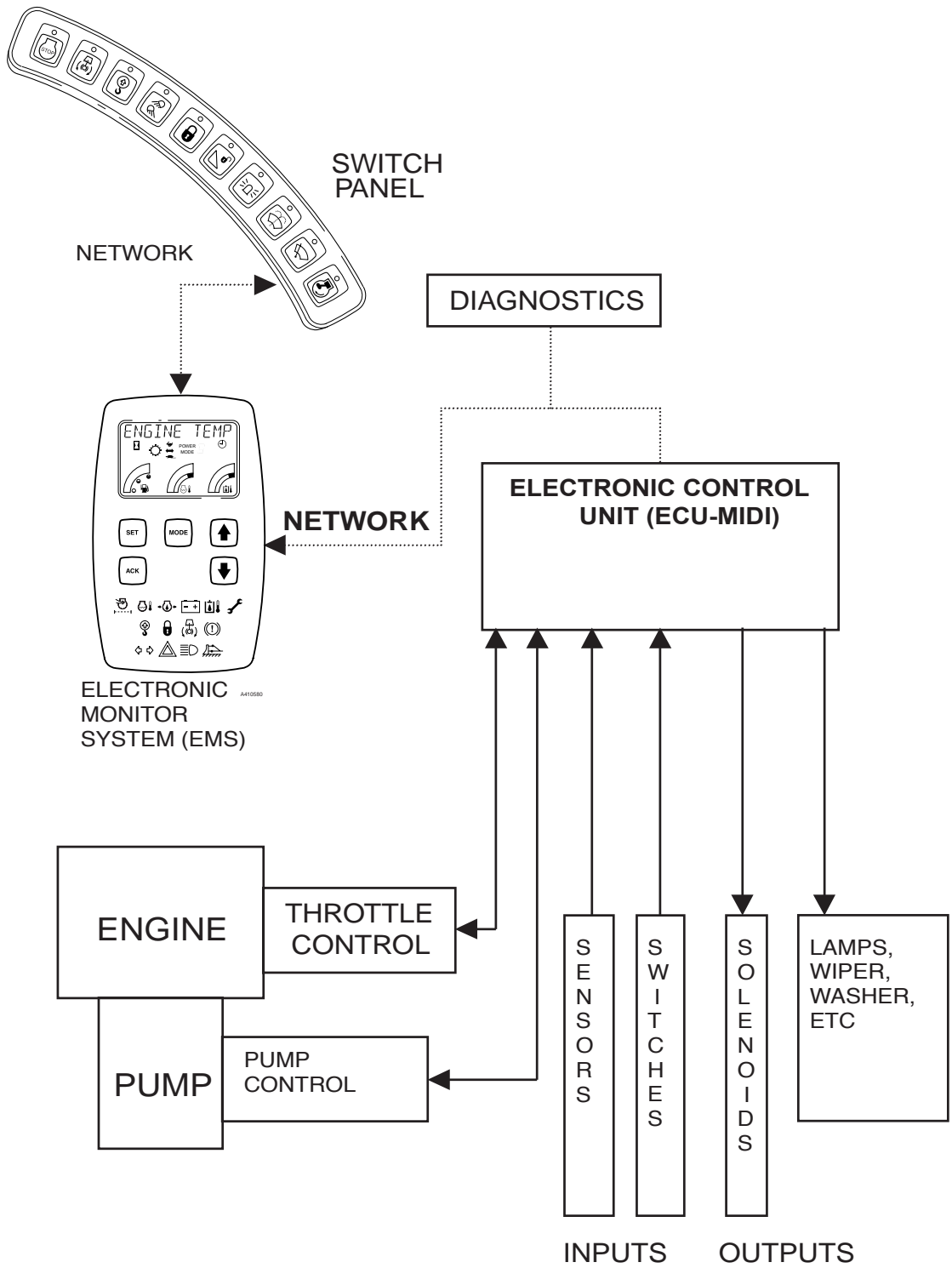
The JCB A.M.S system is a whole machine electronic control system. The system controls engine speed, pump power, transmission, excavator functions, lights, wiper, auxiliary circuits, warning lamps, etc. The system is a 'CAN-BUS' system which links Electronic Control Units (ECUs) on the vehicle. This stands for 'Controlled Area Network' and uses a special cable in the vehicle harness which consists of two signal wires twisted together covered by a metal foil to prevent any electrical interference. These signal wires form the CAN-BUS. The CAN-BUS is used to send text and fault codes between the ECUs.

The electronic units receive inputs from switches and sensors and drive outputs such as solenoids, lamp bulbs and motors. The outputs of the ECUs are rated to the current requirement of the actuator.

The system comprises of the following main electronic components:

- A** Electronic Control Unit (ECU-MIDI), located under panel behind drivers seat.
- B** Electronic Monitoring System (EMS).
- C** Facia switch panel (FSP).





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## Circuit Concepts

### Inputs

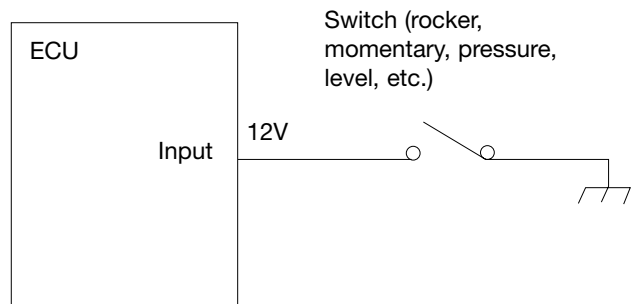
There are two main types of input, Digital and Analogue.

Digital type inputs are on/off type inputs (i.e. switches) and can be Low side inputs or High side inputs. Low side inputs are inputs that provide a ground to the ECU-MIDI. High side inputs are inputs that provide a positive feed to the ECU-MIDI. Analogue Inputs are sensor type inputs that provide a varying type input to the ECU-MIDI, this input could be a resistance or frequency type input.

#### Digital inputs (on/off switch type inputs)

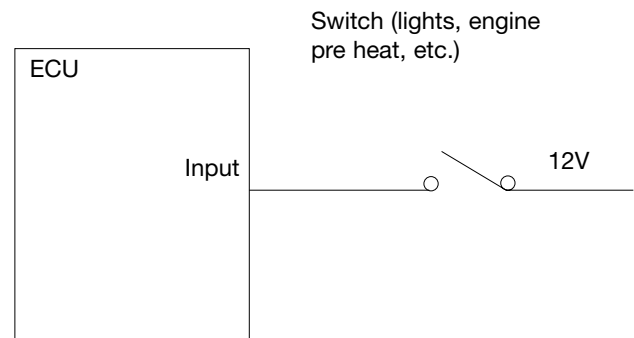
**a Low side input**

The low side input is the most frequently used input on the A.M.S system. The low side input can be in the form of rocker switches or pressure switches.

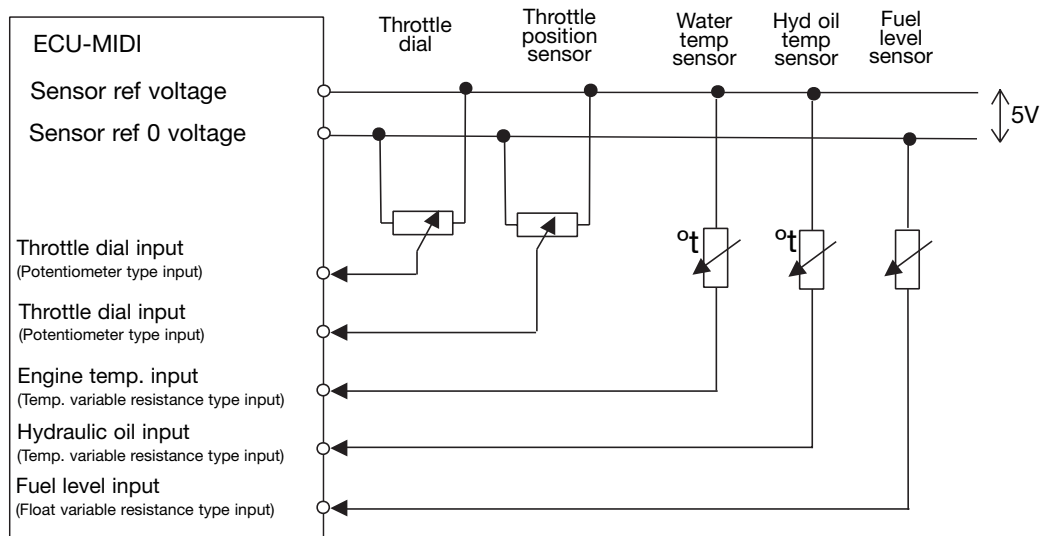


**b High side input**

The high side input is used on circuits that require a positive feed when the ignition is switched off, i.e. sidelights or hazard lights. The high side input is also used on the engine pre heat circuit.



**c Analogue input (i.e. sensor type inputs) Outputs**





## Circuit Concepts (cont'd)

### Outputs

There are three main types of outputs Low side output, High side output and Modulated output.

In the Low side output circuit the actuator (solenoid, relay etc) which is being driven already has a positive feed available, the ECU-MIDI then provides the ground side of the circuit.

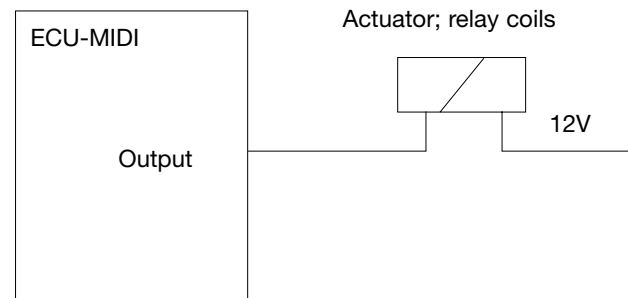
In the High side output circuit the actuator which is being driven already has a ground available, the ECU-MIDI provides the positive side of the circuit.

In the Modulated Output circuit the ECU-MIDI provides a PWM (Pulse Width Modulation) signal to a proportional valve.

As the ECU-MIDI varies the duty cycle of the signal the proportional valve will select more or less depending on the change in duty cycle.

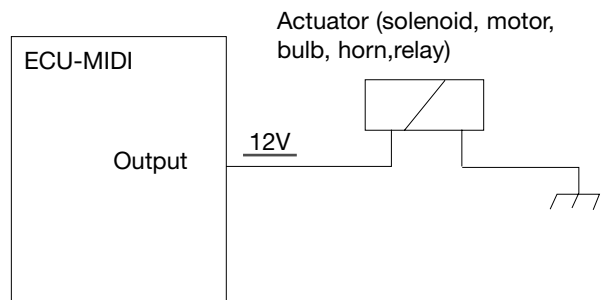
#### a Low side output

Circuits using low side output are pre heat relay, stop solenoid relay and work lights.



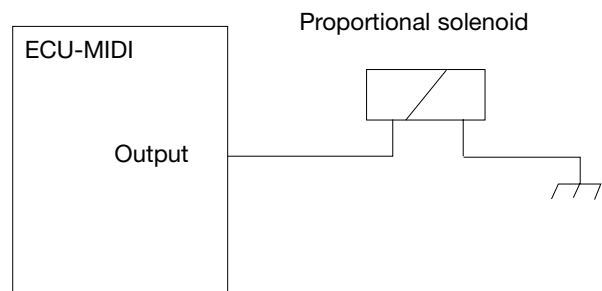
#### b High side output

The high side output is used to operate solenoids, bulbs and horn.



#### c Modulated outputs

Circuits using the modulated output are throttle control, pump control and boom priority.



### Pulse Width Modulation (PWM)

Ohms law states that, the amount of current flow in a circuit is determined by the voltage, and the resistance. A 12V circuit with a resistance of 6 Ohms, would draw a current of 2 Amps. This would be the case for a standard solenoid, which is either on or off.

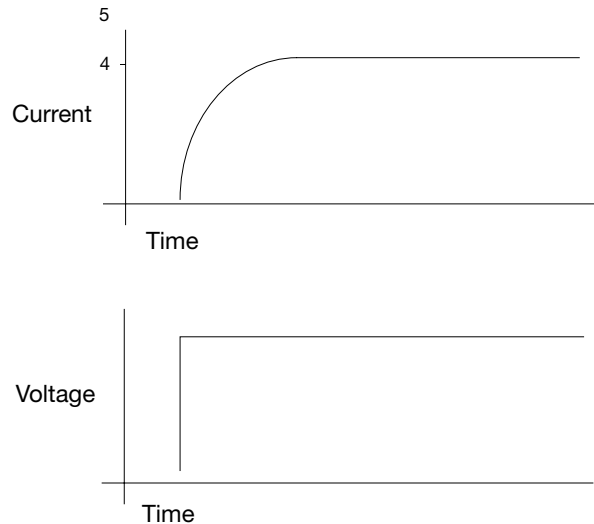
Once the voltage is applied to the circuit, it is present 100% of the time. This would be known as a 100% duty cycle. Therefore the circuit will draw 2 Amps constantly.

A proportional solenoid requires differing amounts of current, depending on its condition. As the coil has a fixed resistance, changing the current rating can be done in either of two ways,

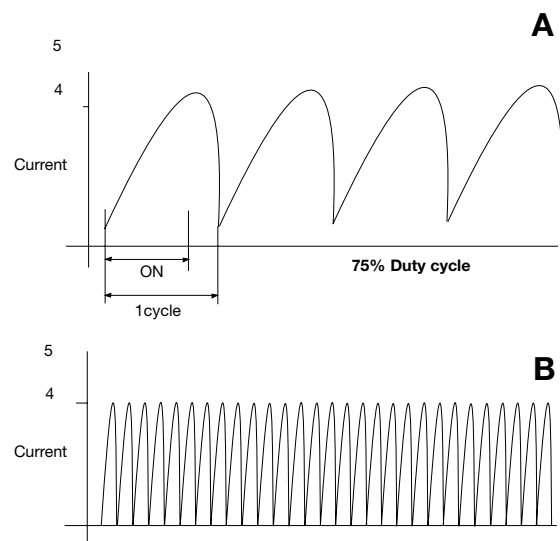
- 1 Having lots of different resistors switched in and out of the circuit at different times to change the current flowing.
- 2 To change the duty cycle of the solenoid.

It is easier, more economical, and more reliable to change the duty cycle of the circuit, especially using today's computer/ controller technology.

The duty cycle is the amount of time a component is switched on compared to the time it is switched off. If a solenoid is on for three seconds, then off for one second, on for three, off for one etc. this would be a 75% duty cycle.

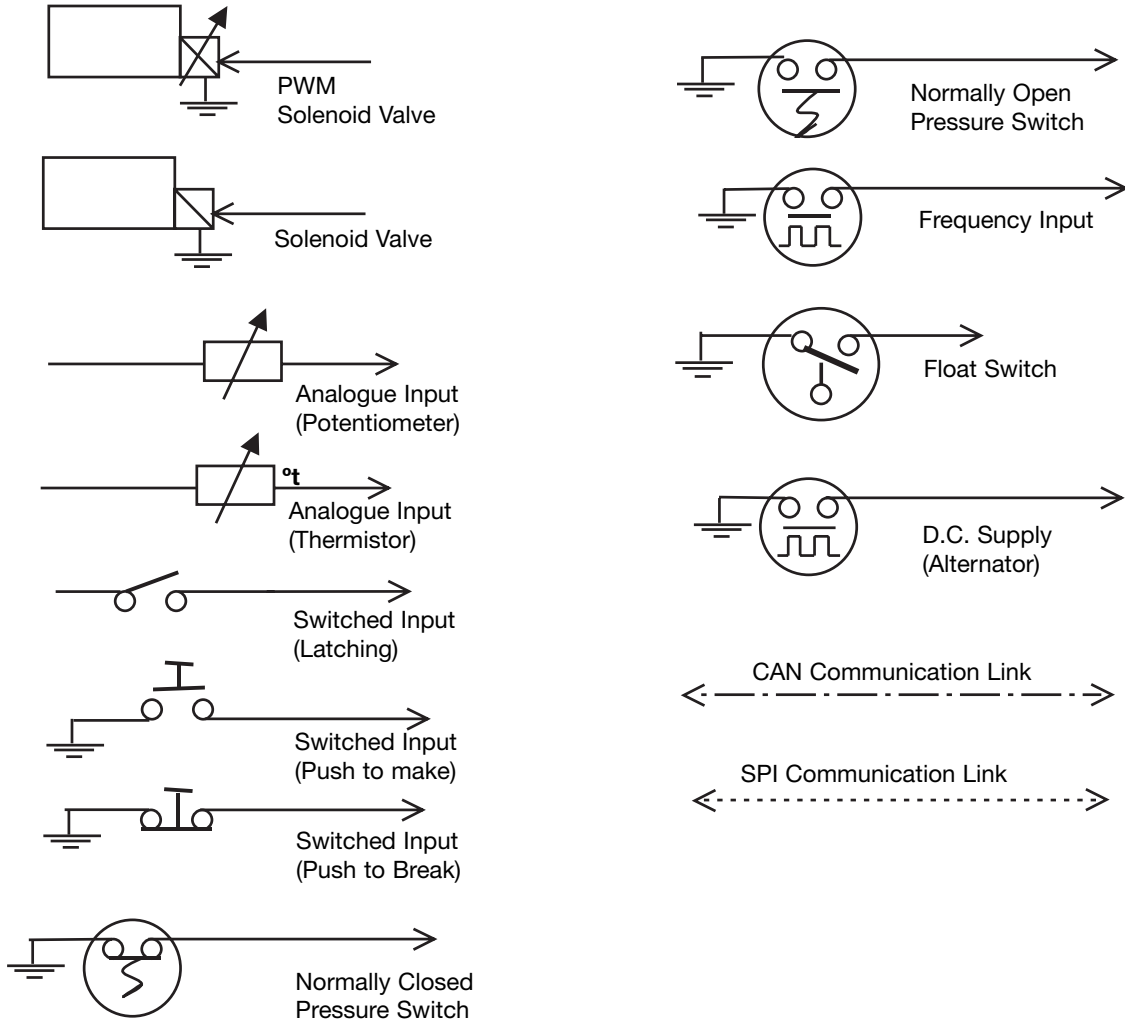


The graph **A**, although unstable, would give a current rating of three amps. To stabilize the current in the circuit, the frequency would need to be increased. If the timescale on the graph **A** was one second, the frequency would be 4 Hz (Hertz (cycles per second)). The graph **B** shows the same duty cycle, but at a higher frequency of 32 Hz. The proportional solenoids fitted to JCB machines operate at a frequency of 125 Hz.



**Functional Description**

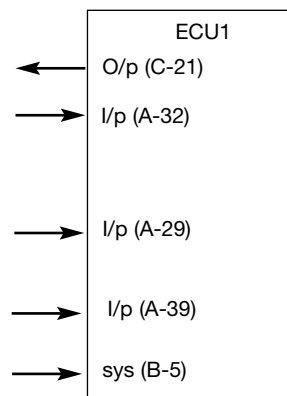
The following notations are used in the functional description circuit drawings.



**Inputs and Outputs**

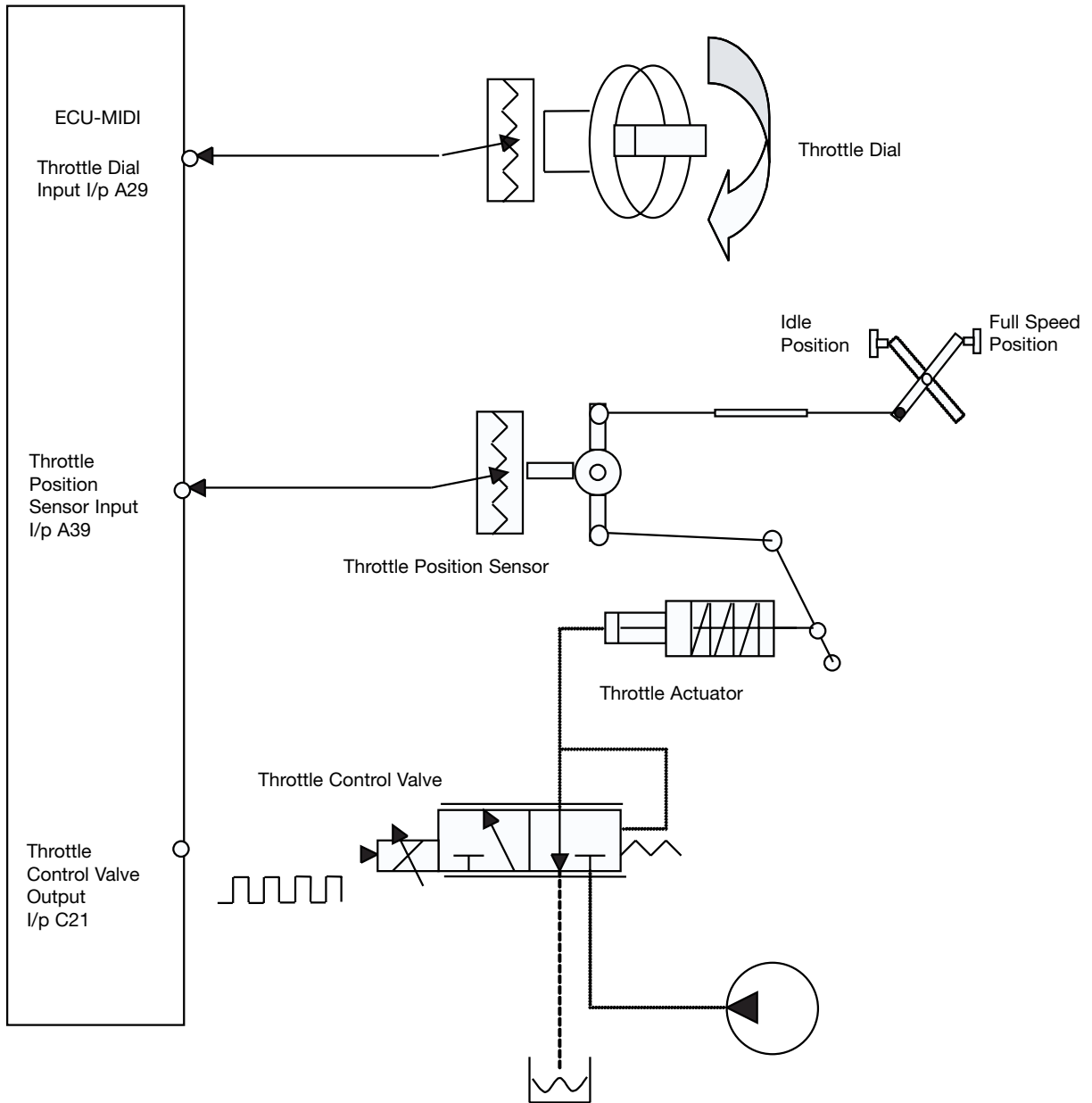
The letters I/p and O/p refer to input and output.

The letters in brackets i.e. (C-21) refer to the connector and pin number.



### Engine Throttle Control

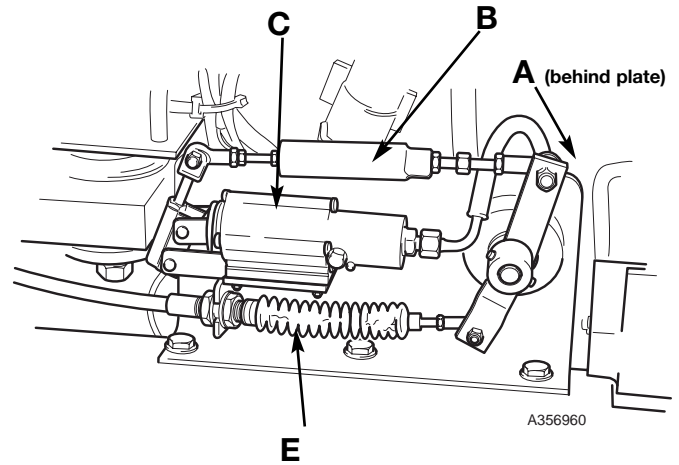
Engine speed is controlled by the electro hydraulic throttle control system. The system consists of a proportional pressure reducing valve (throttle control valve), a hydraulic cylinder (throttle actuator), a throttle position sensor, and throttle dial (potentiometer).



## Engine Throttle Control (cont'd)

### Throttle Control System

Throttle control is achieved by an electro-hydraulic proportional solenoid. The ECU-MIDI supplies a modulated output (which is determined by the working mode selected and throttle dial position), the throttle control valve works as a pressure reducing valve and supplies hydraulic pressure to the throttle actuator which in turn moves the throttle cable to increase/decrease engine speed. A sensor on the throttle lever gives feedback to the ECU-MIDI on the throttle lever position.



### Throttle Control Circuit

If the engine is started with the throttle dial above the  $\frac{1}{4}$  full speed position, the engine will start at idle. No engine speed control will then be possible until the operator turns the throttle dial to a position which is lower than the  $\frac{1}{4}$  full speed position. The throttle control will then function as normal.

If the operator stops the engine from full speed then the throttle actuator will ramp down over a two second time period, reducing the engine rev/min before stopping.

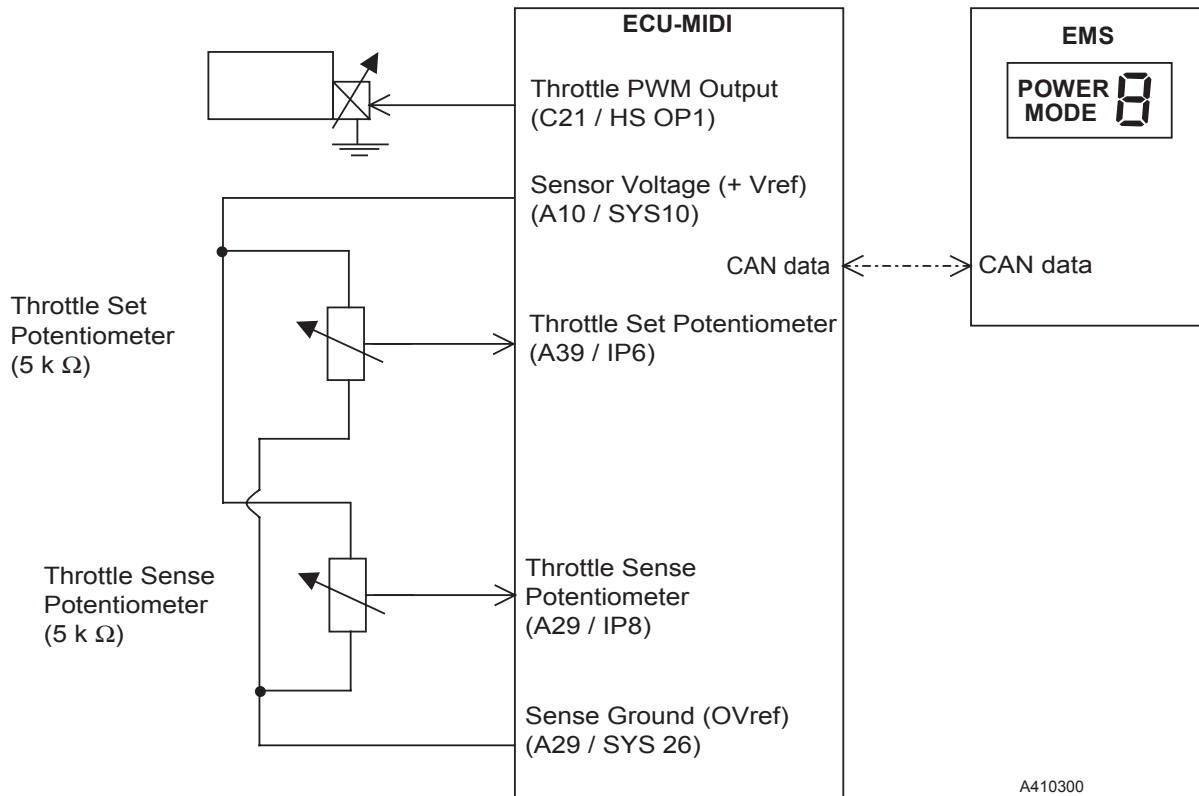
If the operator has selected the one touch idle function before stopping the engine, then when the engine is restarted the throttle control will still be in one touch idle function (i.e. the ECU remembers that one touch idle was selected).

Three Modes of operation can be selected on the EMS Monitor - Standard (S), Heavy (H) and Light (L). the default setting is in Standard Mode. For the relationship between the mode settings and throttle setting see **Power Modes**.

**Note:** Throttle position sensor (behind the throttle lever).

- A Throttle control valve
- B Throttle linkage
- C Throttle actuator
- D Stop solenoid (not shown)
- E Throttle cable
- F Stop cable (not shown)

## Throttle Control



### Operation

The vehicle's diesel engine speed is controlled by the position of its throttle, which in turn is determined by a proportional hydraulic cylinder. The cylinder position is determined by the duty cycle of a switched PWM electrical signal to the cylinder solenoid. Thus, the PWM duty cycle controls the throttle position and the (unloaded) engine speed.

Based on this mechanism, the ECU-MIDI is able to control the throttle position by varying the duty cycle of its throttle PWM output. The components of the throttle control system are:

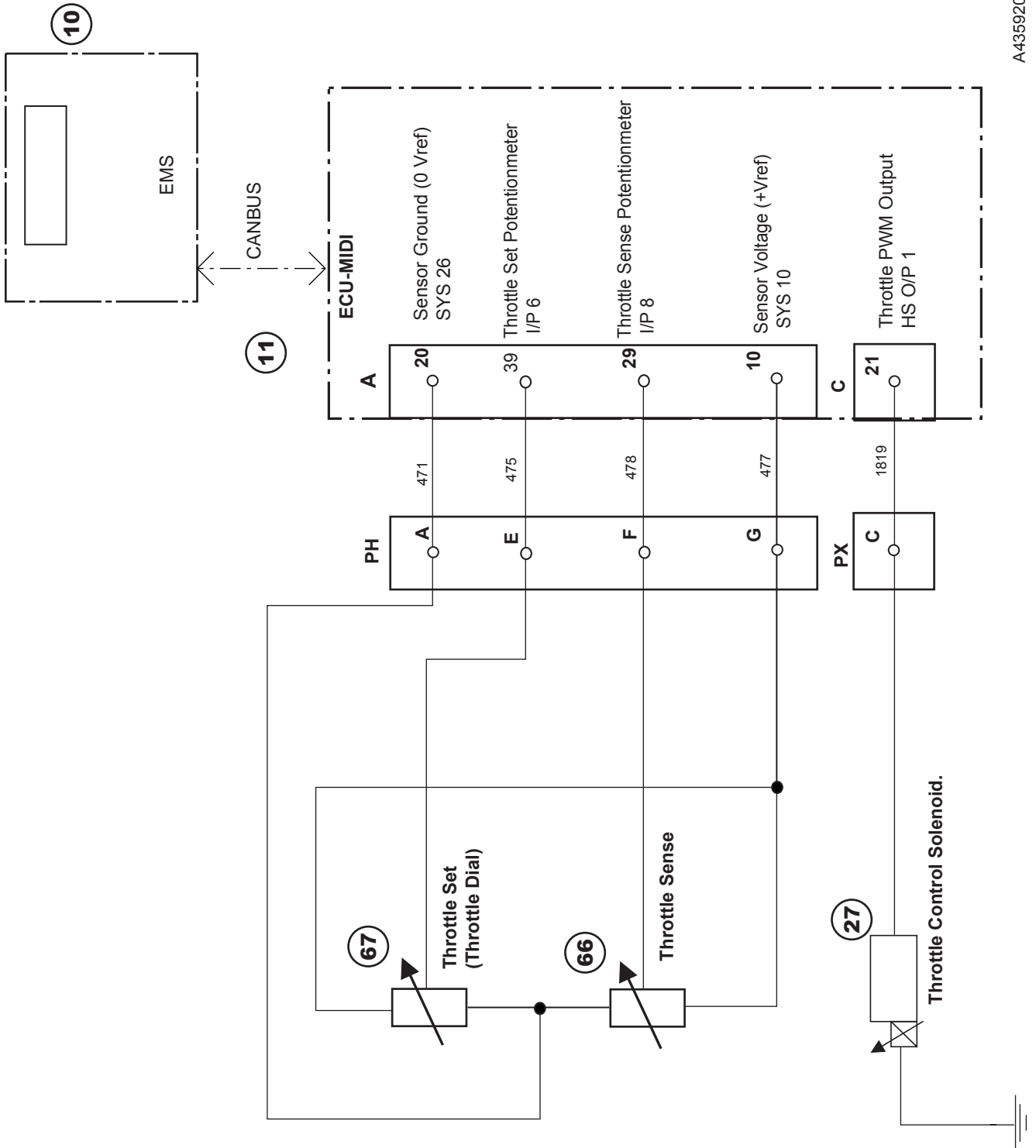
- 5K linear potentiometer that is set by the operator to select a desired throttle position. This is the Throttle Set Potentiometer (Throttle Dial).
- 5K linear potentiometer on the throttle linkage that indicates the actual position of the throttle; used as feedback to the ECU-MIDI. This is the Throttle Sense Potentiometer.
- The hydraulic cylinder that moves the throttle mechanism.
- The ECU-MIDI, which reads the two potentiometers, and sets the duty cycle of the PWM signal to the hydraulic cylinder.

**Note:** This process controls the throttle position, and not the engine rev/min. It is normal for the engine rev/min to vary for a fixed throttle position, depending on the load on the engine, which itself depends on the "work" that the hydraulic system is doing. The vehicle operator uses the varying sound of the engine as feedback when operating the various hydraulic functions of the excavator.

When the vehicle engine is first started, the throttle is set to its minimum (idle), regardless of the setting of the Throttle Dial. This avoids having the engine start off at high rev/min's unexpectedly. The operator must turn the Throttle Dial back to the idle position before the EMS will allow non-idle throttle settings. The throttle control system operates only when the engine is in a running state. If the system is not in a running state, the throttle output is turned off.

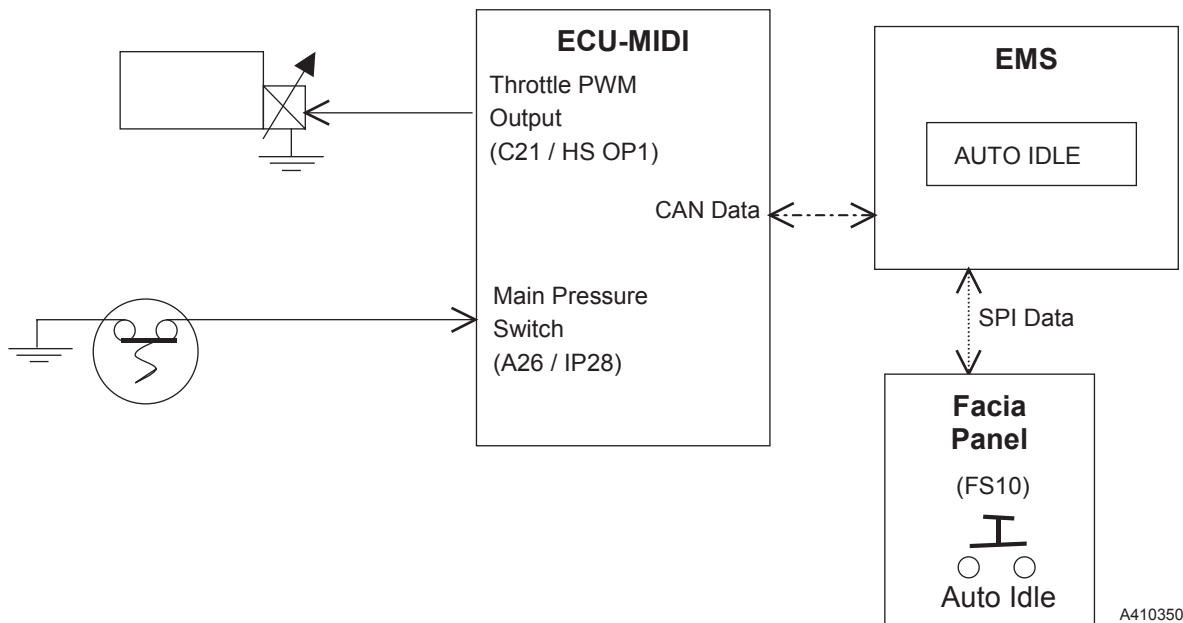
The throttle control system has a self-check to guard against electrical or mechanical problems with the system. When the operator sets a throttle position, the Throttle Sense Potentiometer reading must come to within a certain tolerance of the target value in 20 seconds. If this does not happen, the ECU-MIDI will attempt to set the throttle to idle, and the EMS will display a "NO THROTTLE" error message.

Throttle Control (cont'd)



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## Throttle Control Auto Idle



### Operation

The Auto Idle Facia switch button activates this feature. When active, the status lamp on the facia panel will illuminate and the EMS will display the "AUTO IDLE" message to verify selection. A second press of this switch will disable the function, and extinguish the status indicator.

When activated, this feature allows the engine to return automatically to the low idle setting if the machine has not been used for a pre-set time delay. The default for this time delay is 5 sec. It will be possible to modify the time delay between 5 and 30 seconds via a sub menu on the EMS.

- \* The auto idle feature can be engaged or disengaged when the system is in a Key-on, cranking or a running state. However it will only affect the throttle solenoid output in a running state since that is the only time throttle control is allowed.

The auto idle feature uses the main pressure switch to determine if full engine power is required. A grounded input from the switch indicates that pressure has not been detected. An open signal from the switch indicates that pressure is present.

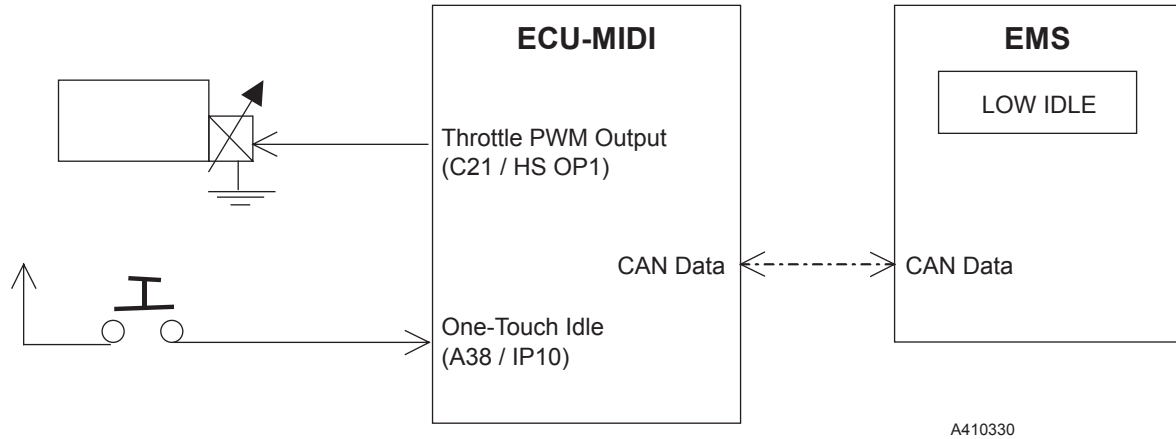
When auto idle is selected, if no pressure has been detected for the pre-set time delay, the automatic idle function will operate and the engine rev/min will drop to the idle value. The EMS will again display the message "AUTO IDLE". The engine rev/min can be increased by pressing the auto idle facia switch or by changing the state of the pressure switch.

If pressure is then detected while auto idle is active, the engine rev/min will return to its previous value as defined by the throttle set pot. The EMS display returns to normal status.

The state of the auto idle feature should be remembered when the system is turned off. This state should be applied when the system is turned back on.



## One Touch Idle



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### Operation

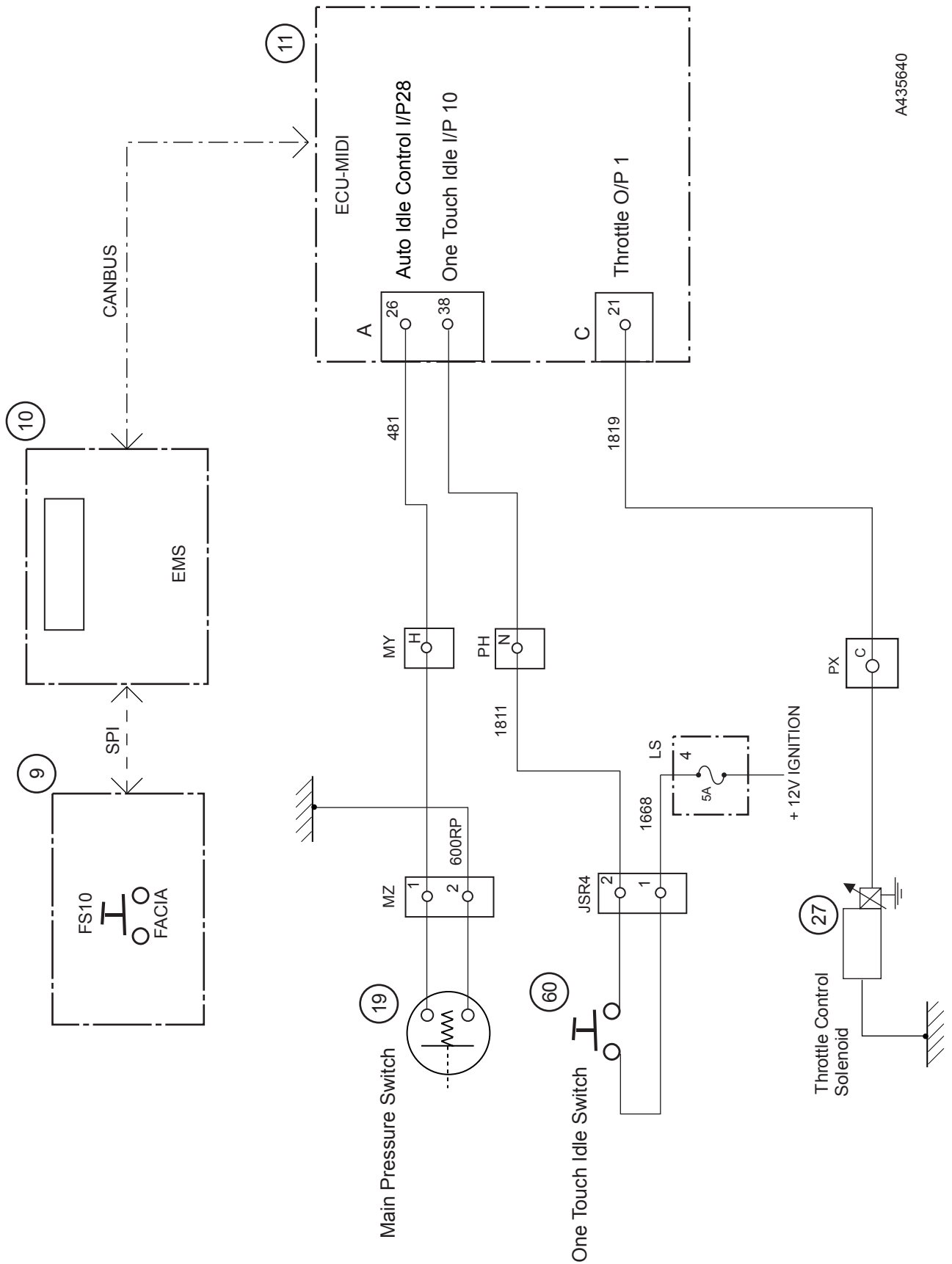
The one touch idle switch is located in the right hand joystick.

The one touch idle switch is a momentary button that will give a grounded +Vbatt input when it is pressed and an open input when it is not pressed. When operated, the engine revs drop automatically to Idle speed.

