



**ELECTRIC  
LOCOMOTIVES  
1990**

**By Authority  
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Freight and Country Passenger**

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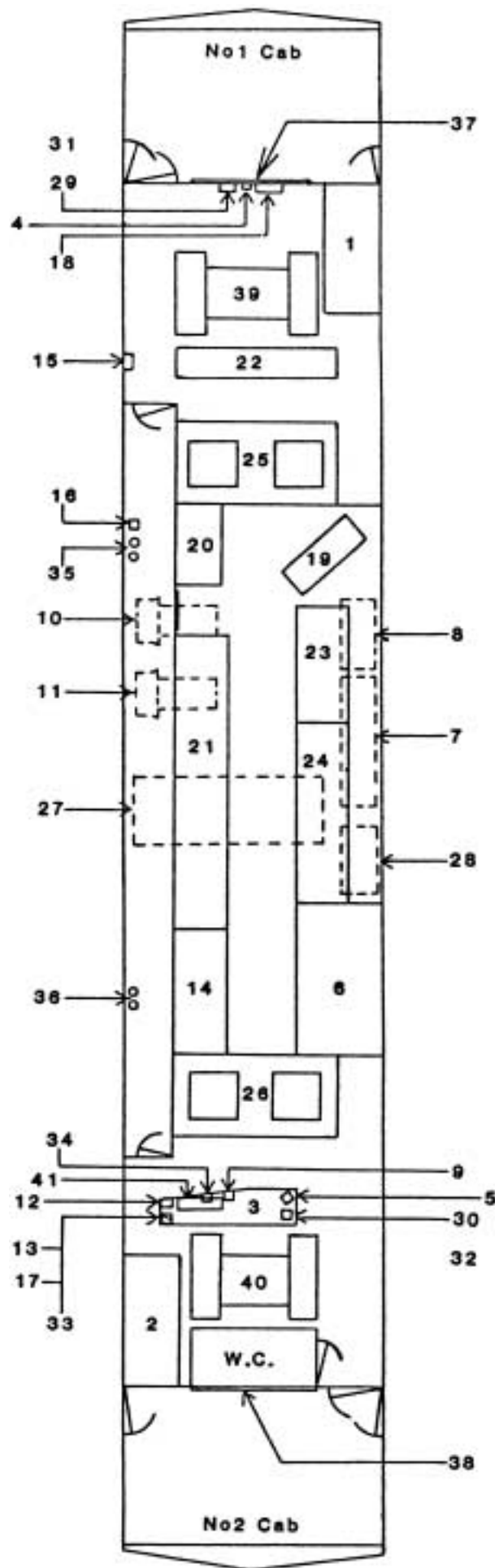
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## 86 CLASS LOCOMOTIVES

The 86 Class electric locomotives are employed in the haulage of freight and passenger trains over the various lines within the electrified area. General particulars are as follows:-

Voltage	1500 D.C.
Wheel Arrangement	CO - CO
Locomotive mass	120 Tonnes
Axle load	20 Tonnes
Length over couplers	20080 mm
Wheel diameter	1250 mm
Total wheel base	15400 mm
Overall width	2886 mm
Height from rail level to top of lowered pantograph	4330 mm
Dead hauling mass	135 Tonnes
Low tension supply	120 V.D.C.
Maximum speed	105 km/h
Continuous rating	2700 kW (3620 H.P.)
One hour rating	2880 kW (3860 H.P.)
Continuous tractive effort	22200 d a N

Locomotive 8650 differs in bogie arrangement (being BO-BO-BO), however, it is electrically, mechanically and operationally the same as existing 86 class locomotives.

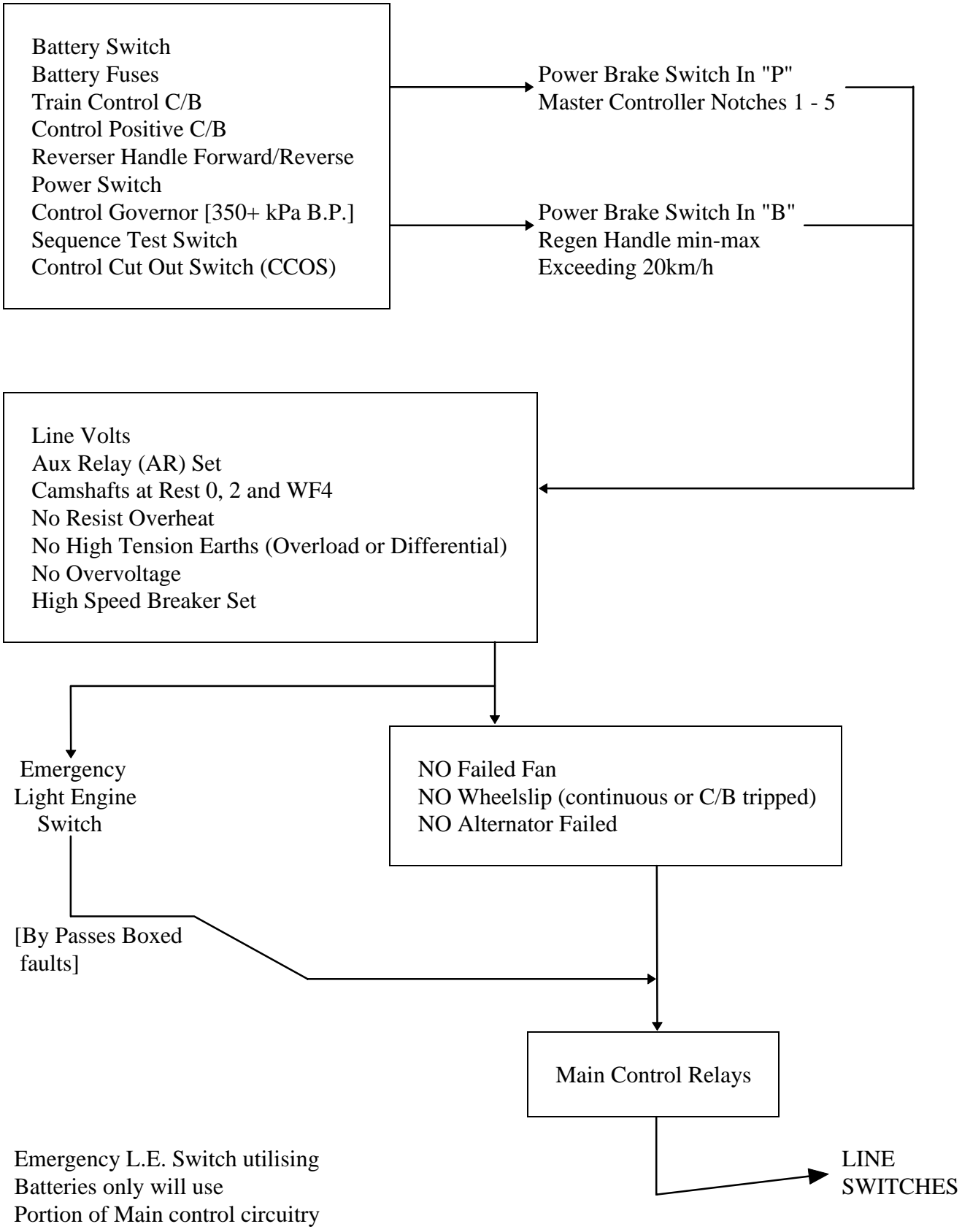


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## LAYOUT

1. Air Conditioner Unit - No. 1 End
2. Air Conditioner Unit - No. 2 End
3. Air Gear Rack
4. Auxiliary Relay - No. 1 End
5. Auxiliary Relay - No. 2 End
6. Auxiliary Resistor Group
7. Battery and Battery Fuse Box (Under Floor)
8. Battery Charger Box (Under Floor)
9. Brake cylinder Pressure Switch
10. Compressor - No. 1 (Under Floor)
11. Compressor - No. 2 (Under Floor)
12. Compressor Governor
13. Control Governor
14. Excitation Cabinet
15. Flange Lubricator Electronic Drive Unit
16. Flange Lubricator Magnet Valve - No. 1 Bogie
17. Flange Lubricator Magnet Valve - No. 2 Bogie
18. Hasler Speedo Stabiliser and Resistors
19. High Speed Circuit Breaker
20. Main Isolating Switch
20. Fuse Panel - High Tension
20. Inductive Shunts
21. Line Switch Group
22. Low Tension Cabinet
23. Main Controller Group - No. 1
24. Main Controller Group - No. 2
25. Main Resistance Cabinet - No. 1
26. Main Resistance Cabinet - No. 2
27. Motor Alternator (Under Floor)
28. Motor Alternator Circuit Breaker - Contactor Box (Under Floor)
29. Pantograph Governor - No. 1 End
30. Pantograph Governor - No. 2 End
31. Pantograph Valve - No. 1 End
32. Pantograph Valve - No. 2 End
33. Park Brake Pressure Switch
34. Regenerative Brake Magnet Valve
35. Sander Magnet Valve - No. 1 Bogie
36. Sander Magnet Valve - No. 2 Bogie
37. Terminal Board for No. 1 Cab (in rear wall)
38. Terminal Board for No. 2 Cab (in rear wall)
39. Traction Motor Blower - No. 1
40. Traction Motor Blower - No. 2
41. Vigilance Control