When activated, this feature allows the engine to run at the low idle setting, regardless of any other input (including the throttle dial). When the one touch idle switch is activated, the EMS will display the "LOW IDLE" message to verify operation and the engine speed will drop to the low idle setting. A second press of this switch will disable the function and the engine speed will return to their previous value as defined by the throttle set pot. The EMS display returns to normal status.

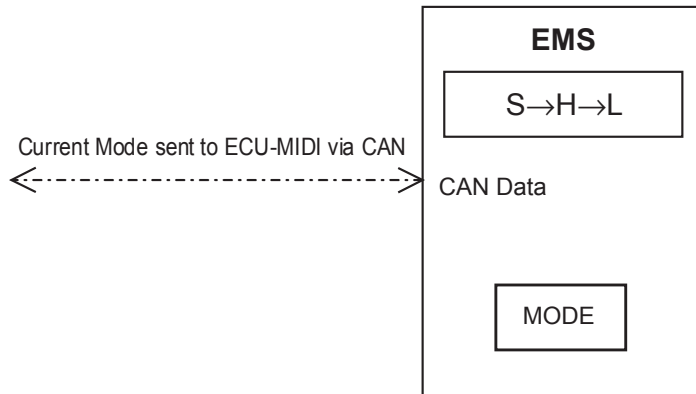
If one touch idle is selected and the ignition is turned off, when the vehicle is started again, the one touch idle is automatically activated.

Throttle Control Auto Idle/One Touch Idle



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**Power Modes**



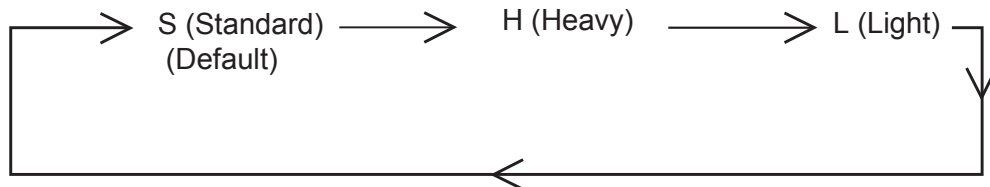
A410320

**Operation**

The machine can operate in three different modes, depending upon the action required. The modes are selected by pressing the "MODE" button on the EMS. The EMS displays the selected mode alongside the power mode legend.

The different modes have the effect of reducing the engine speed for a given throttle setting.

Successive presses of the "MODE" switch will cycle through the different modes in the order shown below. The mode information will be transmitted to the ECU-MIDI via the CAN network so that it can control the throttle solenoid appropriately. The current operating mode will be restored when the ignition key is cycled.



**Mode Definition**

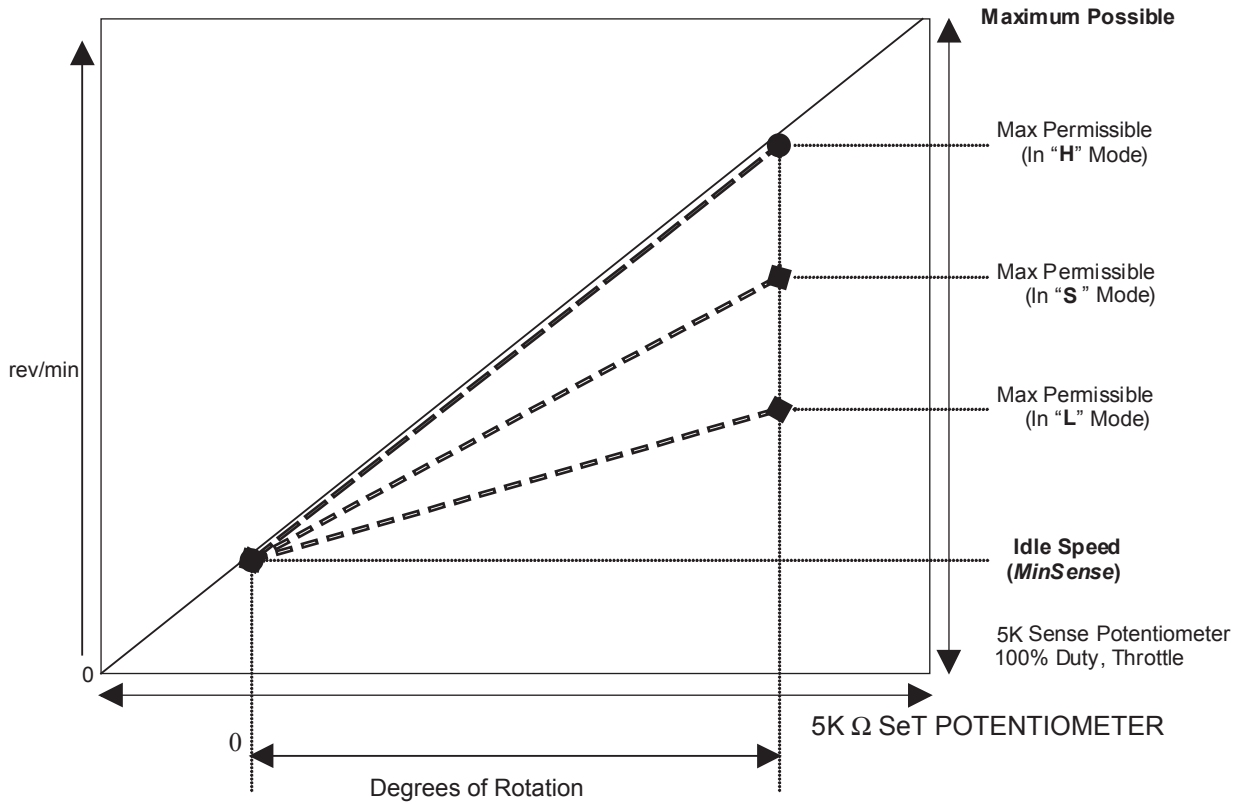
The machine has a minimum engine speed of 1100 ± 25 rev/min and maximum engine speed of 2470 ± 50 rev/min. During calibration, the ECU-MIDI will record the maximum and minimum throttle sense positions. This will define the full working range of the engine.

By changing modes, the user will utilise different amounts of the full engine speed range.

Mode	EMS	Max rev/min
Heavy	H	2200
Standard	S	2000
Light	L	1400

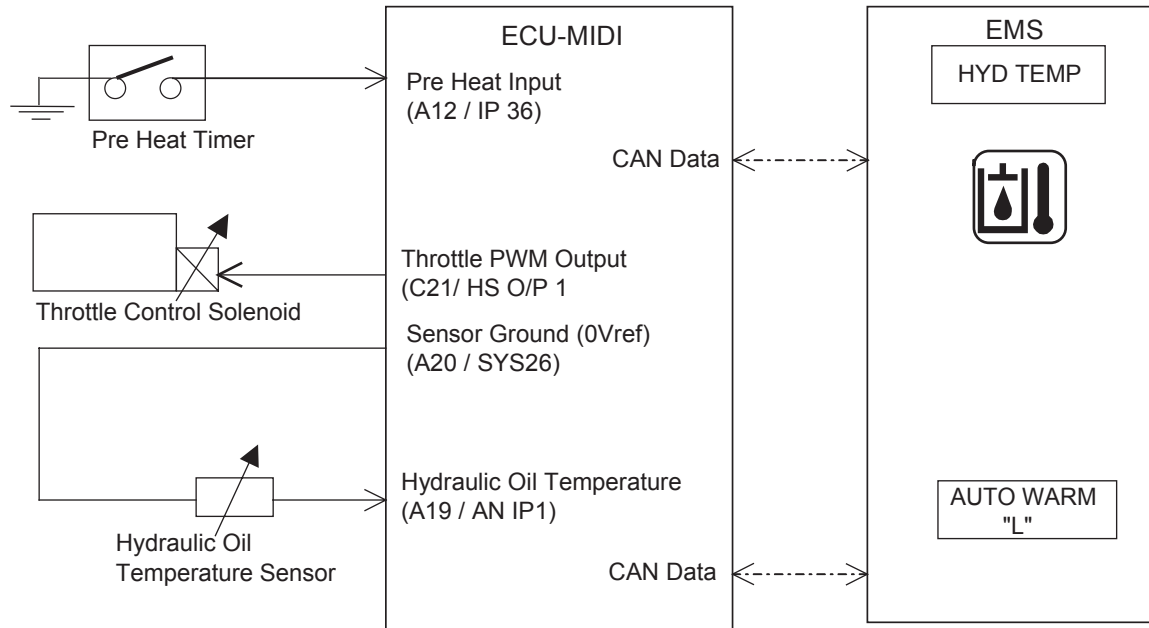
**Power Modes (cont'd)**

Relationship Between Engine rev/min and Throttle Settings for Different Modes.



A410310

## Pre Heating and Auto Warm



A435960

### Pre Heat

#### Operation

This feature allows the engine cylinders to be pre-heated before engine cranking to assist cold start performance.

When the Pre Heat input to the ECU-MIDI is switched low to ground, the EMS notifies the operator of the status and the "PRE HEAT" message is displayed.

### Auto Warm

#### Operation

The engine hydraulic oil temperature sensor is connected so that both ends are tied to the ECU-MIDI: one to the sensor ground and the other to an analogue input.

- \* When the system is in a running state, and the engine hydraulic oil temperature is less than 0 °C (32 °F), the ECU-MIDI will enable the auto warm function. This prevents the engine rev/min's from going too high and causing the hydraulic oil pump to cavitate before the vehicle has had a chance to warm up.

While in auto warm, the vehicle will be put into the 'Light' power mode and no other mode will be allowed. The highest possible rev/min setting will be limited as it is in normal 'Light' mode operation. In this case, however, the letter 'L' on the EMS display will flash at a 2 Hz rate during auto warm operation. The message "AUTO WARM" will also be displayed.

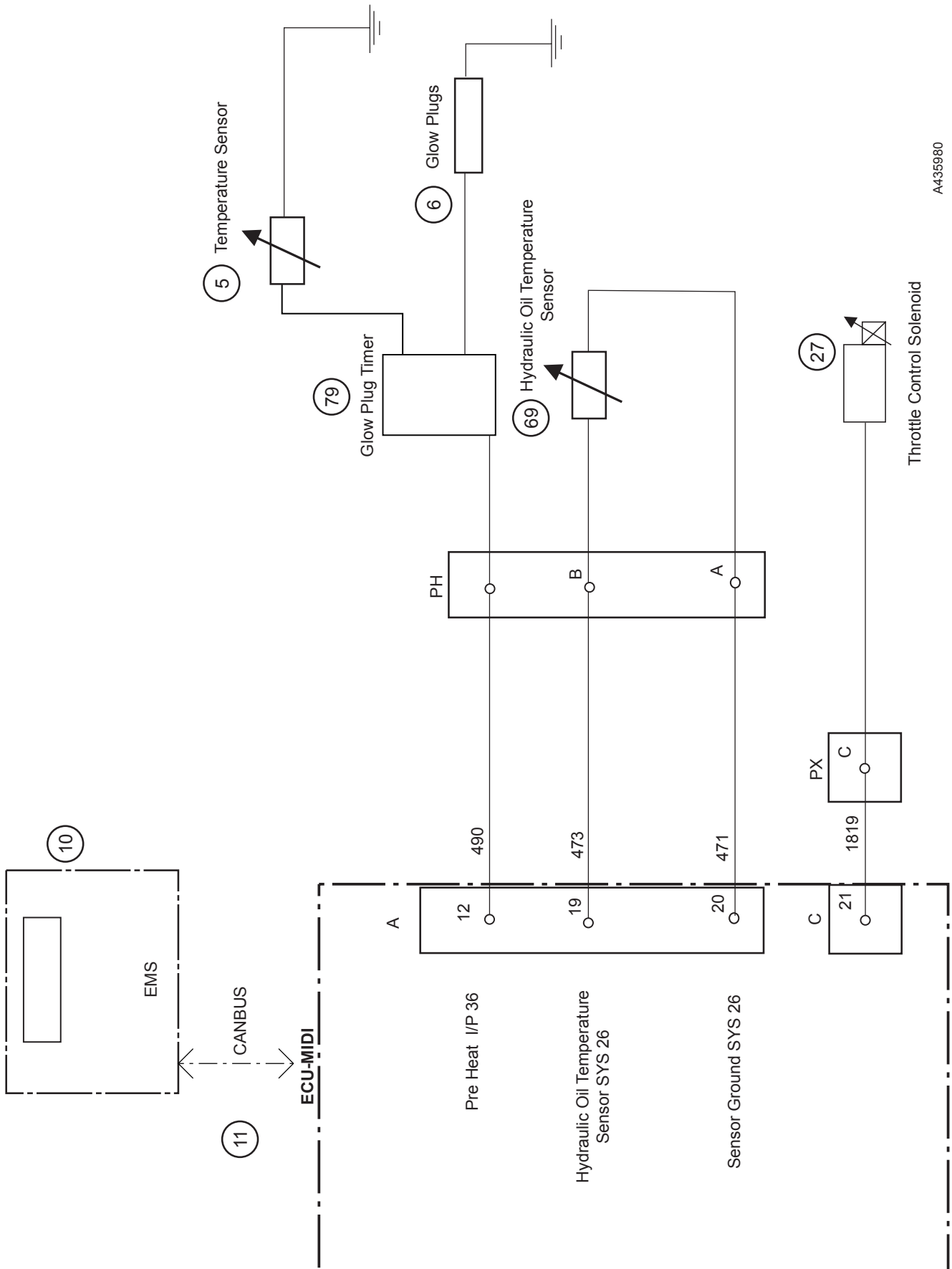
This mode will be maintained until the engine hydraulic oil temperature rises above 0 °C (32 °F). Once this temperature is reached, the "AUTO WARM" message is turned off, the EMS will give a short 0.5 second beep, and the letter "L" will stop flashing. It will now be possible to select Standard or Heavy mode.

It is also possible to cancel the auto warm function by pressing the "ACK" button on the EMS. When this is done, the auto warm feature will turn off in the same manner described in the above.

- \* The auto warm function will only be activated when the system enters a running state. If the system has been running at oil temperatures greater than 0 °C (32 °F), and the temperature drops below 0 °C (32 °F), then the auto warm function will NOT become active.

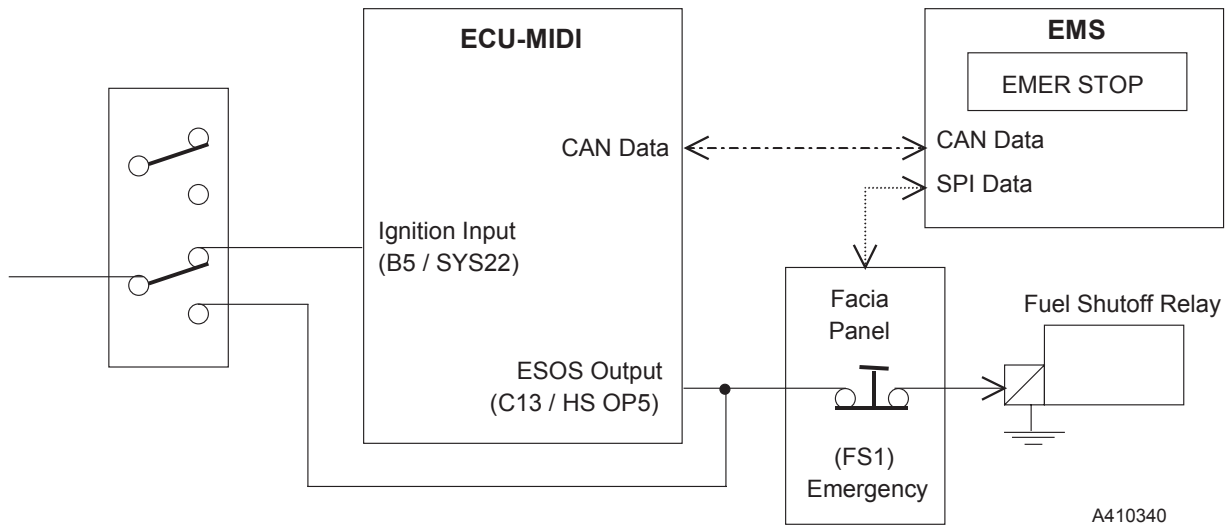
If there is a error with the hydraulic temperature sensor (open or short), then the auto warm feature will not be active.

Pre Heating and Auto Warm (cont'd)



A435980

## Engine Emergency Stop



### Operation

The Engine Emergency stop button is located in the Facia Switch Panel. The system will remember the state of the button when the key switch is cycled. Pressing the button once will either activate or deactivate the emergency stop function.

When the Engine Emergency Stop function is active, both the ECU-MIDI and the Facia Switch Panel remove power to the Engine Shut Of Solenoid (ESOS) thus preventing the engine from running.

When the vehicle is configured in Redundancy mode the Engine Emergency stop function is still allowed since the Facia Switch Panel is still powered.

- \* The emergency stop feature can be turned on and off in a key-on, cranking, or a running state.

### Normal Mode

When the emergency stop function is activated, the normally closed contacts within the facia switch panel open, thus de-energising the ESOS Solenoid output. The RED status indicator on the facia switch panel illuminates and the EMS displays the message "EMER STOP". The ECU-MIDI is notified of this status and will therefore disable the ESOS solenoid output.

**Note:** The engine can still be cranked in this state but will not start since there is no power to the ESOS solenoid. The facia switch panel contacts and the ECU-MIDI output should remain in this state until the emergency stop button is pressed again, regardless of whether the key-switch is cycled. When the emergency stop function is de-activated, the contacts within the facia switch panel close, the EMS message is removed, and ECU-MIDI energises the ESOS solenoid output.

- \* **Note:** The ESOS Solenoid output on the ECU-MIDI should be energised in key-on, cranking, or a running states if the emergency stop function is not de-activated.

The ESOS Solenoid output will be turned off whenever the key is switched to the off position.

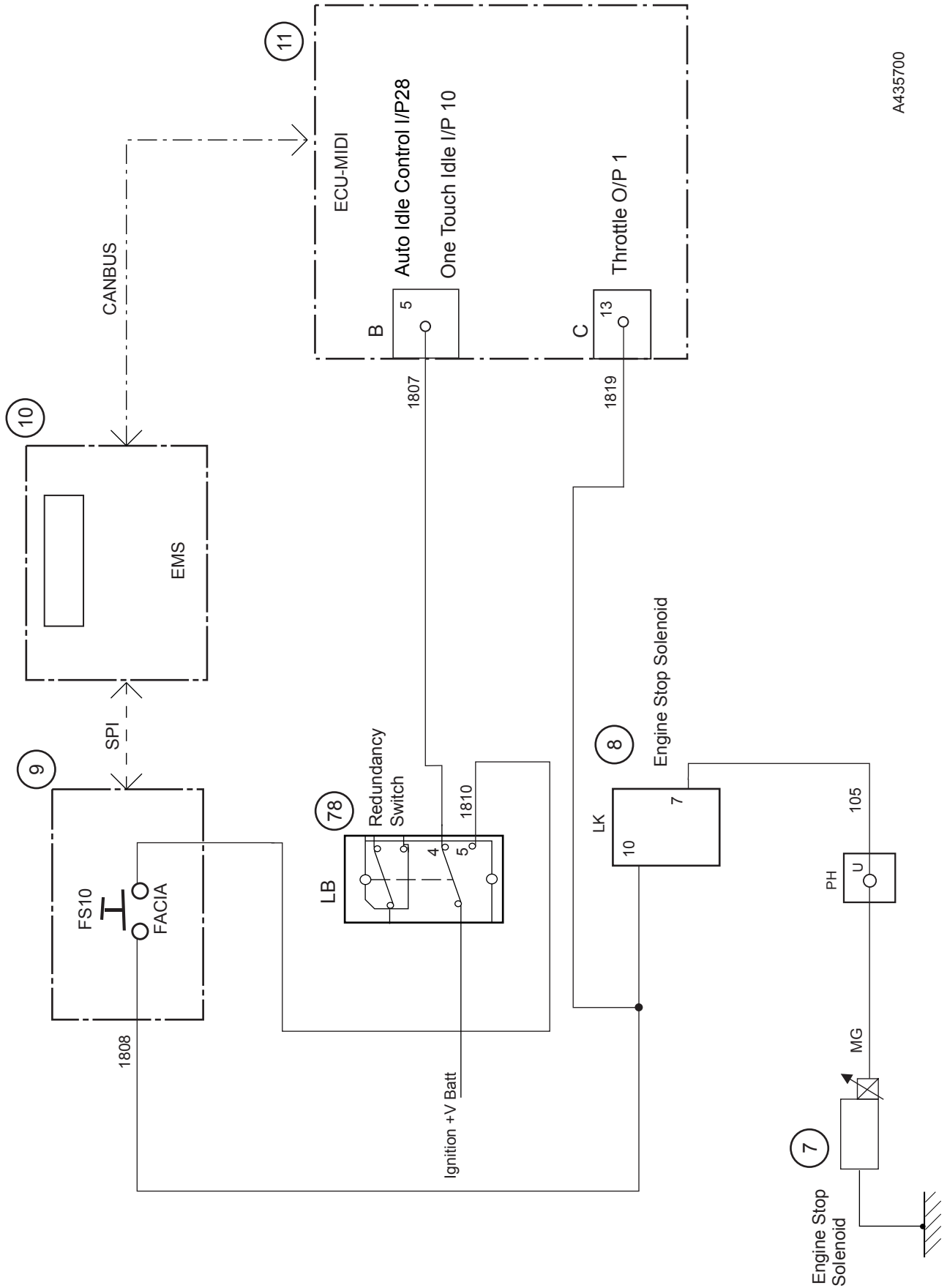
### Redundancy Mode

When the redundancy switch is toggled, the system will operate in redundancy mode. When switched to this mode all ignition supplied electrical power to the ECU-MIDI is disabled and the ESOS solenoid output from the ECU-MIDI will remain off.

However, power is still supplied to the ESOS solenoid via the redundancy switch and the normally closed contact within the facia switch panel. When the facia emergency stop function is activated, the normally closed contacts within the facia switch panel open thus de-energising the ESOS solenoid.

The facia switch panel contacts will remain open, regardless of whether the key-switch is cycled, until the facia emergency stop button is pressed again. Once pressed, the emergency stop function will be de-activated, the facia switch panel contacts close, and power is supplied to the ESOS solenoid.

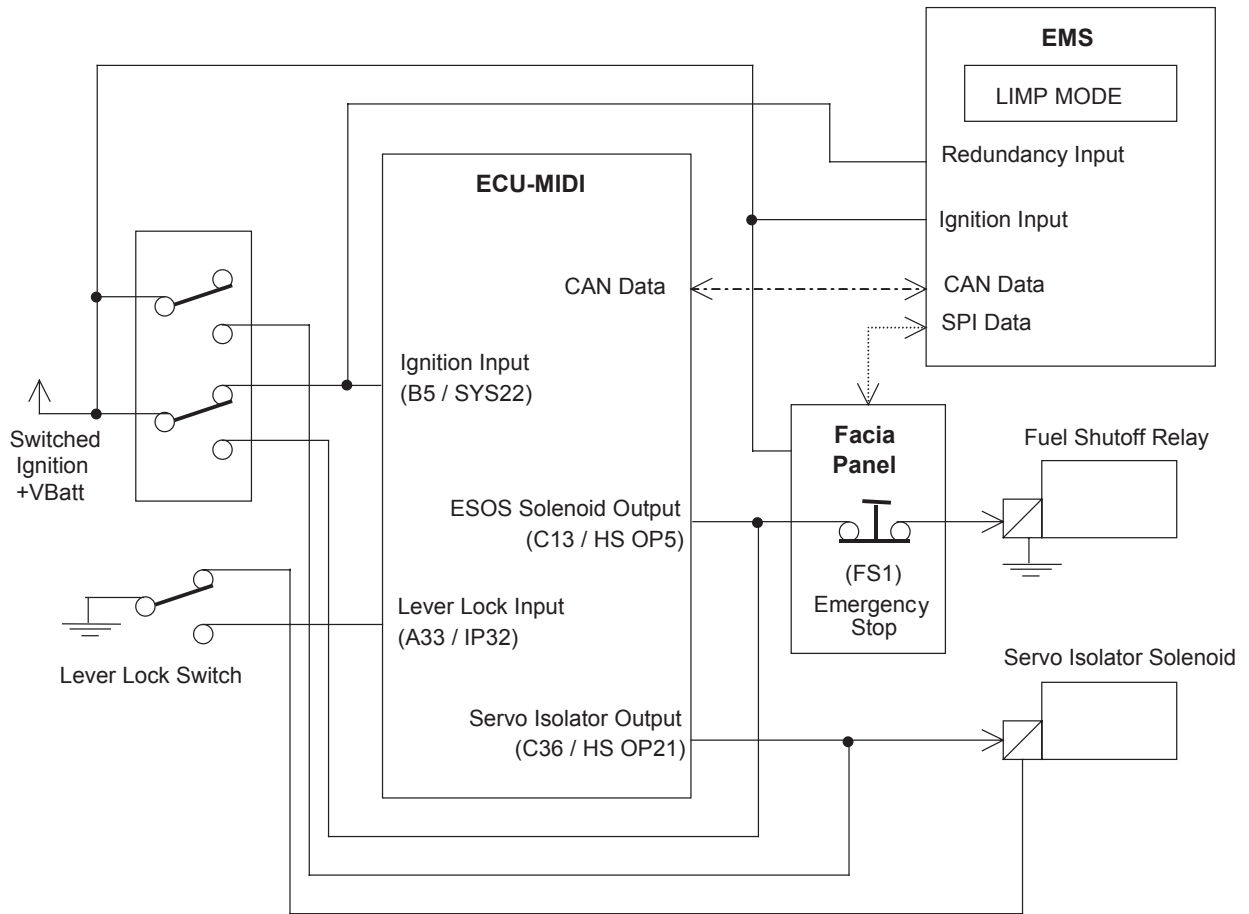
Engine Emergency Stop (cont'd)



A435700



## Redundancy System



A410360

### Operation

When the operator suspects a failure of the ECU-MIDI that causes the machine to fail to start and/or fail to switch on the isolator solenoid valve, the redundancy switch can be pressed to override the function of the ECU-MIDI. The Engine Shut Off Solenoid (ESOS) and the Isolator Solenoid Valve are then powered directly from the Redundancy switch. This will allow the engine to be started and the hydraulics to be operated.

**Note:** When in redundancy mode:

- The ignition power is not supplied to the ECU-MIDI, but the permanent battery feed is still connected. Therefore the wake-up functions are still operational.
- The ignition power is still supplied to the EMS and the facia switch panel since this is branched before the redundancy switch.

When the redundancy switch is pressed, the redundancy input to the EMS is lost. The EMS will permanently display the message "LIMP MODE".

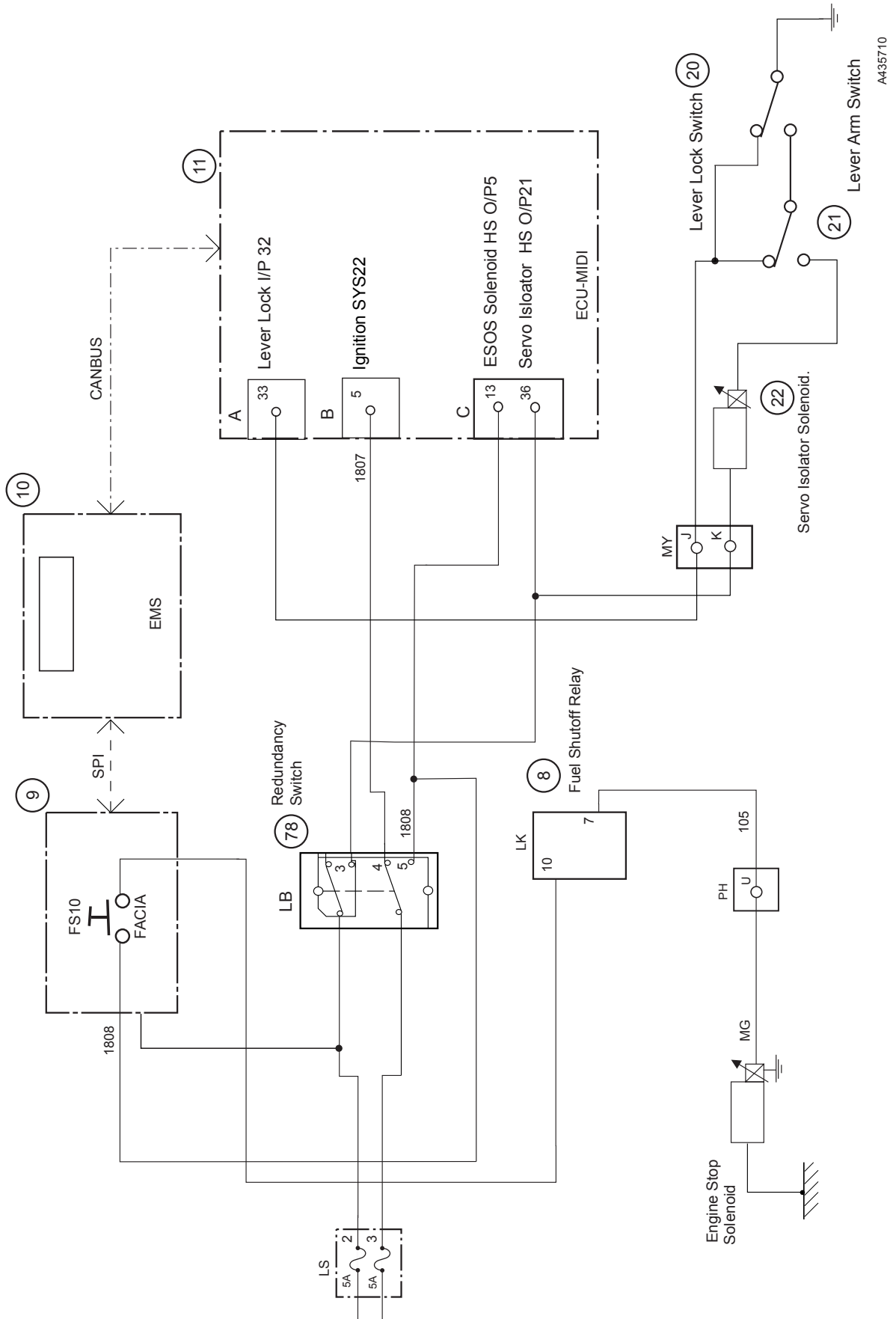
If the Emergency Stop button is activated while in Redundancy mode, "EMER STOP" no message will be given.

When the system is in Redundancy mode, the EMS will inform the ECU-MIDI, that redundancy mode is active via a CAN message.

If the ignition is cycled, the system will remain in redundancy mode until the redundancy switch is toggled back to the normal position.

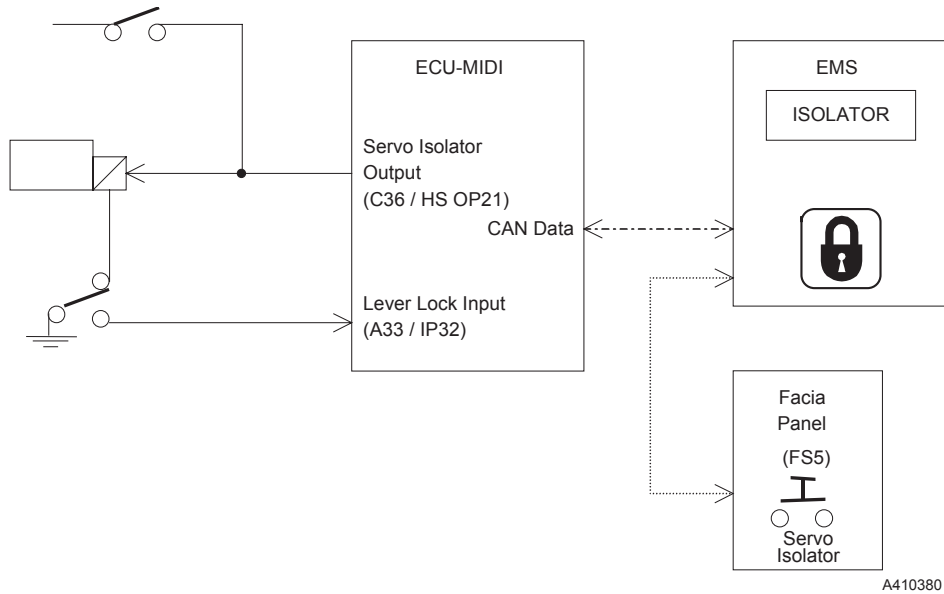
**Note:** In redundancy mode, the engine will run at idle speed. Increased engine speed can be achieved by mechanical adjustment of the throttle linkage.

Redundancy System (cont'd)



A435710

## Lever-Lock/Servo Isolator



### Operation

#### Lever Lock

A gate lever is incorporated at the entrance door to the cab. This has to be lowered before any movement of the machine is allowed. Similarly the operator must raise the gate lever to exit the cab, thus disabling the hydraulic circuits.

When the lever lock is in the lower position, the input to the ECU-MIDI is an open circuit. This causes the ECU-MIDI output to the servo isolator valve to be energised thus enabling the hydraulic circuits. The ground for the servo isolator solenoid is provided through the lever lock switch. A CAN message is sent to the EMS and the Lever Lock warning LED is extinguished.

When the lever lock is raised to the upright position, the input to the ECU-MIDI is grounded. The output from the ECU-MIDI to the servo isolator is de-energised thus disabling the hydraulic circuits. A CAN message is sent to the EMS and the Lever Lock LED is illuminated.

**Note:** For safety reasons this circuit is fail safe and is also used in redundancy mode. In redundancy mode the servo isolator solenoid valve is supplied directly from the redundancy switch. In this mode, the lever lock is still operational and must be in the lowered position to allow hydraulic functions.

#### Servo Isolator

The operator has the ability to isolate the hydraulic movement of the machine by pressing the Servo Isolator facia switch button. The state of this button should be remembered if the ignition key-switch is cycled.

When the Servo Isolator button is pressed, the EMS displays the message "ISOLATOR" and illuminates both the Lever Lock LED and the switch status indicator on the facia switch panel. A CAN message is sent to the ECU-MIDI and the output to the isolator solenoid valve is de-energised.

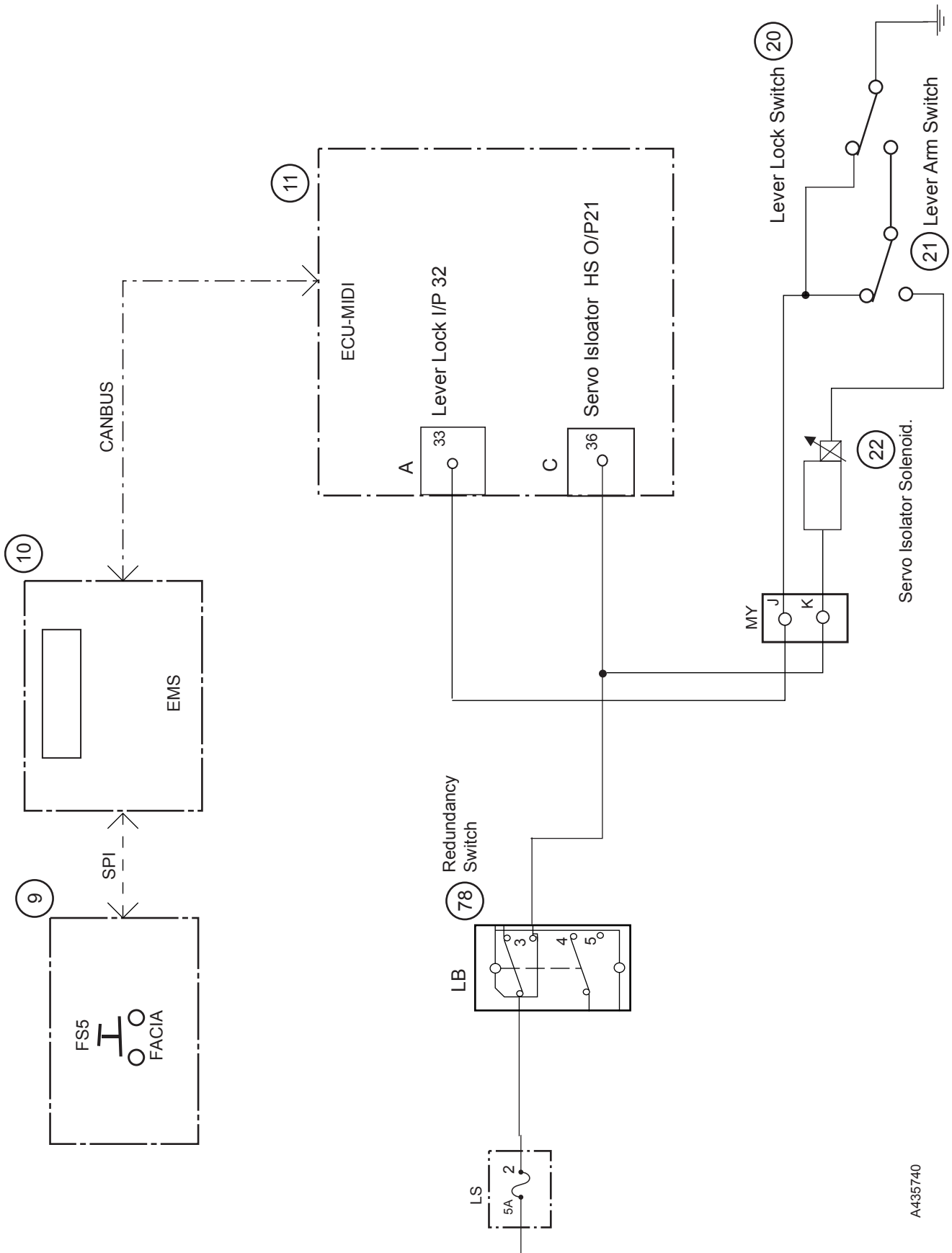
This feature overrides the normal lever lock functions. As long as the servo isolator is active, the lever lock LED should be illuminated and the isolator solenoid output should be off regardless of the lever lock position.

A second press of the Servo Isolator button extinguishes both the Lever Lock LED and the switch status indicator. A CAN message is sent to the ECU-MIDI and the servo isolator output is energised. Provided the lever lock is in the correct position, hydraulic functions will be allowed.

### Truth Table

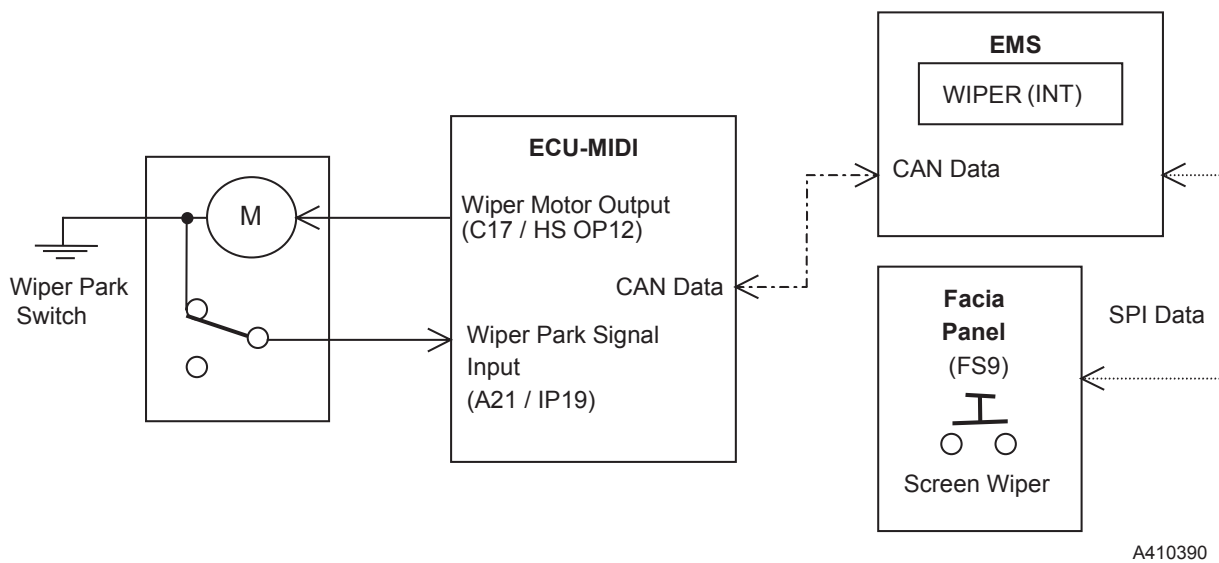
Lever Position	Lever Lock Input	Isolator Function	Servo Isolator Output	EMS Message	Lever Lock LED	Hydraulics
RAISED	GND	OFF	OFF	NONE	ON	Disabled
RAISED	GND	ON	OFF	"ISOLATOR"	ON	Disabled
LOWERED	OPEN	OFF	ON	NONE	OFF	Enabled
LOWERED	OPEN	ON	OFF	"ISOLATOR"	ON	Disabled

Lever-Lock/Servo Isolator (cont'd)



A435740

## Wiper



### Operation

The wiper is fitted to the upper glass panel at the front of the operator's cab.

The wiper has three modes of operation: intermittent, permanently on, and permanently off.

Timing for the intermittent function is to be performed by ECU-MIDI, and can be varied by the up and down arrows on the EMS via a sub menu.

This wiper motor assembly will only move the wiper when voltage is supplied by the ECU-MIDI. A wiper park signal is provided to indicate that the wiper is in the parked position. For 355° of rotation, this will be an open signal. When the wiper reaches its parked position the input to the ECU-MIDI will be grounded, as shown. This indicates that output to the wiper can be turned off.

When the wiper button on the facia panel is pressed, the EMS displays the message "WIPER INT", the switch status LED should flash to indicate that the wipers are in an intermittent mode. The wiper output on the ECU-MIDI is pulsed at a rate determined by a setting in the EMS menu. The length of each pulse is determined by the feedback from the motor assembly such that the output should remain on until a grounded input is seen at the park signal input. A time delay starts when the wiper reaches its parked position, before the output is energised again, thus giving intermittent operation.

The intermittent delay time can be varied to achieve a speed from 5 to 30 cycles per minute. The delay time is accessed via a sub menu on the EMS. When the sub menu is entered, variable intermittent timing is altered by the up and down cursor keys. The default time is 5 cycles per minute. The relationship between the intermittent setting and the wipe rate is shown in the table on the next page.

A second press of the switch enables the wiper to operate continuously and the output is permanently energised. The EMS should display the message "WIPER" and the facia panel LED should be illuminated continuously. A third press of the switch disables wiper operation and the ECU-MIDI will turn the wiper output off once a ground input at the wiper park input is seen.

**Note:** If the key-switch is turned to the off position when the wipers are not in the parked position, the ECU-MIDI should keep itself powered and return the wipers to their parked position.

If at any time the wiper output is energised and wiper park signal has not been seen for 3 seconds or more, the wiper output and function will be turned off. A press of the facia wiper button will once again start the wiper intermittent mode.

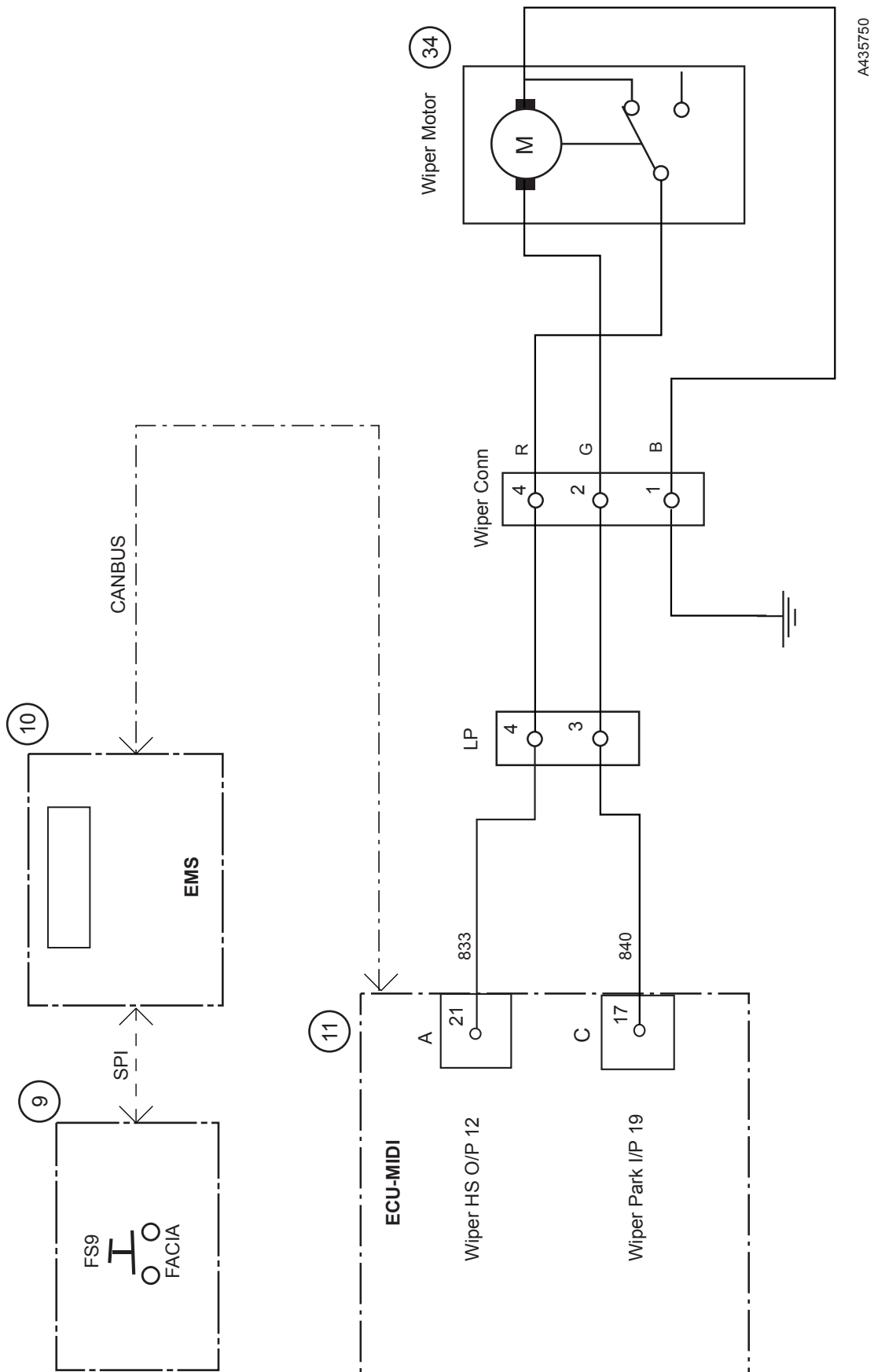
By default the wiper is off when off at key on.

**Wiper (cont'd)****Intermittent Wiper Speed Table**

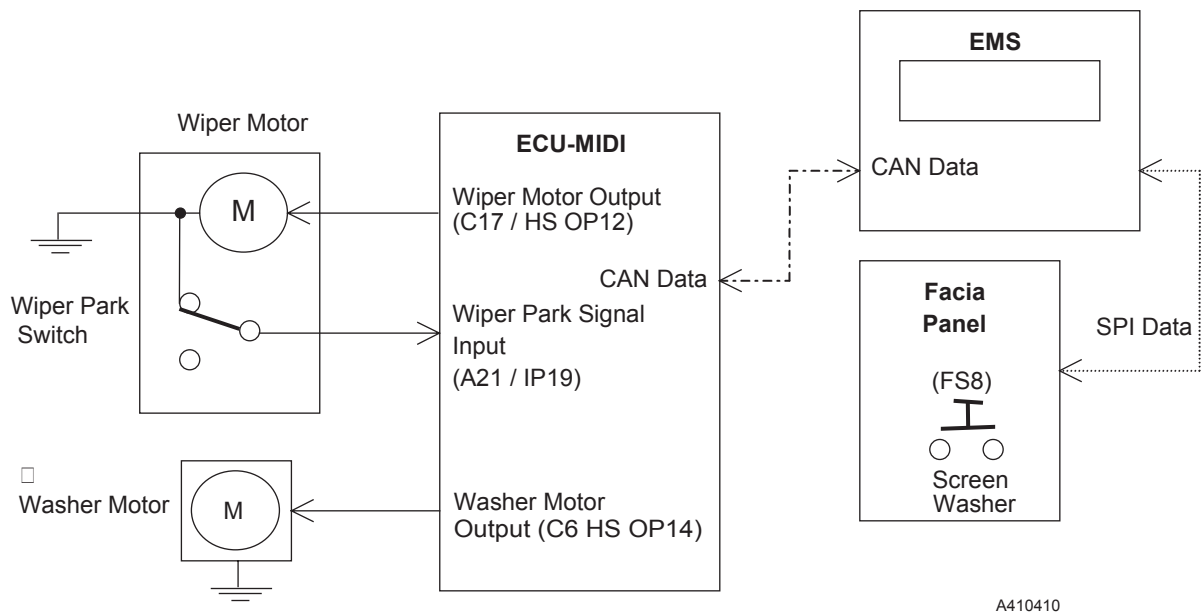
<b>EMS Speed Setting</b>	<b>Wipes/Minute</b>	<b>Wait Time (Seconds)</b>
1	3.00	18.50
2	3.87	13.99
3	5.00	10.49
4	6.46	7.78
5	8.35	5.69
6	10.78	4.07
7	13.92	2.81
8	17.98	1.84
9	23.23	1.08
10	30.00	0.50

The wait time in this table, is the time from the detection of a wiper park signal to the start of the next wiper output pulse. This table assumes that under normal conditions the wiper time will be about 1.5 seconds. The wait time takes this into account.

Wiper (cont'd)



## Washer



### Operation

The washer is fitted to the upper glass panel at the front of the operator's cab.

When the washer button on the facia switch panel is pressed the status LED illuminates and the EMS sends a CAN message to the ECU-MIDI, which in turn powers the output to the washer pump. The ECU-MIDI output should remain energised as long as the facia switch button remains pressed.

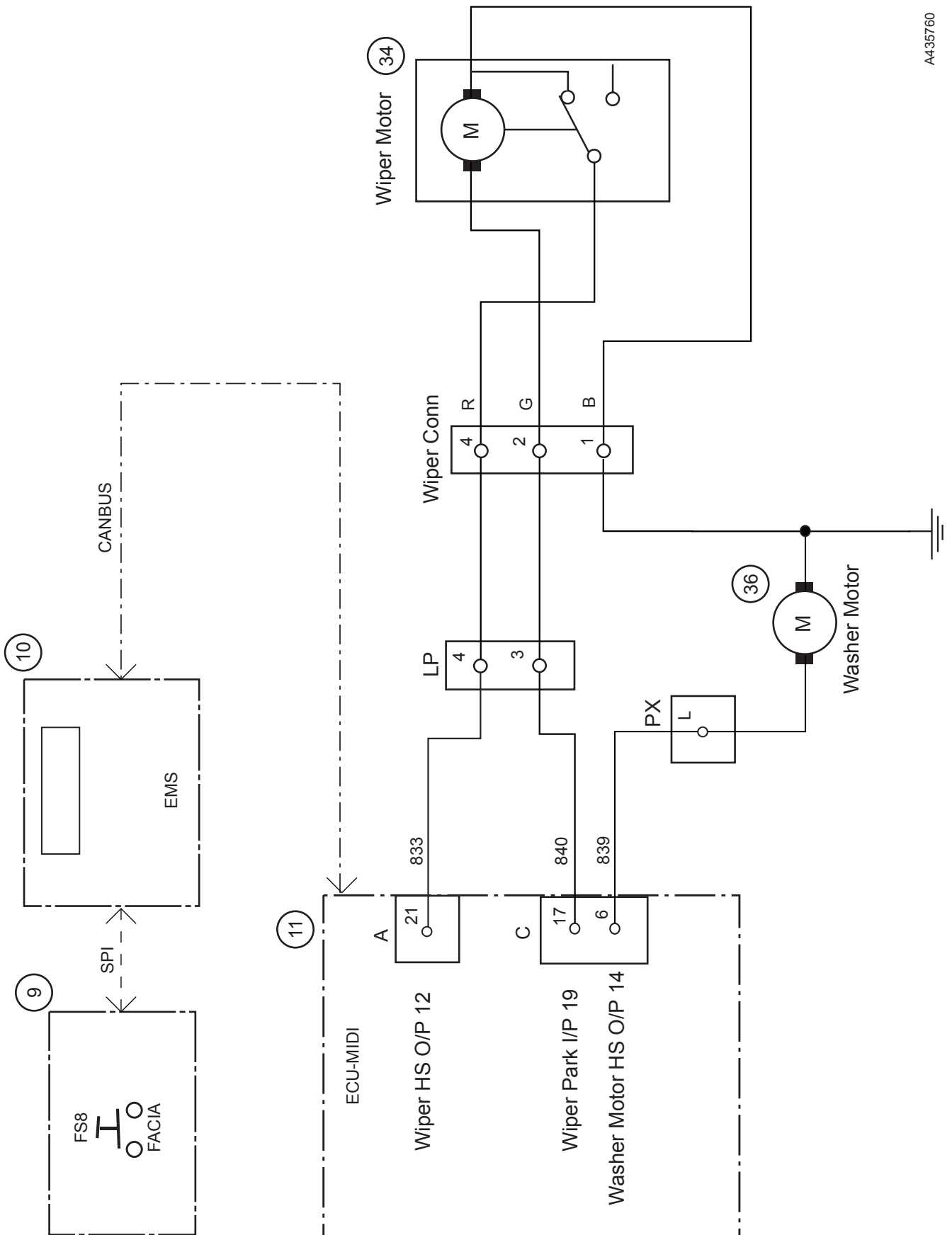
The washer function is allowed in a 'KEY-ON' or 'RUNNING' state. The outputs are temporarily switched off during a 'CRANKING' state.

Whenever the washer output is energised, the wiper output is also energised. When the washer switch is released, the wiper should do a minimum of three additional strokes and then turn itself off, or continue operating in any active wiper mode. To achieve these three additional strokes, the wiper output will be energised for 3 full park position pulses from the wiper park position input. On the detection of the 4th pulse (from the time the facia button was released), the wiper motor output is turned off.

By default the washer output is off at key-on.

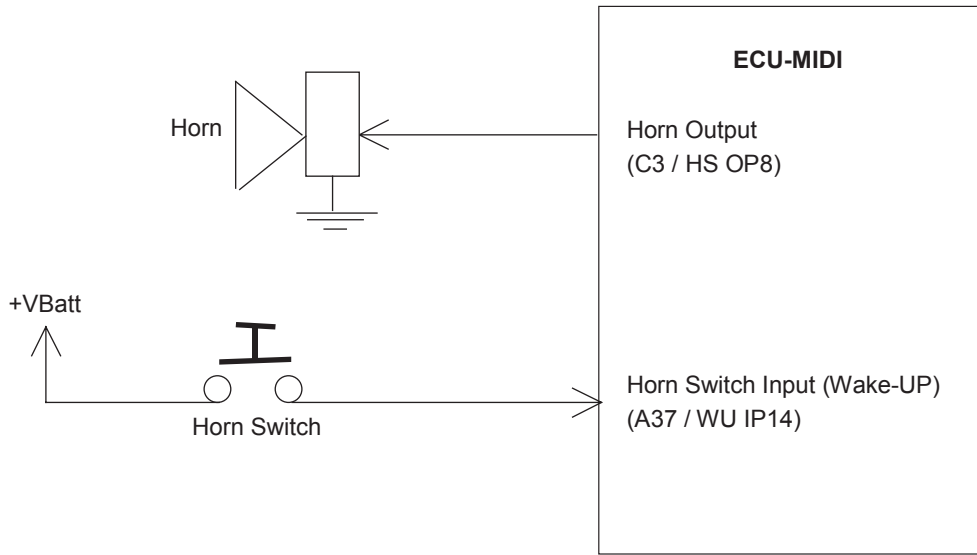


Washer (cont'd)



A435760

**Horn**



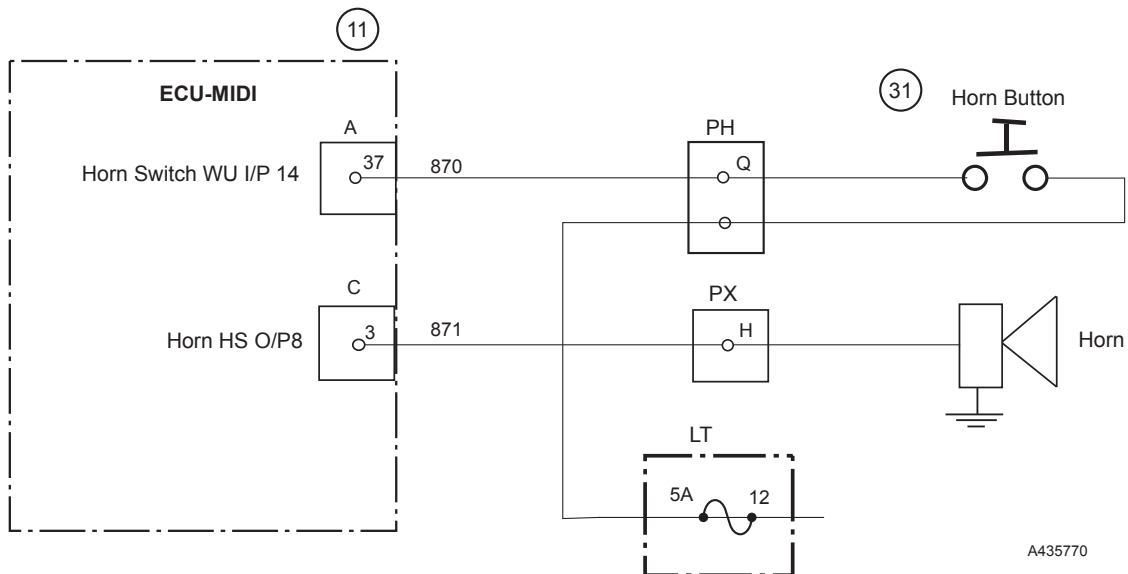
A410430

**Operation**

When the horn button is pressed, the ECU-MIDI reads this on a digital input. The ECU-MIDI then energises the horn output. The output will remain powered as long as the button is pressed. When the button is released, the output will turn off.

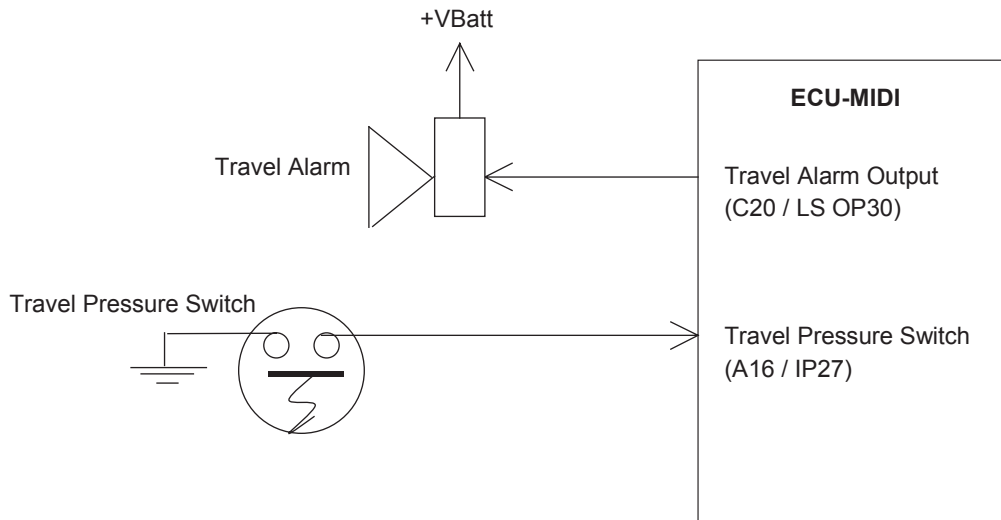
The horn function is allowed in all states: 'WAKE-UP', 'KEY-ON', 'CRANKING', 'RUNNING'.

When system is powered off (key-switch is in the off position), it is necessary for the horn to still be functional. Therefore, the input is also connected to an internal 'Wake-UP' input on the ECU-MIDI. When this input is energised, the ECU-MIDI will power up and determine that the horn input has been activated. The ECU-MIDI will then energise the horn output. When the horn button is released, the ECU-MIDI will de-energise the output and perform its own shutdown.



A435770

**Travel Alarm (Optional)**

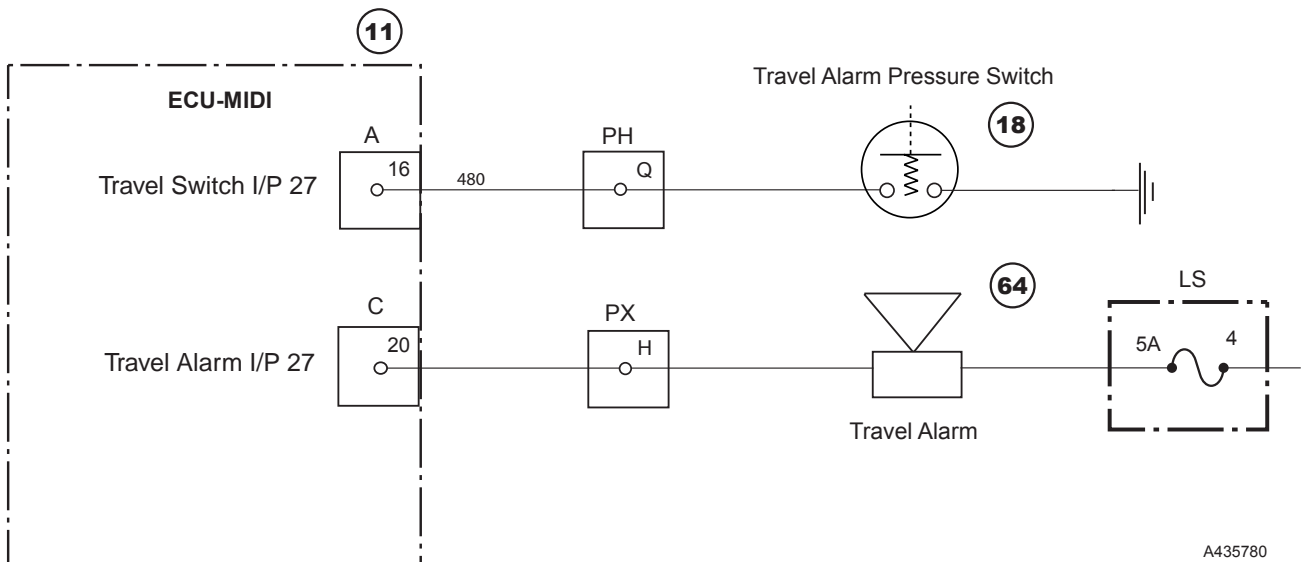


A410440

**Operation**

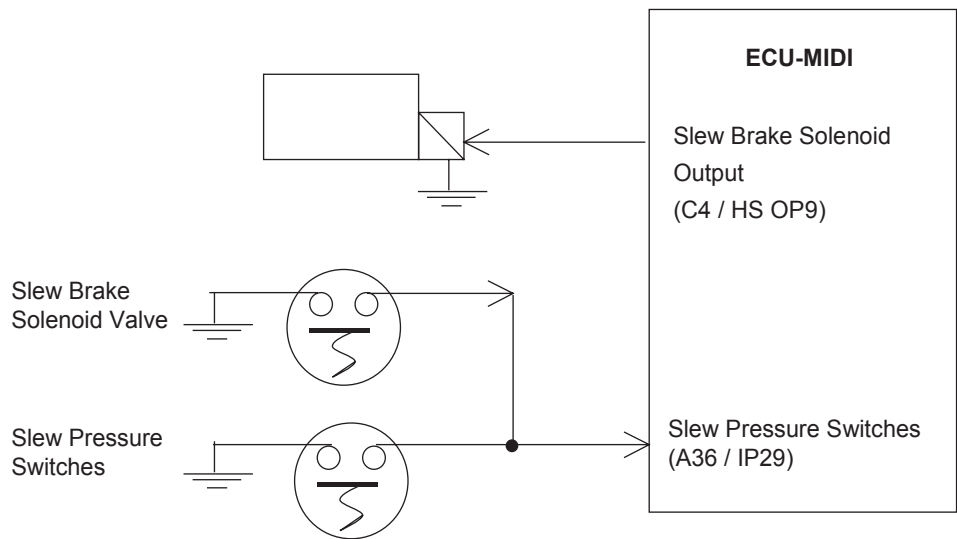
The travel alarm is available as an option.

Travel movement is indicated by the travel pressure switch that is connected to an ECU-MIDI input. When this input is grounded, the travel alarm output is energised.



A435780

## Slew Brake



A435470

### Operation

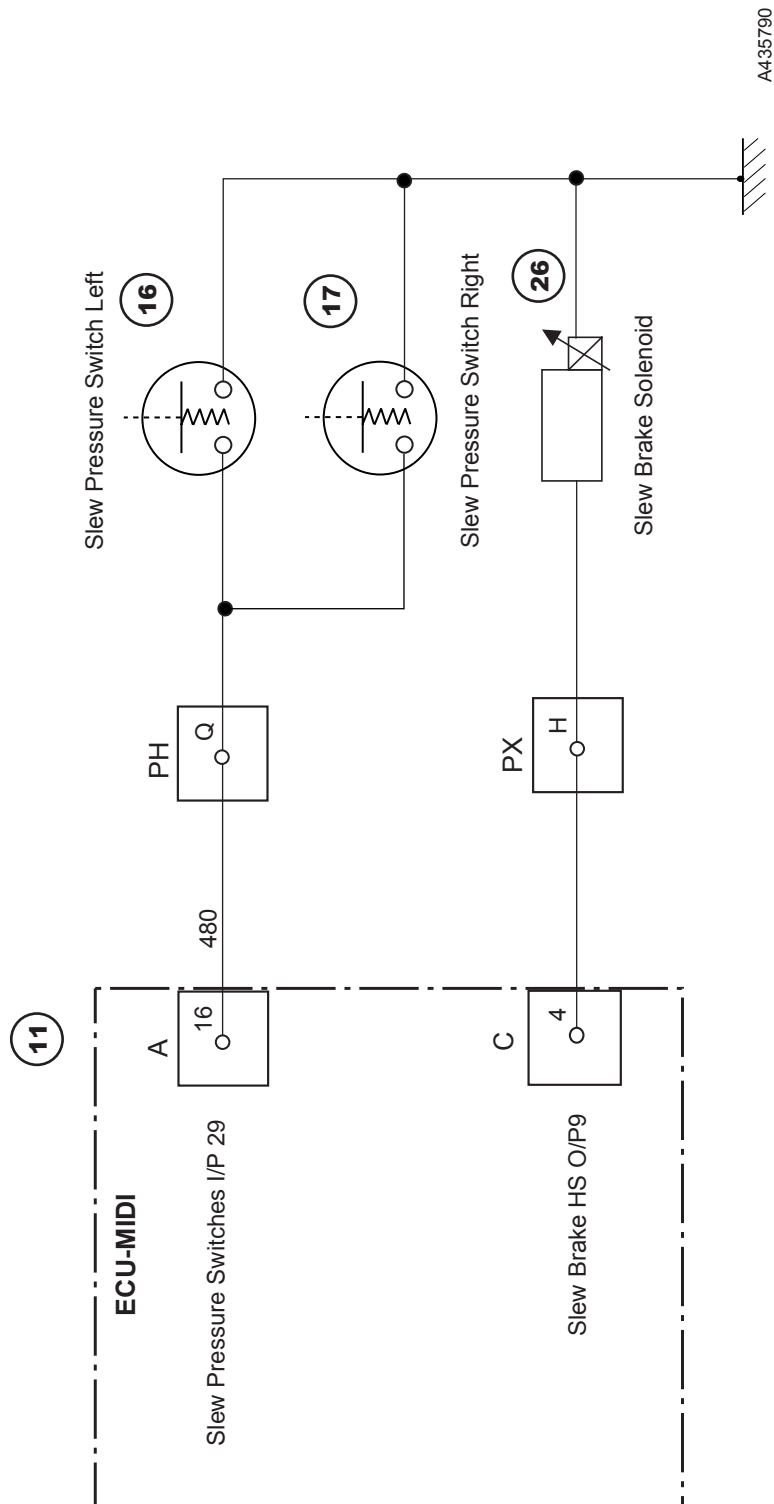
By default, the ECU-MIDI will apply the slew brake by energising the slew brake solenoid output. When the operator starts to use the machine by moving the slew levers from the neutral position, the slew pressure switches will be connected to ground. The ECU-MIDI detects this grounded input and de-energises the slew brake output, thus giving free slew operation of the machine.

When the operator has stopped using the machine, the slew levers are returned to the neutral position. The slew pressure switches will no longer be connected to ground. The ECU-MIDI detects this and the slew brake is applied once the inputs remain grounded for 5 seconds. The output from the ECU-MIDI to the solenoid is energised. Partial pressure is applied to the slew brake using this output, thus giving 50% swing brake.

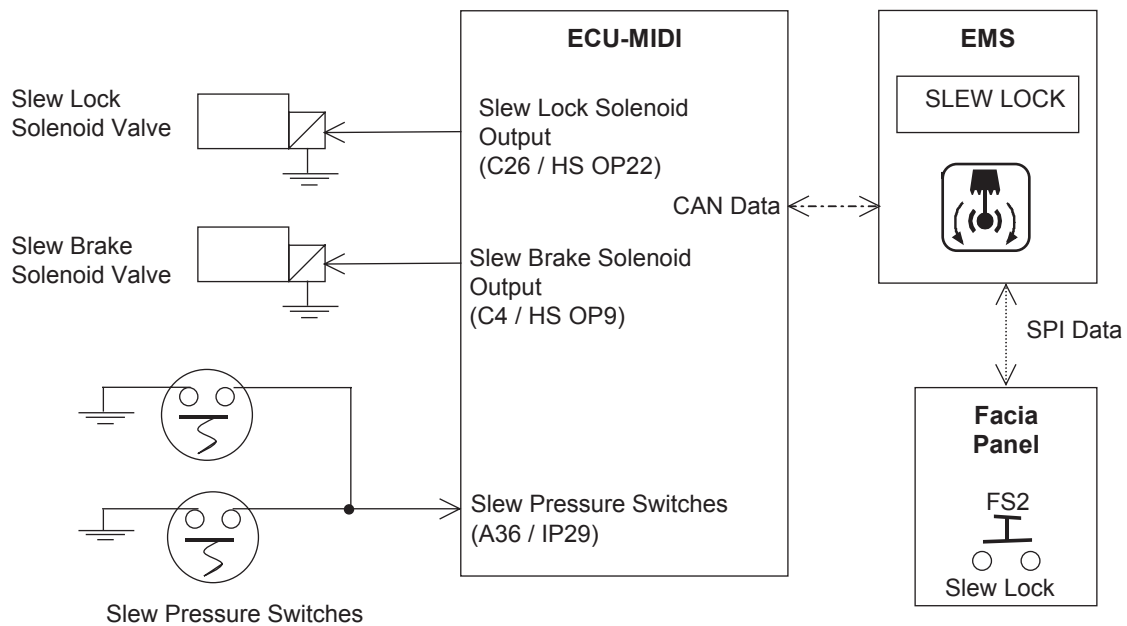
This feature is allowed in a 'CRANKING' or 'RUNNING' state. The slew brake output will be off when the system is in a 'KEY-ON' state in order to reduce unnecessary current draw from the battery.

By default, the brake is turned on when the system enters a 'CRANKING' state.

Slew Brake (cont'd)



## Slew Lock (100% Slew Brake)



A435480

### Operation

Slew lock prevents any slew operation of the machine, even if the joysticks are moved. It effectively provides 100% slew brake by applying equal pressure on either side and disabling the slew pilot circuit.

This feature is allowed in a 'KEY-ON', 'CRANKING' or a 'RUNNING' state.

Pressing the slew lock switch on the facia switch panel turns on and off the lock function. On the first press, the function is turned on. The EMS displays the one time message "SLEW LOCK" and the facia panel status indicator illuminates. The ECU-MIDI will then check the state of the slew brake output.

If the slew brake output is ON, the system will:

- Energise the slew lock solenoid output.
- Illuminate the slew lock LED on the EMS.

If the slew brake output is OFF, the system will:

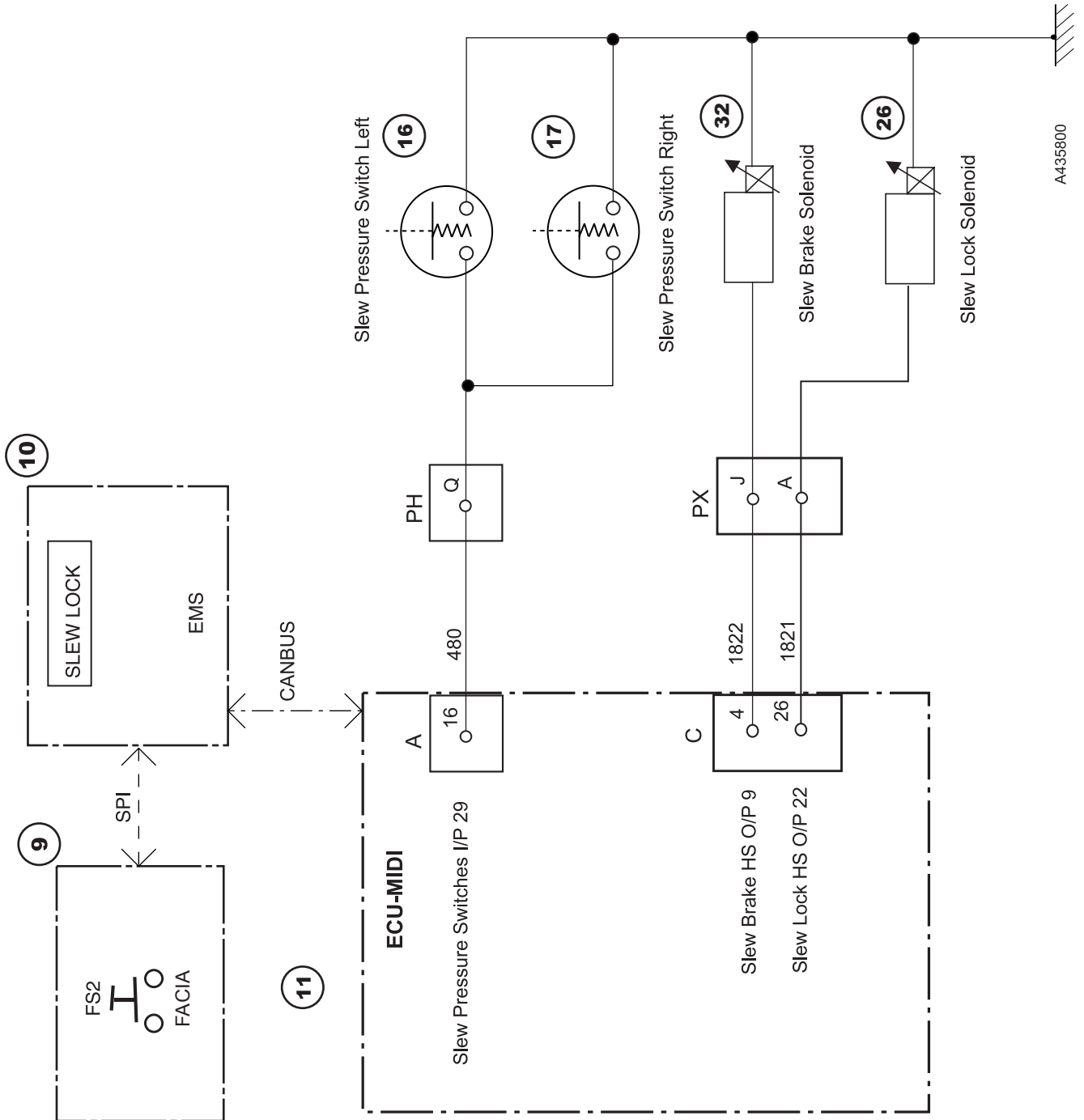
- Flash the slew lock LED on the EMS to indicate that the slew lock has not been applied.
- Wait until the slew brake output comes on.
- Once the slew brake output is ON, the ECU-MIDI will energise the slew lock output.
- The one-time message "SLEW LOCK" will be displayed again.
- The slew lock LED will stop flashing and be illuminated continuously.

If pressure is detected by a grounded input on the slew pressure input while the slew lock output is energised, then both the slew brake and the slew lock outputs will remain energised unless the slew lock function is turned off. This overrides the normal operation of the slew brake function.

A second press of the facia switch button deactivates the slew lock function. This causes the switch status indicator and the EMS warning LED to be extinguished. The ECU-MIDI de-energises the slew lock solenoid valve.

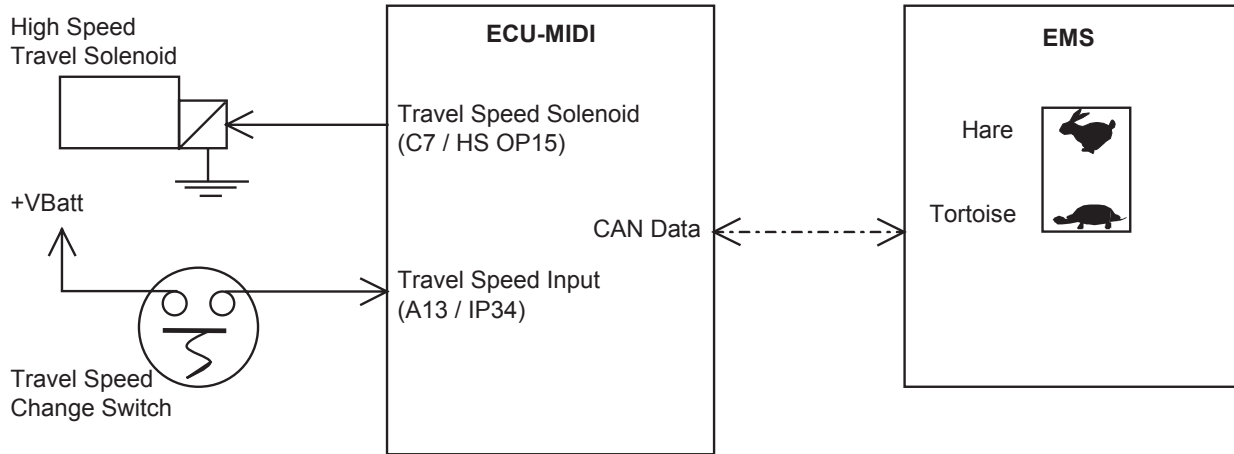
The state of the slew lock function will be remembered when the key-switch is cycled.

Slew Lock (100% Slew Brake) (cont'd)



A435800

**High Speed Travel**



A435490

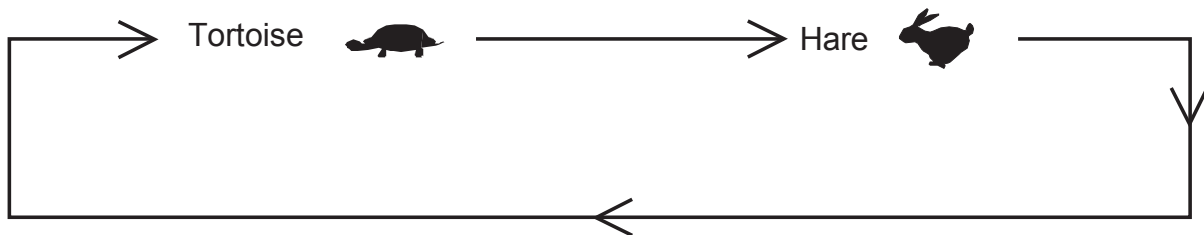
**Operation**

The momentary switch on the right hand travel lever for travel speed determines whether the high-speed travel solenoid is energised. Pressing the switch will toggle between STANDARD LOW and HIGH speed mode.

When the system is in LOW speed, the 'TORTOISE' icon on the EMS should be turned on and the travel speed solenoid output should be OFF.

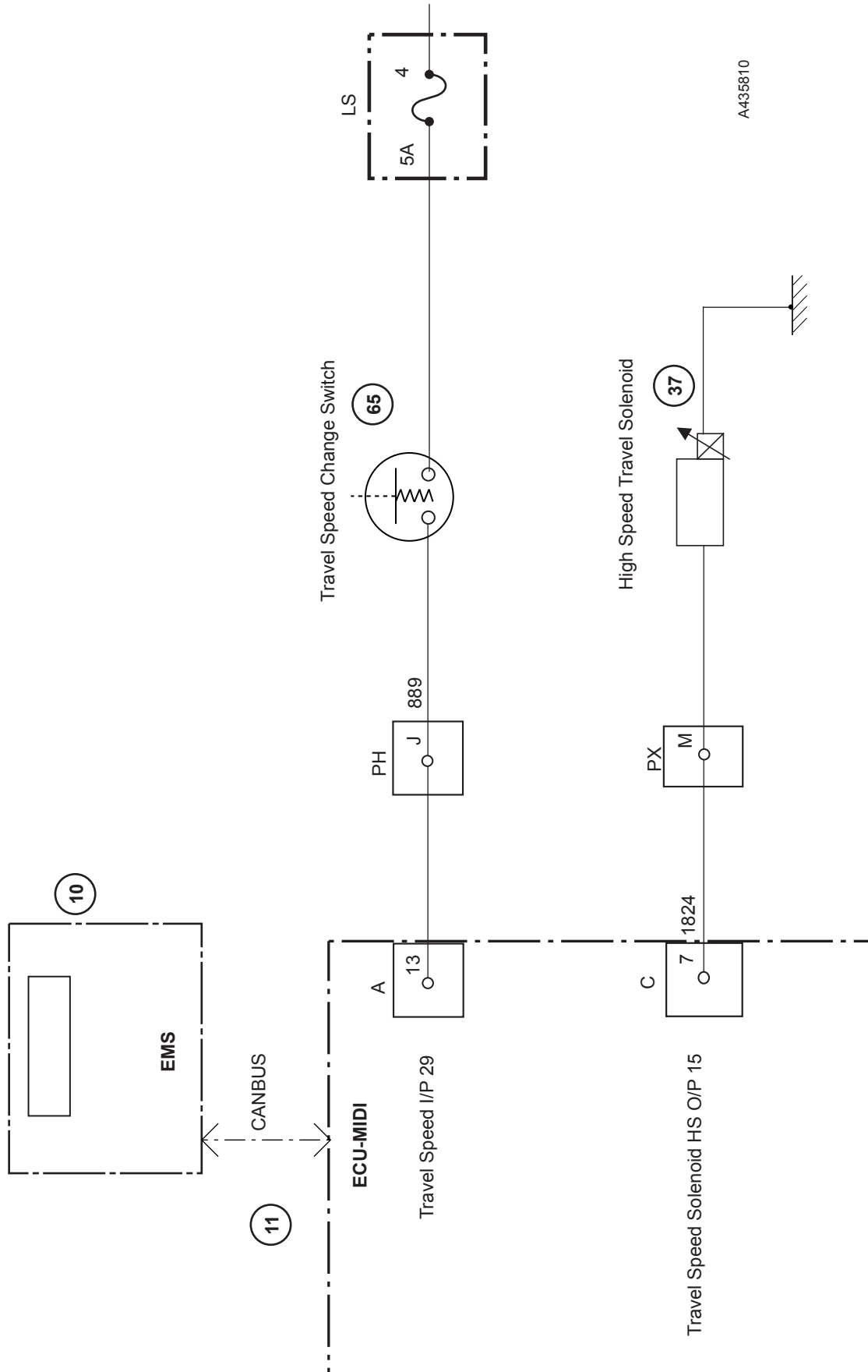
When the system is in HIGH speed, the 'HARE' icon on the EMS should be turned on and the travel speed solenoid output should be ON.

The system will remember the state of the travel speed when the key switch is cycled.

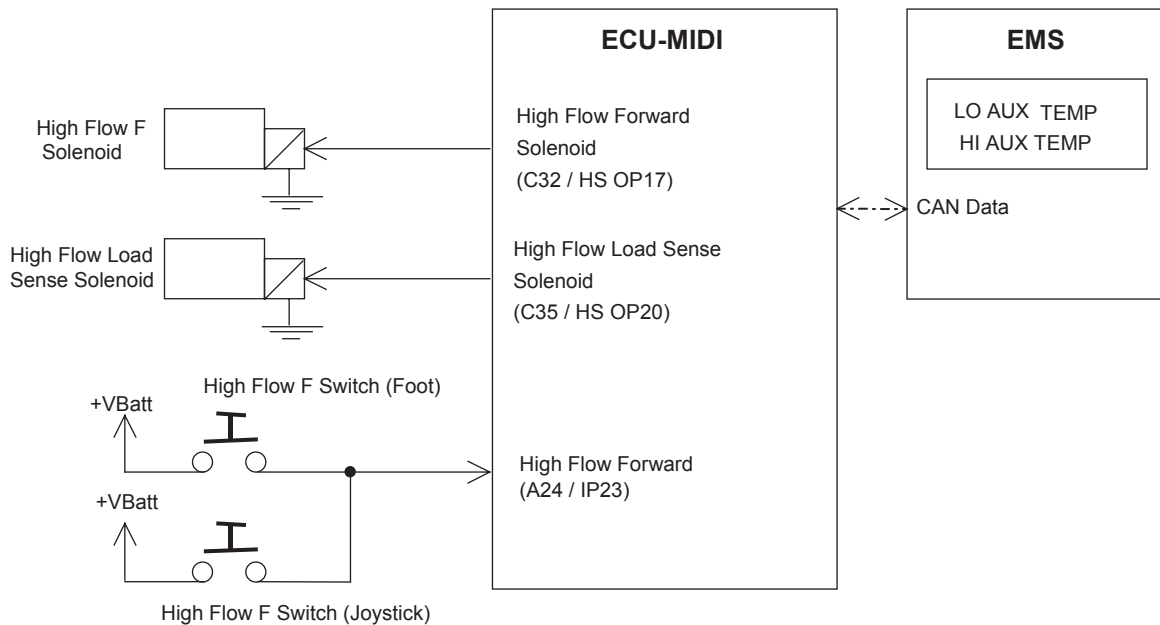




High Speed Travel (cont'd)



## High Flow



A435510

### Operation

The High Flow Forward function is activated by pressing one of the High Flow Forward switches. Both of these switches are momentary and will only provide a powered input to the ECU-MIDI when they are held down. One of these switches is foot operated while the other is located in the right joystick lever.

When the ECU-MIDI detects a high (+Vbatt) at the High Flow Forward input, it will energise both the High Flow Forward Solenoid and the High Flow Load Sense Solenoid. These outputs will remain energised as long as the input is held high.