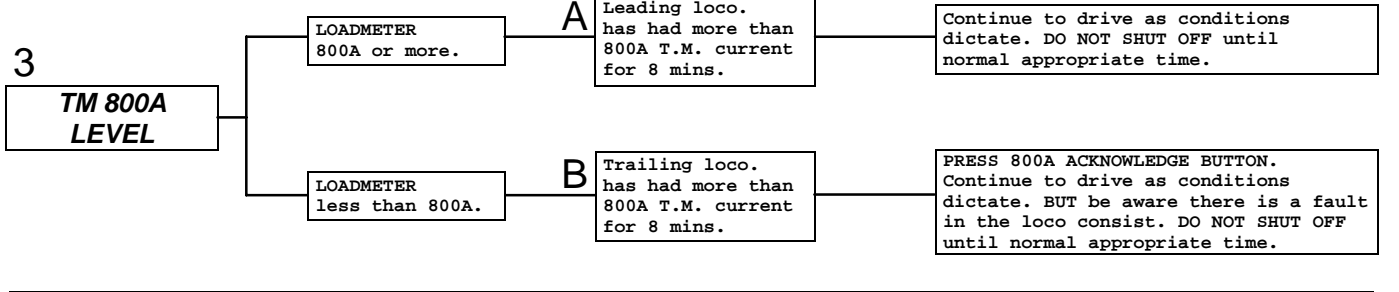
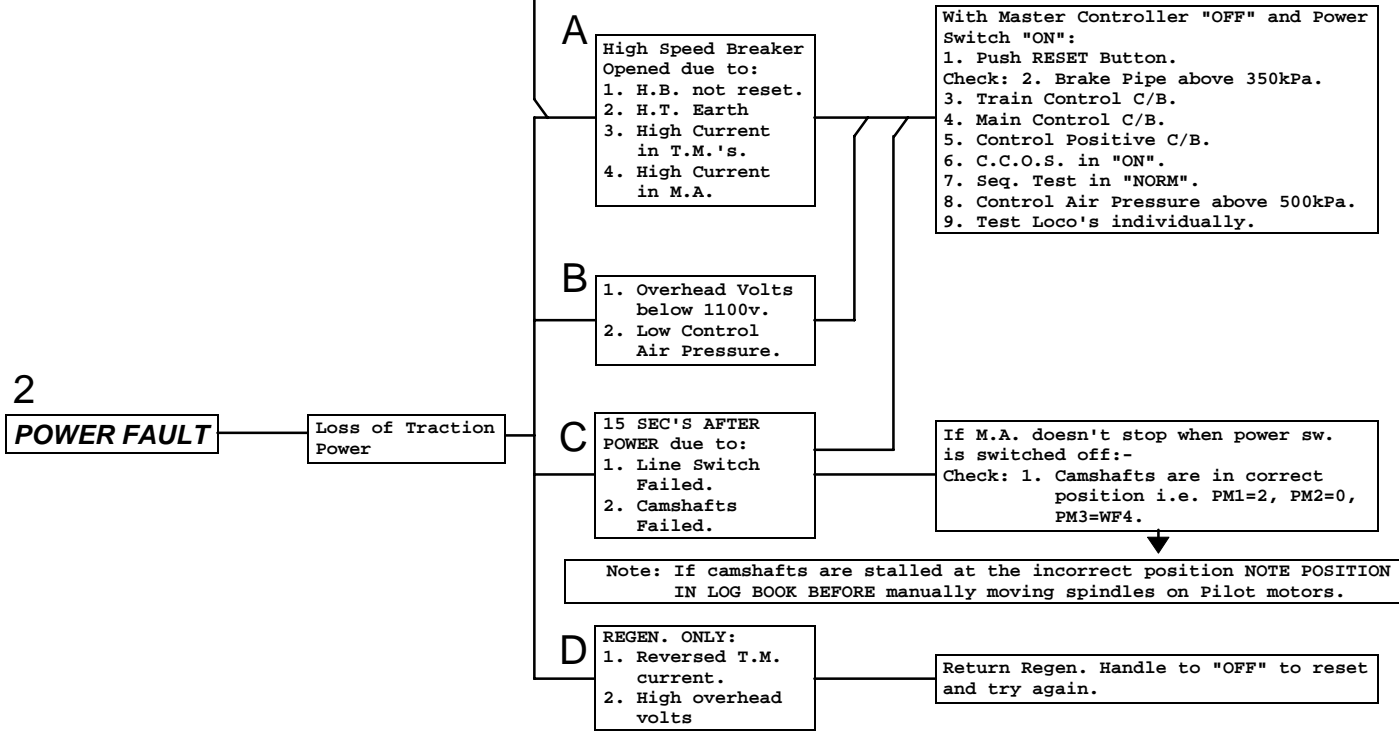
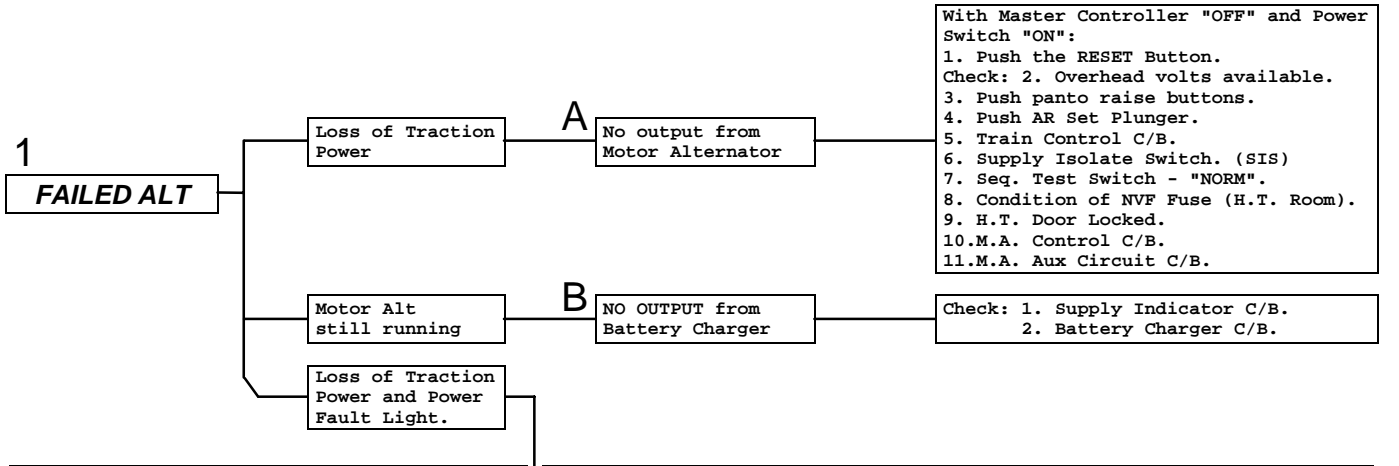
# GENERALISED FLOW CHART TO OBTAIN TRACTION

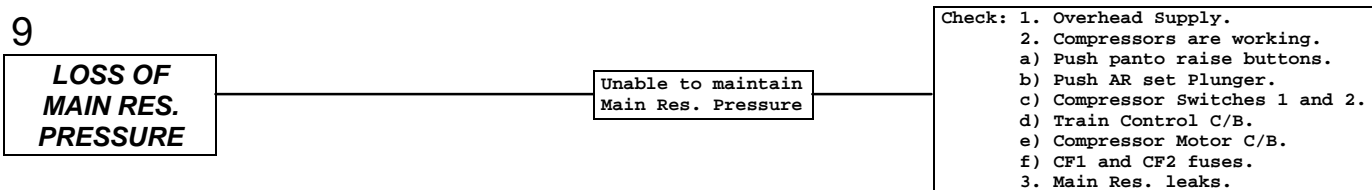
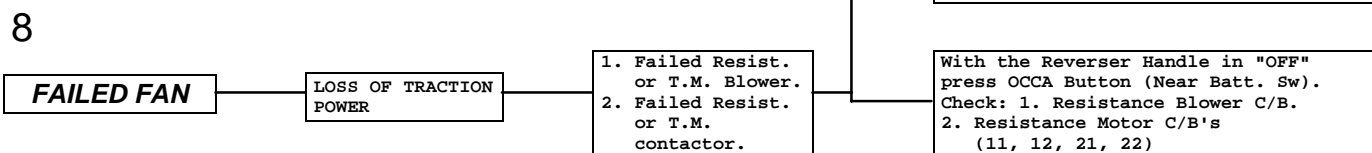
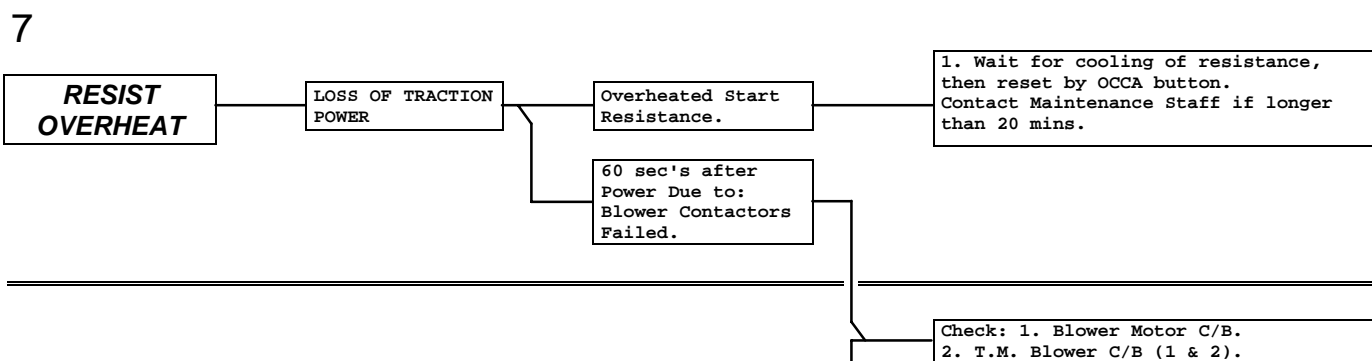
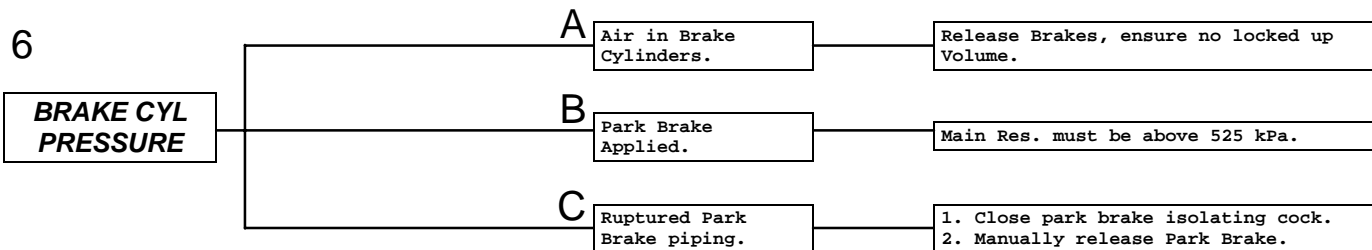
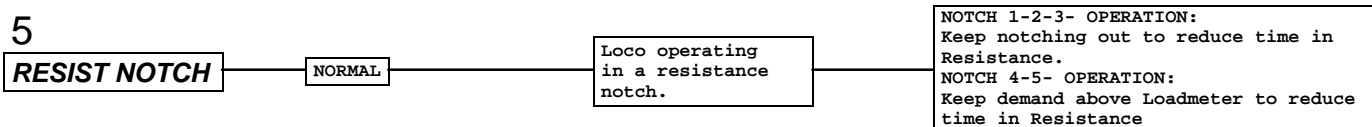
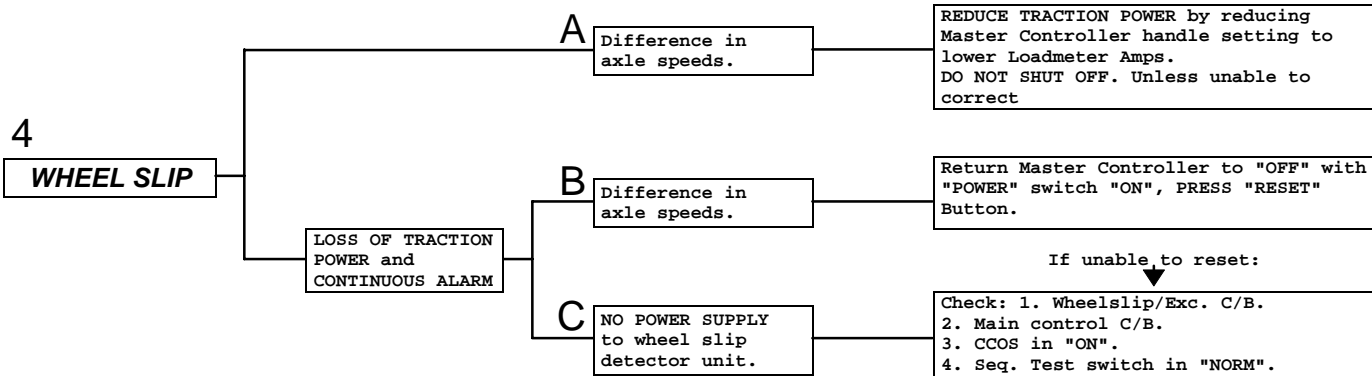
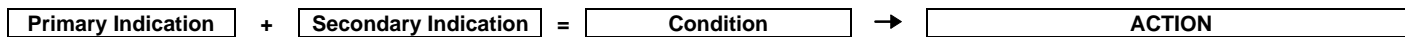