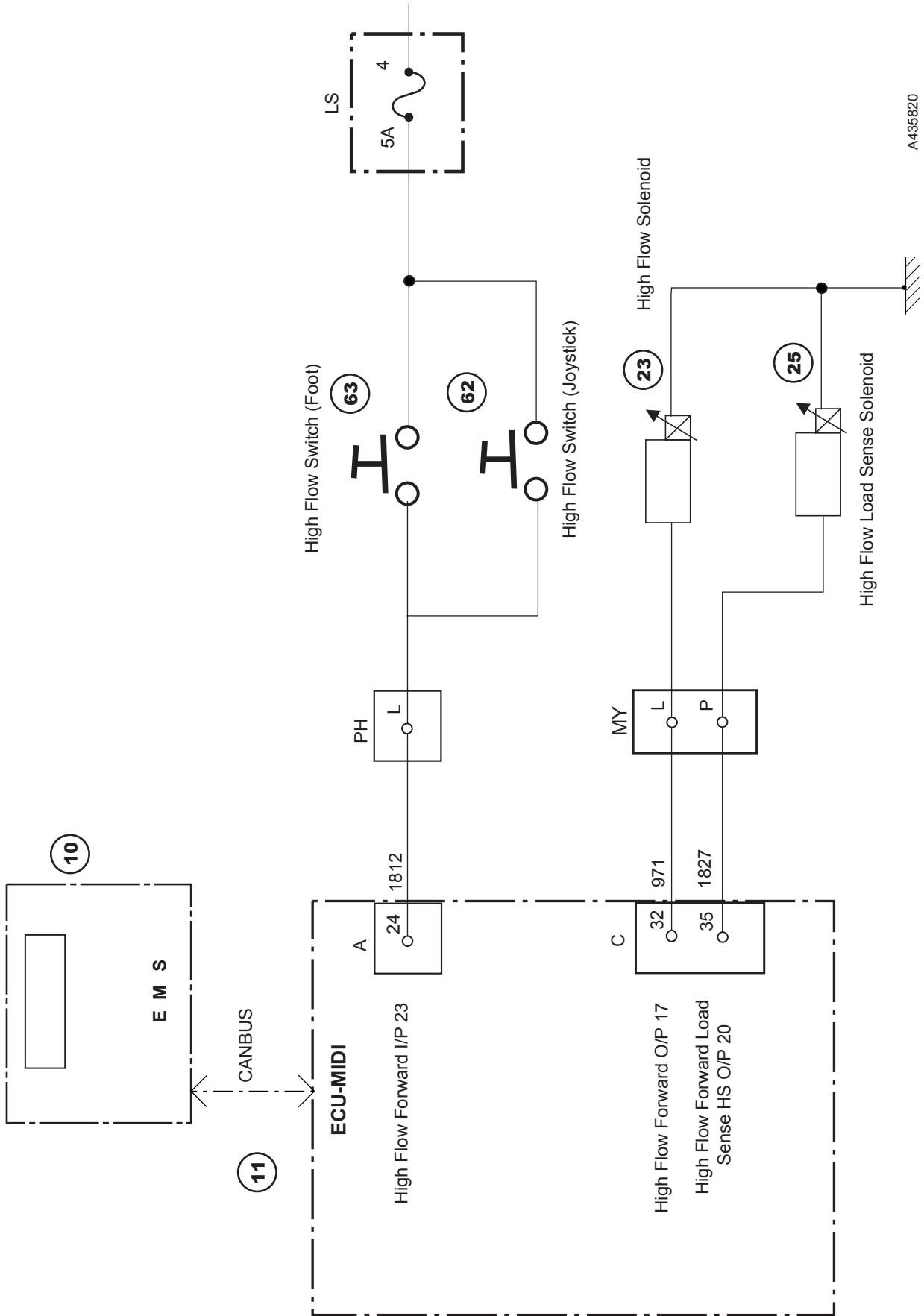
When the input switches to open circuit, the outputs should be turned off.

The ECU-MIDI records the number of hours that the high flow feature has been activated. These hours can be displayed via the EMS 5-second menu.

The following limitations are set to protect the system and pump:

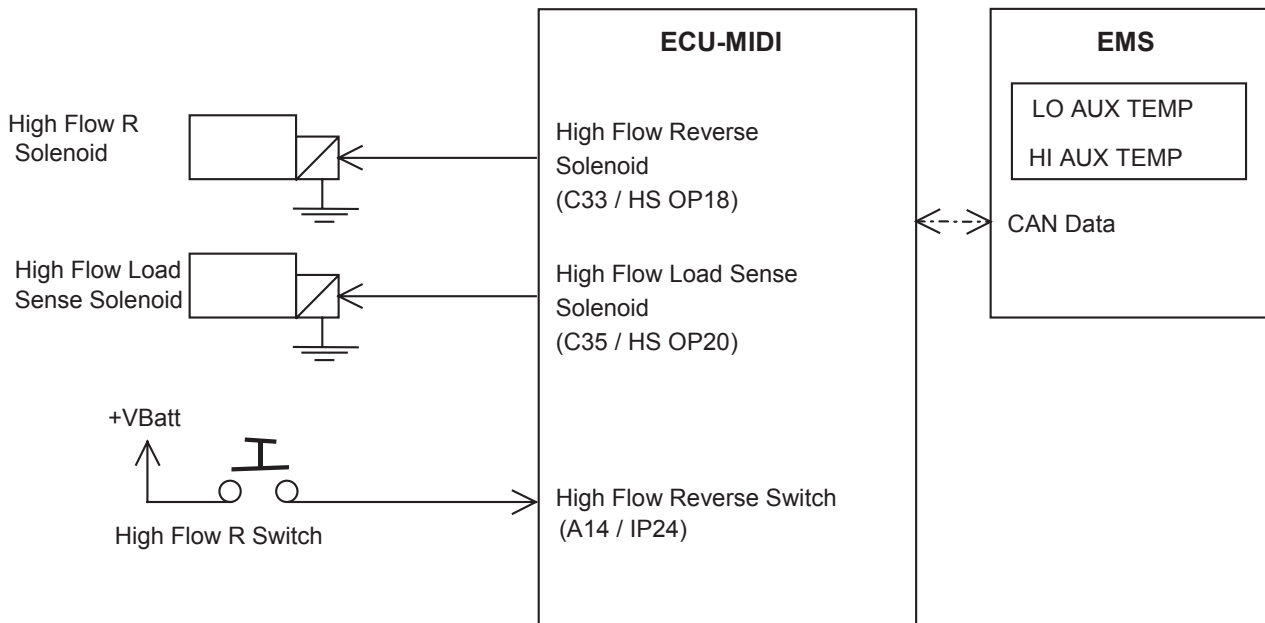
- If the High Flow Forward switch is pressed while the hydraulic oil temperature is less than or equal to 0 °C (32 °F), then the feature will not be allowed. The EMS will display the message "LO AUX TEMP" and a short 1.0-second buzzer will sound.
- If the High Flow Forward switch is pressed while the hydraulic oil temperature is greater than or equal to 98 °C (208 °F), then the feature will not be allowed. The EMS will display the message "HI AUX TEMP" and a short 1.0-second buzzer will sound.

High Flow (cont'd)



A435820

## Double Acting High Flow (Optional)



A435500

### Operation

The High Flow Reverse function is activated by pressing the High Flow Reverse switch which is located in the right hand joystick. This switch is momentary and will only provide a powered input to the ECU-MIDI when it is held down.

When the ECU-MIDI detects a high (+Vbatt) at the High Flow Reverse input, it will energise both the High Flow Reverse Solenoid and the High Flow Load Sense Solenoid. These outputs will remain energised as long as the input is held high.

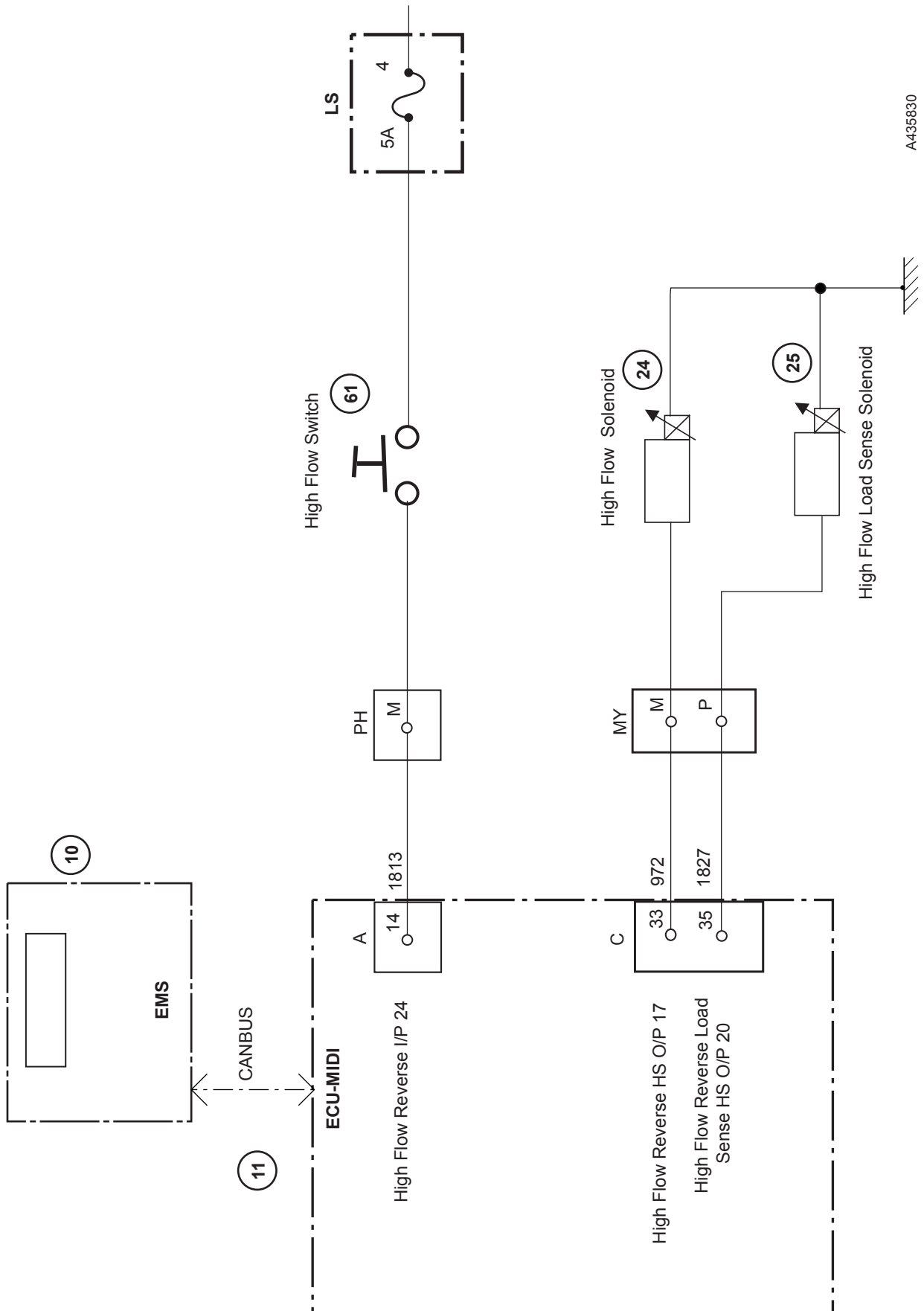
When the input switches to open circuit, the outputs are turned off.

On vehicles that have a double acting high flow, the ECU-MIDI records the number of hours that the feature has been activated. These hours are added to the high flow hours.

The following limitations are set to protect the system and pump:

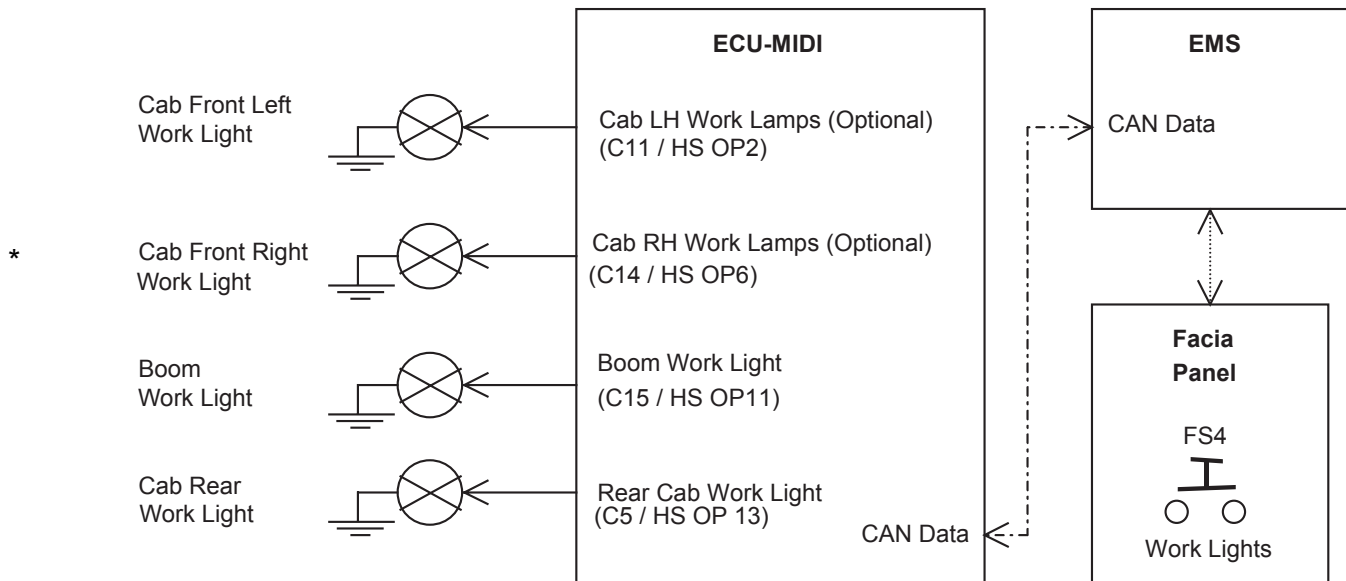
- If the High Flow R switch is pressed while the hydraulic oil temperature is less than or equal to 0 °C (32 °F), then the feature will not be allowed. The EMS displays the message "LO AUX TEMP" and a short 1.0-second buzzer will sound.
- If the High Flow R switch is pressed while the hydraulic oil temperature is greater than or equal to 98 °C (208 °F), then the feature will not be allowed. The EMS displays the message "HI AUX TEMP" and a short 1.0-second buzzer will sound.

Double Acting High Flow (Optional) (cont'd)



A435830

## Work Lights (Boom Light and Optional Work Lights)



A435550

### Operation

A work lamp is located on the Boom of the machine. An optional set of two front work lights and one rear work light can be fitted to the cab and counterweight.

### No Options Installed

When the optional work lights are not installed on a machine, only the boom work light is operational. In this case, one press of the facia panel button will cause the EMS to turn on the facia panel indicator LED. The ECU-MIDI will also turn on the Boom Work Light output. A second press will turn off the indicator LED and the ECU-MIDI output.

### Options Installed

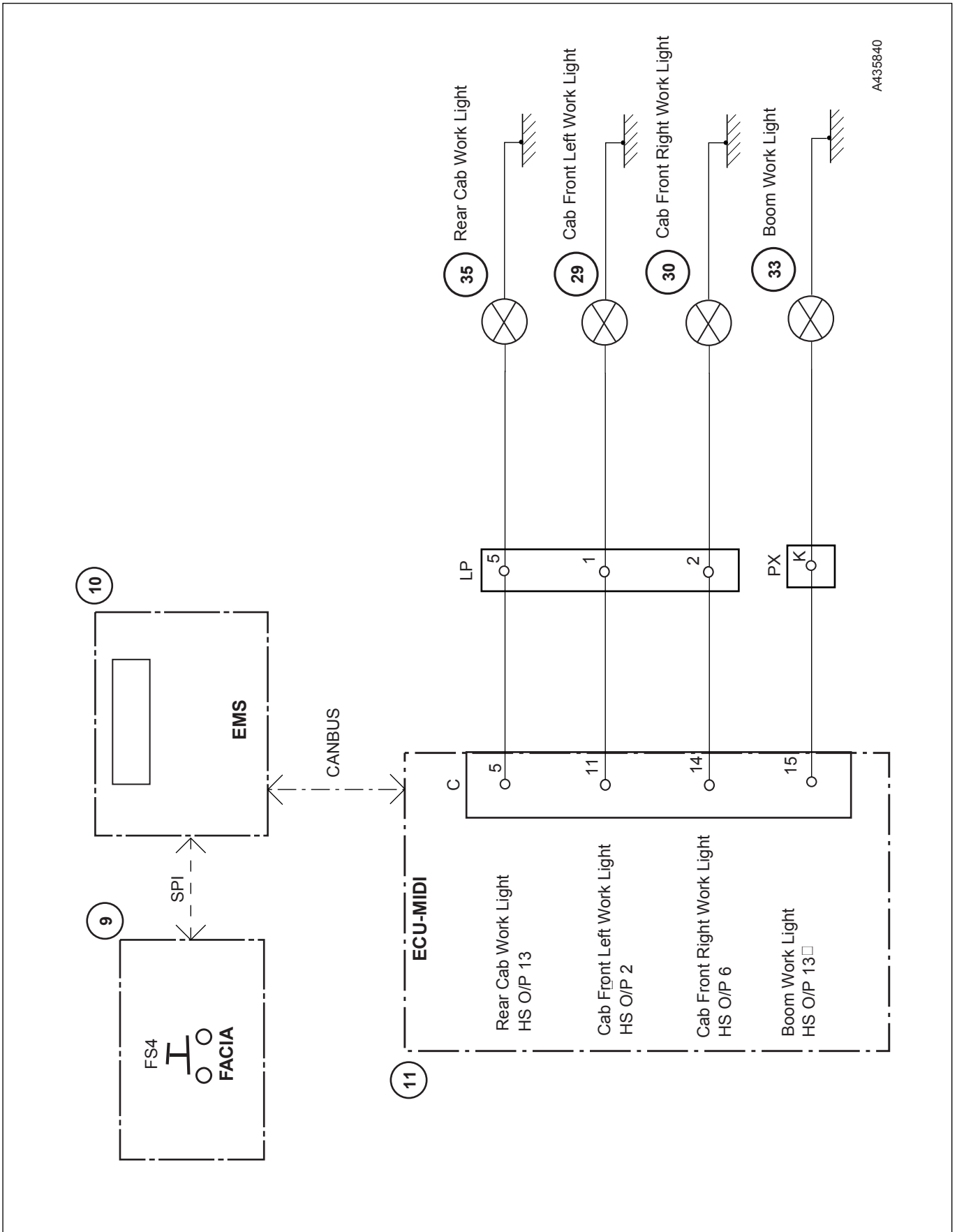
When the optional work lights are installed, the operation of the work lights function is as follows:

On the first press of the facia button, the status indicator will turn on. The boom work light output, the left front work light and the right front work light will all turn on. On the second press of the button, the rear work lights will also turn on. The third press will turn all the outputs off.

When the machine key switch is turned on, the lights should default to the OFF state. If the lights are turned on when the system is in a 'KEY-ON' state, then the buzzer should sound. Pressing the "ACK" button will silence this buzzer. If any lights are on when the system enters a 'CRANKING' state, those lights should be temporarily turned off while in the 'CRANKING' state.

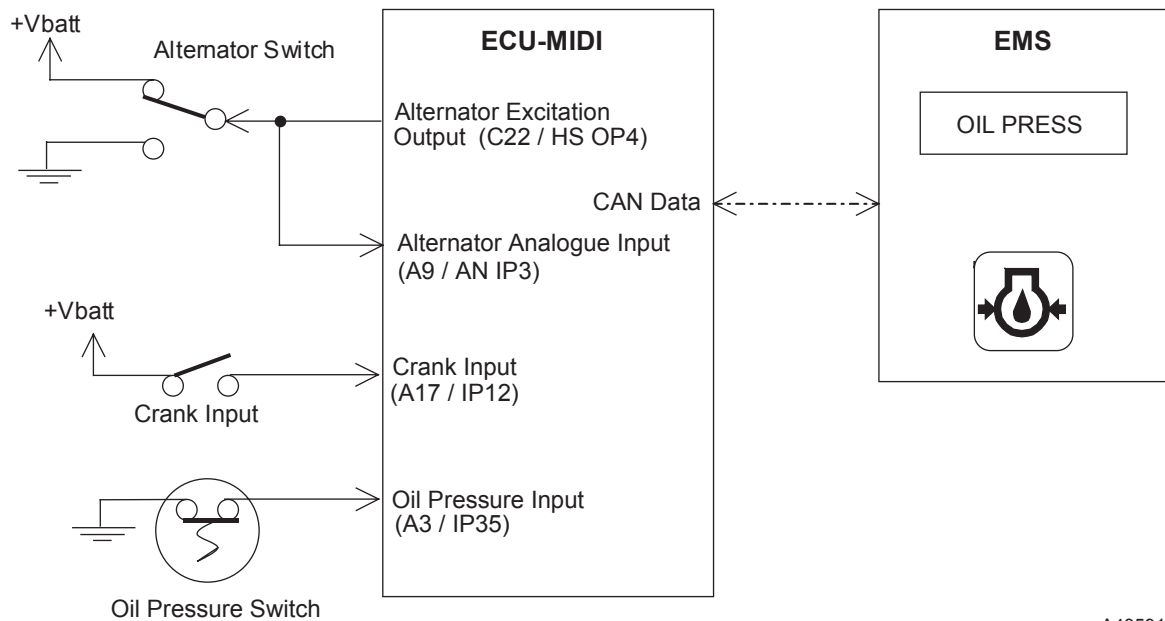
Work Lights (Boom Light and OPTIONAL Work Lights) (cont'd)

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A435840

## Engine Oil Pressure Warning



A435910

### Operation

In the case of a loss of engine oil, a blocked oil filter or the engine running backwards, the oil pump is unable to produce sufficient oil pressure within the engine. All of these conditions can result in damage to the engine and hydraulic pump. An engine oil pressure switch is included for the detection of these faults.

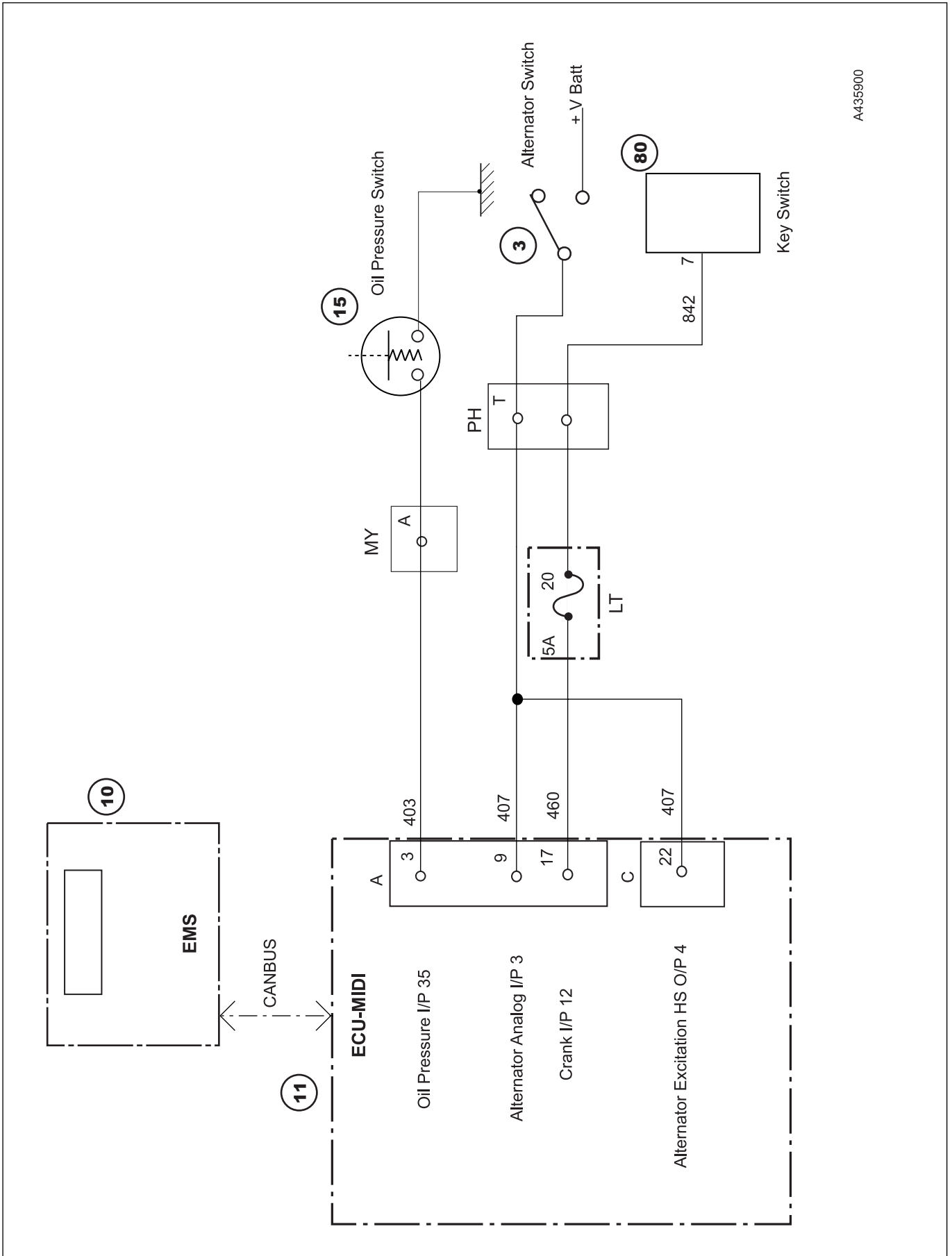
At all times, the 'OIL PRESSURE' LED will reflect the state of the oil pressure switch as given below:

- If the input is open, there is oil pressure and the LED will be OFF.
- If the input is grounded, there is no oil pressure and the LED will be ON.

If no oil pressure is detected, the message "OIL PRESS" will be displayed and the buzzer will sound. This buzzer can NOT be silenced. The engine rev/min on the throttle will be reduced to idle speed automatically in order to protect the engine. This will happen regardless of the throttle demanded by the operator.



Engine Oil Pressure Warning (cont'd)

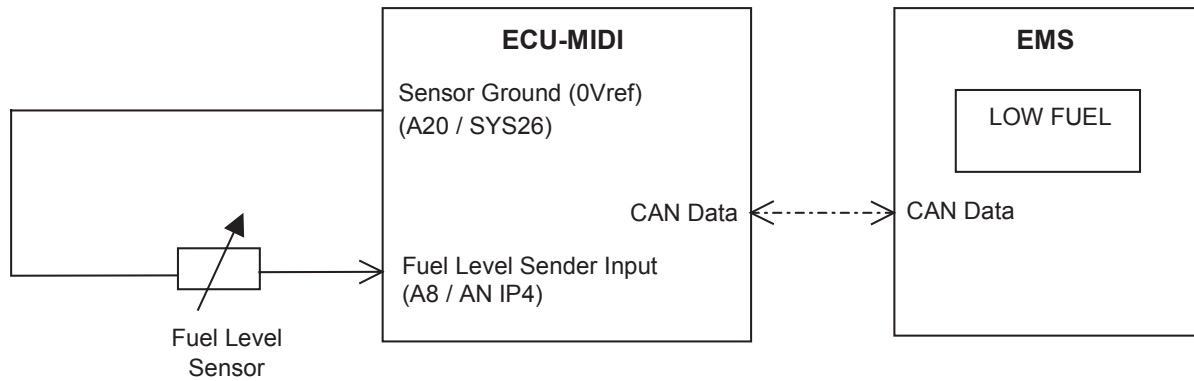


A435900

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## Fuel Level Sensor/Warning

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A435580

### Operation

A float sensor is fitted to the fuel tank to measure the level of fuel in the tank. The fuel level is displayed to the operator by means of a bar graph gauge. The actual values can be displayed via the EMS's SET+ MODE menu. Readings from the sensor are averaged over time, in order to present a smooth display.

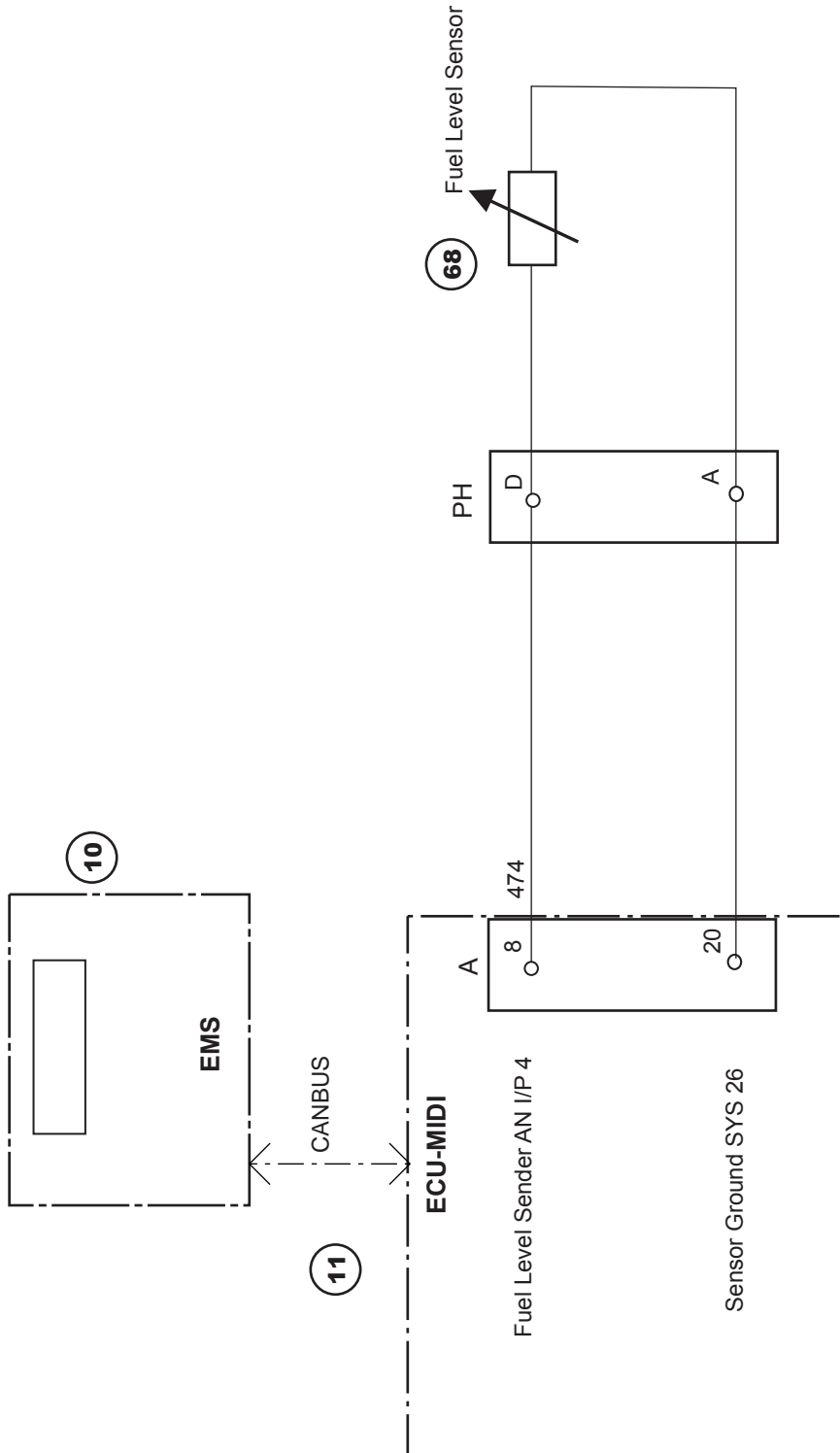
The resistance values read from this sensor will change in discrete steps as the fuel level changes. These values are shown in the table below. Continuous resistor values in between the discrete steps will not be seen.

The EMS provides warnings to the operator if the fuel level is low:

- When the fuel level drops to 3 or 4 bars on the bar graph, a "LOW FUEL" message is displayed on the LCD display and a short beep is provided by the EMS.
- When the fuel level drops to 2 or 1 bars on the bar graph, the message "LOW FUEL" is displayed on the LCD display, the EMS warning buzzer sounds, and the bottom 2, or 1, bars on the bar graph will flash at a 1Hz flash rate. The operator can silence the buzzer by pressing the "ACK" button. The "LOW FUEL" message will flash periodically even after the buzzer is silenced.
- When the fuel level reaches 0%, the message "NO FUEL" is displayed on the LCD display, and the EMS warning buzzer sounds. The operator can silence the buzzer by pressing the "ACK" button. No fuel level bars should be showing.

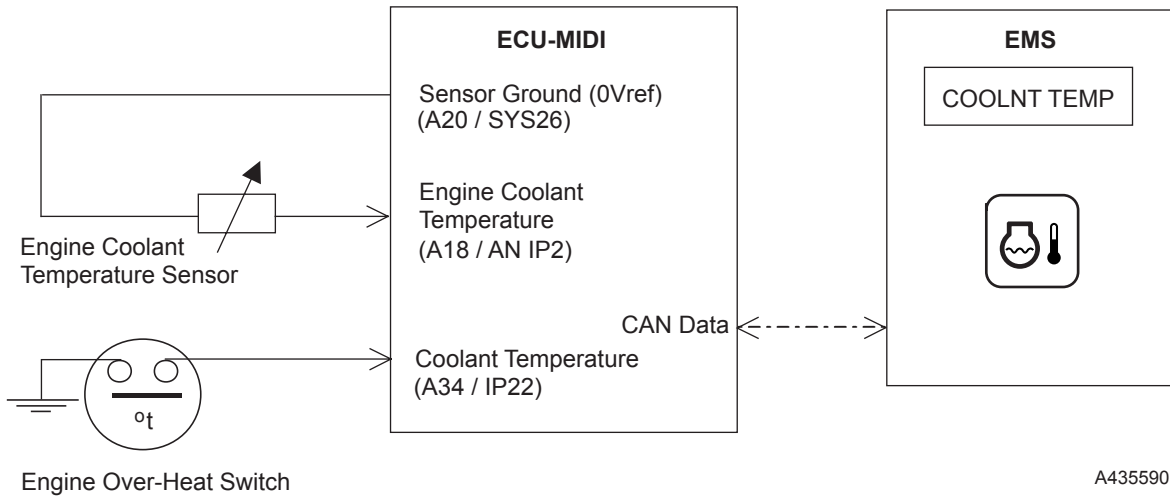
Bars On	Percentage Full	Sensor Resistance (Ohms $\Omega$ )	Bar graph Condition	Buzzer	EMS Message
0	0%	10.0	All Off	ON	"NO FUEL"
1	5%	18.2	1 Bars Flashing	ON	"LOW FUEL"
2	10%	26.4	2 Bars Flashing	ON	"LOW FUEL"
3	15%	34.6	NORMAL	1 Sec Beep	"LOW FUEL"
4	20%	42.8	NORMAL	Off 1 Sec Beep	"LOW FUEL"
5	25%	51.0	NORMAL	OFF	
6	30%	59.2	NORMAL	OFF	
7	35%	67.4	NORMAL	OFF	
8	40%	75.6	NORMAL	OFF	
9	45%	83.8	NORMAL	OFF	
10	50%	92.0	NORMAL	OFF	
11	55%	100.2	NORMAL	OFF	
12	60%	108.4	NORMAL	OFF	
13	65%	116.6	NORMAL	OFF	
14	70%	124.8	NORMAL	OFF	
15	75%	133.0	NORMAL	OFF	
16	80%	141.2	NORMAL	OFF	
17	85%	149.4	NORMAL	OFF	
18	90%	157.6	NORMAL	OFF	
19	95%	165.8	NORMAL	OFF	
20	100%	174.0	NORMAL	OFF	

Fuel Level Sensor/Warning (cont'd)



A435850

**Engine Temperature Sensor/Warning**



**Operation**

A thermistor sensor is fitted to the engine along with a thermal switch to measure temperatures. The temperature is displayed to the operator by means of a bar graph gauge on the EMS. The actual values can be displayed via the EMS's SET+ MODE menu.

The EMS will provide the following warnings for this sensor:

- When the 17th or 18th bar is illuminated the coolant temperature LED on the cluster will also illuminate.
- If the 19th or 20th bar is reached, the coolant temperature LED will illuminate, the message "COOLNT TEMP" will be displayed and an audible alarm will also sound. This audible alarm can NOT be cancelled.

The over-heat switch is included as a safety measure in case of the thermistor failure. This switch is designed to close at 105°C (221 °F). If this input is grounded then the EMS will illuminate the coolant temperature LED, sound the audible alarm and display the "COOLNT TEMP" message. The audible warning can NOT be cancelled by pressing the "ACK" button on the EMS.

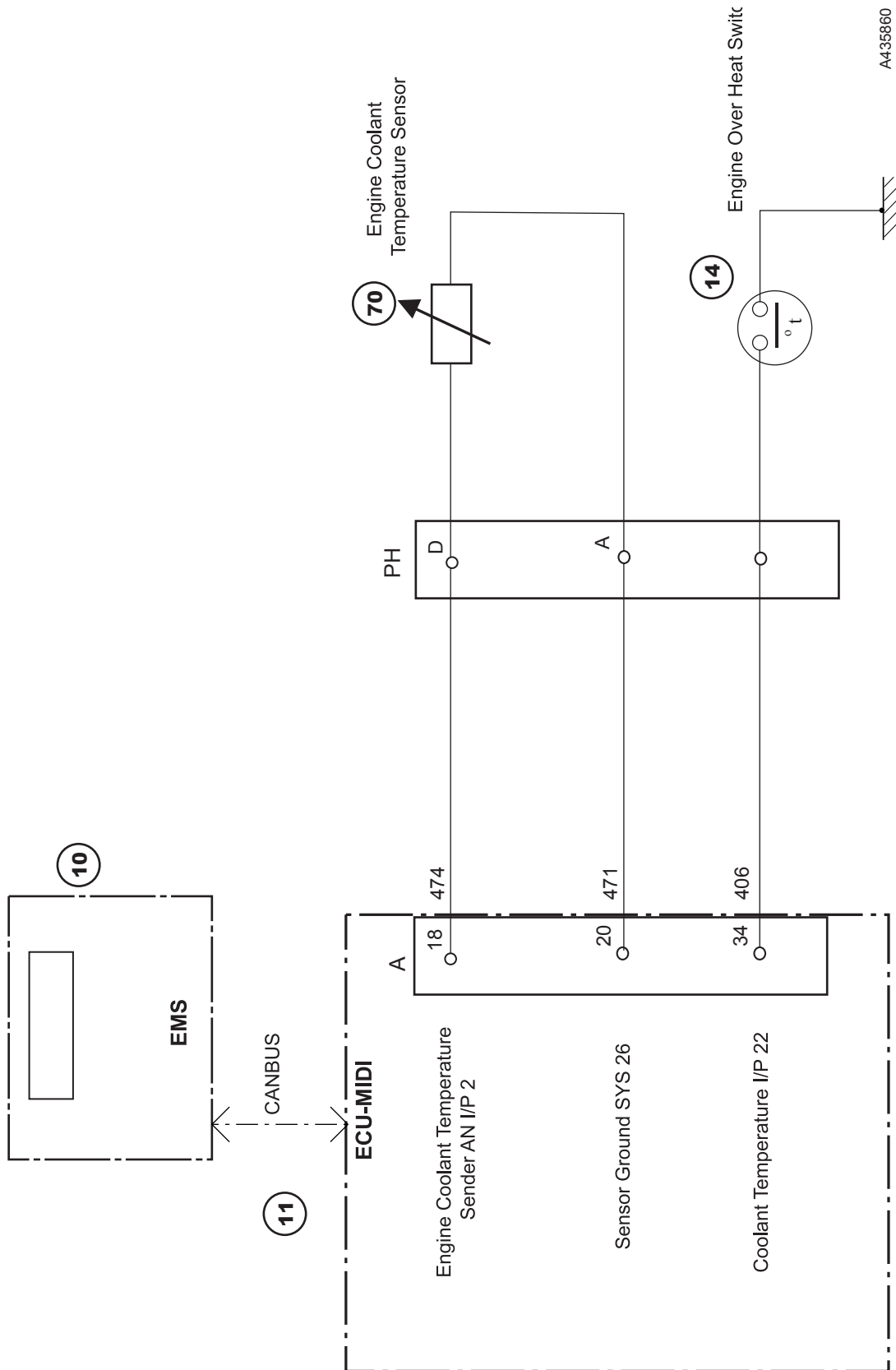
Any overheat condition signalled by either the bar graph reaching the 19th bar, or by the over-heat switch, will be logged by the ECU-MIDI.

This feature operates so that either the analogue temperature reading or the over-heat switch can generate an over-heat error.

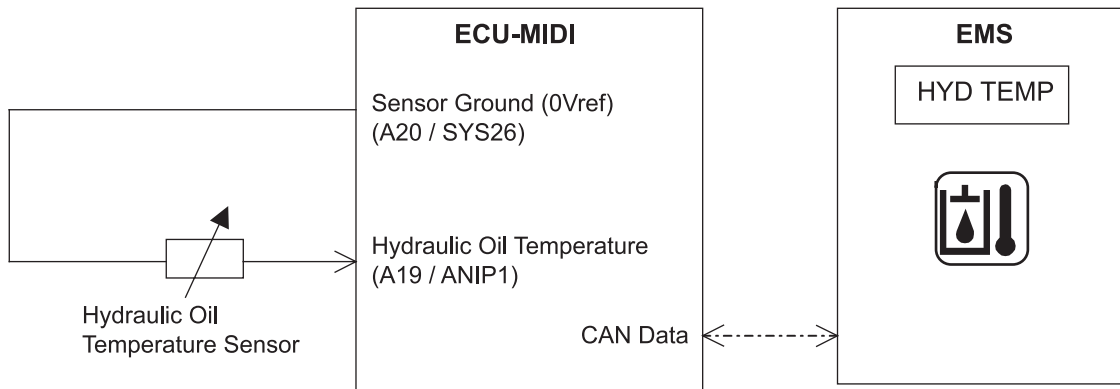
**Engine Coolant Temperature Characteristics**

Bars ON	Temp	Sensor Resistance (Ohms Ω)	Temp On	Temp Off	LED	BUZZER	MESSAGE
0	35 °C (95 °F)	4400			OFF	OFF	
1	40 °C (104 °F)	3500	>=40	<39	OFF	OFF	
2	45 °C (113 °F)	2900	>=45	<44	OFF	OFF	
3	50 °C (122 °F)	2400	>=50	<49	OFF	OFF	
4	55 °C (131 °F)	2000	>=55	<54	OFF	OFF	
5	60 °C (140 °F)	1650	>=60	<59	OFF	OFF	
6	65 °C (149 °F)	1400	>=65	<64	OFF	OFF	
7	70 °C (158 °F)	1150	>=70	<69	OFF	OFF	
8	75 °C (167 °F)	1000	>=75	<74	OFF	OFF	
9	80 °C (176 °F)	850	>=80	<79	OFF	OFF	
10	85 °C (185 °F)	725	>=85	<84	OFF	OFF	
11	90 °C (194 °F)	620	>=90	<89	OFF	OFF	
12	92 °C (198 °F)	586	>=92	<91	OFF	OFF	
13	94 °C (201 °F)	552	>=94	<93	OFF	OFF	
14	96 °C (205 °F)	520	>=96	<95	OFF	OFF	
15	98 °C (208 °F)	490	>=98	<97	OFF	OFF	
16	100 °C (212 °F)	463	>=100	<99	OFF	OFF	
17	102 °C (216 °F)	438	>=102	<101	ON	OFF	
18	105 °C (221 °F)	402	>=105	<104	ON	OFF	
19	108 °C (226 °F)	370	>=108	<107	ON	ON	"COOLNT TEMP"
20	110 °C (230 °F)	350	>=110	<109	ON	ON	"COOLNT TEMP"

Engine Temperature Sensor/Warning (cont'd)



### Hydraulic Temperature Sensor/Warning



A435600

#### Operation

A thermistor sensor is fitted to the hydraulic circuit along with a thermal switch to measure the hydraulic oil temperature. The temperature is displayed to the operator by means of a bar graph gauge on the EMS. The actual values can be displayed via the EMS's SET+ MODE menu.

The EMS provides the following warnings for this sensor:

- When the 17th or 18th bar is illuminated, the warning lamp on the cluster will also illuminate.
- If the 19th or 20th bar is reached, the hydraulic oil temperature LED will illuminate, the message "HYD TEMP" will be displayed and an audible alarm will also sound. The audible alarm can NOT be cancelled.

\* Any hydraulic oil over-heat condition signalled by the bar graph reaching the 19th bar will be logged by the ECU-MIDI.

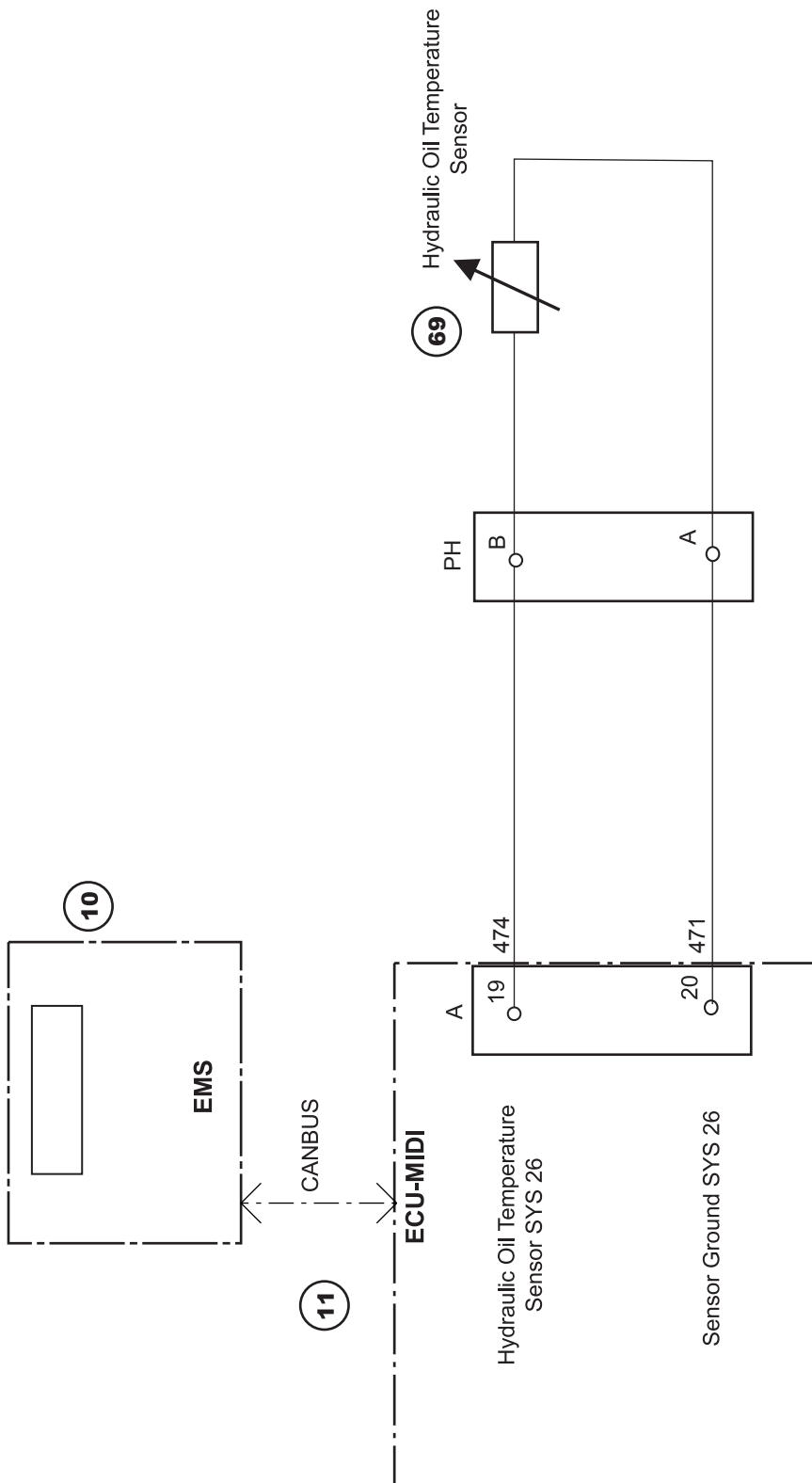
#### Hydraulic Oil Temperature Sensor Characteristics

Bars ON	Temp	Sensor Resistance (Ohms Ω)	Temp On	Temp Off	LED	BUZZER	MESSAGE
0	-10 °C (14 °F)	40217			OFF	OFF	
0	-5 °C (23 °F)	30324			OFF	OFF	
0	0 °C (32 °F)	23103			OFF	OFF	
0	1 °C (34 °F)	22000			OFF	OFF	
0	10 °C (50 °F)	13802			OFF	OFF	
0	20 °C (68 °F)	8540			OFF	OFF	
0	30 °C (86 °F)	5455			OFF	OFF	
0	35 °C (95 °F)	4400			OFF	OFF	
1	40 °C (104 °F)	3500	>=40	<39	OFF	OFF	
2	45 °C (113 °F)	2900	>=45	<44	OFF	OFF	
3	50 °C (122 °F)	2400	>=50	<49	OFF	OFF	
4	55 °C (131 °F)	2000	>=55	<54	OFF	OFF	
5	60 °C (140 °F)	1650	>=60	<59	OFF	OFF	
6	65 °C (149 °F)	1400	>=65	<64	OFF	OFF	
7	70 °C (158 °F)	1150	>=70	<69	OFF	OFF	
8	75 °C (167 °F)	1000	>=75	<74	OFF	OFF	
9	80 °C (176 °F)	850	>=80	<79	OFF	OFF	
10	85 °C (185 °F)	725	>=85	<84	OFF	OFF	
11	90 °C (194 °F)	620	>=90	<89	OFF	OFF	
12	92 °C (198 °F)	586	>=92	<91	OFF	OFF	
13	94 °C (201 °F)	552	>=94	<93	OFF	OFF	
14	96 °C (205 °F)	520	>=96	<95	OFF	OFF	
15	98 °C (208 °F)	490	>=98	<97	OFF	OFF	
16	100 °C (212 °F)	463	>=100	<99	OFF	OFF	
17	102 °C (216 °F)	438	>=102	<101	ON	OFF	
18	105 °C (221 °F)	402	>=105	<104	ON	OFF	
19	108 °C (226 °F)	370	>=108	<107	ON	ON	"HYD TEMP"
20	110 °C (230 °F)	350	>=110	<109	ON	ON	"HYD TEMP"

\*

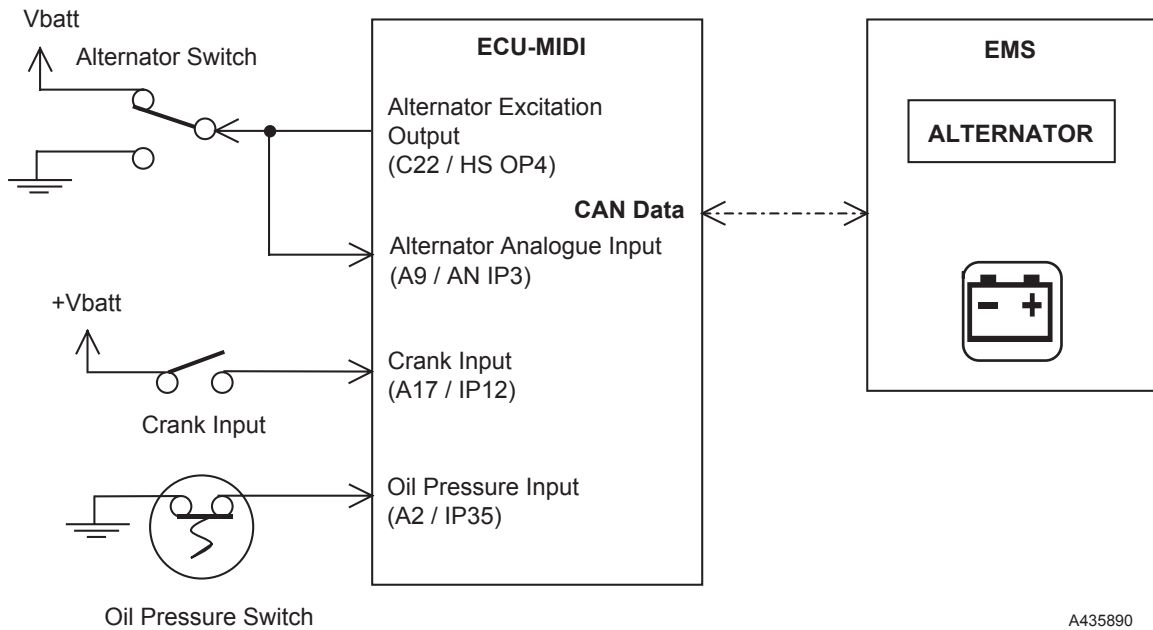
Hydraulic Temperature Sensor/Warning (cont'd)

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A435670

**Alternator Charging**



A435890

**Operation**

**Alternator Excitation**

The Alternator requires an excitation current to one of its terminals to begin its charging process. Different values of excitation current will cause the alternator to begin charging at different engine speeds. During operation the alternator will begin charging at a speed greater than the cranking speed, but less than the low idle speed. The ECU-MIDI has been designed so that the output current will cause the alternator to turn on at this desired point.

**Input**

The ECU-MIDI uses the alternator analogue input to determine if the alternator is charging or not. When the alternator is not charging, a low (ground) will be measured at the alternator input. When the alternator is charging, a high (+Vbatt) will be measured at the alternator input.

**Alternator State Table**

ALTERNATOR STATE	ALTERNATOR CHARGING	ALTERNATOR ANALOGUE INPUT
YES	IS CHARGING	> 6 V
NO	IS NOT CHARGING	< 6 V

**Output**

The alternator excitation process begins when:

- When engine cranking is complete
- When the engine oil pressure switch is in an open state ie when oil pressure is detected.

If the system leaves this condition, the alternator excitation process will stop.

During this process, the output is pulsed on for 1 second and then off for 5 seconds. When the output is on, current is provided to the alternator so that charging can begin.

This process continues until one of the following occurs:

- The alternator is charging and therefore the alternator is in a 'YES' state, as defined above.
- Engine Cranking takes place.

When either of these events has occurred the alternator excitation output is turned OFF.



## Alternator Charging (cont'd)

### Alternator

The connection between the ECU-MIDI and the alternator is through an output from the ECU-MIDI. When this output is turned off, the state of the alternator can be monitored.

Unless it is illuminated by some other function, the 'NO CHARGE WARNING' LED, will always reflect the state of the alternator as follows:

- If the output is low (ground), the alternator is not charging and the LED will be ON.
- If the output is high (+Vbatt), the alternator is charging and the LED will be OFF.

When the system has recognised an alternator fault that the alternator is not charging, the message "ALTERNATOR" should be displayed on the EMS and the buzzer should sound. These signals are in addition to the illuminated LED. Pressing the "ACK" button will silence this buzzer.

### Battery

The voltage level of the battery is sensed on the ignition switched input to the ECU-MIDI. This analogue reading is monitored for faults as follows.

When the system is NOT in a 'RUNNING' state, the following thresholds are used:

- If the battery voltage is less than 10V for more than 5 seconds, then there is a fault.
- If the battery voltage is greater than 15V for more than 15 seconds, then there is a fault.

When the system is in a 'RUNNING' state, the following thresholds should be used:

- If the battery voltage is less than 12V for more than 5 seconds, then there is a fault.
- If the battery voltage is greater than 15V for more than 5 seconds, then there is a fault.

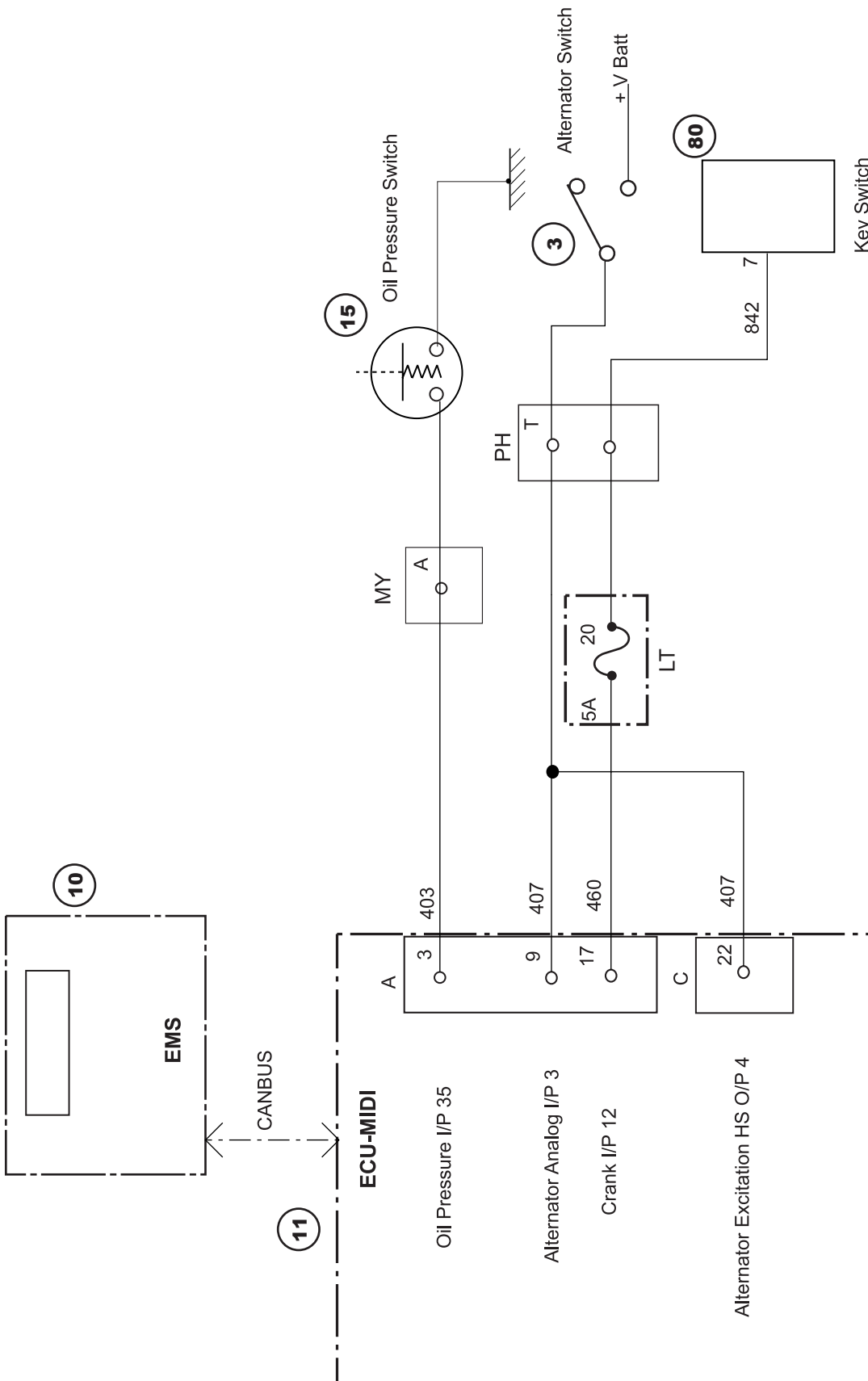
In the case of a battery voltage fault, the 'NO CHARGE WARNING' LED should be illuminated, the message "BATT VOLTS" should be displayed and the buzzer should sound. This buzzer can NOT be silenced.

### Sensor Voltage

The sensor voltage (+Vref), which is supplied to some of the external sensors on the vehicle, is also monitored by the ECU-MIDI. If, at any time, this voltage level drops below 4 Volts, then a sensor voltage fault will be active.

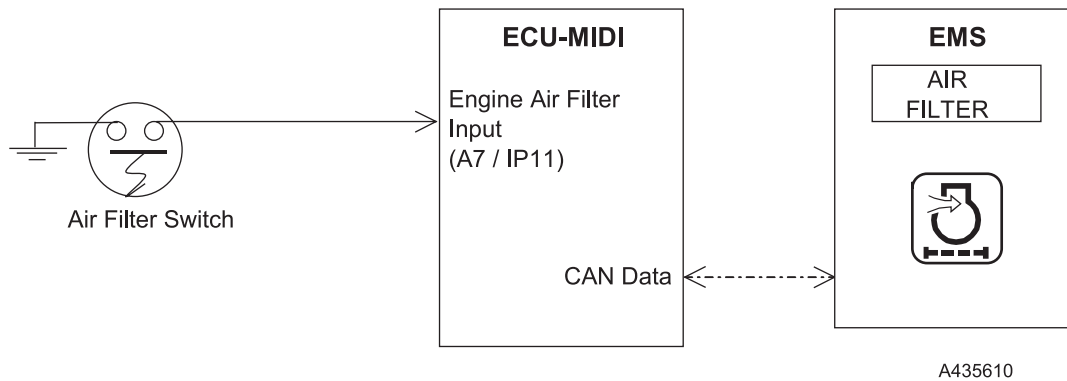
In the case of a sensor voltage fault, the 'NO CHARGE WARNING' LED should be illuminated, the message "SENSOR VOLTS" should be displayed, and the buzzer should sound. Pressing the "ACK" button will silence this buzzer.

Alternator Charging (cont'd)



A435900

## Air Filter Blocked



### Operation

A pressure switch is fitted to the engine air filter. When the filter is blocked, the pressure increases thus triggering the switch and the ECU-MIDI input becomes grounded. This causes a CAN message to be transmitted to the EMS, which then illuminates the air filter warning lamp. The message "AIR FILTER" is displayed and the internal buzzer is sounded.

The buzzer can be cancelled by pressing the "ACK" button on the EMS, however the LED will remain illuminated and the message will be displayed periodically.

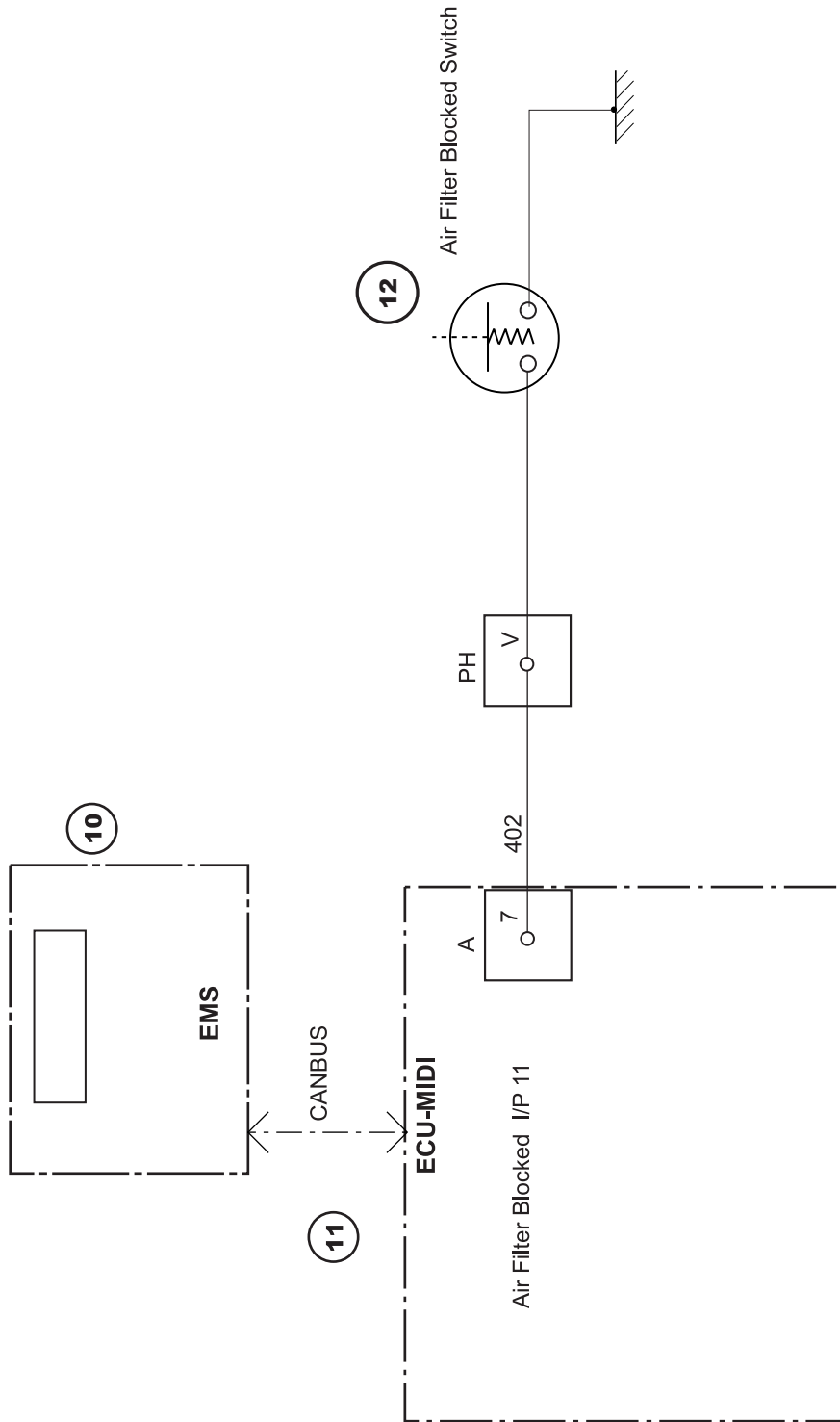
If the air filter input goes open circuit, then all the warnings are turned OFF.

In order to prevent false errors, the ECU-MIDI ensures that the air filter input is grounded for 5 seconds before sending the CAN message to the EMS. The ECU-MIDI also ensures that the input is open for 5 seconds before clearing the error.

If the air filter remains blocked for 10 minutes or more when in a 'RUNNING' state, this event will be logged by the ECU-MIDI. There will be only one log per occurrence of a blocked air filter. When the key-switch is cycled, this will count as a new occurrence.

If the air filter is blocked when in a 'KEY-ON' state, then the system will assume that the air filter switch is faulty. If the system has arrived at a 'KEY-ON' state from a 'RUNNING' state, then the ECU-MIDI will wait 5 seconds before flagging this error.

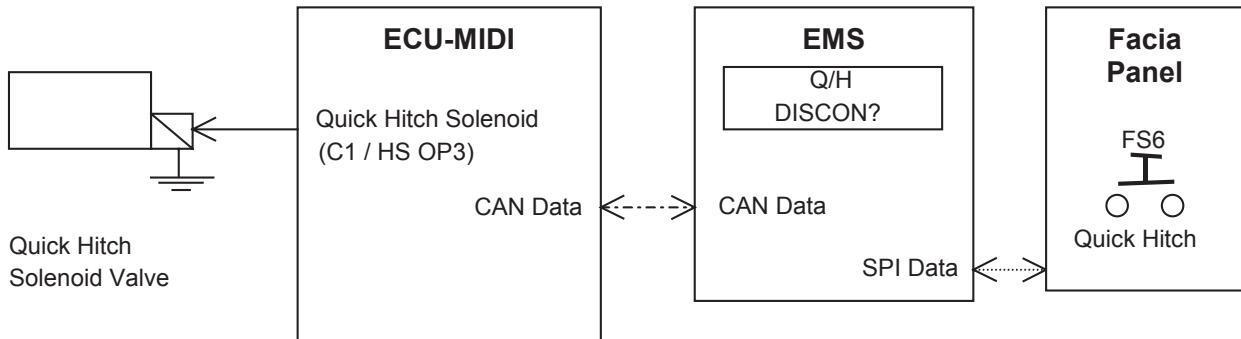
**Air Filter Blocked (cont'd)**



A435880

## Quick Hitch (Optional)

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A436140

### Operation

The Quick hitch is a customer fit option. It allows the operator to quickly change the implement attached to the end of the boom, from within the cab. There are two types that can be fitted and they operate in different ways:

- Quick Hitch Type 1:** Q/H (Connected) = Solenoid Output is switched ON.  
Q/H (Disconnected) = Solenoid Output is switched OFF.
- Quick Hitch Type 2:** Q/H (Connected) = Solenoid Output is switched OFF.  
Q/H (Disconnected) = Solenoid Output is switched ON.

If the Quick Hitch function has been selected as an option on the machine, then it can be enabled and configured via the SET + MODE (5 seconds) menu:

- Press the "SET" + "MODE" buttons for 5 seconds.
- Scroll to Q/H option and press "ACK".
- "QH ENABLE?" → Then press "ACK".
- "QH ON" → Scroll up/down to toggle between ON and OFF → "ACK" to select.
- "QH TYPE?" → Then press "ACK".
- "QH TYPE 1" → Scroll up/down to toggle between type 1 and 2 → "ACK" to select.

Once enabled, the quick hitch will default to the 'connected' state.

When the quick hitch button on the facia panel is pressed, the EMS will display the "Q/H DISCON?" message, to verify the switch operation, and the switch status indicator will illuminate.

If the "ACK" button on the EMS is not pressed within 5 seconds, the display reverts to normal and the switch status indicator is extinguished.

If the "ACK" button is pressed within 5 seconds, the EMS displays the message "Q/H DISCON" and the ECU-MIDI output is de-energised (Type 1) or energised (Type 2). The buzzer is sounded while quick hitch is disconnected. This buzzer can NOT be silenced.

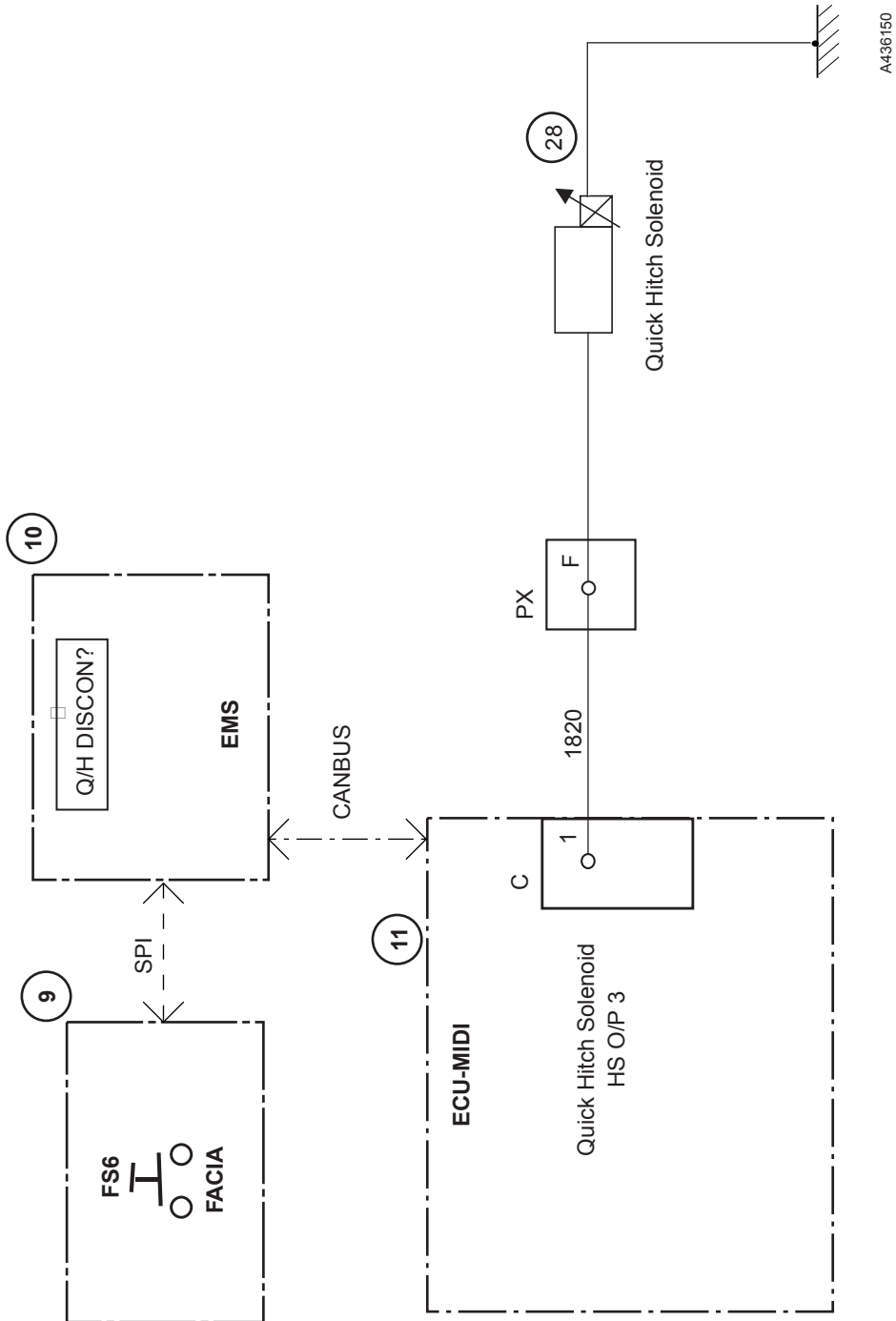
A second press of the quick hitch button on the facia panel will connect the quick hitch and cause the ECU-MIDI to energise (Type 1) or de-energised (Type 2) its output. The new attachment is gripped, the EMS message is turned off, the switch status indicator is extinguished and buzzer is switched off.

If the quick hitch is not enabled then the output will be turned OFF. The facia panel button will not respond to button presses.

The state of the quick hitch function is remembered when the machine is switched off. If it is enabled, the system will also remember the type and if the quick hitch is turned ON or OFF.

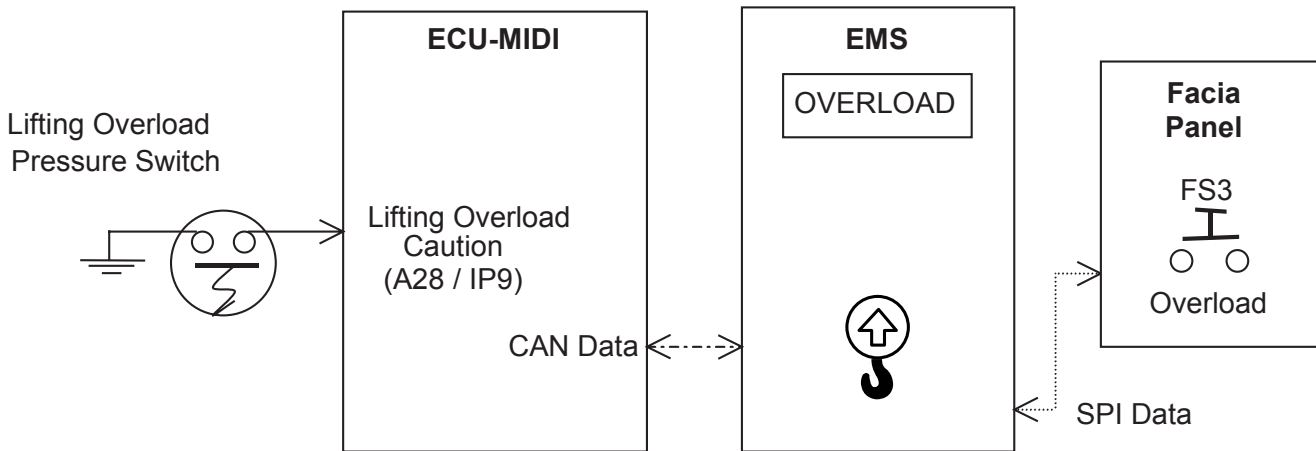
Quick Hitch (Optional) (cont'd)

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## Overload Caution (Optional)

\*



A436160

### Operation

The overload caution is used as a warning to the operator that the machine is lifting a mass that is exceeding the safe load capacity of the machine. A pressure switch input to the ECU-MIDI will indicate when an overload situation has occurred.

This feature can be turned on and off using a button on the facia switch panel. The first press of this button will turn the feature ON. The one-time message "OVERLOAD ON" will be displayed on the EMS and the facia status LED turned on.

When the feature is ON, if a grounded input is seen at the lifting overload caution input, then an overload warning is given. The message "OVERLOAD" is displayed on the EMS, the EMS LED icon will be illuminated, and the buzzer will sound. This buzzer can NOT be silenced. If the lifting overload caution input goes open circuit, then the warning is turned off.

If the facia button is pressed again, the overload feature will be turned off. The one-time message "OVERLOAD OFF" is displayed and the status indicator LED on the facia panel is turned off.

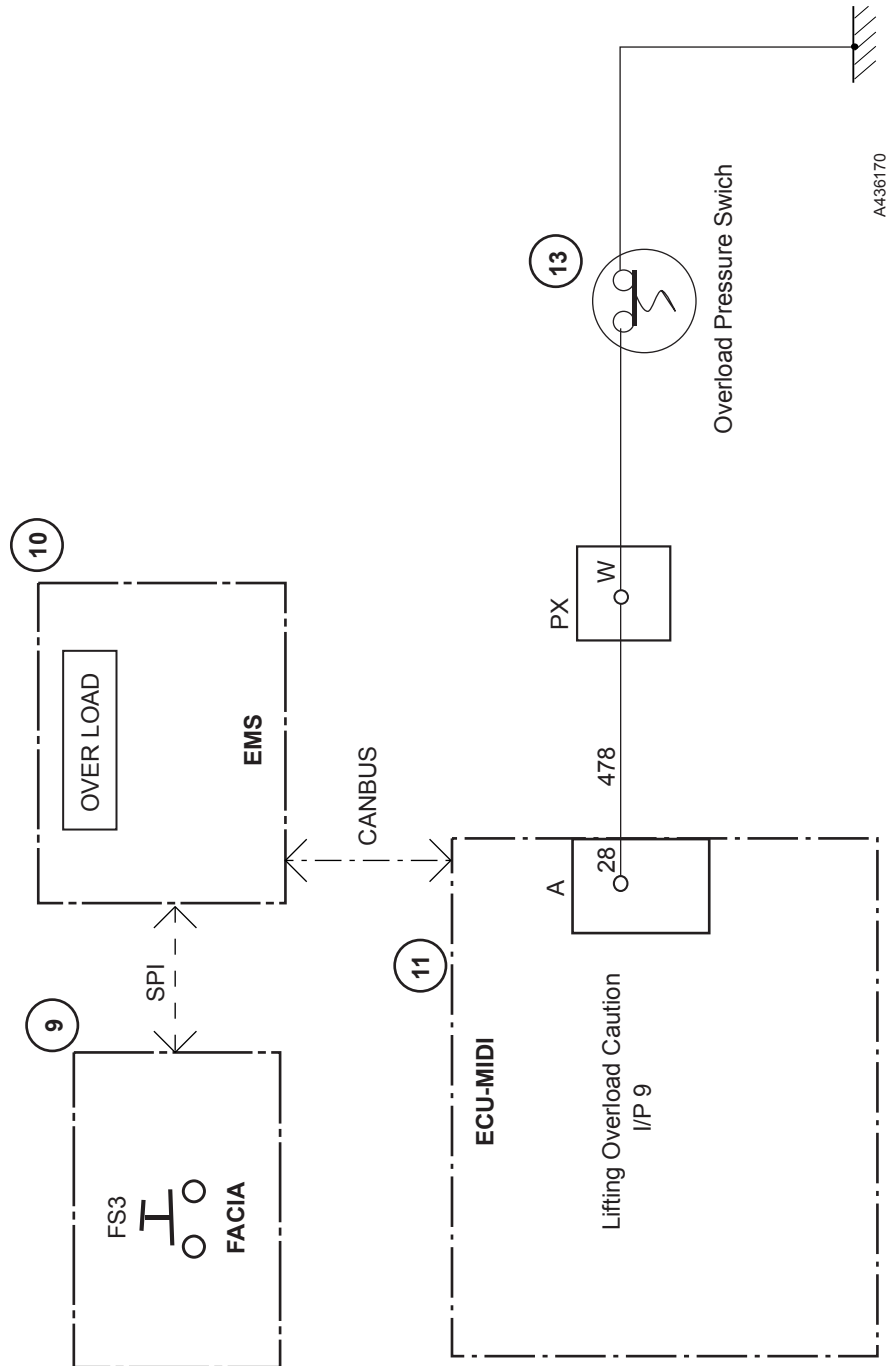
When the feature is OFF, no warnings are given regardless of the lifting overload caution input.

The state of the overload feature is remembered, when the key-switch is cycled.

If the overload caution feature has not been selected as an option, then pressing the facia panel button will have no effect.

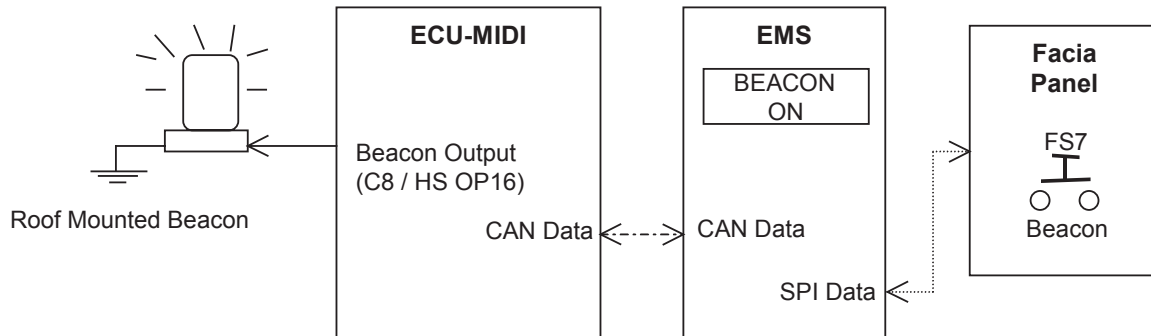
Overload Caution (Optional) (cont'd)

\*





## Beacon



A436210

### Operation

Pressing the beacon button on the facia switch panel causes the switch status LED to illuminate and the EMS to display the message "BEACON ON". This, in turn, communicates to the ECU-MIDI via the CAN network, which turns on the beacon output.

A second press of the facia switch button disables the ECU-MIDI output, and extinguishes the status LED on the facia panel.

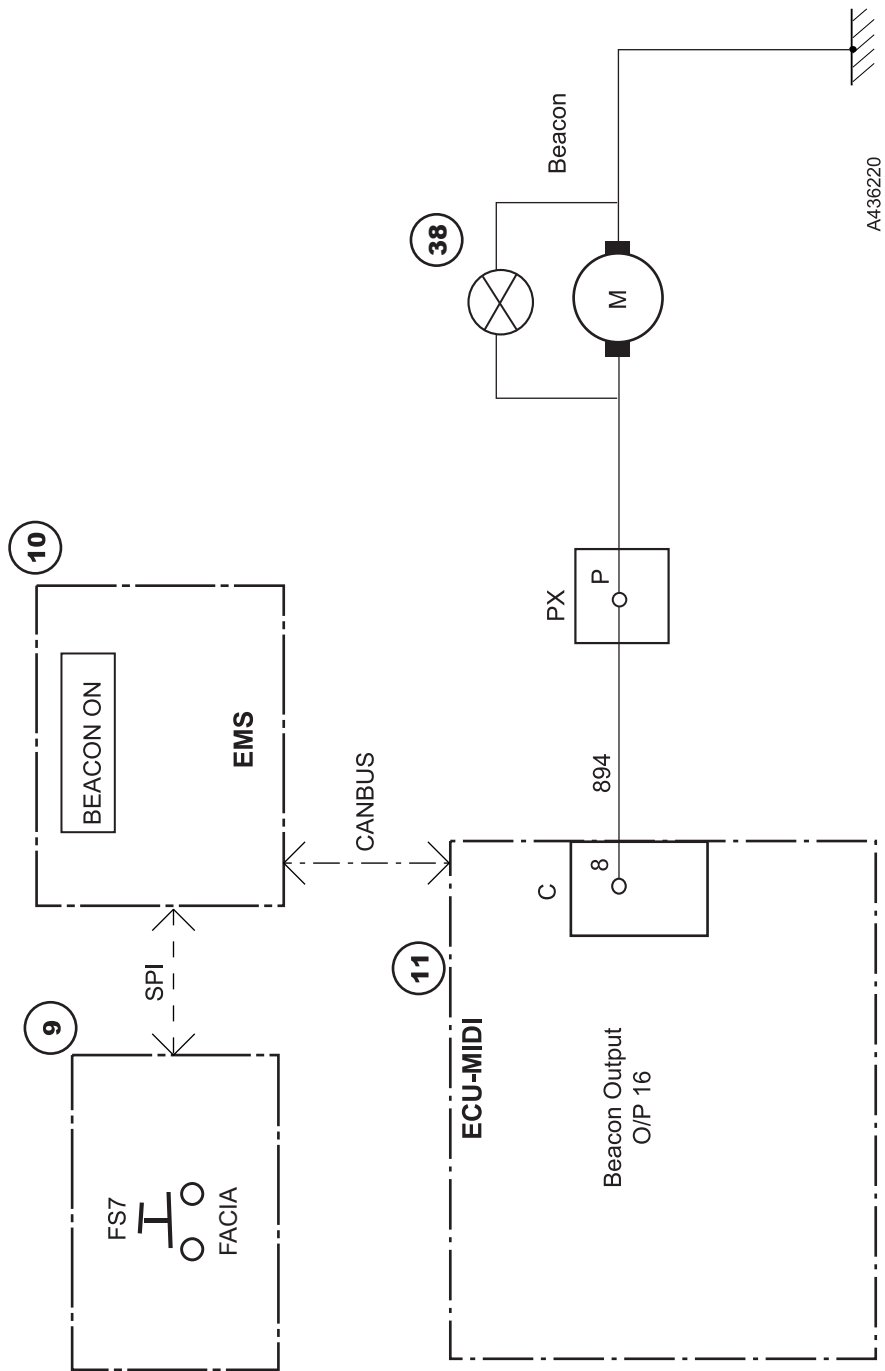
This feature is enabled for all vehicles and no error message will be generated if the switch is pressed and no beacon is fitted.

The output will only be energised on the detection of a load. If no beacon is fitted, the conformation message will not be displayed and the switch status LED will not be illuminated.