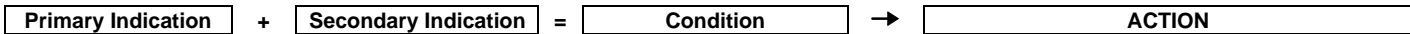
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# **FAULT & INDICATION FLOW CHART**

Primary Indication + Secondary Indication = Condition → ACTION







10

**NO  
LOADMETER  
READING**

NO ALARMS

Powering

Regen

Check: 1. Regen Handle - "OFF"  
2. Master Controller - 1 - 5.  
3. Reverser Handle - F or R  
4. Power Switch - "ON"  
5. All C/B's - "ON"  
(Except RSB)

Note:- SER. REGEN. will not pick up below 18 km/h and will drop out below 14 km/h. SER-PAR. REGEN will not pick up below 38 km/h and will drop out below 34 km/h.

Check:- 1. Regen Handle between MIN-MAX  
2. Master Controller in "OFF"  
3. Reverser Handle in "FOR"  
4. Return Regen Handle to "OFF", move Master Controller to Notch 1 until Loadmeter registers, then try Regen. Again.  
5. Regen Control C/B  
6. PTF Fuse (H.T.)  
7. Brake Switch (PB) is in B  
8. Rev. Switch (RV) is in correct direction of travel  
9. Excitation output C/B

11

**LOADMETER  
READING**

NO RESIST STEPPING OR W/FIELD STEPPING

1. Camshafts not working  
2. Loss of signal from control stand.  
3. Demand lower than Loadmeter

Shut off and try again.  
Check: 1. Demand signal is more than Loadmeter.  
2. Pilot motor C/B

12

**UNABLE  
TO START**

POWER FAULT and FAILED ALT.

FAILED ALT.

WHEELSLIP

FAILED FAN

HIGH SPEED BREAKER NOT RESET

No alternator output.

No supply to slip detector unit.

Failed T.M. Blower

Reverser in "OFF", Master Controller in "OFF", power switch "ON", Brake Pipe 350+ kPa, push RESET Button.  
Check:- 1. Battery Fuses.  
2. See 2A

See 1A

See 4C

See 8A

13

**PANTO'S  
WON'T RAISE**

Check:- 1. Reverser Handle is "OFF"  
2. Main Res. supply available  
3. Pantograph control C/B  
4. H.T. Room LOCKED  
5. Pantograph isolating cock  
6. Push the RAISE Plunger on Panto Valve.  
7. Panto Air cock (in corridor)  
8. Operate panto foot pump

14

**TM CURRENT RATING**

This is to be used as a GUIDE ONLY

1100 Amps	-	10 seconds
900 Amps	-	5 minutes
750 Amps	-	60 minutes
725 Amps	-	Continuous

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15

**TECHNIQUES FOR  
HEAVY GRADES**

1. Under normal circumstances Master Controller should be regulated to maintain 750 - 800 amps during heavy pulls at speeds above 20 km/h.
2. Dispose of one weak field at a time as speed falls and amperage rises above 800 amps.
3. If amperage exceeds 900 amps with no weak fields engaged, a lower Traction Motor combination may be required.
4. Watch for adverse short section of track (grease pots, wet rail in cutting etc.) and be mindful of tendency of wheel slip.
5. Listen for wheel creep or whine, watch amp meter and reduce traction power by reducing the number of weak fields (4 minimum).

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16

**STARTING  
AFTER PULLED TO STAND  
ON HEAVY GRADES**

**AUTOMATIC BRAKES RELEASED. INDEPENDENT APPLIED**

1. Using precise notch out mechanism (3-2-pause-3-2-pause etc), load Traction Motors to 600 amps, apply sand.
2. Release Independent brake. Do not depress brake valve handle.
3. Continue using precise notch out until movement occurs.
4. If wheels begin to slip re-insert a resistance (2-pause-1-2-pause).
5. Remove resistances slowly until Resistance Notch indicator light extinguishes.
6. Continued use of precise method after Resistance light extinguishes enables weak field/s to be inserted or eliminated in similar manner to resistances.
7. It is not possible to re-insert resistances after Resistance Notch light extinguishes.

NOTE 1.: THE USE OF NOTCH 4 OR 5 IS NOT RECOMMENDED FOR STARTING ON HEAVY GRADES WITH MORE THAN 50% FULL LOAD.

NOTE 2.: THE USE OF NOTCH 5 prior to the actual time transition is required only serves to considerably extend the duration of Resistance Notching, and in addition, weak fields will not be available until all resistances in 'Parallel' have been eliminated.

**Cab** - The locomotive has a driving position at each end with suitable accommodation for the enginemen.

Housed within the locomotive is the control equipment, traction motor blowers, starting resistances and blower fans.

## DRIVER'S DESK

It is located directly in front of the driver and is equipped with following:-

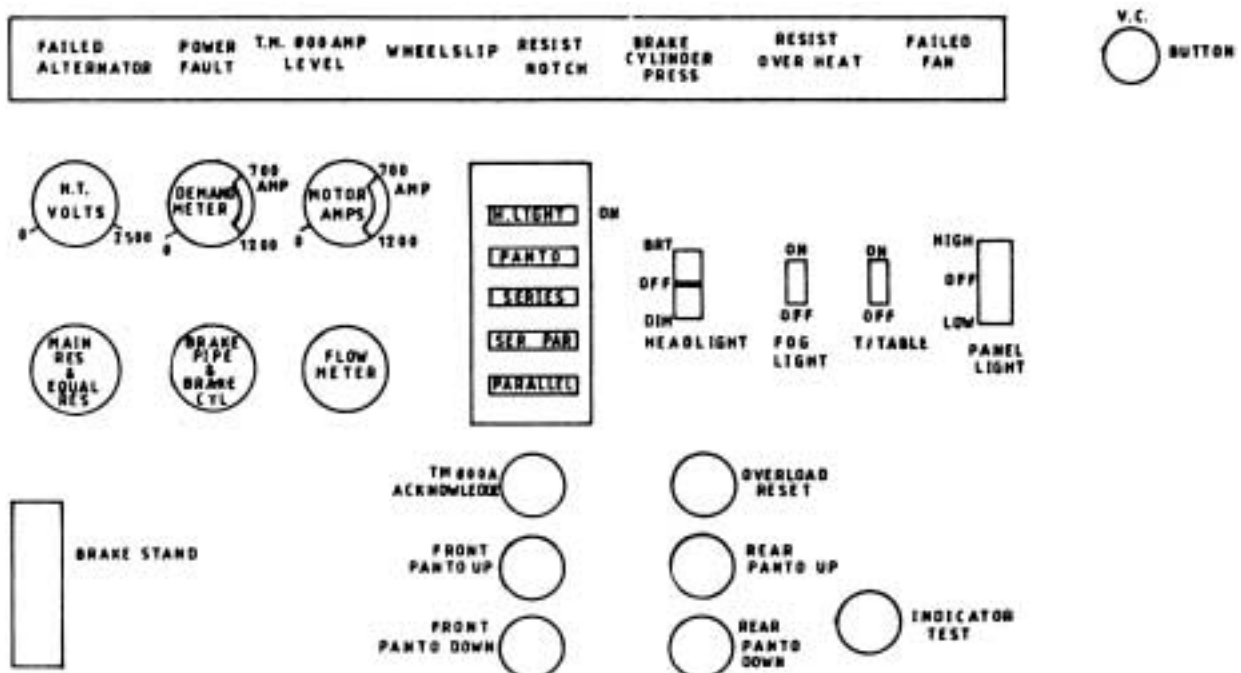
1. Two air brake pressure gauges.
2. Flowmeter.
3. Loadmeter.
4. Voltmeter.
5. Demand meter.
6. Pan. up buttons front and rear.
7. Pan. down. buttons front and rear.
8. Headlight switch (3 positions).
9. Foglight switch.
10. Overload reset button.
11. T/M 800A acknowledge button.
12. Timetable light switch.
13. Panel lights switch (3 positions).
14. Indicator test button.

### Driver's Switch Panel

This panel is located above the driver's side window and contains the following:-

- |  |  |
|--|--|
| <ol style="list-style-type: none"> <li>1. Cab light.</li> <li>2. Heater (low - high)</li> <li>3. Demister.</li> <li>4. Power cut out.</li> </ol> | <p>Located below the side window are:-</p> <ol style="list-style-type: none"> <li>1. Two position horn stalk (city/country).</li> <li>2. Windscreen wiper.</li> <li>3. Windscreen washer.</li> </ol> |
|--|--|

### 86 CLASS ELECTRIC LOCOMOTIVE DRIVER'S DESK



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## Observer's Switch Panel

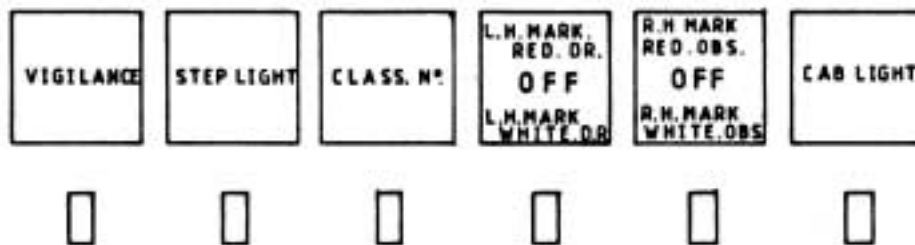
This panel is located above the driver's side window and contains the following:-

1. Vigilance acknowledge button.
2. Step light.
3. Class number.
4. Left hand marker lights; white-off-red.
5. Right hand marker lights; white - off - red.
6. Cab light.

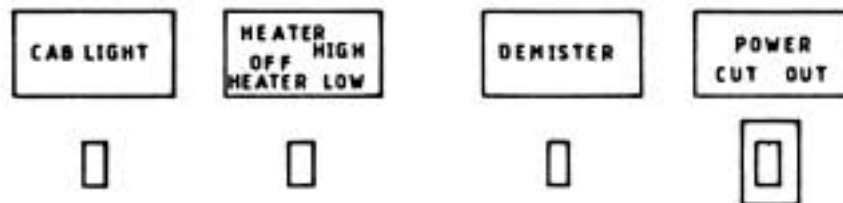
Located below the side window are:-

1. Two position horn stalk (city/country).
2. Window wiper.

### OBSERVER'S SIDE - ABOVE SIDE WINDOW



### DRIVER'S SIDE - ABOVE SIDE WINDOW



## Demisters

Electric demister elements are provided in the front cab windows, and are supplied with 74 V.D.C. power through a demister supply circuit breaker and controlled by a toggle switch above the left side window.

## Hotplate

A hotplate is provided in each cab and is operated by a 74 volt supply via a transformer from the 240 volt A.C. supply from the Motor Alternator. The "Aux Trans" circuit breaker protects this transformer.

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## **Headlights**

Twin sealed beam headlights are provided at each end and fed from 240 volt A.C. power supply via headlight circuit breakers located on circuit breaker panel. Each pair of headlights is controlled by a three position switch located on the driver's console in each cab. Circuit breakers are also provided for the bright and dim circuits.

## **Fog Lights**

The locomotive is fitted with two fog lights at each end. They are controlled by a foglight switch located on the driver's gauge panel.

## **Cab Refrigerator**

Each cab is fitted with a refrigerator which is of simple design and uses air at high pressure for cooling under thermostatic control.

The cabinet is a top loading type and has a capacity of holding a water bottle and a supply of foodstuffs which may require to be kept cool.

It is the utmost importance that enginemen keep the refrigerator in a clean and hygienic condition at all times and do not place items of an odorous nature in them.

The air supply to the refrigerator passes through a two position isolating cock, which is open in the vertical position and closed in the horizontal position. The cock is located on the side panel of the cabinet.

The air demands for the operation of the refrigerators is high and to ensure sufficient air supply is available for other equipment on the locomotive, it is essential that before vacating the cab, Enginemen close off the air supply to the refrigerator by placing two position isolating cock in the horizontal position and ensure that only one refrigerator is in use at any time.

# **AIR CONDITIONING**

Air conditioning is provided in both locomotive cabs with 415 V A.C. power supplied from the motor alternator (MA) set.

To avoid wear, the air conditioning unit in unoccupied cabs should be switched off.

Each air conditioning system consists of the compressor condenser and evaporator unit. The units are mounted on the right hand wall of the locomotive at both ends and contain the circuit breakers for each unit. A main air conditioning circuit breaker is located on the circuit breaker panel.

A test key switch is provided for maintenance purposes and is located beside the A.C. selector switch.

The air conditioning selector switch is located on the wall behind the observer's cab door, and is labelled - OFF - COOL 1 - COOL 2 - COOL 3 - VENT - HEAT. Should the MA set fail the air conditioning will be inoperative.

Air nozzles are located below roof level towards the front of the cab and can be used to direct the flow of air by both the Driver and Observer.

Cab heating is best achieved by using the individual cab heaters in front of the Driver and Observer in conjunction with the heaters in the air conditioning unit.

The heaters in each cab are supplied with 415 volt A.C. power through cab heater circuit breakers located on circuit breakers panel. Each heater is controlled through a High - Low switch on the driver's side.

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## VIGILANCE CONTROL

The vigilance control equipment fitted is the E.H. type with a solid state timing unit controlling a penalty application magnet valve which upon being de-energised will exhaust brake pipe pressure to atmosphere, i.e. the system is fail safe.

In the absence of an acknowledgment, after a further period of time, a pair of contacts will close, causing a penalty brake application. When this occurs the bell is silenced and at the same time the acknowledgment buttons are rendered inoperative for one to three minutes.

The penalty brake application can be released after the one to three minutes time interval by depressing the acknowledgment button and operating the brake valve in the normal manner.

### Isolating of Equipment

When isolating the apparatus it should be kept in mind that there are two stages of isolation for vigilance control equipment as follows:-

(a) *Isolation of Emergency Application Valve Only*

This condition eliminates a vigilance control brake application and still permits the flashing light - audible warning portion of the equipment to function. The associated isolating cock, located at the emergency application valve inside the locomotive is to be closed.

(b) *Isolation of the Complete Equipment*

The isolating cock under vigilance equipment is to be closed.  
The main vigilance control circuit breaker (VCB) must be opened.

**NOTE:** In every case where trouble is being experienced the procedure set out in (a) above must first be observed and only if a remedy is effected by this means shall the procedure for (b) be applied.

### Battery Switch

Before opening, close both Driver's brake valve isolating cocks. Vigilance control penalty valve when de-energised will dump brake pipe pressure.

This action is necessary to ensure the vigilance control is isolated by closure of the isolating cocks before the electrical circuit to the penalty magnet valve is interrupted by opening the battery switch.

### Underframe

The Motor alternator and two electrically driven compressors are mounted on the underframe of the locomotive.

**CAUTION: These are both 1500V machines.**

## CIRCUIT BREAKERS AND SWITCHES

1. Remote Supply	-	Completes circuit from the source of supply on another locomotive in the case of flat batteries. Sealed in the "off" position.
2. Indicator Supply	-	Operates failed alternator indication and buzzer to show loss of motor alternator (A.C.) supply. This circuit breaker tripping will give the same indication.
3. Regen. Brake	-	Regenerative brake control circuits.
4. Blower Control	-	Traction motor and resistance fan blowers control circuit.
5. Vigilance Control	-	Vigilance control circuits.
6. Compressor Control	-	Compressor control circuits, both compressors.
7. Panto. control & AR Set	-	Pan up, Pan down and auxiliary relays set and trip coils. Motor alternator and compressor operation.
8. Train control	-	Feeds, no volt relay, regen. powering controls in and control positive circuits. Also reset button.
9. Control Positive	-	Feeds, powering and regen. controls in multiple unit operation.
10. Compressor Synchro.	-	Compressor synchronising circuit.
11. Spare		
12. Spare		
13. MC/MR lights	-	Machine room, high tension compartment and toilet lights.
14. Step and coupler light	-	Step and coupler lights both ends.
15. Cab lights 1 end	-	As indicated.
16. Cab lights 2 end	-	As indicated.
17. Marker lights	-	Marker lights both ends.
18. Fault	-	Fault indication and buzzer.
19. Hasler speedometer	-	As indicated.
20. Flange lube	-	As indicated.
21. Sander valves	-	All sander magnet valves.
22. Head light bright	-	Headlight bright circuit.
23. Head light dim	-	Headlight dim circuit.
24. Fog lights	-	Foglight circuit.
25. Pilot motor	-	Main supply to the master controllers and camshaft pilot motors.
26. Excitation Power	-	Protection for main traction circuit and external (415V) power supply circuit. Protects wheelslip and slide circuits.
27. Wheel slip/slide	-	Protection for main traction circuit and external (415V) power supply circuit. Protects wheelslip and slide circuits.
28. Battery Charging	-	Protects Battery Charging Circuits.

### **The Sequence Test Switch**

(SQ. TEST SW.) is a four position rotary switch with the following positions. "NORMAL" and "TEST" The switch is carried in the "Normal" position and is only placed in the "Test" position when a sequence check test is conducted without high tension supply at the workshop.

## Control Cut Out Switch

(CCOS) is a four position rotary switch with the positions "ON", "OFF", "ON", "OFF".

In the "OFF" position the traction control circuits, motor alternator, power "fault" indication and "failed fan" indication are isolated.

The S.I.S. Switch should also be turned "OFF" when CCOS is "OFF".

### AUXILIARY LOW TENSION GROUP

Battery knife switch  
Sequence test switch (SQ. TEST SWITCH)  
OCCA - Reset button  
acknowledge cancel.

Control Cut Out Switch (CCOS)  
Emergency light engine

### MACHINE COMPARTMENT

Function

- Isolates battery current.
- For testing of the control circuits.
- Push button for:-
  - TRACTION MOTOR 800A.
  - Resistor overheat reset.
  - Failed Fan reset.
- Power control circuits.
- Light engine operation when MA is not running or continuous wheel slip or Failed Fan.

## EMERGENCY LIGHT ENGINE SWITCH

The Emergency Light Engine Switch is located in the Auxiliary Low Tension Cabinet near the battery switch. It is provided as an emergency feature only, basically to clear the section. The switch is to be sealed prior to leaving a servicing depot.