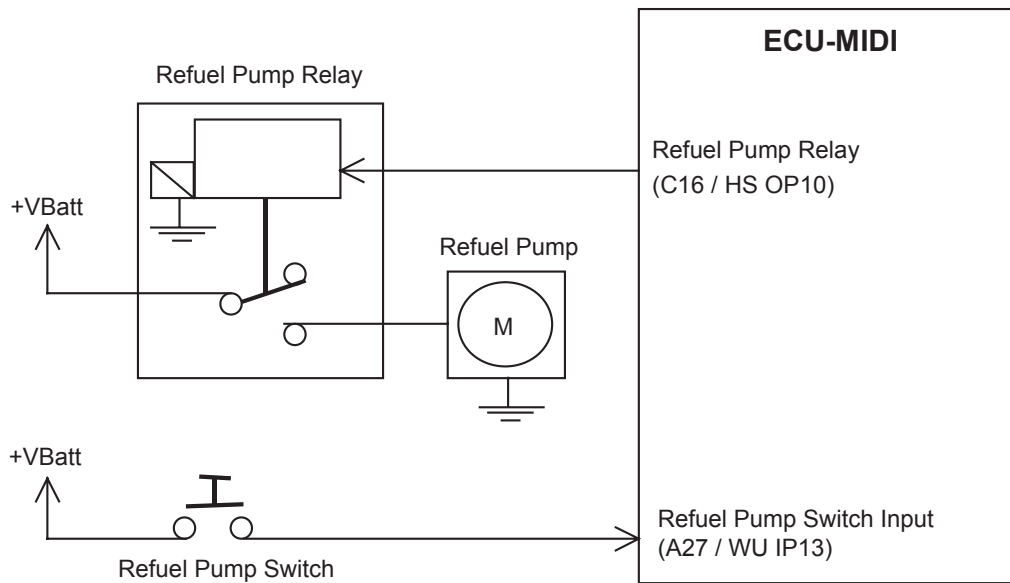
The state of the beacon function is remembered when the key-switch is cycled.

If the beacon is operated while the system is in a 'KEY-ON' state, then the buzzer will sound. This buzzer can be cancelled by pressing the "ACK" button.

Beacon (cont'd)



## Refuelling Pump (Optional)



A436230

### Operation

The Refuelling pump can be used in two different modes: automatic or manual.

#### Automatic Mode

A short press of the fuel pump momentary switch will turn on and off the fuel pump's automatic mode.

When the refuelling pump switch is pressed, a high (+VBatt) will be measured at the input to the ECU-MIDI. When the button is released, the input will be open circuit and a 'Low' will be measured by the ECU-MIDI. If the button was held for less than 2 seconds, then this falling edge will trigger the refuelling pump feature into automatic mode.

While in automatic mode, the output to the refuelling pump relay will be energised. The fuel level input is monitored during this function. When the fuel level reaches 90% full, the fuel pump output is turned off.

The filtering that is normally used to smooth out fuel level readings is not used in this case so that there is no delay in the fuel level reading.

If a second falling edge is detected on the fuel pump input, then the feature is deactivated and the fuel pump output turned off.

**Note:** If any errors are present on the fuel level sensor, then the refuel pump's automatic mode will not be allowed. If the refuel pump output has been on for 15 seconds without any change to the fuel level in the tank, then the refuel pump output is turned off, to prevent running the refuel pump dry.

#### Manual Mode

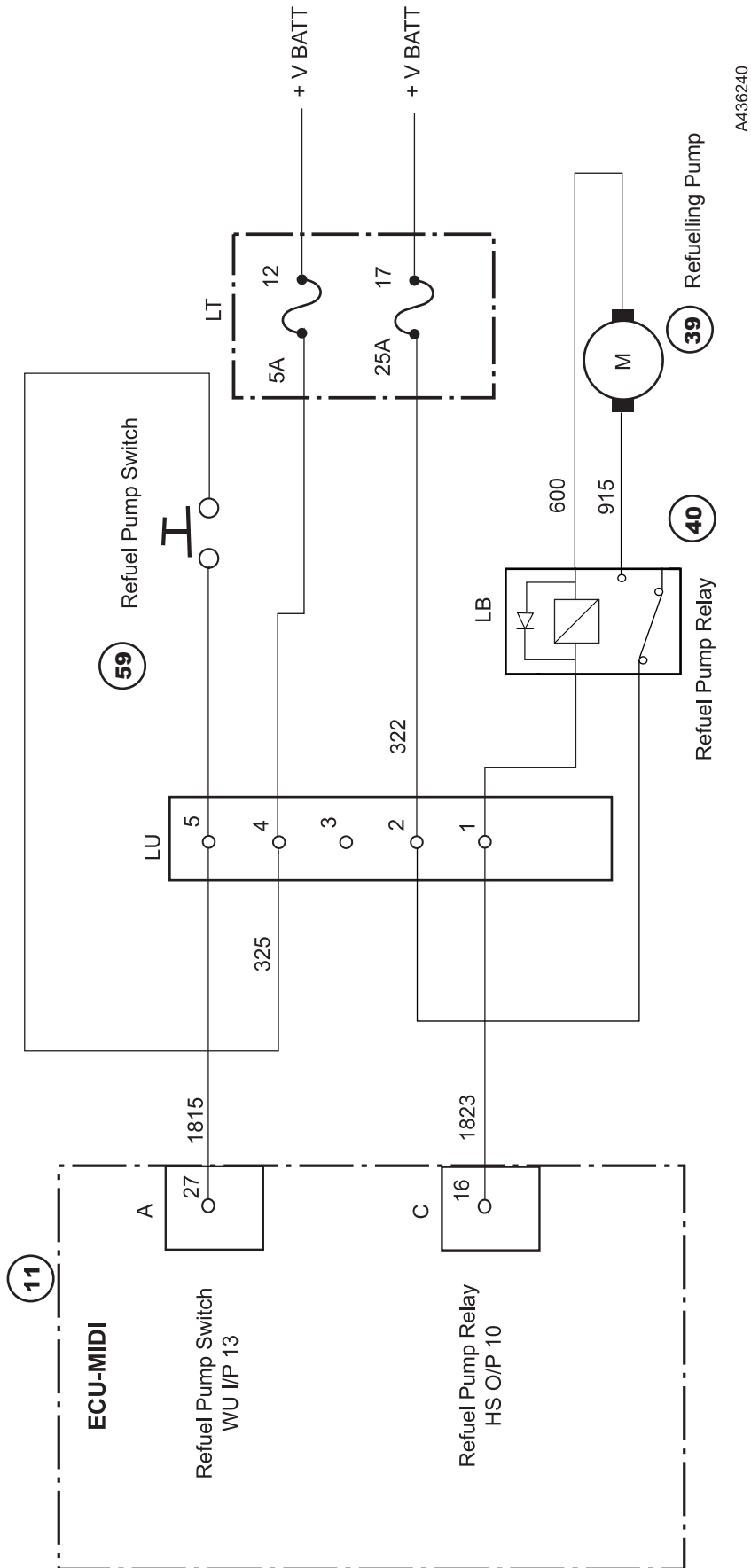
If, at any time, the refuelling pump input is pressed and held for more than 2 seconds, then the refuelling pump will be in manual mode. This mode allows the user to manually add fuel to the tank.

Once in manual mode, the refuelling pump output is turned on. The output will remain on until the refuelling switch has been released. At this point the output will turn off and the refuelling feature will be off.

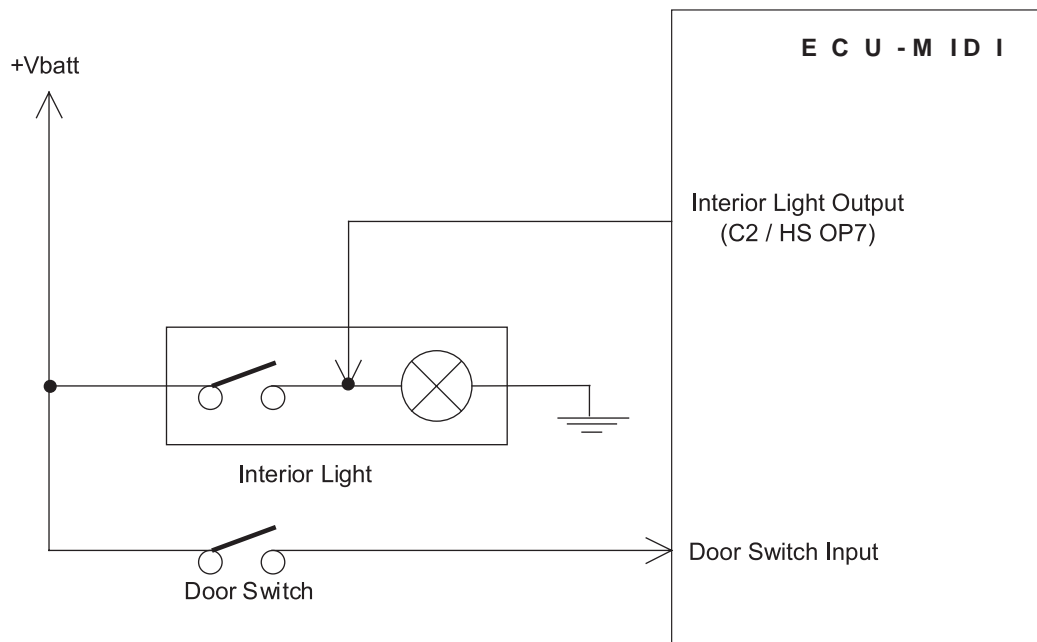
**Note:** If manual mode is entered from automatic mode, then automatic mode is NOT resumed when the switch is released.

**Note:** The refuelling pump switch is connected to one of the wake-up inputs on the ECU-MIDI. If the ECU-MIDI is in a 'WAKE-UP' state this feature will operate normally.

Refueling Pump (Optional) (cont'd)



## Interior Light



A436260

### Operation

The cab interior light is controlled by the ECU-MIDI and is turned on and off in response to various machine inputs. The light switch also contains its own on/off button that can be used to turn on the light as required by the operator. Turning this switch on overrides the output from the ECU-MIDI.

The door of the cab also contains a switch to indicate if the door is open or closed. When the door is closed, the switch is open and a low will be measured by the ECU-MIDI at the door switch input. When the door is open, the switch is closed and a high (+Vbatt) will be measured by the ECU-MIDI at the door switch input.

The door switch input is configured as a wake-up input on the ECU-MIDI, allowing interior light operation when the key-switch is in the OFF position.

### Turning ON

The ECU-MIDI will turn on its interior light output in either of the following cases:

- When the door opens and a high (+Vbatt) is measured at the door switch input.
- When the key-switch is turned to the OFF position. In this case the ECU-MIDI will keep itself powered so that the interior light will remain illuminated.

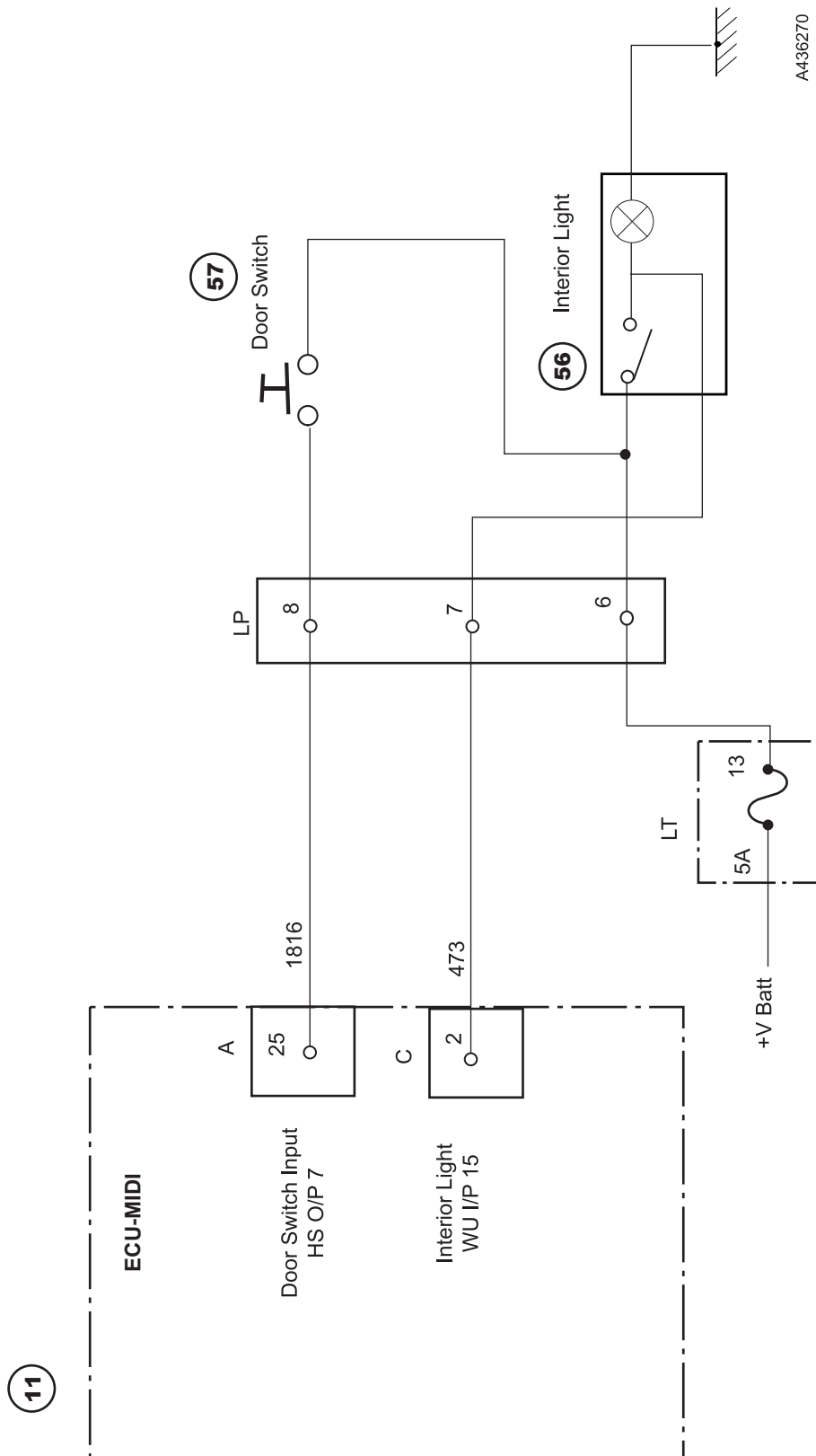
### Turning OFF

When the ECU-MIDI turns off the interior light, it will 'dim' from on to off. The ECU-MIDI will PWM the output from a 100% duty cycle to a 0% duty cycle over a 2-second period. This will occur every time the light is turned off.

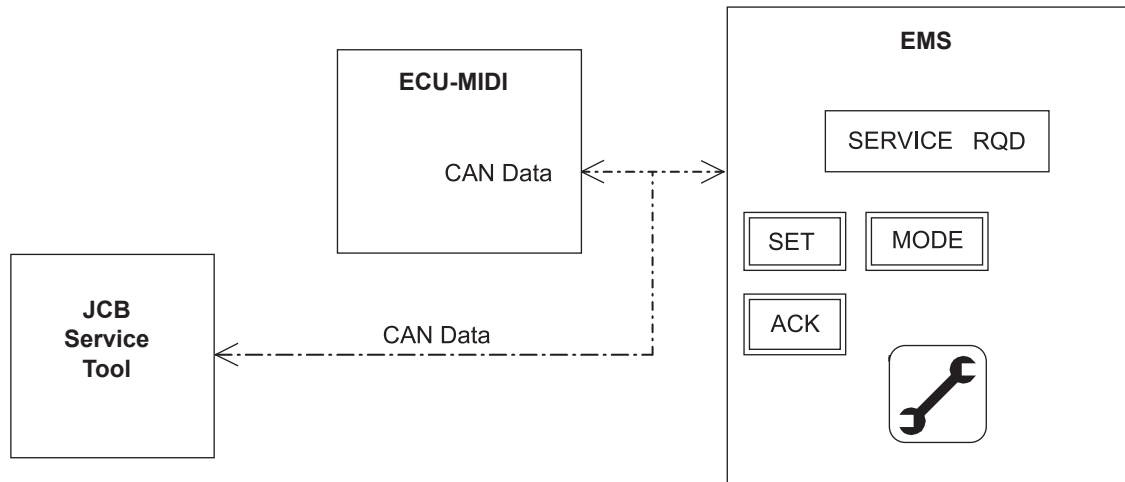
The ECU-MIDI will turn off its interior light output when any of the following has occurred:

- When 15 seconds have passed since the ECU-MIDI turned the light ON.
- When the door of the cab is closed, the ECU-MIDI will wait 15 seconds and then turn off the interior light. This event is triggered by the changing state of the door switch input indicating that the door has just been closed.
- When the system enters a 'KEY-ON' state, the light will be turned off immediately with no delay.

Interior Light (cont'd)



## Service Required Warning



A435620

### Operation

The service required warning LED on the EMS will illuminate when the next service is due according to the service schedule. The elapsed time is based on the engine hours.

When a service interval has been reached, the following sequence of events will alert the operator that service is required:

- At 20 hours before the service interval, the service required LED will illuminate and the message "SERVICE RQD" will be displayed. Pressing the "ACK" button will clear the message, but the LED will remain lit.
- When the machine is keyed on, the system will repeat this warning.
- Once the engine hours have incremented to 20 beyond the service interval, the message "SERVICE RQD" will be displayed again and the LED will remain lit. A missed service interval will be logged in the system's data logger. Once the "ACK" button is pressed, the message will clear and the service required LED will start flashing.
- When the machine is keyed on, these warnings should be repeated.

The LED will continue to flash until a service dealer resets it by entering their service code number.

After the dealer has entered their code, a new entry is created in the service log that is stored in memory. This service history can be retrieved using the factory service tool.

The code number can be entered either using the factory service tool, or through the EMS' SET + MODE menu. This information is stored in memory and can only be accessed by the factory service tool.

Warnings will be given at the following intervals:

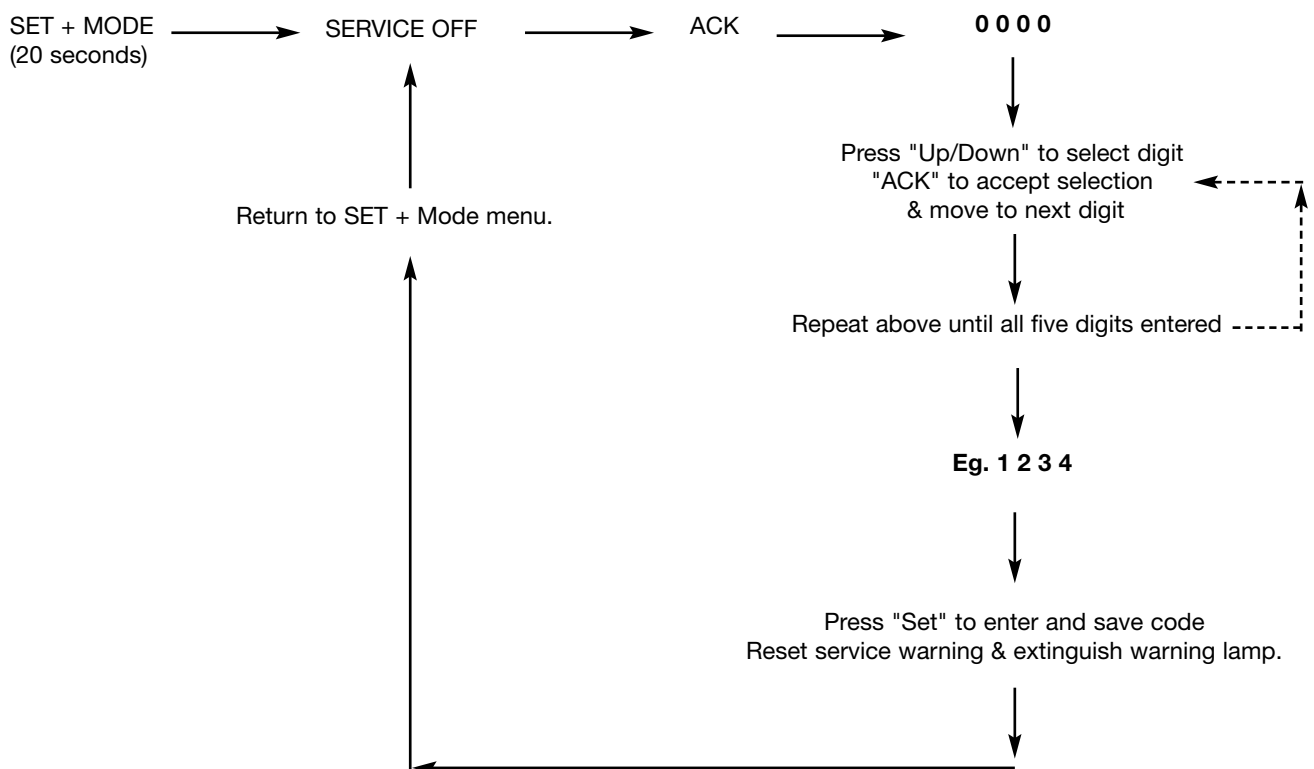
- 1 100 hours (1st service only)
- 2 250 hours (150 hours after 1st service actual hours)
- 3 500 hours (250 hours after previous service actual hours)
- 4 750 hours (250 hours after previous service actual hours)
- 5 1000 hours (250 hours after previous service actual hours)
- 6 1250 hours (250 hours after previous service actual hours)
- 7 etc. every subsequent 250 hours after previous service actual hours

### Cancellation of the Service Indicator

JCB Service personnel will be able to cancel the main service indicator by entering their service code number either by using the factory service tool or through the SET+ Mode menu structure. This is only required for major service intervals.

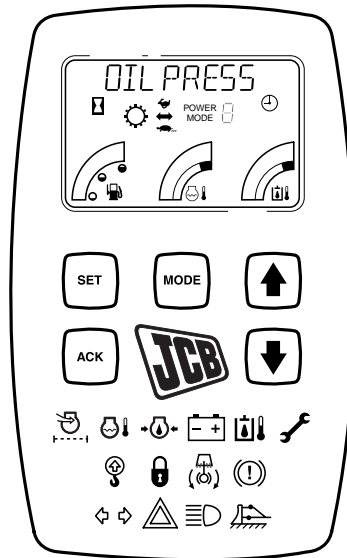
When the Service sub menu is reached and entered, the dealer will be prompted to enter a four-digit code by the use of the "Up/Down" keys and the "ACK" button. The required digit will flash until the ACK button is pressed, after which the next digit will flash until all of the digits have been entered. Once the code is entered, the set button is pressed, the service warning is cancelled and the code saved in memory. The saved data will be updated at the next service interval by the newly entered dealer code.

**Note:** Only factory service engineers can access the service history.





## Types of Message Displayed on EMS



A410580

There are 4 different types of messages that can be displayed on the EMS. They are shown here in the order that they are prioritised during operation:

- \* • Menu (Message shown when the EMS menu is used).
- Errors (Error messages that indicate some kind of problem).
- One Time (Messages that appear as a result of some action).
- Repetitive (Messages that are shown periodically).

For each message there can be other actions that are required by the system. These actions include:

- Buzzer.
- Functions if the "ACK" button is pressed.
- Logging of events.

## Menu - Messages

### Set Menu

Message	Meaning
12/24 12	Clock 12-hour format.
12/24 24	Clock 24-hour format.
AUTO IDLE T	Delay time for automatic idle feature.
CLOCK	Set current time.
DATE	Set current date.
HIGH FLOW	Display the hours in high flow.
INT WIPER S	Set Intermittent wiper speed to a setting from 1 to 10.
LANGUAGE	Choose the language for the EMS.
RESET HRS?	Confirm that the high flow hours are to be reset.

**Menu Messages (cont'd)****Diagnostic Menu - Set + Mode 5 seconds**

Message	Meaning
ALT CHARGE	Shows if the alternator is charging or not.
ECU--M--v X.XX	The hardware or software version number for the ECU-MIDI.
EMS--v X.XX	The hardware or software version number for the EMS.
FUEL LEVEL	Display the amount of fuel remaining.
HRDWARE VER	Display the hardware version numbers of the EMS and the ECU-MIDI.
HYD TEMP	Display the current hydraulic oil temperature.
MAIN OFF	Main pressure switch is off.
MAIN ON	Main pressure switch is on.
MODEL NUM	Show the model of the vehicle.
OFF	The alternator is not charging.
ON	The alternator is charging.
PILOT SWTCH	Show the state of the machine pressure switches.
QH ENABLE?	Menu option for enabling and configuring the quick hitch.
QH OFF	Disable the quick hitch.
QH ON	Enable the quick hitch.
QH TYPE 1	Set the quick hitch to type 1.
QH TYPE 2	Set the quick hitch to type 2.
QH TYPE?	Set the type of quick hitch on the machine.
SENSE POT	Displays the reading of the throttle sense potentiometer.
SENSOR VOLT	Displays the measurement of the sensor voltage (5V supply).
SERIAL NO	Display the serial number of the machine.
SFTWARE VER	Display the software version numbers of the EMS and the ECU-MIDI.
SLEW OFF	Slew pressure switch is off.
SLEW ON	Slew pressure switch is on.
SYS VOLTS	Displays the measurement of the battery voltage.
THROTTL PWM	Display the PWM duty cycle being provided to the throttle actuator.
THRITTLE POT	Displays the reading of the throttle set potentiometer.
TRAVEL OFF	Travel pressure switch is off.
TRAVEL ON	Travel pressure switch is on.
WATER TEMP	Display the current engine water temperature.
X.XX VOLTS	The sensor voltage reading.
XX DEG C	Current temperature reading of either the water or hydraulic oil.
XX PERC	The reading of the fuel level given in percent full.
XX VOLTS	The battery voltage reading.
XX.X PERC	The PWM reading in percent duty cycle.
XXXX OHMS	The measurement in Ohms of the throttle sense or set potentiometer.

## Menu Messages (cont'd)

### Calibration Menu - Set + Mode 20 seconds

Message	Meaning
CALIBRATE	Calibrate the throttle on the machine.
DEFAULT SET	Set all the machine settings back to their default values.
ID-XXXX	Enter the service ID to clear the warning.
OVER-RIDE	Solenoid override feature menu option. Also displayed when the feature is activated.
OVER-RIDE?	Confirmation to turn the solenoid override feature on.
RESET?	Confirmation that the machine settings should be reset.
SERVICE OFF	Used to cancel a service warning notification.
TSENS	The ECU-MIDI is now auto detecting the min and max sense potentiometer positions.
TVOL MAX	Move the throttle set potentiometer to the maximum position.
TVOL MIN	Move the throttle set potentiometer to the minimum position.

## Repetitive Messages

The following messages are repetitive messages. They will be displayed periodically as long as the source of the message still requires the message to be displayed. The table shows which messages have buzzers. The 'ACK' column indicates if the buzzer can be silenced or not by pressing the "ACK" button. If the event is logged in any way, then this is shown as "YES" in the 'Log' column.

Message	Log	Meaning	Buzzer	ACK
ALTERNATOR	YES	The engine is running and the alternator is not charging.	YES	YES
AUTO IDLE	NO	The auto idle feature is active and therefore the system has been dropped to low idle.	NO	N/A
BATT VOLTS	YES	The battery voltage is out of range.	YES	NO
NO THROTTLE	NO	This will be displayed whenever there is a throttle related error. Errors (304-307).	YES	YES
OIL PRESS	YES	The engine is running with no oil pressure.	YES	NO
RECALIBRATE	NO	The ECU-MIDI has not had its throttle calibrated.	YES	YES
SENSOR VOLT	YES	The sensor voltage is less than 4V.	YES	YES
SETUP RQD	NO	Either the EMS or the ECU-MIDI requires set-up.	YES	YES

## One Time Messages

The following messages are one time messages. They are displayed as soon as the event happens and take priority over repetitive messages. The 'ACK' column indicates what happens when the "ACK" button is pressed while the message is displayed.

- REPET - The message becomes a repetitive message and any buzzer is silenced.
- CLEAR - The message is cleared and any buzzer is silenced.
- NONE - The "ACK" button has no effect on this message and any message cannot be silenced.

The 'Log' column indicates if there is any logging associated with the message. The 'Buzzer' column indicates if a buzzer is required or not.

Message	ACK	Log	Meaning	Buzzer
AIR FILTER	REPET	YES	The air filter is blocked.	YES
AUTO IDLE	CLEAR	YES	The auto idle feature has been activated.	NO
AUTO WARM	REPET	NO	The system is cold and has been put into its auto warm mode.	NO
BEACON ON	CLEAR	NO	The beacon has been turned on during a 'RUNNING' state.	NO
BEACON ON	CLEAR	NO	The beacon has been turned on during a 'KEY-ON' state.	YES
COOLNT TEMP	NONE	YES	The engine temperature is greater than 108°C and is overheating.	YES
EMER STOP	REPET	YES	The Emergency Stop feature is active and therefore no power is supplied to the ESOS output.	NO
HI AUX TEMP	NONE	NO	The high flow feature has been requested when the hydraulic oil is greater than or equal to 98°C	YES (1 sec)
HYD TEMP	NONE	YES	The engine temperature is greater than 108°C and is overheating.	YES
ISOLATOR	CLEAR	NO	The isolator button on the facia panel has been pressed and the system will inhibit hydraulic functions.	NO
LIMP MODE	NONE	NO	The system's redundancy switch has been turned on and has disabled the ECU-MIDI.	NO
LO AUX TEMP	NONE	NO	The high flow feature has been requested when the hydraulic oil is less than or equal to 0 °C (32 °F).	YES (1 sec)
LOW FUEL	REPET	NO	The fuel level is sitting at 3 or 4 bars.	YES (1 sec)
LOW FUEL	REPET	NO	The fuel level is sitting at 1 or 2 bars.	YES
LOW IDLE	REPET	YES	The one touch idle feature is active and will hold the engine at low idle.	NO
NO FUEL	REPET	YES	The fuel level is sitting at 0 bars on the bargraph.	YES
OVERLOAD	NONE	YES	The system is overloaded and notification is being given to the operator.	YES
OVERLOAD OF	CLEAR	NO	The overload caution feature has been turned off.	NO
OVERLOAD ON	CLEAR	NO	The overload caution feature has been turned on.	NO
PRE HEAT	REPET	NO	The engine is in a pre-heat mode.	NO
Q/H DISCON	NONE	NO	The quick hitch has been disconnected.	YES
Q/H DISCON?	CLEAR	NO	The quick hitch button has been pressed and the system is displaying this confirmation message.	NO
SERVICE RQD	CLEAR	YES	A new service interval has been reached. The vehicle should be taken for service.	NO
SLEW LOCK	CLEAR	NO	The slew lock button has been pressed, or the system has turned on the slew lock output.	NO
WIPER	CLEAR	NO	The wipers have been turned on continuously.	NO
WIPER INT	CLEAR	NO	The wipers have been put into intermittent mode.	NO

## Error Codes

The following table shows the error codes for this system. If an error code is active, the message will be display right away and a log will be entered by the ECU-MIDI. If the error is removed, the message will also clear.

If the "ACK" button is pressed to acknowledge the error, then the message will become a repetitive message. If more then one error is active, then the error messages should be entered into their own repetitive message queue until they are acknowledged.

Errors associated with optional features are disabled if the feature is not selected for the vehicle.

The errors are organised according to the type of error. Open circuit errors are given 1XX numbers. Short circuit errors are given 2XX numbers. System errors are given 3XX numbers. The XX number will depend on the function with the error.

**Example:** The Horn error number is 15. Therefore if the horn is open circuit the error number will be 115 and if the horn is short circuit the error number will be 215.

MESSAGE	ERR #	DESCRIPTION
101 CRANK	1	A crank signal was not seen by the ECU-MIDI.
102 ALT ERR	2	The alternator is reading high when the engine is off and is therefore open circuit.
103 OIL SW	3	The oil pressure switch is open circuit.
108 THR SOL	8	The throttle solenoid is open circuit as detected in the OFF condition.
109 SENS PT	9	The throttle sense pot is measuring a ground (<0.5?) and is therefore open circuit.
110 SET PT	10	The throttle set pot is measuring a ground and is therefore open circuit.
111 ESOS	11	The ESOS output is open circuit.
112 SERVO	12	The servo solenoid output is open circuit.
113 WIPER	13	The wiper output is open circuit.
114 WASHER	14	The washer output is open circuit.
115 HORN	15	The horn output is open circuit.
116 TRAVEL	16	The travel alarm output is open circuit.
117 SWG BRK	17	The slew brake output is open circuit.
118 SWG LCK	18	The swing lock output is open circuit.
119 TRAVEL	19	The travel speed output is open circuit.
120 FLOW F	20	The high flow F solenoid is open circuit.
121 FLOW LD	21	The high flow load solenoid is open circuit.
122 FLOW R	22	The high flow R solenoid is open circuit.
123 LOW TAB	23	The low flow TAB changeover solenoid is open circuit.
124 LH LT	24	The LH work lamps output is open circuit.
125 RH LT	25	The RH work lamps output is open circuit.
126 BOOM	26	The boom work lamps output is open circuit.
127 REAR LT	27	The rear work lamps output is open circuit.
128 FUEL	28	The fuel level is reading more than 200 Ohms and is therefore open circuit.
129 EN TEMP	29	The engine temperature input is open circuit.
130 HYD TMP	30	The engine temperature input is open circuit.
132 Q HITCH	32	The quick hitch output is open circuit.
133 REFUEL	33	The refuelling pump output is open circuit.
202 ALT ERR	2	The alternator output is shorted to ground.
208 THR SOL	8	The throttle solenoid is short circuit as detected in the ON condition.
209 SENS PT	9	The throttle sense pot is measuring 5V (>4.5?) and is therefore shorted to power.
210 SET PT	10	The throttle set pot is measuring 5V and is therefore shorted to power.
211 ESOS	11	The ESOS output is short circuit.
212 SERVO	12	The servo solenoid output is short circuit.
213 WIPER	13	The wiper output is short circuit.
214 WASHER	14	The washer output is short circuit.
215 HORN	15	The horn output is short circuit.
216 TRAVEL	16	The travel alarm output is short circuit.

**Error Codes (cont'd)**

MESSAGE	ERR #	DESCRIPTION
217 SWG BRK	17	The slew brake output is short circuit.
218 SWG LCK	18	The slew lock output is short circuit.
219 TRAVEL	19	The travel speed output is short circuit.
220 FLOW F	20	The high flow F solenoid is short circuit.
221 FLOW LD	21	The high flow load solenoid is short circuit.
222 FLOW R	22	The high flow R solenoid is short circuit.
223 LOW TAB	23	The low flow TAB changeover solenoid is short circuit.
224 LH LT	24	The LH work lamps output is short circuit.
225 RH LT	25	The RH work lamps output is short circuit.
226 BOOM	26	The boom work lamps output is short circuit.
227 REAR LT	27	The rear work lamps output is short circuit.
228 FUEL	28	The fuel level is reading less than 5 Ohms and is therefore short circuit.
229 EN TEMP	29	The engine temperature input is short circuit.
230 HYD TMP	30	The engine temperature input is short circuit.
231 AIR FIL	31	The air filter input is short circuit.
232 Q HITCH	32	The quick hitch output is short circuit.
233 REFUEL	33	The refuelling pump output is short circuit.
234 LIGHT	34	The courtesy light is short circuit.
304 CAL ERR	4	The max and min values for the dial pot are less than 100. Recalibrate.
305 CAL ERR	5	The max and min values for the sense pot are less than 20. Recalibrate.
306 THROTTLE	6	The requested throttle is greater than 10% away from idle and the sense pot is still at idle. (There is a 15 second delay on this error)
307 THROTTLE	7	The desired and actual throttle sense values have not matched for 20 seconds.

## Engine Throttle Control Calibration

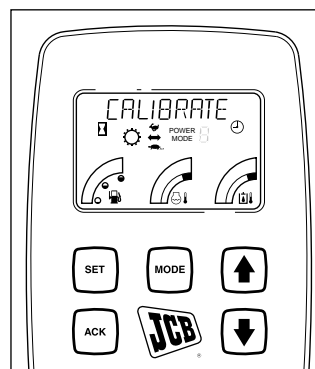
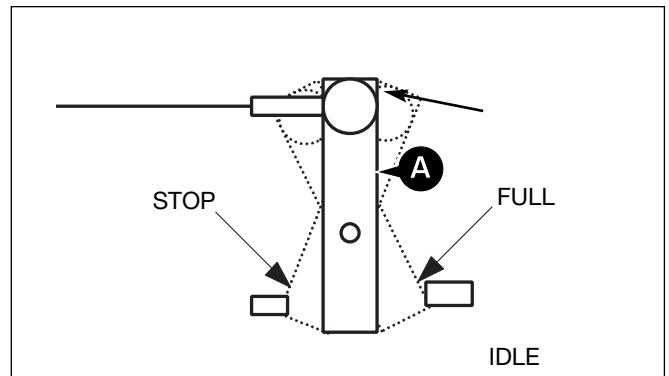
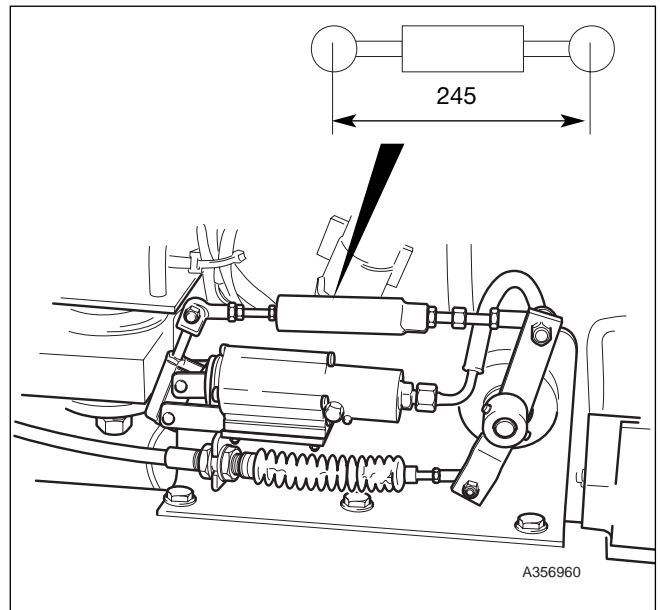
**Note:** Throttle calibration must be done whenever:

- A new ECU-MIDI is installed or replaced in a vehicle.
- The Throttle Sense Pot is replaced.
- Changes are made to the position of the Throttle Sense Pot, the throttle end-stops, or any of the mechanical linkages or hydraulic components of the engine throttle mechanism.

- 1 Assemble the throttle system ensuring the damper length is 245 mm.
- 2 Adjustment can be made on the throttle cable outer cable using the adjusters.
- 3 Start the engine, display engine speed on monitor. Press **SET & MODE** buttons together for 20 seconds then press arrow keys to select CALIBRATE on the EMS
- 4 Start engine, press **SET & MODE** buttons together for 20 seconds then press arrow keys until **CALIBRATE** is shown then press **ACK**.

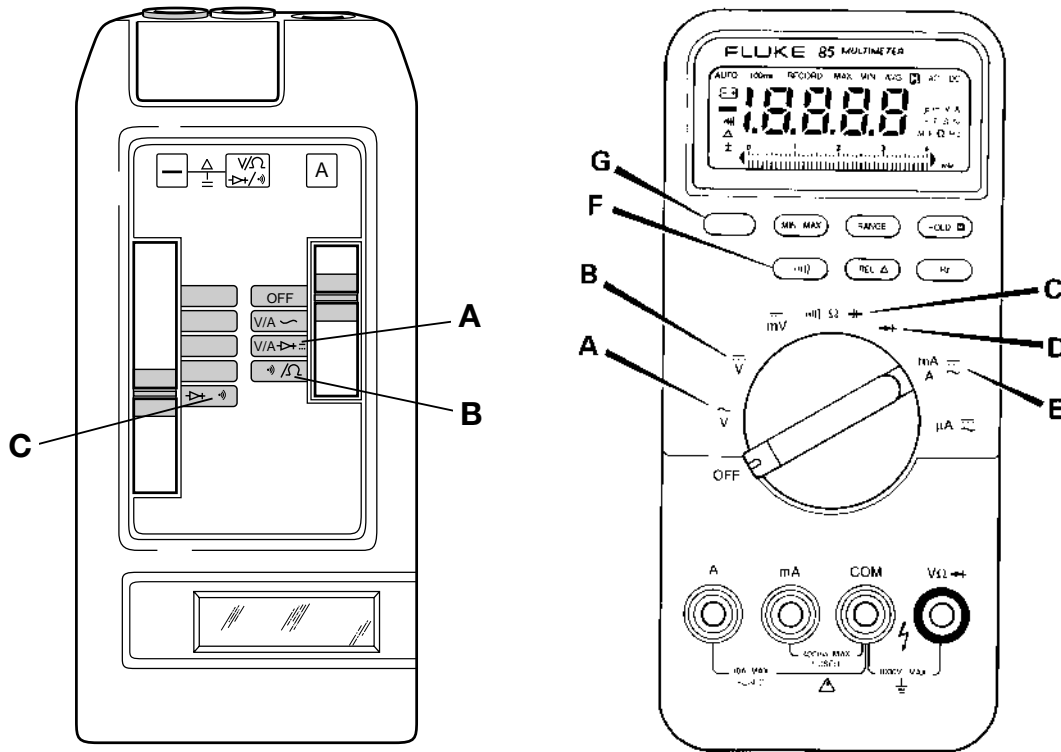
**Note:** The Throttle Set Pot (Throttle Dial) will be calibrated first followed by the Throttle Sense Pot (Throttle position sensor).

- 5 The monitor will display **TVOL MAX**, turn throttle dial to maximum then press **ACK**. The Message will be cleared and the value saved.
- 6 The monitor will display **TVOL MIN**, turn throttle dial to minimum then press **ACK**. The Message will be cleared and the value saved.
- 7 The monitor will display **TSEN**, the throttle cylinder will move to its minimum position, when movement has stopped, the value will then be stored by the ECU-MIDI. The throttle actuator will then be driven to it's maximum position, when movement has stopped the value will be stored on the ECU-MIDI.
- 8 The EMS will now exit the calibration mode and return to normal operation.
- 9 The Throttle will now be calibrated. If the system was not calibrated the EMS will display RECALIBRATE on power up and a warning buzzer will sound. Pressing ACK will silence the buzzer but the message will be displayed periodically until a calibration has been performed.



## Electrical Testing Methods - Using a Multimeter

These instructions are intended to cover the use of the recommended multimeters.



A171900

S153070

- 1 Make sure that the test leads are plugged into the correct sockets. The black test lead should be plugged into the black socket (sometimes, this socket is also marked by a "-", or "E" or marked as "COMMON" or "COM"). The red test lead should be plugged into the red socket marked with "+", "V" or "Ω".
- 2 When making measurements ensure that the test probes have a good clean contact with bare metal, free from grease, dirt, and corrosion as these can cause a false reading.
- 3 When measuring voltage:  
Make sure that the correct range is selected, that is set the selector to a value equal to or greater than that you are about to measure.