The low tension circuits of the locomotive are supplied by transformed and/or rectified current from the Motor Alternator. The batteries are not capable of producing the many and varied A.C. and D.C. voltages used within the electronics, therefore a separate and isolated circuit is provided, bypassing most of the control circuits to operate the camshafts/pilot motors. The end result is the locomotive, with the emergency Light engine Switch "IN" will only operate in series, and notch four will not be operative. Stepping resistances out will need to be achieved using notches 2 and 3. In addition, a timing relay will only allow the driver sixty seconds - one minute to notch out through all resistances in series. If the driver is still in a resistance notch after this time has elapsed, the line switches are opened, disconnecting traction circuits for a period of three (3) minutes.

The Emergency Light Engine Switch is used in the event of being a single locomotive which has:-

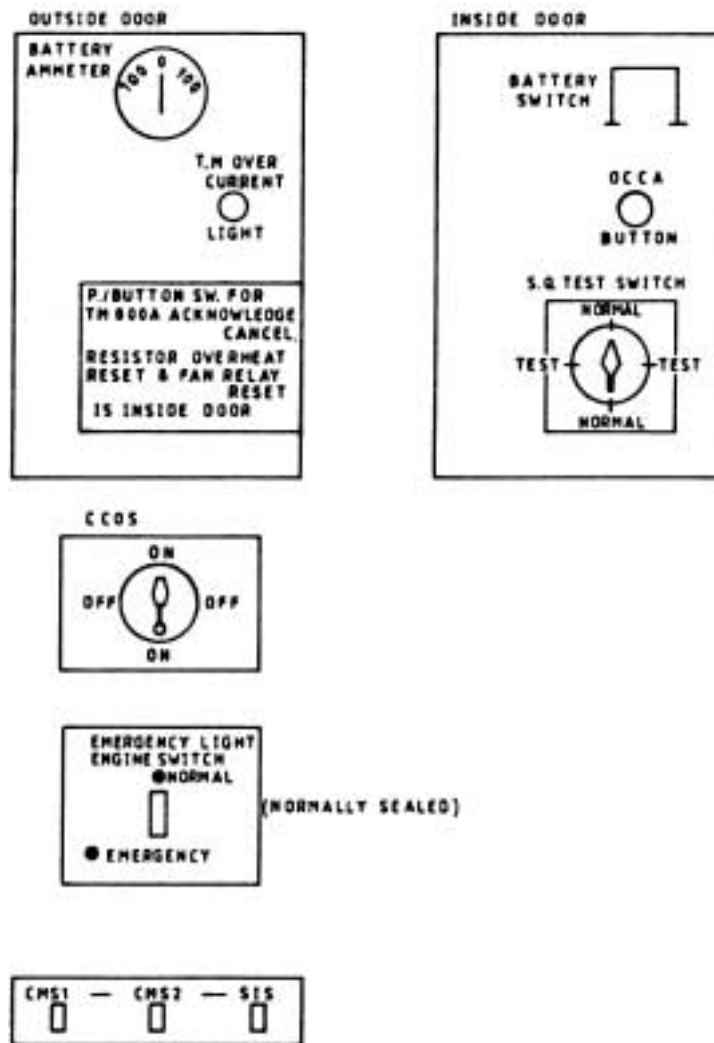
- (i) No Motor Alternator Output
- (ii) Failed Blower Fan/s
- (iii) Permanent wheelslip/Excitation circuit breaker failure.

Every endeavour should be made to rectify any of the above listed faults prior to resorting to the Emergency Light Engine Switch.

If Item (iii) is the cause of the need to use the Emergency Light engine Switch, a load meter reading will not register, however, traction can be applied. The driver will need to count the amount of resistances taken out of circuit by manipulating the master controller to notch three eight times (from Notch 2) in order to prevent the timing relay energising within sixty (60) seconds in resistance.

NOTCH FOUR, DURING EMERGENCY LIGHT ENGINE SWITCH OPERATION WILL NOT NOTCH OUT. IT IS THE EQUIVALENT OF NOTCH ONE AND THE TIME DELAY WILL OPEN THE LINE SWITCHES IN SIXTY SECONDS. THERE IS NO PROVISION FOR TRANSITION. SERIES ONLY.

## AUXILIARY LOW TENSION GROUP NO. 1 END MACHINE COMPARTMENT



## HIGH TENSION COMPARTMENT

The high tension compartment door is mechanically interlocked.  
The following equipment is situated inside the high tension compartment.

### Fuses

1 x 20 amps: Compressor Motor Fuse.

1 x 20 amps: Compressor Motor Fuse.

They provide protection for the compressor motors.

1 x 10 amp: NVR Protection for the no volt relay circuit.

1 x 10 amp: VMF Voltmeter circuit protection for both meters.

One at each end of the locomotive.

1 x 10 amp: PTF: Protects the regen. voltage detection circuit.

One spare 20 amp and one spare 10 amp fuse are located in a small cabinet in the machine compartment.

## MAIN ISOLATING SWITCH AND HIGH TENSION COMPARTMENT ENTRY

It is necessary for this switch to be closed for any of the 1500 volt equipment to operate. The switch is interlocked with the doors of the high tension compartment so that the switch cannot be closed unless the doors are closed, and the doors cannot be opened unless the switch is open, and the equipment earthed.

The switch is unlocked by first inserting the reverser handle in the "Panto Up" position and then moving it across to the "Panto Down" position - to ensure the pantographs are lowered and isolated. The handle is then withdrawn and re-inserted in the "Power On" position.

Move reverser handle to "Handwheel Unlocked" position arrows. Then rotate the handwheel to operate the switch. Move reverser key to "Power Off" position and then remove. Move the door lock lever to the unlocked position to release the door.

To lock door, reverse above procedure.

## MANUAL PANTOGRAPH ISOLATING SWITCHES

Manual pantograph isolating switches are located inside the high tension compartment and enable individual pantographs to be isolated under emergency conditions. The rotation of the spider wheel opens the pantograph knife switch, isolating the pantograph from the rest of the locomotive.

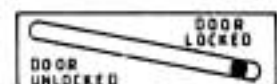
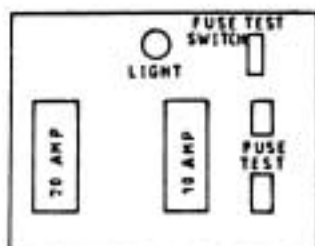
The manual pantograph isolating switches have been burnt through interference with the rotary wheels in the high tension compartment.

To eliminate this problem, the maintenance staff will fully close the isolating switch and seal them.

Should it be necessary for the pantograph to be isolated under emergency conditions. Then enginemen may break the seal and operate the rotary wheel concerned. A suitable entry must be recorded in the log book.

**NOTE:** In the case of the locomotive becoming derailed, enginemen are reminded it is dangerous to touch any part of the framework of the car or bogie, unless the pantograph is in the lowered position and clear of the overhead wiring. If the pantograph cannot be isolated from the overhead wire the manual isolating switches should be operated to the "Open" position.

## HIGH TENSION COMPARTMENT ENTRY AND CORRIDOR MACHINE COMPARTMENT



## PILOT MOTORS AND CAMSHAFTS

There are three pilot motors and associated camshafts located inside the high tension compartment. They are operated by the control system of the locomotive. Pilot Motor No. 2 (PM2) is the vernier resistance camshaft, which smooths the stepping out procedures. Pilot Motor No. 1 (PM1) is the main resistance camshaft and Pilot Motor No. 3 (PM3) is the weak field camshaft. Each Pilot Motor has a pointer and dial system which enables the driver to observe the position of the camshaft. Whilst the locomotive is not being utilised the camshaft positions are as follows:-

PM1 - 2  
PM2 - 0  
PM3 - WF4

During preparation, the driver may spin the camshaft pilot motors, ensuring free movement. Pilot motor operation is directly controlled by:-

- (a) Master Controller
- (b) Speed of the axles

which is co-ordinated and monitored by the electronic excitation control system. Pilot motors can jam or stick in a fixed location of their rotating cycle due to large and quick movements of the master controller - particularly at transition changes if the master controller is placed into the 4 minimum position immediately after selecting notch 5.

Should the pilot motor/s be suspected as having jammed, the choice is to persevere and remain in resistance without a stepping out facility, or, shut off, allow the pilot to return to its laying or rest position and re apply traction.

If it is discovered after re-applying traction (or not being able to re-apply traction due to Power Fault indication) that the pilot motors have again jammed, it may be necessary to stop, secure, lower the pantographs and enter the high tension compartment. BEFORE physically rotating any pilot motor, examine the indicating pointer on each pilot motor and note its position. If a camshaft is not indicating 0, 2 or WF4 respectively, the motor is to be manually rotated. Appropriate bookings including the number at which the motor stalled must be included.

## HIGH SPEED CIRCUIT BREAKER

### Identification

The high speed circuit breaker (HB) is provided on the locomotive to protect the high tension power circuits and the motor circuit of the motor alternator, should a fault develop.

The circuit breaker incorporates three operating coils:-

- (a) A "RESET" magnet valve for the initial picking up of the circuit breaker. This magnet valve is only energised while ever the overload reset button is pressed.
- (b) A "HOLDING" coil, this coil holds the circuit breaker closed when the overload reset button is released.
- (c) A "TRIPPING" coil or "Bucking Bar" which caused the circuit breaker to trip in the event of a fault in the high tension.

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## **Operation**

The high speed circuit breaker is closed by pneumatic action when the high speed circuit breaker "RESET" magnet valve is energised. The "RESET" magnet valve energises when the overload reset button on the driver's instrument panel is pressed, and the reset relay operates and closes its contacts which are in series with the high speed circuit breaker "RESET" magnet valve.

To maintain the circuit breaker in the closed position once the overload reset button is released, a holding coil located within the circuit breaker is energised. In series with the holding coil are normally closed interlocks of the overload relays, OLR1, OLR2, and OLR3, motor alternator over current relay MAOCR, and the differential relay DFR. If any of these relays trip, the holding coil will de-energise and the high speed circuit breaker will open, This, in turn, will indicate on the Driver's Annunciator Panel a Failed Alternator and/or Power Fault.

## **RESISTANCE BLOWER MOTORS**

### **Identification**

Two, three phase, 415 volt A.C. brushless motors are located at the bottom of each resistance box. Each motor contains an integral fan which functions to draw in air from the machine room and force cool the main and vernier resistance.