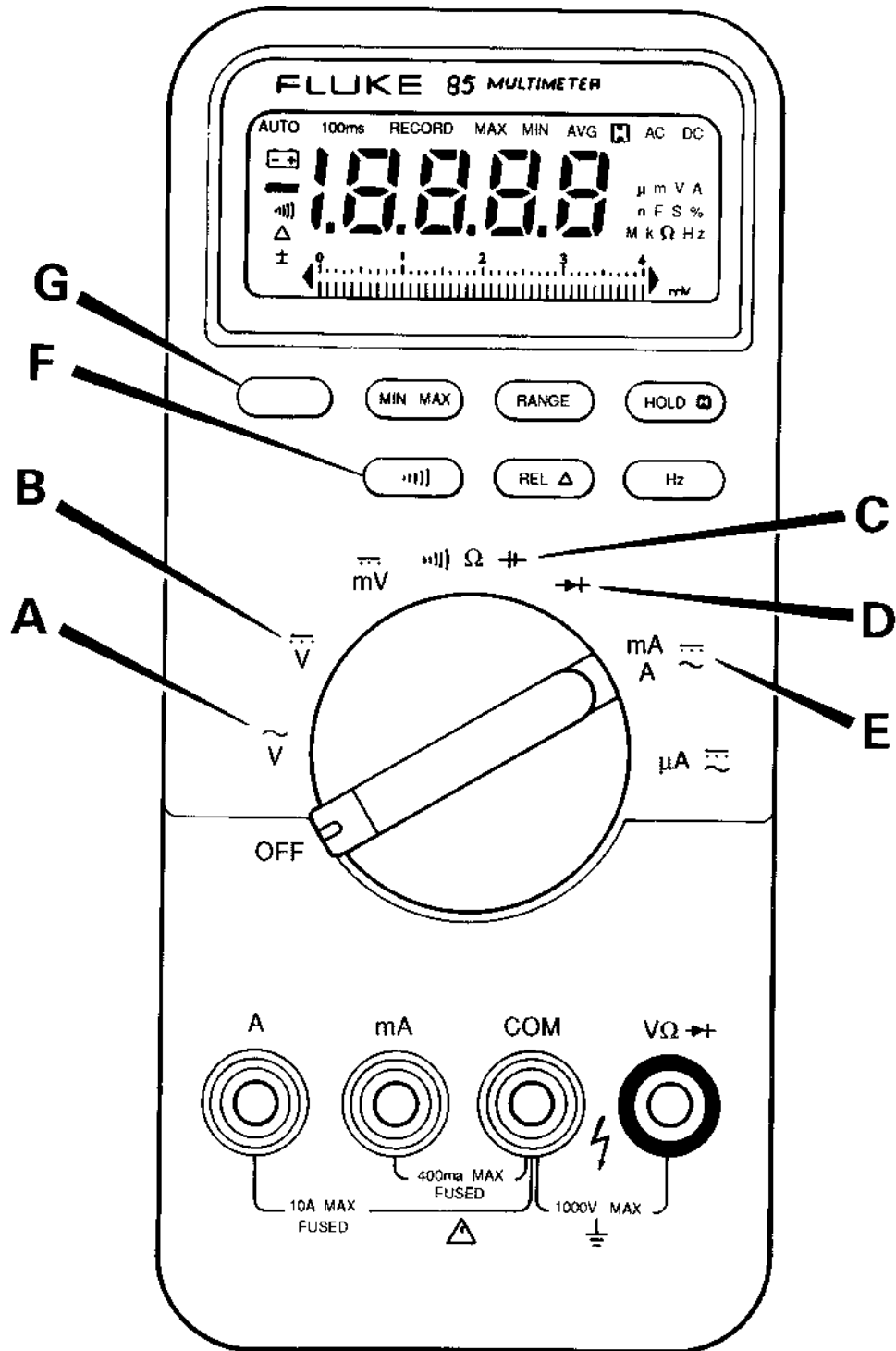
e.g. If asked to measure 12 Volts, set the selector to the 12V range. If there is no 12V range, set the selector to the next range higher, 20V for instance.

If the meter is set to a range that is too low, it may be damaged.

e.g. setting to the 2V range to measure 12V.



**Electrical Testing Methods**  
**- Using a Multimeter (cont'd)**



S153070

## Electrical Testing Methods - Using a Multimeter (cont'd)

### 1 Measuring DC Voltage

- a On the FLUKE 85  
Turn the switch to position **B**.
- \* b On the AVO 2003  
Move the right slider switch to position **A**, and the left hand slider switch to the appropriate range.
- c On an analogue meter  
Turn the dial to the appropriate DC Volts range.

Connect the black probe to the nearest available suitable earth point, usually this will be the starter motor earth, the battery negative, or the chassis. Connect the red probe to the wire or contact from which you are measuring the voltage.

### 2 Measuring Resistance

Make sure there is no power to the part of the circuit you are about to measure.

Connect one probe at one end of the component or wire to be checked and the other probe at the other end. It does not matter which way round the two probes are placed.

- a On the FLUKE 85  
Turn the switch to position **C** and check that the  $\Omega$  sign at the right hand side of the display window is on. If the **F** sign is on instead, press the blue button **G** to change the reading to  $\Omega$ .  
  
Touch the meter lead probes together and press the **REL** <sup>3</sup> key on the meter to eliminate the lead resistance from the meter reading.
- \* b On the AVO 2003  
Move the right hand slider switch to position **B**, and the left hand slider switch to the appropriate Ohms ( $\Omega$ ) range.
- c On an analogue meter  
Move the dial to the appropriate Ohms ( $\Omega$ ) range.

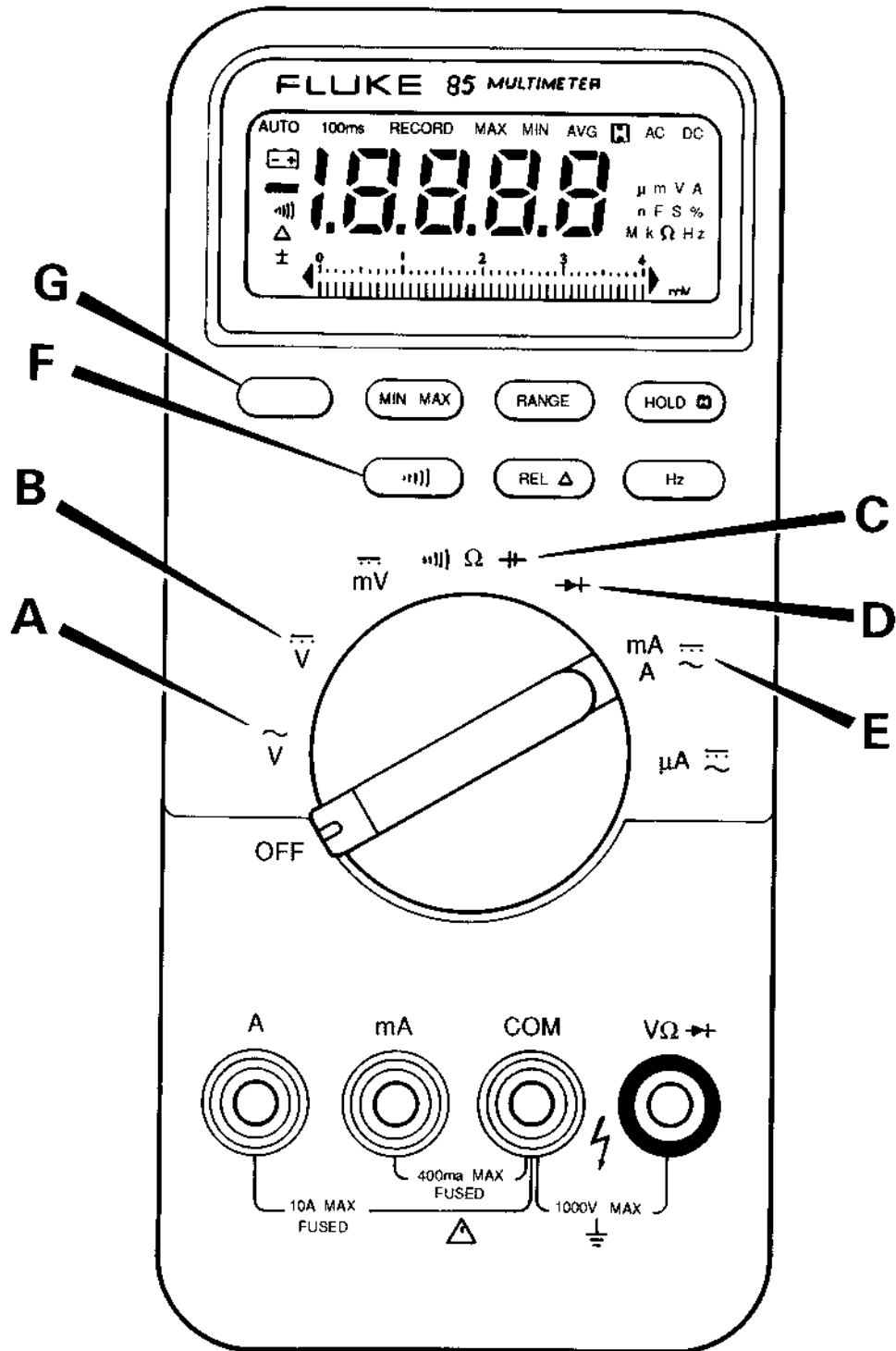
### 3 Measuring Continuity

Make sure there is no power to the part of the circuit you are checking for continuity.

Connect one probe to one end of the component or wire to be checked and the other probe to the other end. It does not matter which way round the two probes are placed.

- a On the FLUKE 85  
Turn the switch to position **C** and check that the beeper symbol appears at the left hand side of the display window. If the **F** sign is on instead, press the button labelled **F** in the meter drawing.  
  
If there is continuity in the circuit, the beeper will sound. If there is no continuity (open circuit), the beeper will not sound.
- \* b On the AVO 2003  
Move the right hand slider switch to position **B**, and the left hand slider switch to position **C**.  
  
If there is continuity (i.e. very low resistance) between two points the buzzer will sound.
- c On an analogue meter  
Turn the dial to the lowest Ohms ( $\Omega$ ) range.  
  
If there is continuity (i.e. very low resistance) between two points the needle will move across fully (or almost fully) to the right hand side of the scale.

**Electrical Testing Methods**  
**- Using a Multimeter (cont'd)**



## Electrical Testing Methods - Using a Multimeter (cont'd)

### 4 Testing a Diode or a Diode Wire

A diode wire is a diode with male connector fitted on one end and a female connector fitted on the other end. The diode is sealed in heatshrink sleeving.

- a On the FLUKE 85  
Turn the switch to position **D**.

Press the **HOLD** button and check that the **H** sign appears at the top right hand side of the display window.

Connect the black probe to the end of the diode with a band or to the male connector of the diode wire. Connect the red probe to the other end of the diode or diode wire. If the beeper does not sound the diode or diode wire is faulty.

Connect the red probe to the end of the diode marked with a band, or to the male connector of the diode wire, the black probe should be connected to the other end of the diode or diode wire. If the beeper sounds or the meter does not read **O.L.**, the diode or diode wire is faulty.

Press the **HOLD** button and check that the **H** sign disappears from the right hand side of the display window.

- \* b On the AVO 2003  
Move the right hand slider to position **A**, and the left hand slider switch to position **C**.

Connect the black probe to the end of the diode marked with a band, or to the male connector of the diode wire, the red probe should be connected to the other end of the diode or diode wire. If the Avometer does not buzz the diode is faulty.

Connect the red probe to the end of the diode marked with a band, or to the male connector of the diode wire, the black probe should be connected to the other end of the diode or diode wire. If the Avometer does not read "1" the diode is faulty.

- c On an analogue meter  
Select the Ohms 1000s (1k) range.  
Connect the black probe to the end of the diode marked with a band, or to the male connector of the diode wire, the red probe should be connected to the other end of the diode or diode wire. The meter should read 20-400 K $\Omega$ , if it reads more than this the diode is faulty.

Select the Ohms 100s range.

Connect the red probe to the end of the diode marked with a band, or to the male connector of the diode wire, the black probe should be connected to the other end of the diode or diode wire. The meter should read 300-400 $\Omega$ , if it reads less than this the diode is faulty.

### Testing of ECU Inputs + Outputs

Remove panel behind drivers seat, for access to the ECU-MIDI **A**.

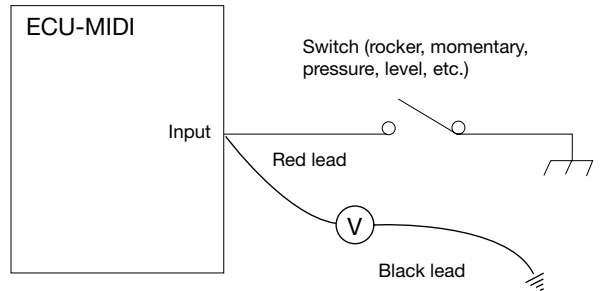
Care should be taken when testing the inputs + outputs of the ECU-MIDI to ensure that correct test method is used to determine if the ECU-MIDI is functioning normally.

**Note:** Inputs/outputs should be checked with engine running or in solenoid override mode

#### Testing low side input

With the switch open the meter will read approximately 5V.

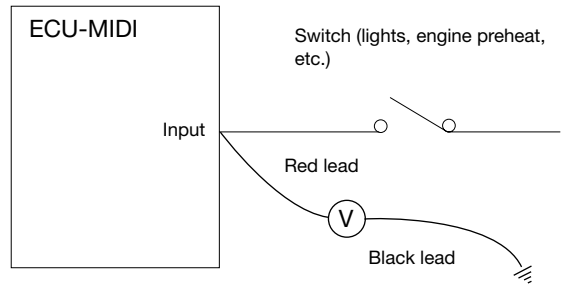
With the switch closed the meter will read 0V.



#### Testing High side input

With the switch open the meter will read 0 V.

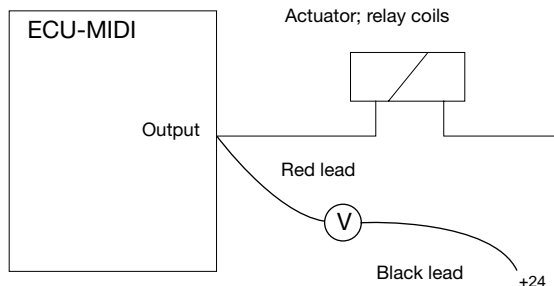
With the switch closed the meter will read 12-15 V.



#### Testing low side output

With the output off the meter will read 0v.

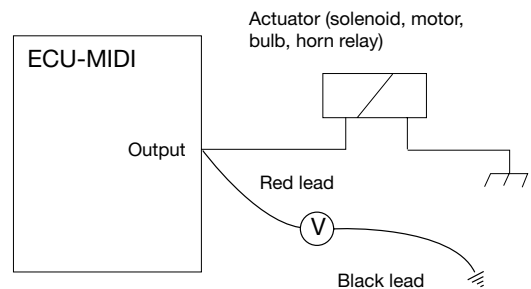
With the output on the meter will read 12-15 V.



#### Testing high side output

With the output off the meter will read 0 V.

With the output on the meter will read 12-15 V.



## Testing of ECU Inputs + Outputs (cont'd)

### Testing High Side Outputs (cont'd)

The ECU-MIDI is internally configured to give short circuit protection and detection of short circuit/open circuit, this is done by internal resistors. This internal configuration can give some confusing results when testing the outputs on the ECU-MIDI.

#### Voltage at point A:

Solenoid connected output off = 0.1 V approx.

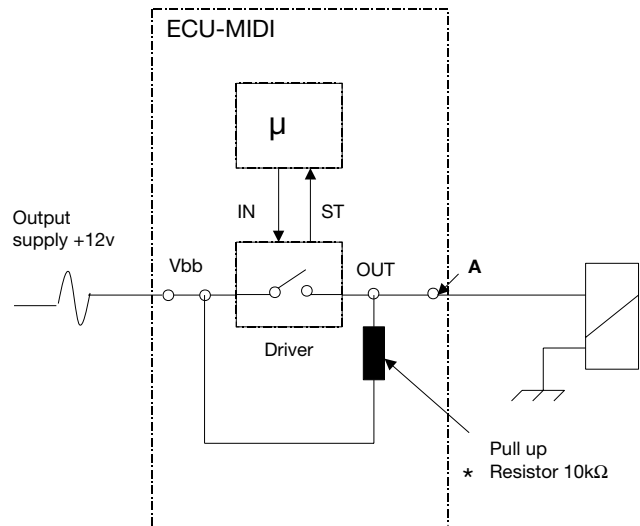
Solenoid connected output on = battery voltages nominal.

Solenoid disconnected output off = reduced voltage (12 - 15 V).

Solenoid disconnected output on = battery voltage nominal.

Shorted to ground = 0 V.

Shorted high (to positive) = battery voltage.



## Wiring Harness

### Introduction

Instances do occur where it is necessary to incorporate auxiliary electrical components into existing electrical circuits and, although unlikely with present wiring harnesses, repair or replace specific individual wires within a harness. This will also apply to other machines in addition to those of JCB manufacture.

To ensure that either the inclusion of an auxiliary electrical component or a repair within a harness is completed to an acceptable standard it is strongly recommended that the following tools, equipment and procedures are always used. Note that JCB harnesses have an International Protection rating of 67 (I.P.67).

The sheath covering of the recommended splice is heat shrunk onto the original wire insulation. This results in a seal and corresponding joint to IP 67 specifications.

### **⚠ CAUTION**

**When installing Auxiliary Electrical Components always ensure that the additional load rating is suitable for that particular circuit. It is unacceptable to simply increase the fuse rating as this can cause overloading and consequential failure of wiring, along with failure of integral circuit components, which the fuse is protecting.**

ELEC 2 - 1

### **⚠ WARNING**

**In addition to the warnings incorporated into the procedure, extreme care should be taken when handling the gas heating tool to ensure that the flame does not damage or set fire to any items in the vicinity of the repair, i.e. other wires, floor panels, floor mats, sound proofing, paintwork. etc. This tool should not be used in any restricted location prohibiting the use of 'Naked Flames' or where risk of explosive gas or similar safety parameters apply. No other heat source should be used to attempt a sealed joint .**

ELEC 2 - 2

### **⚠ CAUTION**

**When the heater is in use, the reflector and the air coming out are extremely hot. Keep away to avoid accidental burns. Do not touch the reflector until it has had time to cool down after switching off. If flame reappears at the reflector when the heater is in use, the catalytic element is damaged or used up. Stop work immediately and replace the heater.**

ELEC 2-3

### Tools Required

892/00350	Butane Heater assembly	1
892/00349	Crimp tool	1
892/00351	Splice 0.5-1.5 mm (Red)	50
892/00352	Splice 1.5-2.5 mm (Blue)	50
892/00353	Splice 3.0-6.0 mm (Yellow)	50

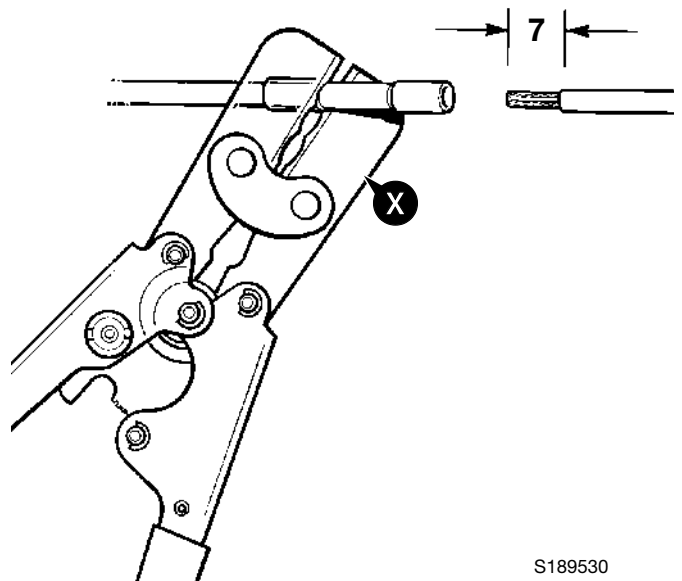
### Repair Procedure

- 1 Cut the wire and remove the protective insulation for a suitable distance dependent upon the size of wire and splice to be used. For the splices detailed above, the dimension is 7mm.
- 2 Using the correct sized splice, attach the new section of wire required or auxiliary flying lead to the existing harness and secure using the crimp tool **X**, part number 892/00349.

Note that each of the splices detailed is colour-coded to make size and range readily visible. They are secured using the corresponding size and matching colour-coded jaws of the crimp tool to ensure joint security. This tool also incorporates a ratchet closing mechanism which will not release until the splice is fully closed to the correct compression size.

- 3 With the Butane heater assembly, 892/00350, seal the connection using the procedure on the next page.

....continued

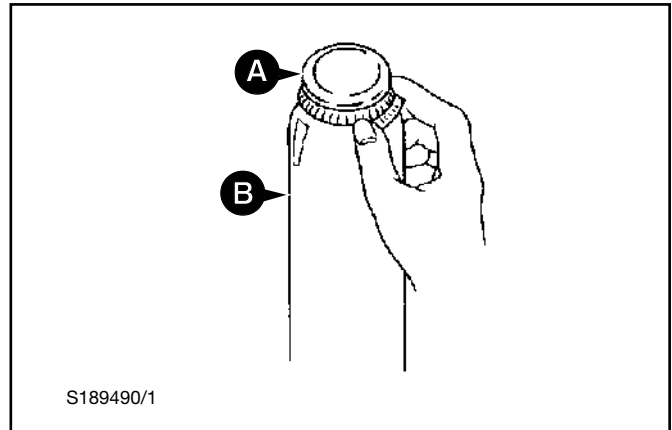


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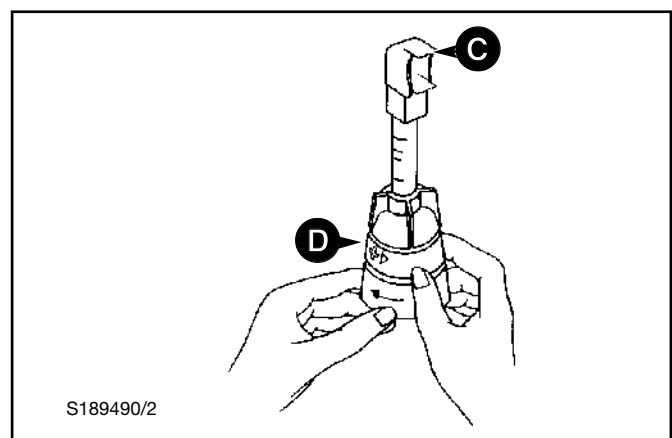
**Wiring Harness - Repair Procedure (cont'd)**

With the Butane Heater assembly 892/00350, seal the connection using the following procedure.

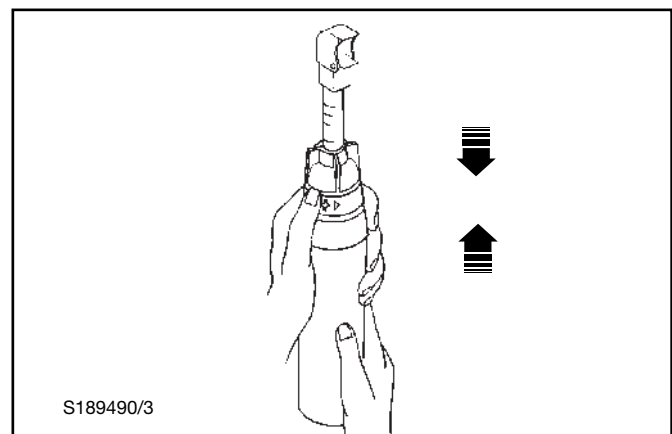
- a Remove the cap **A** from the end of the disposable gas cartridge **B**.



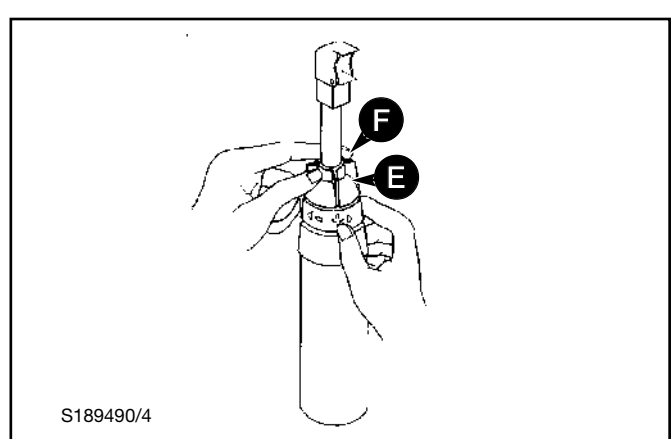
- b Before assembling the gas cartridge to the reflector element **C**, turn the red ring **D** to the left, (in the direction of the minus sign marked on the ring).



- c Position the tube hanging down from inside the reflector assembly into the hole at the top of the gas cartridge. Then press the gas cartridge up into the reflector assembly as far as possible until the two elements are clasped firmly together. A click will be heard.



- d Turn the small ring **E** so that the air holes at **F** are completely closed.

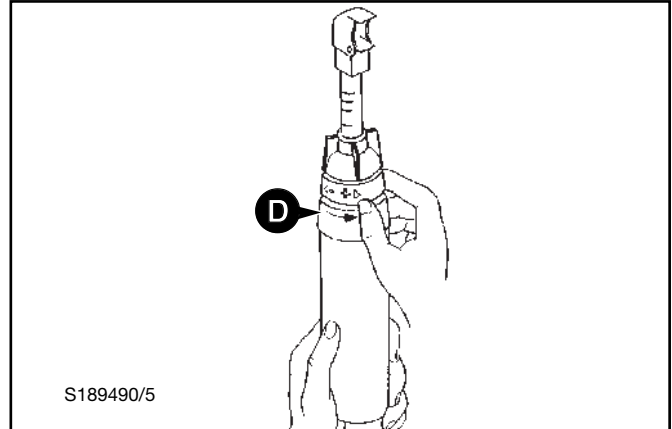




### Wiring Harness - Repair Procedure (cont'd)

- e Turn the red ring **D** to the right (in the direction of the plus sign) in order to turn on the gas.

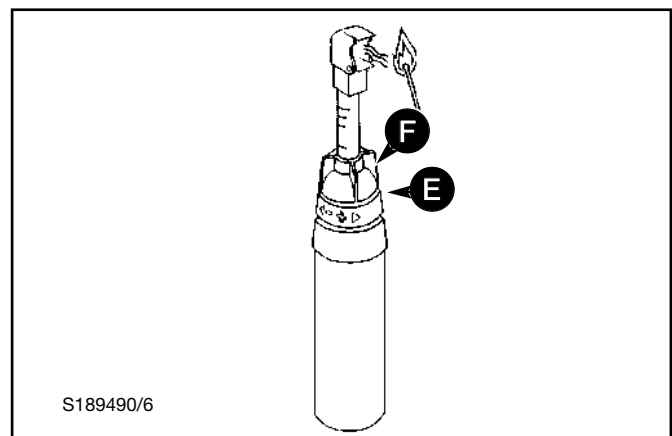
**IMPORTANT:** Before turning the heater on, make sure that the cartridge is not hotter than the reflector element. This may occur if the cartridge is held in the hand for a long time. The temperature difference between the cartridge and the reflector element may cause long yellow flames to appear on ignition.



- f Hold the heater vertically and, using a match or cigarette lighter, light the gas as shown.

**Note:** The fact that the sound of liquid cannot be heard when the cartridge is shaken does not mean it is empty. No sound will be heard even when the cartridge is full.

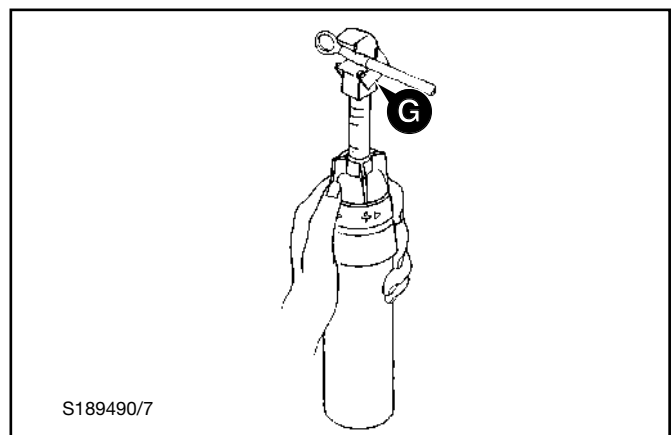
Hold the heater vertically for 1 to 2 minutes until the catalytic reaction occurs. This is indicated when the blue flame fades and the ceramic element glows red. Then turn the small ring **E** until the air holes at **F** are completely open. The tool is ready for use.



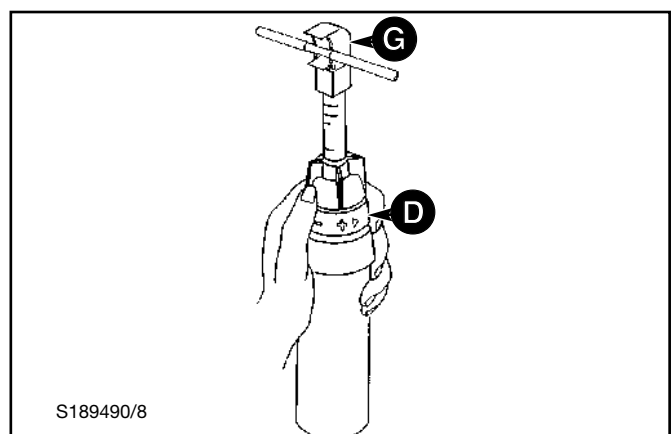
The heater can be used in two modes:

- g Side wings **G** down, reflector head completely open. In this mode the infra-red heat waves are dominant (recommended for the light coloured plastic splices).

Side wings **G** up (see fig at step h), reflector head opening reduced. In this mode the heating is done only by the hot gas (use for dark coloured plastic splices).



- h To switch off the heater, turn the red ring **D** to the left (in the direction of the minus sign).



## Battery

### Maintenance

To ensure that the battery provides optimum performance the following steps should be observed:

- 1 Make sure that the electrical connections are clean and tight. Smear petroleum jelly on connectors to prevent corrosion.
- 2 When applicable - never allow the electrolyte level to fall below the recommended level - 6 mm (1/4 in) above the plates. Use only distilled water for topping up.
- 3 Keep the battery at least three quarters charged, otherwise the plates may become sulphated (hardened) - this condition makes recharging the battery very difficult.

Extra precautions must be taken when bench charging maintenance free batteries, they are more prone to damage by overcharging than the standard type of battery:

- NEVER boost-charge a maintenance free battery.
- NEVER charge a maintenance free battery at a voltage in excess of 15.8 Volts.
- NEVER continue to charge a maintenance free battery after it begins to gas.

### Safety

#### **WARNING**

Batteries give off an explosive gas. Do not smoke when handling or working on the battery. Keep the battery away from sparks and flames.

Battery electrolyte contains sulphuric acid. It can burn you if it touches your skin or eyes. Wear goggles. Handle the battery carefully to prevent spillage. Keep metallic items (watches, rings, zips etc) away from the battery terminals. Such items could short the terminals and burn you.

Set all switches in the cab to OFF before disconnecting and connecting the battery. When disconnecting the battery, take off the earth (-) lead first.

When reconnecting, fit the positive (+) lead first.

Re-charge the battery away from the machine, in a well ventilated area. Switch the charging circuit off before connecting or disconnecting the battery. When you have installed the battery in the machine, wait five minutes before connecting it up.

### First Aid - Electrolyte

Do the following if electrolyte:

#### **GETS INTO YOUR EYES**

Immediately flush with water for 15 minutes, always get medical help.

#### **IS SWALLOWED**

Do not induce vomiting. Drink large quantities of water or milk. Then drink milk of magnesia, beaten egg or vegetable oil. Get medical help.

#### **GETS ONTO YOUR SKIN**

Flush with water, remove affected clothing. Cover burns with a sterile dressing then get medical help.

5-3-4-3/1

**Battery (cont'd)**

**Testing**

This test is to determine the electrical condition of the battery and to give an indication of the remaining useful 'life'.

Before testing ensure that the battery is at least 75% charged (SG of 1.23 to 1.25 for ambient temperature up to 27 °C (80 °F).

Ensure that the battery is completely disconnected from the vehicle.

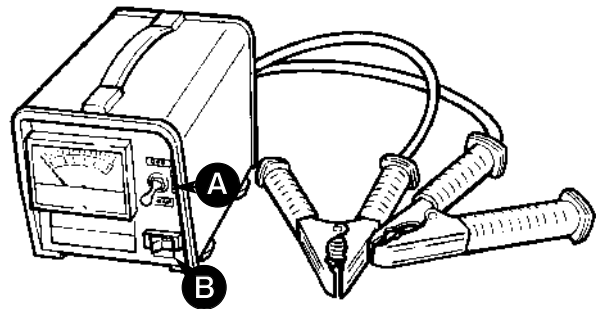
Connect up the battery tester (part no. 993/85700) as follows:

- 1 Set the CHECK/LOAD switch **A** to OFF.
- 2 Set rocker switch **B** to the battery voltage (12V).
- 3 Connect the red flying lead to the battery positive (+) terminal and the black flying lead to the battery negative (-) terminal.
- 4 Set the CHECK/LOAD switch **A** to CHECK to read the battery no-load voltage which should be at least 12.4 volts.

- 5 Set the CHECK/LOAD switch **A** to LOAD and hold down for 5 - 10 seconds until the meter reading stabilises. The reading should be at least 9 volts.

**Note:** Do not hold the switch in the LOAD position for more than 10 seconds.

- 6 If the foregoing tests are unsatisfactory, consult Fault Diagnosis below.



239510

**Fault Diagnosis**

Battery Tester Readings	Remedy
1 CHECK: 0 - 12.6 Volts LOAD: less than 6 Volts	Renew battery
2 CHECK: 6 - 12.4 Volts LOAD: less than 9 Volts and falls steadily but remains in yellow zone.	Recharge and re-test. If tests still unsatisfactory renew battery.
3 CHECK: less than 10 Volts LOAD: less than 3 Volts	Indicates battery has been over-discharged and unlikely to recover. Renew battery.
4 CHECK: more than 11 Volts LOAD: 6 - 10 Volts steady	Charge battery which will probably recover.

**Specific Gravity Testing**

The specific gravity of the electrolyte gives an idea of the state of charge of the battery. Readings should be taken using a hydrometer, when the electrolyte temperature is 15 °C (60 °F). If the battery has recently been on charge, wait approximately one hour (or slightly discharge the battery) to dissipate the surface charge before testing.

Readings should be as tabulated and should not vary between cells by more than 0.04. A greater variation indicates an internal fault on that particular cell.

If the electrolyte temperature is other than 15 °C (60 °F) a 'correction factor' must be applied to the reading obtained. Add 0.07 per 10 °C (18 °F) if the temperature is higher than 15 °C (60 °F) and subtract the same if the temperature is lower.

Specific Gravity at 15 °C (60 °F)	Fully Charged	Half Discharged	Fully Discharged
Ambient temperature up to 27 °C (80 °F)	1.270 - 1.290	1.190 - 1.210	1.110 - 1.130
Ambient temperature above 27 °C (80 °F)	1.240 - 1.260	1.170 - 1.190	1.090 - 1.110

## Alternator

### General

The alternator is a three phase generator having a rotating field winding and static power windings.

When the ignition is turned on, current from the battery flows by way of the "No Charge" warning light to the field winding. This creates a magnetic field which supplements the residual magnetism in the rotor poles. As the engine is started, the fan belt drives the rotor and alternating current is generated in the power windings as they are cut by the rotating magnetic field. Output is controlled by a solid state regulator which varies the field current in accordance with electrical demand.

### Service Precautions

- 1 Ensure that the battery negative terminal is connected to the earthing cable.
- 2 Never make or break connections to the battery or alternator, or any part of the charging circuit whilst the engine is running. Disregarding this instruction will result in damage to the regulator or rectifying diodes.
- 3 Main output cables are 'Live' even when the engine is not running. Take care not to earth connectors in the moulded plug if it is removed from the alternator.
- 4 During arc welding on the machine, protect the alternator by removing the alternator connections.
- 5 If slave starting is necessary, connect the second battery in parallel without disconnecting the machine battery from the charging circuit. The slave battery may then be safely removed after a start has been obtained. Take care to connect batteries positive to positive, negative to negative.

### Charging Test

If the battery is in a fully charged condition, switch on the working lights for approximately 3 minutes before commencing the charging test. Alternatively, operate the ignition for a few moments with the ESOS fuse removed.

Install a 100 amp open - type shunt between the battery and the positive lead terminal.

Connect a multimeter positive lead to the machine side of the shunt and the negative lead to the battery side of the shunt. Connect the leads to the meter and set the meter to the relevant range as follows:

#### AVO 2002

Red lead to volts (middle) socket on meter.  
Black lead to negative on meter.  
Right hand slider to DC voltage.  
Left hand slider as shown at A.

#### AVO 2003

Red lead to Amps (marked A) on the meter.  
Black lead to negative on meter,  
Right Hand slider to DC voltage.  
Left Hand slider to 200 Ohms shunt.

Start the engine and run at a maximum speed. The meter should show a maximum alternator output in Amps.

**Note:** The meter reading should be taken as soon as possible after starting the engine, as the charging current rapidly falls.

A zero reading indicates failure of the alternator and may be caused by one of the following conditions. These are listed in order of probability.

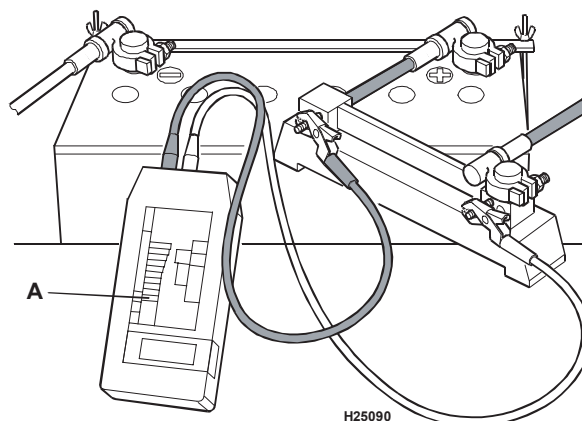
- 1 Defective suppression capacitor.
- 2 Dirty slip rings or worn brushes.
- 3 Defective regulator.
- 4 Defective rectifier.
- 5 Open or short circuited field (rotor) windings.
- 6 Open or short circuited power (stator) windings.

To check for fault 1, disconnect the capacitor and repeat the charging test. Renew the capacitor as necessary.

To check for faults 2 and 3, remove the regulator and brush box assembly. Check the condition of the brushes and, if necessary, clean the slip rings using extra-fine glasspaper.

The regulator may only be checked by substitution.

Faults on 4, 5 and 6 may be checked only by removing and dismantling the alternator for further testing.



**Starter Motor**

**Starting Circuit Test**

Before carrying out the voltmeter tests, check the battery condition (see **Battery Testing**) and ensure that all connections are clean and tight.

To prevent the engine starting during the tests ensure that the engine stop fuse is removed, (refer to **Fuse Identification** page).

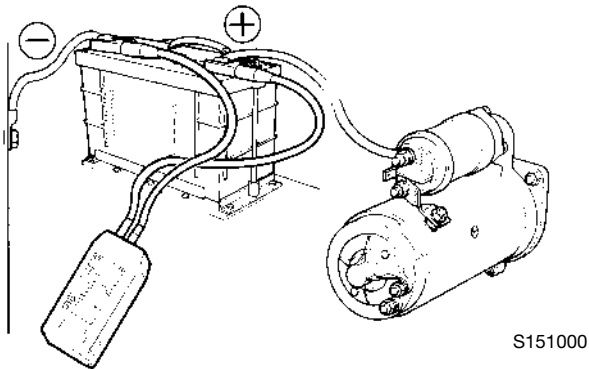
Check the readings in the following sequence using a voltmeter. Unless otherwise stated, the readings must be taken with the starter switch held in the 'start' position ('HS') and the transmission forward/reverse selector in neutral.

**Note:** Do not operate the starter motor for more than 20 seconds at one time. Let the starter motor cool for at least two minutes between starts.

**Test 1**

Connect the voltmeter across the battery terminals. Reading in 'start' position: 10.0V approximately. Minimum permissible reading in 'start' position 9.5V.

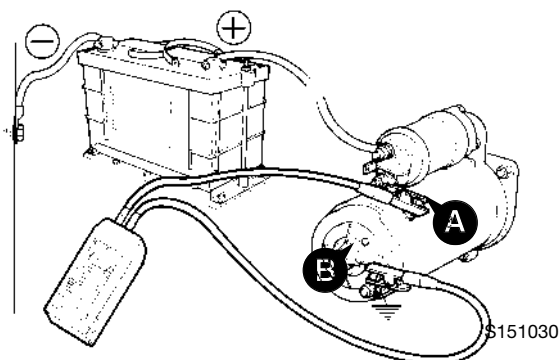
A low reading probably indicates a fault in the starter motor.



**Test 2**

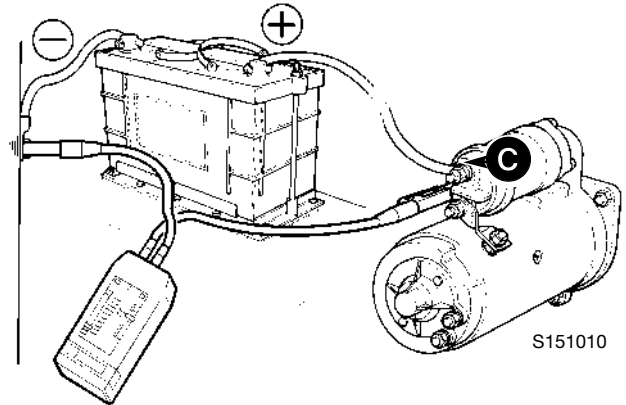
Connect the voltmeter between the starter main terminal **A** and the commutator end bracket **B**. In the 'start' position, the reading should not be more than 0.5V below the reading obtained in Test 1. Minimum permissible reading in 'start' position 9.0V.

If the reading is within this limit, continue to Test 3. If the reading is outside the limit, proceed to Tests 4 and 5.



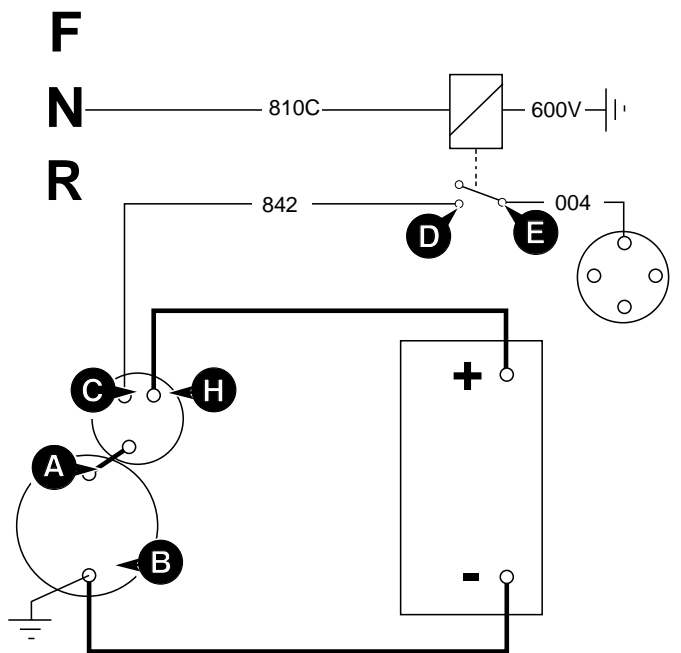
**Test 3**

Connect the voltmeter between the solenoid terminal **C** and a good earth. Minimum permissible reading in 'start' position: 8.0V.



**Test 3a**

If the reading is less than specified, connect the voltmeter between the neutral start relay terminal **D** and earth. An increase in reading to 8.0V indicates a fault in the wiring from the start relay to the solenoid.



## Starter Motor (cont'd)

### Starting Circuit Test (cont'd)

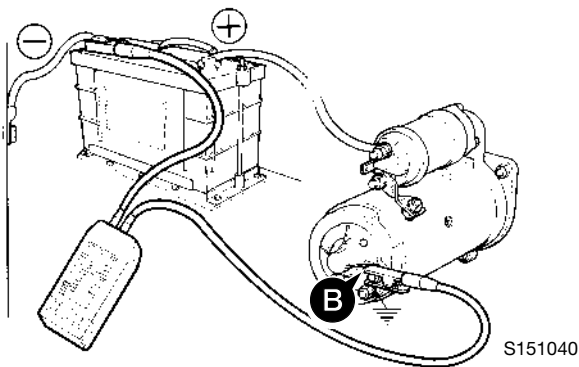
#### Test 3b

If the reading between terminal **D** and earth is below 8.0V, connect the voltmeter between terminal **E** and earth. An increase in the reading to 8.0V indicates either a faulty start relay or a fault in the feed from the transmission selector switch to the relay solenoid. Check also the solenoid earth connection.