### **Location**

Resistance blower motors RBM11 and RBM12 are located in the No. 1 main resistance box and resistance blower motors RBM21 and RBM22 are located in the No. 2 main resistance box.

### **Operation**

With the motor alternator operating and the powering handle of the master controller placed for resistance notching, the blower time delay relay will energise.

After a time delay of ten seconds from when resistance notching was selected the resistance blower contactor and the resistance blower motors, RBM11, RBM12, RBM21 and RBM22, the motors will commence to rotate.

After notching off, resistance blower motors will continue to run for a further 180 seconds. The reason for this delay in the dropping out of the resistance blower contactor is to ensure that the resistances are cooled sufficiently.

### **Protection**

If a resistance blower circuit breaker trips or the blower contactor fails to operate while in resistance notching, the failed fan relay, will energise. When it energises it causes the circuit to the main control relays to open. The line switches will open and all power will be removed from the tractive circuits until the cause has been rectified. Various circuit breakers are provided, i.e., Blower Control, Resister Blower 11, 12, 21 and 22 (each number being a separate circuit breaker).

### **Traction Motors**

There are six (6) traction motors, three on each bogie giving traction on all wheels. Each traction motor is supported by axle suspension bearings. A lateral hydraulic snubber is provided on the bogie located adjacent to the inner axle. In addition, two traction snubbers are used to control swivelling of the bogie.

Shrunk onto the motor armature shaft is a pinion that meshes with a drive gear pressed onto the driving axle. The gear ratio between the pinion and the drive gear is expressed by two figures, such as 79/20 for the 130 km/h gearing used on this locomotive. The second number indicates the number of teeth on the pinion.

Armature bearings are of the roller type and axle suspension bearings are also roller bearing type.

### **Battery Switch and Batteries**

The Battery switch being a double pole knife type located on the upper portion of the low tension cupboard, to the side of the circuit breaker panel. Output from the batteries is 108V D.C., Output from the M.A. to the batteries is 120V via the Battery Charger.

### **Motor Alternator (MA) Set**

The motor alternator (MA) set produces three phase 415 volts of current for the operation of the traction motor blowers, starting resistance fan motors, cab heaters, air conditioning and alternating current (A.C.) control apparatus. Portion of this current is rectified to 120 volts D.C. for operation of the control circuit and battery charging. The locomotive is fitted with a battery voltage relay (BVR) which opens if battery voltage falls below 85 volts this disconnects battery supply to all lighting circuits except the marker lights.

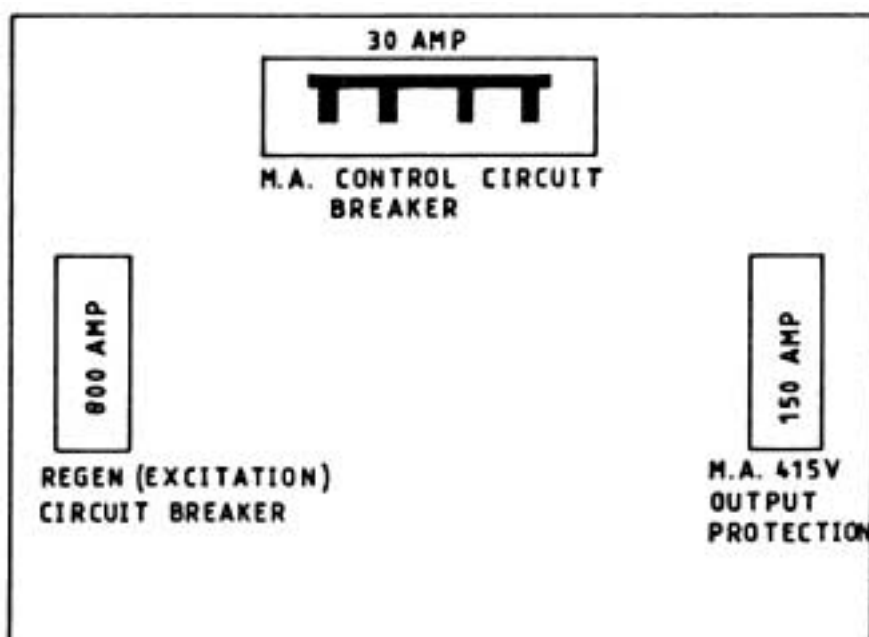
The hot plates and window demisters are operated by a 74 volt supply via a transformer from the 240 volt A.C. supply.

A separate three phase supply is provided by the motor alternator for regenerative braking.

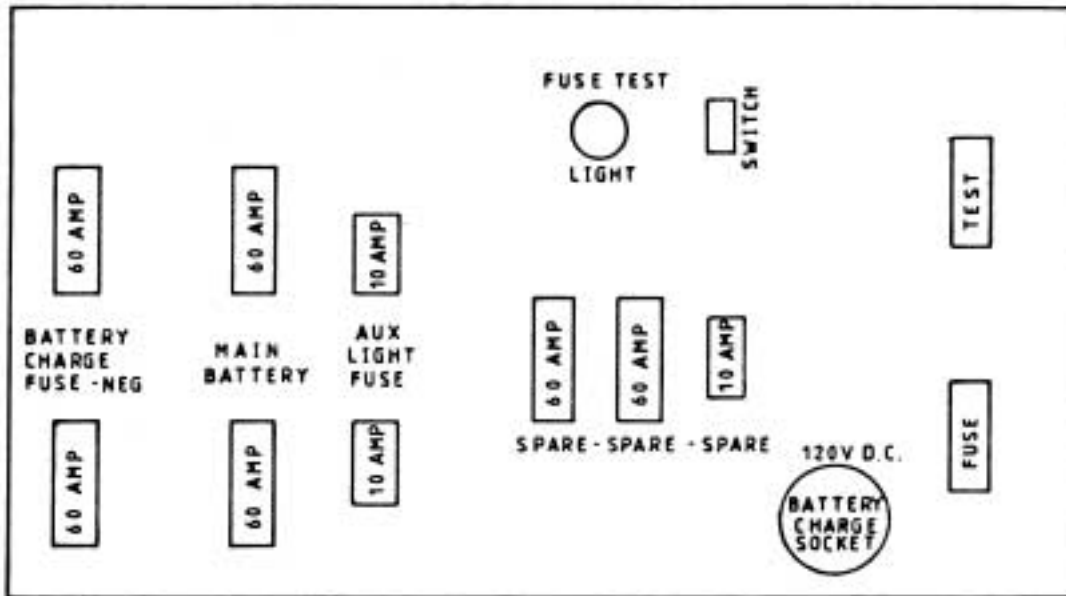
Adjacent to the Motor Alternator is the M.A. circuit breaker cabinet housing the following equipment:-

- 800 AMP Excitation (Regen.) circuit breaker
- 150 AMP Alternator 415V output circuit breaker
- 4 Pole 30 AMP Motor Alternator control circuit breaker

## **MOTOR ALTERNATOR - CIRCUIT BREAKER CABINET**



## BATTERY FUSE BOX - (RIGHT SIDE OF LOCOMOTIVE)



### BATTERY FUSE PANEL

The battery fuse panel, located adjacent to the battery boxes, contains the following equipment:-

- (a) Five (5) battery fuses.
  - (i) 60 amp battery positive fuse
  - (ii) 60 amp battery negative fuse
  - (iii) 60 amp battery charging positive
  - (iv) 60 amp battery charging negative
  - (v) 60 amp battery spare fuse
- (b) Three (3) auxiliary fuses.
  - (i) 10 amp auxiliary positive fuse
  - (ii) 10 amp auxiliary negative fuse
  - (iii) 10 amp auxiliary spare fuse
- (c) A fuse tester
- (d) A battery charging socket.

The auxiliary fuses protect the two fuse testers, the one located within the battery fuse panel and secondly the fuse tester located adjacent to the high tension compartment.

During preparation, the spare fuses are to be tested in the following manner:-

1. Operate light switch to ensure light bulb functions.
2. Provided all fuses appear to be intact, operate switch to "Fuse Test"
3. Light will shine proving all low tension fuses are OK.

If light does not shine it will be necessary to manually test each fuse by laying it across the test block.

**NOTE:** The 10 amp auxiliary positive and negative fuses must be in circuit for fuse test switch, test block and globe to function.

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## AIR COMPRESSORS

### Identification

The compressors are driven by 1500 V D.C. motors and supply compressed air for pneumatic braking, control air for the operation of traction control equipment and air for cab accessories such as cab refrigerators, windshield wipers and locomotive horns.

The compressors contain three vertical in line cylinders and have two stage operation. A compact, light weight intercooler complete with safety valve is provided between the low and high pressure cylinders.

### Characteristics

Make .....	Westinghouse
Type .....	3 VC 75B
Power .....	9 kW
Operating Voltage .....	1450 V D.C.
Speed .....	1000 rpm
Delivery Pressure .....	965 kPa (140 lbs/sq inch)
Weight (dry) .....	400 kg (880 lbs)

### Location

The motor driven compressors are mounted transversely between the two bogies under the foot plate on the left side of the locomotive.

### Operation

#### Low Tension Control Circuit

In order for the compressor contactors CC1 and CC2 to operate the following circuit breakers and switches must be switched on:-

- (a) Train Control Circuit Breaker, this is located on the main circuit breaker panel.
- (b) Compressor circuit Breaker CMGB also located on the main circuit breaker panel.

A feed is also fed to train line wire No. 22 via the compressor synchronising circuit breaker (also mounted on the main circuit breaker panel), this ensures that all compressors start and stop together.

The compressors are under the direct control of the compressor governor, which is located on the air gear rack in the machine compartment.

The two compressor control switches CMS1 and CMS2 are provided to facilitate individual starting and stopping of the compressors and if required, a means of isolating either of the compressors if a fault develops.

#### High Tension Control Circuit

Each motor is supplied with 1500 volt D.C. current from the overhead wire and are protected individually by high tension 20 amp fuses, CF1 and CF2, which are mounted on the fuse panel in the high tension compartment.

Once the compressor contactors CC1 and CC2 are energised as discussed previously, their contacts will close and current will begin to flow through the motor armatures CM1 and CM2 and the compressor motors commence to rotate.

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## TRACTION MOTOR BLOWERS

### Identification

There are two traction motor blowers provided for traction motor cooling. Each blower supplies the pressurized cooling air for three traction motors. As well as cooling traction motors, the two blowers are also used to:-

- (a) Pressurize the high tension compartment, by passing air through fibreglass filters at the bottom of the excitation box and then through the Thyristor and Diode stack (to cool this equipment) into the High tension compartment.
- (b) Force cool the motor alternator and motor driven air compressors. Each traction motor blower consists of an A.C. motor driving two fans, one being mounted at either end of the motor.

### Location

Both traction motor blowers are located in the machine compartment. No. 1 blower is mounted between the auxiliary low tension compartment and the No. 1 cab bulkhead. No. 2 blower is located between the air and brake gear rack and the toilet cubicle.

### Operation

The traction motor blowers are supplied with three phase 415 volt A.C. power produced by the motor alternator.

### Protection

Circuit breakers, (Blower Control, Traction Motor Blower 1 and Traction Motor Blower 2) are provided on the circuit Breaker Panel on the Auxiliary Low Tension Cupboard.

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## AUXILIARY RELAYS AR 1 AND 2

Two Auxiliary relays are mounted at each end of the locomotive adjacent to the respective "Pan Up" and "Pan Down" magnet valves.

An auxiliary relay (AR) must be energised before the no volt auxiliary relay (NVAR) will operate and energise the motor alternator contactor (MAC) Compressor contactor (CC) and lighting circuits, permitting these auxiliary machines to operate. At the same time the fault alarm circuits also become operative when the "Pan Up" button is pressed and Auxiliary relays (AR) energised.

When the "Pan Down" button is pressed, the Auxiliary Relays (AR) are de-energised, opening the motor alternator contactor (MAC) and Compressor Contactor (CC) before the pantographs leave the overhead wire.

This ensures that current is not flowing from the overhead wire to the auxiliary machines and prevents any arcing that may damage the pantograph strips or contact wire.

**NOTE:** When stabling both Pan down buttons must be pressed.

### No Volt Relay (NVR)

This relay is provided to prevent a re-application of power to the traction

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motors in the event of a loss of overhead current when power is restored. When this relay operates it is necessary for the operator to return the accelerating or regeneration handle to the "Off" position to reset the No Volt Relay.

This relay will close when 1100 volts is present in the overhead and will open if overhead falls below a predetermined point.

**Overload Relays (OLR1, OLR2, OLR3)** the overload relays trip if the current flow to the traction motors exceeds 1400 amperes.

**Differential Current Detector** trips if the amount of current flowing into the circuit is different from the amount flowing out. This indicates an earth fault in the equipment. The High Speed breaker will then trip.

The differential and overload relays are reset by first returning the accelerating or regeneration handle to the "off" position and then by pressing the overload "Reset" button on the driver's stand.

They should not be reset more than twice in quick succession. Repeated settings will damage the equipment and may result in a fire.

When the accelerating or regeneration handle is in the open position the tripping of the overload relays and differential current detector is indicated by the presence of the Red Power Fault indicator light on the affected unit and the sonic alarm on all units in multiple.

### **Overvoltage Relay (OVR)**

This relay is energised during regeneration and opens the line switches if the voltage which is being generated exceeds 2050 volts. It is reset by returning the regenerative handle to the "OFF" position.

Indication Red "Power Fault Indicator" on affected locomotive. Alarm on all units in multiple.

**NOTE:** This fault is more likely to occur when in multiple with 85 class locos as the 85 class is not fitted with voltage limiters.

## **THE VOLTMETER**

The Voltmeter self illuminates during darkness and provides an indication of the overhead voltage available. A No Volt relay is provided, which will allow voltages in excess of 1100 to operate the locomotive and its auxiliaries, and, will "drop out" at approximately 900 volts should the voltage supply become this low. Voltage is not now a primary consideration in train performance as the LOAD or AMP Meter now holds far more relevance for a more efficient train performance.

## **OVERHEAD VOLTAGES RISING AND FALLING**

It will be noted that overhead voltages fluctuate en route. Some of this is due to the amount of current the locomotive is using at the time. Another reason is the voltage tends to rise when in close proximity to a substation, and to a lesser extent, when nearing a section hut. Away from these two areas, the voltage may decrease by up to two hundred volts.

It is absolutely essential to realise that when near or at substations or section huts, the locomotive and overhead wiring is most likely not to supply the current or power demands of the driver, should they be excessive. The weak point of the overhead supply is at these locations.

The Sydney Metropolitan Area electrical substations, on average, have the two circuit breakers controlling the section of wire being utilised set at 4000 amps. Outside the Sydney Metrop. Area, most are set at approximately 5000-5500 amps. The nearer the train is to a substation or section hut means that the majority of current is coming via or through the circuit breaker at that end. In the area between the substation and section hut the current (or amperage demand) is divided between the circuit breakers at each end of the electrical section.

In real terms, this means that given that yours is the only train in that direction on this electrical section, the substation or section hut circuit breaker will trip (taking with it, the circuit breaker at the other end of the section) at or about 4000 amps (Sydney) or 5000 amps (Outside Metrop.) whilst in the vicinity of the substation or section hut. However, between these locations, because the current supply is being shared by the two circuit breakers it may be possible to achieve up to an 8000 amp supply - tapering off as the substation or section hut becomes closer. This is in spite of the natural voltage rise when nearing these locations.

From this, the driver must constantly be aware of the traction motor combinations and multiplication factors when running multiple units to avoid high amperage demands at substations and section huts.

The following table is provided for your guidance.

Multiply amperage by the number of banks of motors times the amount of locomotives.

Load Meter Amps	Traction Motor Combination	Total Amps	Number of Locos	Equals
400	Series	400	1	400
600	Series	600	3	1800
600	Series-Parallel	1200	1	1800
600	Series-Parallel	1200	3	3600
800	Parallel	2400	1	2400
800	Parallel	2400	2	4800
700	Parallel	2100	3	6300

In the examples above, it is easy to exceed the substation circuit breaker amperage. In the final example, 6300 amps may be achievable **between** the substation and section hut, but would certainly "pull the power" **at** the substation or section hut.

Should the voltmeter take a sudden fall to approximately 900 - 1000 volts it would most likely be only one of the two circuit breakers tripping. Normally, when one circuit breaker trips it takes the other (at the other end of the section) with it, however, there have been times when only one circuit breaker has tripped.

The opened circuit breaker at the substation or section hut cannot reset if the train is drawing more than 2000 amps. The driver has two options:-

- (i) Persevere with low voltage until next substation or section hut.
- (ii) Perhaps reduce the amount of amps required to below 2000 amps overall. This could possibly be achieved by transition back to series combination until full voltage is restored.

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## THE DEMAND METER AND AMP METER

The Demand Meter is a valuable help in setting up the locomotive for normal running when used to its best advantage.

The Load or Amp Meter IN ALL CASES will try to match the demand meter reading. Of course, in some instances such as high speed or a lower traction motor combination relative to the speed of the train e.g. (Series selected at 80 km/h), this will not be achievable, however, the electronics within the locomotives will still attempt to carry out this function.

The demand meter will only function if the Master Controller has been operated in Notch four (4). The excitation system of the locomotive is coupled directly to the master controller and, in turn, the demand meter.

When stepping out resistances using notch 4, the demand meter reading must always EXCEED the amperage on the Amp meter. Failure to carry out this task will result in the camshaft wheel stopping or perhaps put resistances back into circuit as the speed decreases and the current flow rises. In other words, the locomotive will stay in resistance notching whilst the demand does not exceed the supply.

Should the driver reduce the demand setting whilst stepping out, could result in the camshaft or pilot motor "sticking" which may give cause of concern when the demand is increased but the camshaft is unable to follow due to the jammed pilot motor.

### Maximum Amperages in Train Working

1100 amps when lifting or starting for 10 seconds

900 amps for five (5) minutes

800 amps for twenty (20) minutes

750 amps for one (1) hour

725 amps continuously

The above amperages represent a guide only and will depend largely on the temperature of the traction motors and atmosphere conditions prior to utilising in excess of 750 amps, therefore, the above amperages should not restrict the driver under normal to fairly severe conditions.

### Maximum Amperages utilising Emergency Light Engine Switch

270 amps for 15 minutes

230 amps for 25 minutes

150 amps continuously

The above amperages will only be available for approximately one minute unless out of resistance. Operation 2-3-2 method only.

Regen is not available.

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## THE MASTER CONTROLLER

The Master Controller has five separate operating positions, however, notch four (4) has an extended zone or operating area. This area ranges from four minimum to four maximum.

Notch 1	Notch Down
Notch 2	Holding or Pivot Notch
Notch 3	Notch Up
Notch 4	Normal Traction Notch
Notch 5	Transition select

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## **NOTCHES 1, 2 and 3**

Notches 1, 2 and 3 offer precise control when shunting, and, more particularly when starting on heavy grades. The three notches (1, 2 and 3) are not in circuit if: (a) Notch four of five has been utilised.

(b) Any motor combination other than series has been selected.

Initially, notch one two and three are of the same traction (amperage) value. The control system has been designed to enable a precise notch out method in extreme circumstances.

### **To Notch Up (Remove Resistances)**

The master controller is moved to notch three and then back to notch two. The master controller is to be paused in notch two and advanced again to notch three. Another resistance will then be removed. The master controller is to be moved back to notch two each time notch three has been selected. The master controller **MUST** be paused in notch two for this system to operate. Numerically, the system looks like this:-

0, 1, 2, 3, 2 pause, 3, 2 pause, 3, 2 pause etc.

Each time the master controller is paused in notch 2 and placed in notch 3 another resistance is taken out of circuit. There are nine resistances within the series combination. Full resistance is achieved at the initial opening of the Master Controller, the resistances can be removed one by one using the 2-3-2 method. After the resistances have been removed (indicated by the "resist notch" light extinguishing on the annunciator panel or by counting each resistance as you remove them) weak fields can then be placed into circuit if required by using the same 2,3,2 pause method.

### **To Notch Down (Re-Insert resistances)**

When using the precise control method, that is, notches 1, 2 and 3, it is also possible to re-insert a resistance to reduce the amperage and remedy a wheelslip.

To do this, the master controller when paused in notch two is then placed into notch one and then back to notch two to pause again. It is not possible to reinsert sufficient resistances to lower the motor amperage below 400 amps. After the slip has been stabilised, the 2-3-2-3 method of notch up can again be utilised. Should the locomotive be out of resistance and placed in weak field operation, all four weak fields can be withdrawn using the 2-1-2 pause method.