If the reading between **E** and earth is less than 8.0V, the fault must be in either the starter switch or in the wiring between the solenoid, starter switch, and the start relay.

#### Test 4

Connect the voltmeter between battery negative and starter earth connection **B**. The reading in the 'start' position should be practically zero, maximum permissible reading 0.25V.

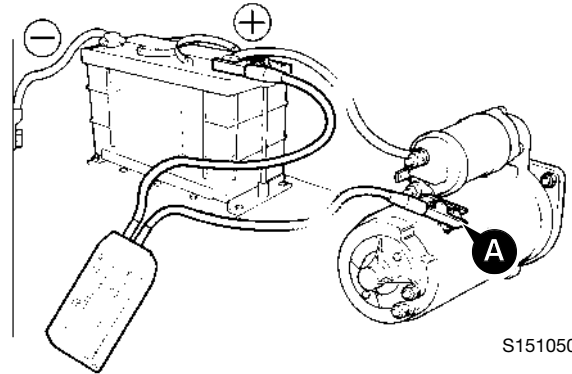


S151040

If the reading is above 0.25V, a high resistance in the earth lead or connections is indicated.

#### Test 5

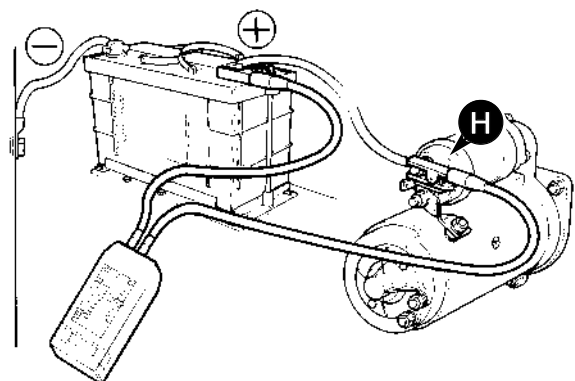
Connect the voltmeter between battery positive and the starter main terminal **A**. With the starter switch 'off', the voltmeter should indicate battery voltage, but it should fall to practically zero when the switch is turned to the 'on' position, maximum permissible reading 0.25V.



S151050

#### Test 5a

If the reading is above 0.25V, a high resistance is present in the insulated lead or in the solenoid. Connect the voltmeter between the battery positive and solenoid connection **H**. If the voltmeter now reads zero with the switch closed, the fault is in the solenoid.



Finally refit the engine stop fuse.

## Alternator

### Removing and Replacement

#### Removal

- 1 Park the machine on firm level ground and remove the starter key.
- 2 Raise and support the engine cover. Disconnect the battery.

#### **⚠ WARNING**

##### **Battery Terminals**

The machine is negatively earthed. Always connect the negative pole of the battery to earth.

When connecting the battery, connect the earth (-) lead last.

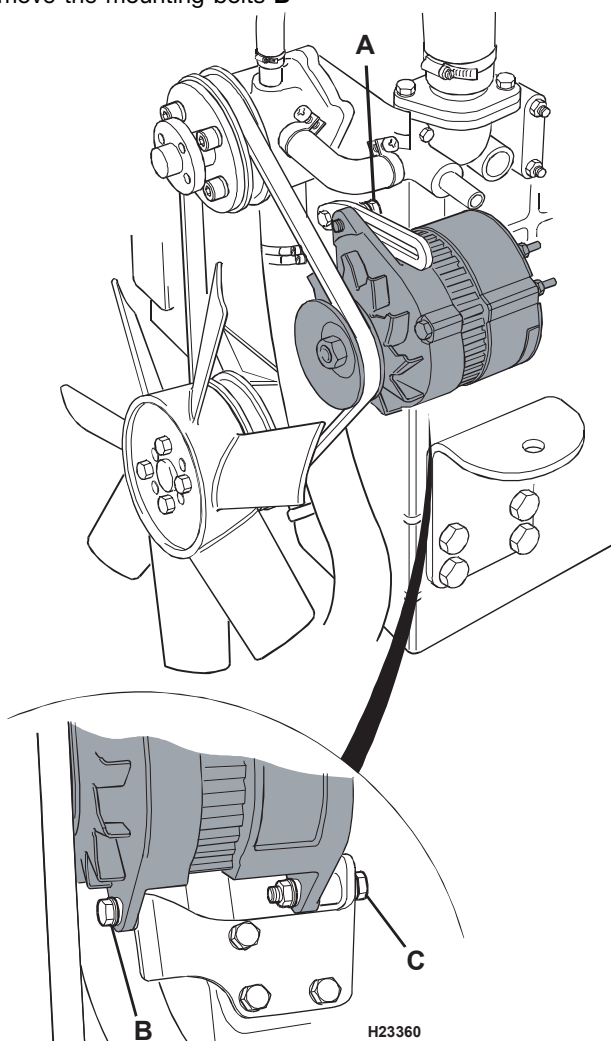
When disconnecting the battery, disconnect the earth (-) lead first.

INT-3-1-9

- 3 Disconnect the electrical connections.
- 4 Support the alternator and remove the mounting bolts **B** and **C**.
- 5 Remove the adjusting bolt **A**.
- 6 Remove the alternator.

#### Replacement

- 1 Put the alternator in position and align with the fan belt.
- 2 Fit the mounting bolts **B** & **C** and the adjusting bolt **A**.
- 3 Adjust the fan belt tension and tighten the mountings in the following order:
  - a Adjusting bolt **A**.
  - b Drive End Mounts **B**.
  - c Slip Ring End Sliding Bush **C**.
- 4 Reconnect the electrical connections.
- 5 Reconnect the battery. Connect the earth lead last.
- 6 Close the engine cover.



## Removal and Replacement

### Removal

- 1 Park the machine on firm level ground and remove the starter key.
- 2 Raise and support the engine cover. Disconnect the battery.

### **⚠ WARNING**

#### **Battery Terminals**

**The machine is negatively earthed. Always connect the negative pole of the battery to earth.**

**When connecting the battery, connect the earth (-) lead last.**

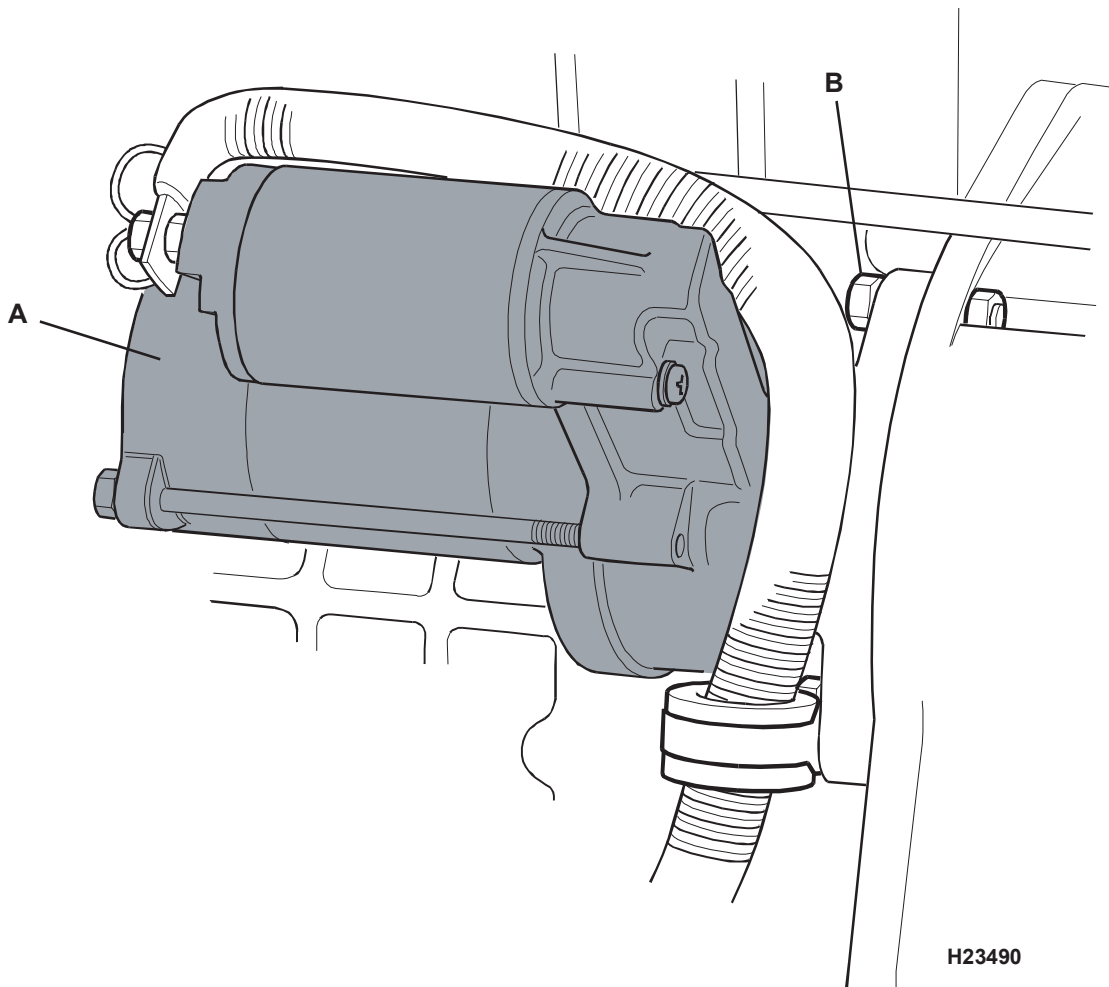
**When disconnecting the battery, disconnect the earth (-) lead first.**

INT-3-1-9

- 3 Disconnect the starter electrical connections.
- 4 Support the starter motor **A**, loosen and remove the securing bolts **B**.
- 5 Disengage the pinion from the flywheel gear teeth and remove the starter motor.

### Replacement

- 1 Put the starter motor in position and align the pinion in the flywheel gear teeth.
- 2 Fit and tighten the securing bolts **B**.
- 3 Connect the electrical connections.
- 4 Connect the battery terminals. Connect the earth terminal last.
- 5 Close the engine cover.



H23490



### Mounting

The rotating beacon relies on the force of a magnet to hold it in position on the machine. A cable and plug from the beacon fits into a socket located on the R.H. pod in the cab of the machine. The panel can be wired to provide a beacon operating switch and warning light.

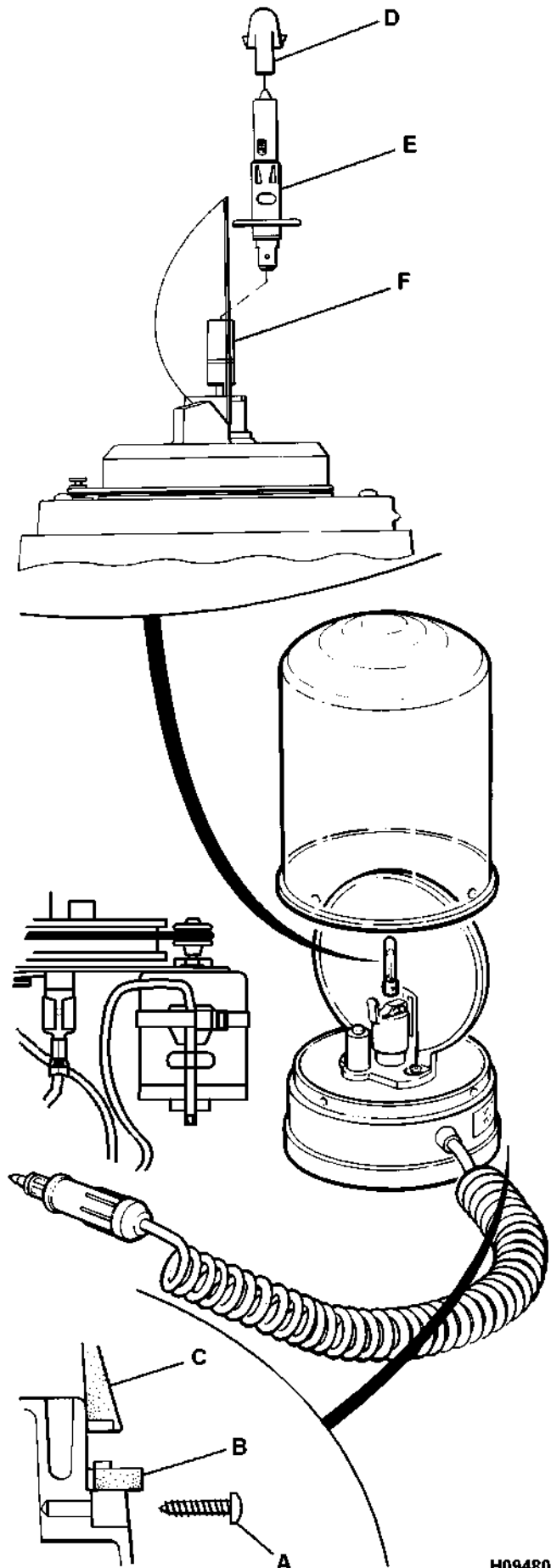
The intended beacon mounting position must be flat, clean and dry. When mounted, particularly ensure beacon positioning conforms to the following:

- Is in accordance with National and local legal requirements.
- The light is visible from any point at a reasonable distance from the machine.
- Beacon base parallel to the ground and on the machine longitudinal centre line.
- If radio equipment is fitted to the machine, there should be a minimum distance of 500 mm (20 in) between the beacon and the radio antenna.

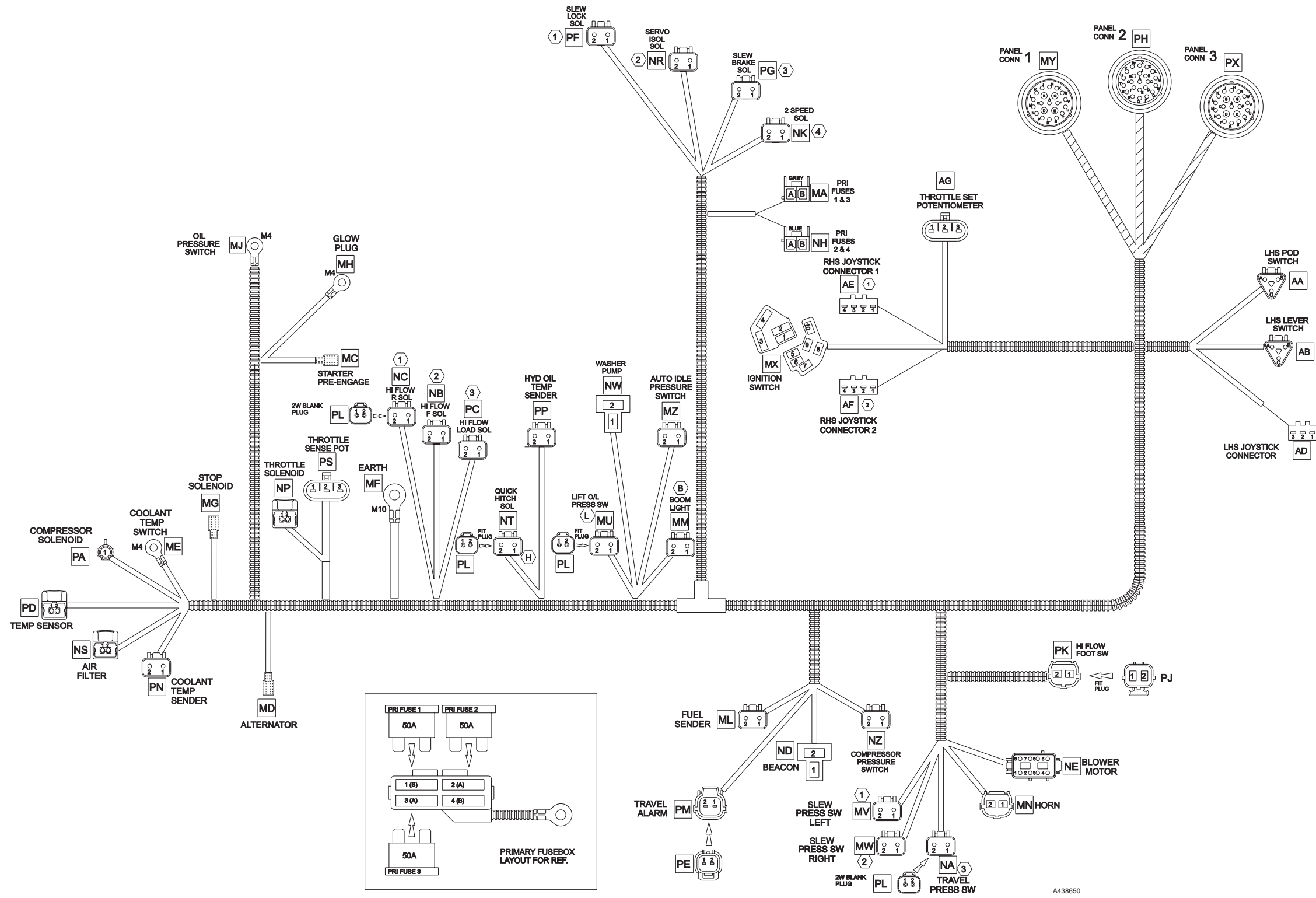
### Bulb Change

- 1 Remove the lens latch locking screw **A**.
- 2 Push down the lens latch **B**. Turn lens **C** anti-clockwise to release and remove it.
- 3 Taking care not to touch the bulb glass, release the bulb retaining clip **D** and lift bulb **E** and attached clip from the connector **F**. Disconnect bulb **E**.
- 4 Remove the unserviceable bulb from clip **D**.
- 5 Fit a new bulb and assemble the beacon in reverse order of dismantling. Do not tighten the lens latch locking screw **A** to more than 0.65 Nm (5.75 lbf in.).

**Note:** Ensure the drive motor is fitted with the red pulley for correct operation on 12V systems.

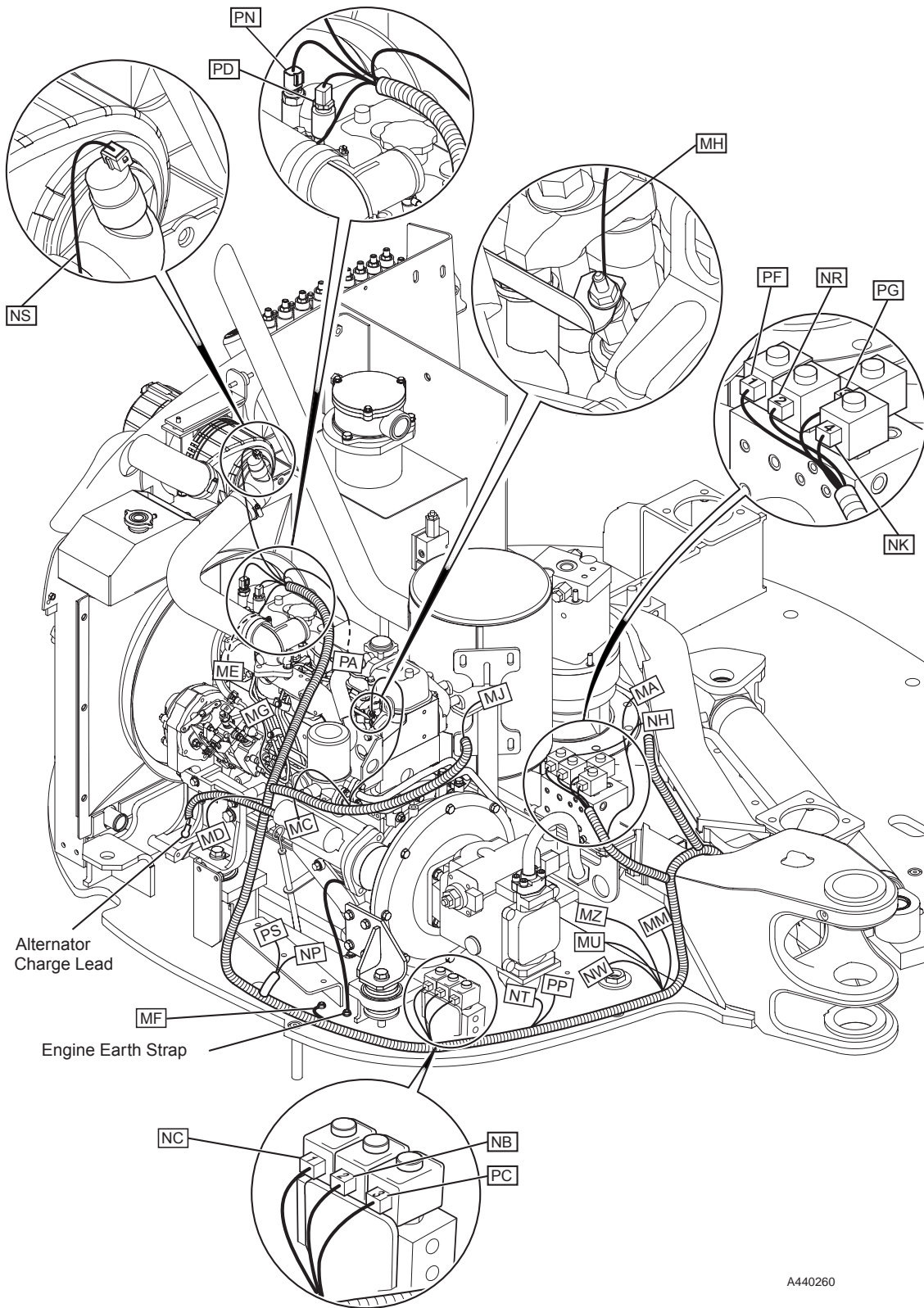


Slewpan Harness Drawing



A438650

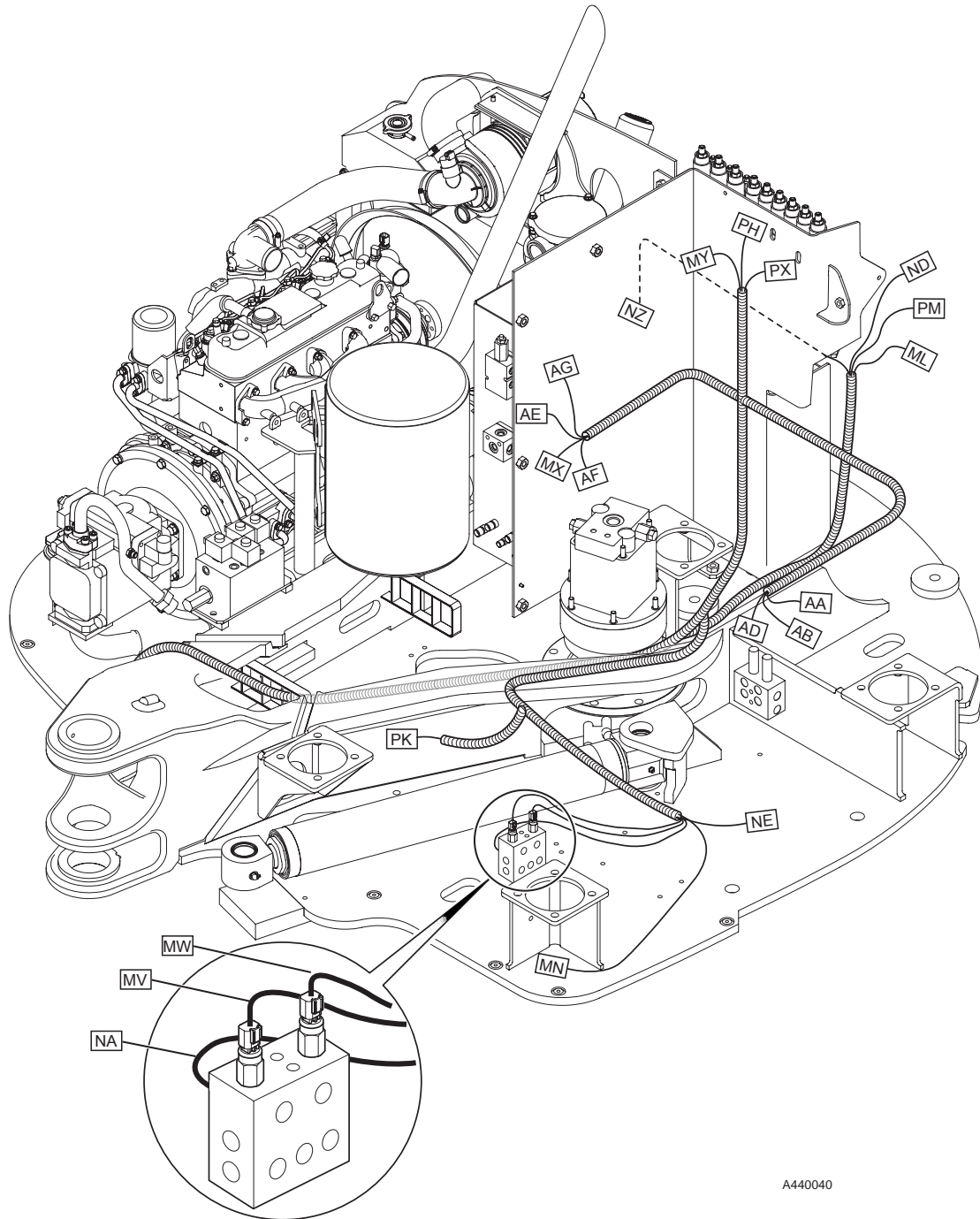
**Slewpan Harness Connector Locations - right side**



A440260

Refer to schematic diagram on page 35-1 to identify components connected to the harness.

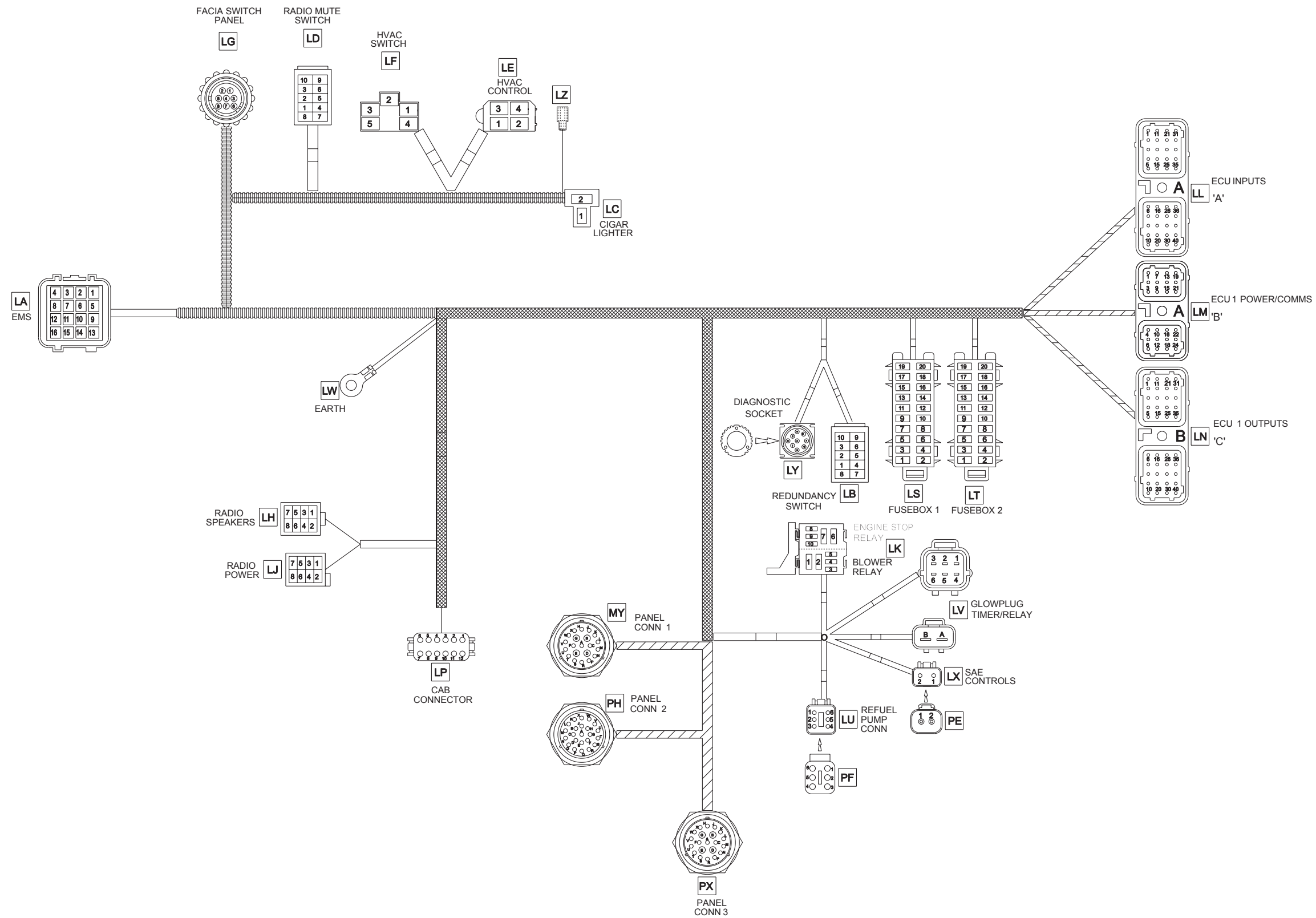
**Slewpan Harness Connector Locations -  
left side**



A440040

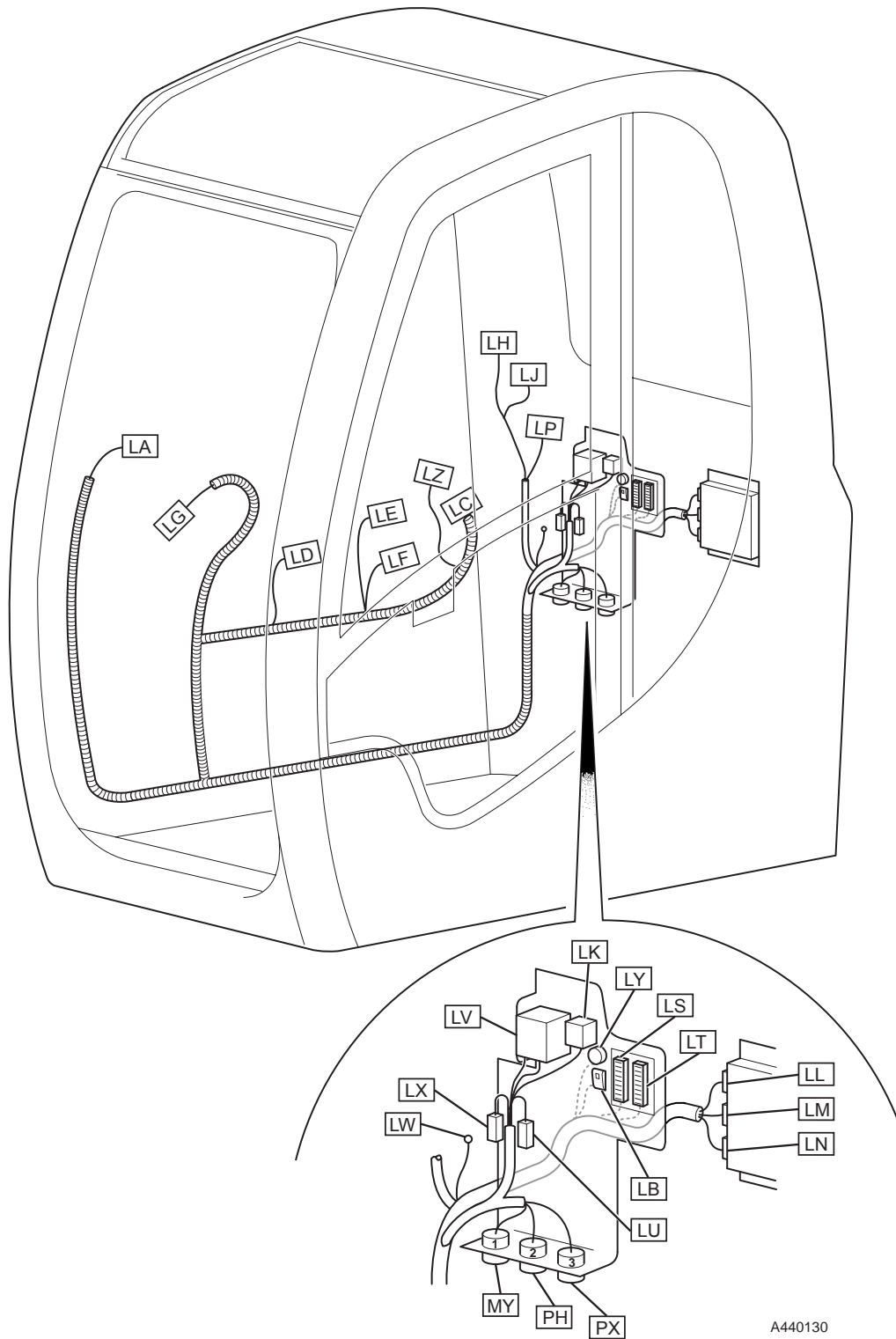
Refer to schematic diagram on page 35-1 to identify components connected to the harness.

Main Cab Harness Drawing



A438610

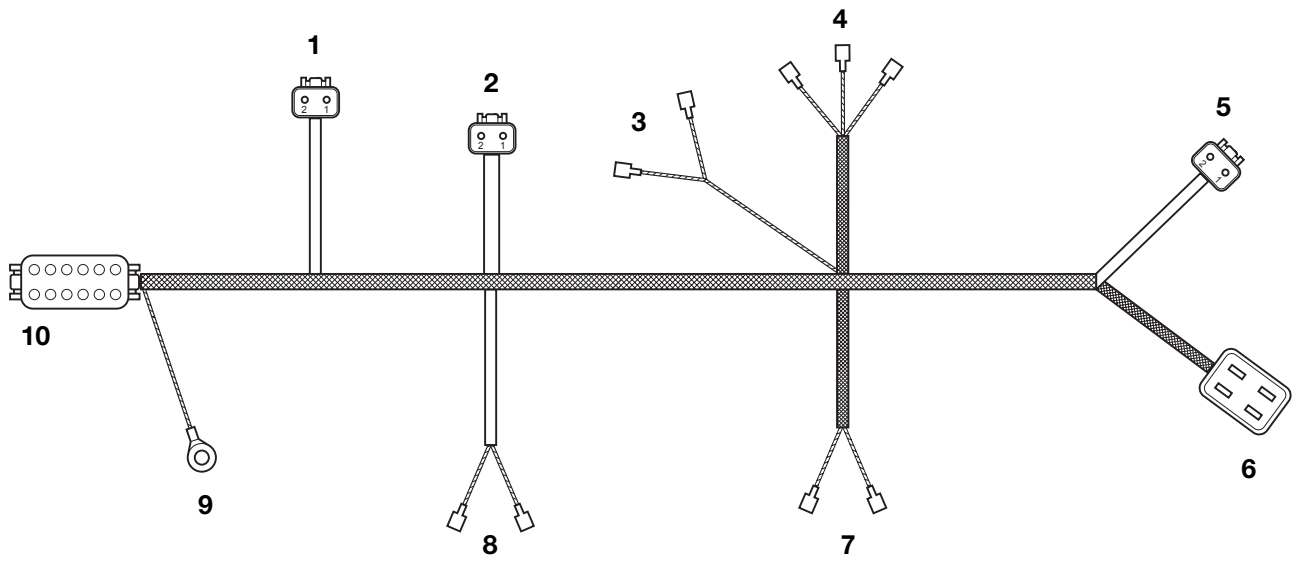
**Main Cab Harness Connector Locations**



A440130

Refer to schematic diagram on page 4-6 to identify components connected to the harness.

## Upper Cab Harness Drawing

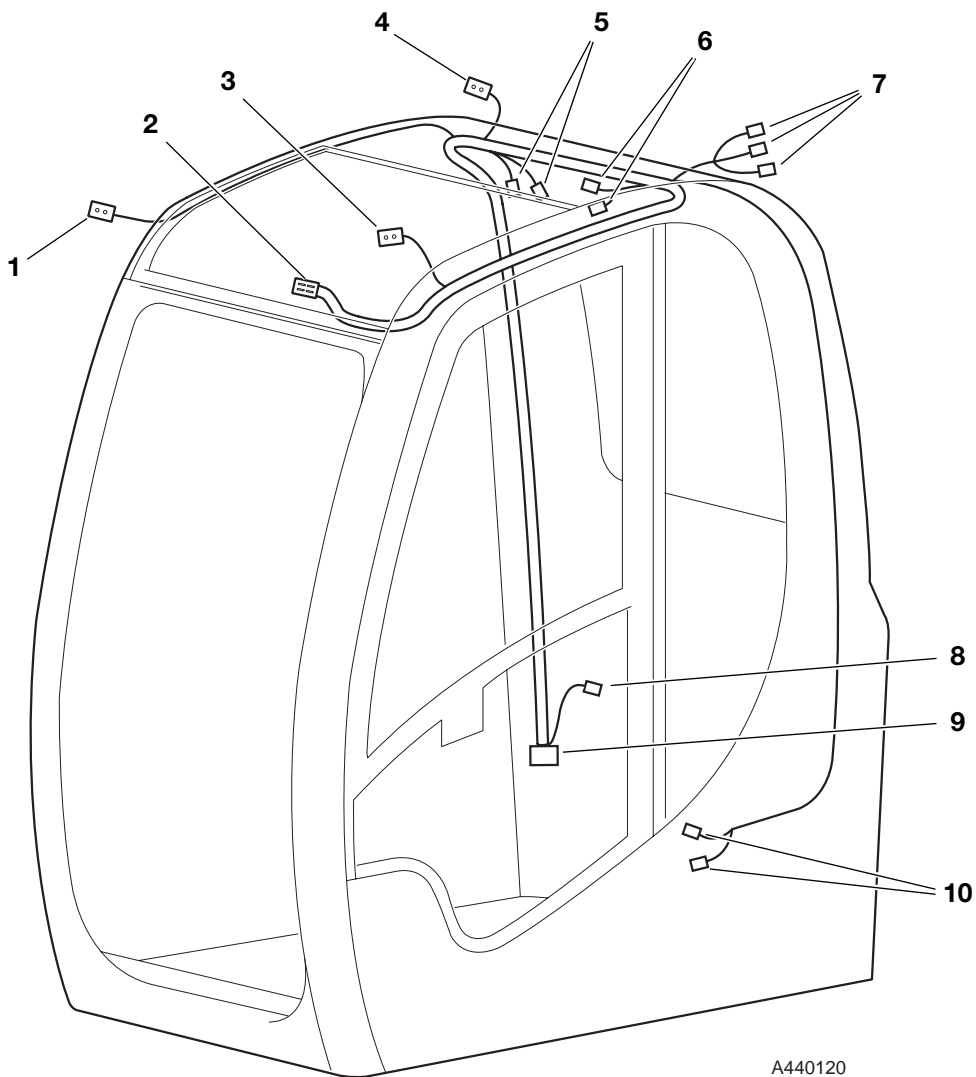


A440350

- 1 Work light, front right side
- 2 Work light, rear
- 3 Speaker, left side
- 4 Interior lamp
- 5 Work light, front left side
- 6 Wiper motor
- 7 Door Connector
- 8 Speaker, right side
- 9 Earth
- 10 Connector to Main Cab Harness

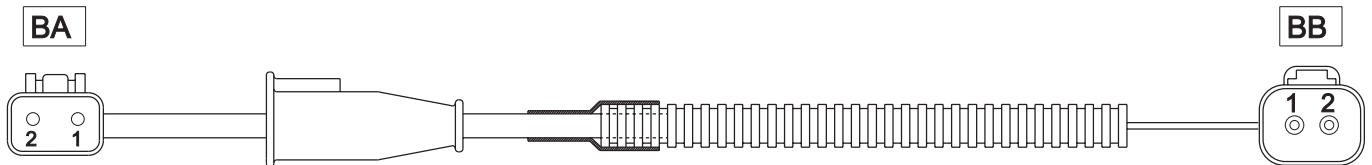


### Upper Cab Harness Connector Locations



- 1 Work light, front right side
- 2 Wiper motor
- 3 Work light, front left side
- 4 Work light, rear
- 5 Speaker, right side
- 6 Speaker, left side
- 7 Interior lamp
- 8 Earth
- 9 Connector to Main Cab Harness
- 10 Door Connector

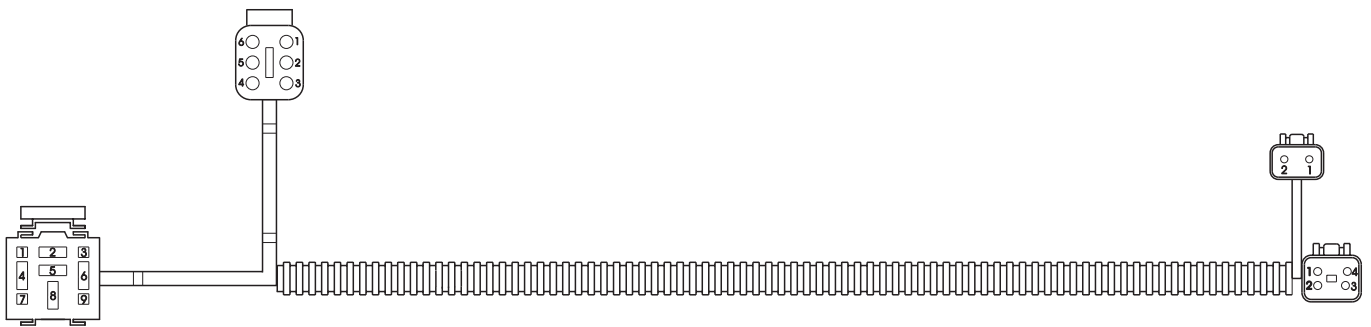


**Boom Light Harness**

A706460

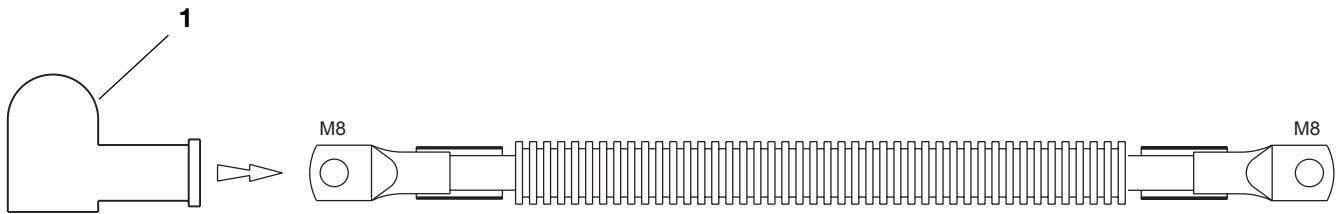
**Note:** If the boom light harness is removed and refitted, or if a new boom light harness is fitted, it is important that it follows the exact route used by the original harness, with particular attention given its route through the kingpost.

### Refuel Pump Harness



A706470

**Note:** If a refuel pump is retrofitted, it will not function until the software has been updated by a JCB Dealer using the electronic set-up tool.

**Alternator Charge Lead**

A709590

The alternator charge lead is fitted between the B+ terminal on the alternator and the pre-engage terminal on the starter motor. The terminal boot **1** is fitted at the alternator end of the lead.