**NOTE:** It is not possible to re-insert resistances after the resist notch light is extinguished.

### **Normal Notching and Acceleration. Notch 4**

Notch four operation is the most common form of acceleration. The notch has an operating area or zone commencing at the No. 4 position (minimum) through a green zone and partial red area (maximum) prior to notch five. This area or zone enables the driver to vary the amperage to control the train. The demand meter will also operate immediately notch 4 is selected. In addition, notches 1, 2 and 3 become non existent and are not available at any time after notch 4 has been selected unless the master controller is first returned to the "off" position. Basically, the less use or variation of demand by the master controller in notch 4, the better. The excitation system is very sensitive, therefore any movement of the master controller in the "4 zone" is felt immediately in the control system. This in turn dictates whether the camshafts rotate one way or the other. Fanning (minimum to maximum and vice versa) the master controller will possibly cause sticking pilot motors as they try to keep in step with the demand meter.

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There are times when the driver does not have total control of the weak fields. As explained earlier, the amp meter tries to match the demand meter. When speed is such that a particular combination cannot supply the demand in full field, weak fields are inserted by the excitation system in an attempt to satisfy the demand. It will be noted that at times the driver only has manual control of one or two of the four weak fields. Sometimes, all weak fields are in circuit regardless of the master controller position in the notch 4 zone e.g. above approximately 50 km/h in series, 80 km/h in series-parallel.

As a general guide, if the master controller and demand meter is set for 700 to 800 amps in reasonable conditions, the locomotive will accelerate in a trouble free way. In adverse conditions, lower the demand accordingly to perhaps 550 - 600 amps. Acceleration will be marginally slower but helps prevent slipping. In all cases when accelerating, remember to keep the demand above the amp meter reading and try not to overuse the master controller.

### **Notch 5 (Transition)**

Notch 5 is used only for transition purposes. It is strongly recommended that notch 5 not be utilised until such time transition is required. Camshaft rotation is in relation to axle speed, therefore, the faster the locomotive is going, the less time in resistance, which means the camshafts have to spin much quicker - reducing the chance of sticking pilot motors. The recommended speeds transition to be selected is 20 km/h series to series-parallel and 40 km/h series-parallel to parallel. Notch 5 is not used for backward transitions.

When selecting transition, the master controller is to be placed into notch 5, paused, and replaced at the desired demand meter setting in the notch 4 zone.

*Series to Series-Parallel* - should the locomotive/s still be in "resist notch" when the transition is selected, various relays or "memory" is energised. Transition will take place when all resistances in series have been eliminated. The "resist notch" indication will continue to shine until all four series-parallel resistances are out of circuit.

*Series-Parallel to Parallel* - The method of transition is the same, however, the "memory" feature is not energised until the first two series-parallel resistances are eliminated. This is to protect against inadvertently holding the master controller too long in Notch 5 when changing from series to series-parallel, thereby, accidentally selecting parallel by mistake.

Maintaining the master controller in notch 5 is not recommended as this serves to actually slow the acceleration process by not allowing any weak fields into series or series-parallel. It also causes the locomotive to stay in resistance mode continuously until approximately 45 km/h

### **Backward Transition**

A red backward transition button is located on the master controller stand. The button will only enable transition from Parallel to Series-Parallel combinations. No adjustment to the master controller is necessary. When the button is pressed, the camshafts return to the first resistance in series-parallel. The camshafts must then proceed through the resistance to extinguish the "resist notch" light. Backward transition to series can only be effected by returning the master controller to "off" and then back into the powering zone. Generally, backward transition to series-parallel from parallel would be desired by the driver by the time the locomotive dropped in speed to approximately 30 to 35 km/h and transition back to series at approximately 20 km/h

A very smooth and effective shut off can be achieved in parallel if the backward transition button is pressed. When both the parallel and series-parallel indicator lights shine, close the master controller.

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## REGENERATIVE BRAKE

The regen brake on the 86 class is electronically controlled. A regen handle is provided adjacent to the master controller. The handle has an operating zone commencing at MIN and can be varied up to the MAX position and vice versa. The electronic control system monitors and regulates braking in addition to the driver's actions. Whilst it is not impossible, it is difficult to "overvolt" the system as it has its own limiters regulated to below the overvolt relay of 2050 volts. Should the overhead voltage be high prior to selecting regen, the excitation is limited to compensate. Once having selected regen, the system gives the locomotive ten seconds to produce 70 amps. If this cannot be achieved due to substation deficiency or volts too high the regen will drop out within the ten second period.

Another important feature of the regen is the reverser handle must be in forward and at a point prior to selecting regen, the line switches must have closed to throw the reverser switch to forward. As an example:-

Shunt performed prior to departure. Locomotive reversed onto train. Train standing on down hill grade. At departure, locomotive and train allowed to roll away. Regen selected at 25 km/h. Regen not working due to reverser switch (cam) still in reverse from shunt even though reverser handle in forward. Remedy - dispense with regen, apply power using notch 1 of master controller. When load meter registers, shut off, introduce regen.

It is not possible to motor in regen. This also enables the control system to drop out the regen brake when 70 amps cannot be produced. This occurs at approximately 15 km/h in series regen in deceleration and at approximately 35 km/h in series-parallel regen in deceleration. When the speed is rising series regen will be available at approximately 18-20 km/h and series-parallel regen at approximately 38-40 km/h - both depending on the overhead voltage value at the time.

During the time in regen, depending on other trains in the vicinity and substation output, a position of the master controller may be producing 500 amps with 1800 volts in the overhead. The very same exact position of the regen handle in another electrical section may be indicating 350 amps with 1950 volts in the overhead. This is the excitation system compensating for the high voltage by reducing excitation, and therefore, output amps, to guard against an overvoltage situation.

**NOTE:-** This feature is NOT available on 85 class locos.

## WHEEL SLIP

The wheelslip control system is integrated into the main excitation electronics. It relies on Motor Alternator output in addition to a data feed from the six axle generators. The detector unit receives the output from the axle generators, averages the speed of the axles and detects if an axle is "out of average" slipping or sliding. The electronics compensate and remove portion of the current to that traction motor to arrest the slip. Should the slip persist for more than 2 seconds the wheelslip indicator light on the annunciator panel will illuminate. If the slip continues and can't be corrected by the driver applying sand or reducing tractive effort, all traction power will be lost within 10 seconds \*.

The alarm will operate continuously. In this event, the master controller is to be shut off, the overload reset button pushed (on the driver's front console), power

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or traction may then be re applied. If this fails to reset the alarm indication and restore traction, the wheelslip/slide and excitation circuit breaker on the circuit breaker panel may have tripped. It is important to trip and reset this circuit breaker as it doesn't necessarily "trip" visually.

If the circuit breaker will not reset or the Wheel Slip annunciator indication continues to shine, it may be necessary to utilise the Emergency Light Engine Switch to clear the section as a Light Engine only. The Master Controller and control circuits remaining will eliminate resistances in series using the 2-3-2 method only.

**NOTE:** Whilst this fault persists and the Light Engine Switch is used, No load meter reading will show, however by counting the resistances as they are removed using the 2-3-2 method will ensure the light locomotive is not used excessively in resistance.

\* **NOTE 2:** The Wheelslip detector and electronic unit has a fifteen (15) second "slip" span. Due to the wheelslip not being indicated as an alarm for the first two seconds, it is quite possible for multiples of un-indicated slips to occur or "blips" on the annunciator to occur. When a "blip" occurs, the wheels have slipped for three (3) seconds. Two blips or flashes of wheelslip indication is approximately six (6) seconds (in two different but close proximity instances), leaving less than 10 seconds of slip before the electronics withdraw traction because of continuous wheelslip.

## SANDING

These locomotives are fitted with axle generator sensing equipment which compares the speed of each axle. This information is monitored by an electronic device controlling wheelslip/slide and excitation. When the Wheelslip indication appears, one or more axles have been detected as slipping for a minimum of two (2) seconds. Sand operation prior to and during the indication is automatic. A manual footbutton is also provided which allows the driver to manually control the sanding function should it be considered necessary. This feature **MUST** be used sparingly.

Under no circumstances, other than during preparation, should manual sanding be used during Light Engine running.

Should continuous sanding take place during Light Engine or Train working, the sanding magnet valves are to be isolated, and the condition reported to Control, Locomotive Depot or nearest attended station/signal box, via either Two-way radio or Telephone in addition to making a suitable entry in the locomotive log book.

## ALARMS AND SAFEGUARDS

The locomotive is equipped with the following alarms and safeguards:-

1. A sonic alarm ("beeper") is provided to warn the driver that at least one of the safeguards has operated.
2. An annunciator panel is located above the driver's desk to indicate, in conjunction with the sonic alarm, that any of the following indications are provided:-

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Failed Alternator - Power Fault - T.M.800 Amp Level - Wheel Slip - Resistance Notch - Brake Cylinder Pressure - Resist Over Heat - Failed Fan.

The Vigilance Control acknowledgment button is on the right side of this panel.

An Indicator panel is placed vertically below the annunciator panel and indicates - Headlight ON - Panto. (light on indicates response) - Series - Series Par. - Parallel.

## **MOTOR ALTERNATOR FAILURE**

Failed alternator and beeper indication will operate immediately output is lost.

To reset the motor alternator overcurrent relay (MAOCR) operate the fault overload button on the driver's control stand. This will cancel the fault indication and immediately the motor alternator commences to produce current the alarm will cease to function. A time delay of approximately fifteen (15) seconds applies.

A failed alternator and sonic alarm indication will operate when the output from the motor alternator is lost due to the following:-

- (i) Motor alternator 30 amp. circuit breaker tripped.
- (ii) Motor alternator 150 amp. output circuit breaker tripped.
- (iii) Battery charging circuit defective. Battery charging or Indicator supply circuit breaker tripped.

Under normal circumstances the visual indication and the sonic alarm will be cancelled when output supply is restored by resetting of the circuit breakers or by renewing fuses.

### **Power Fault Indication**

Power fault indication if any of the following occurs:-

- (a) Fault in traction circuit.
- (b) Overcurrent in traction motors (straight overload operation 1400 amperes).
- (c) Overcurrent on motor side of motor alternator (high tension).
- (d) Opening of the control governor.
- (e) Overvoltage relay tripped out (2050 volts).
- (f) Failure in camshaft control to respond correctly.

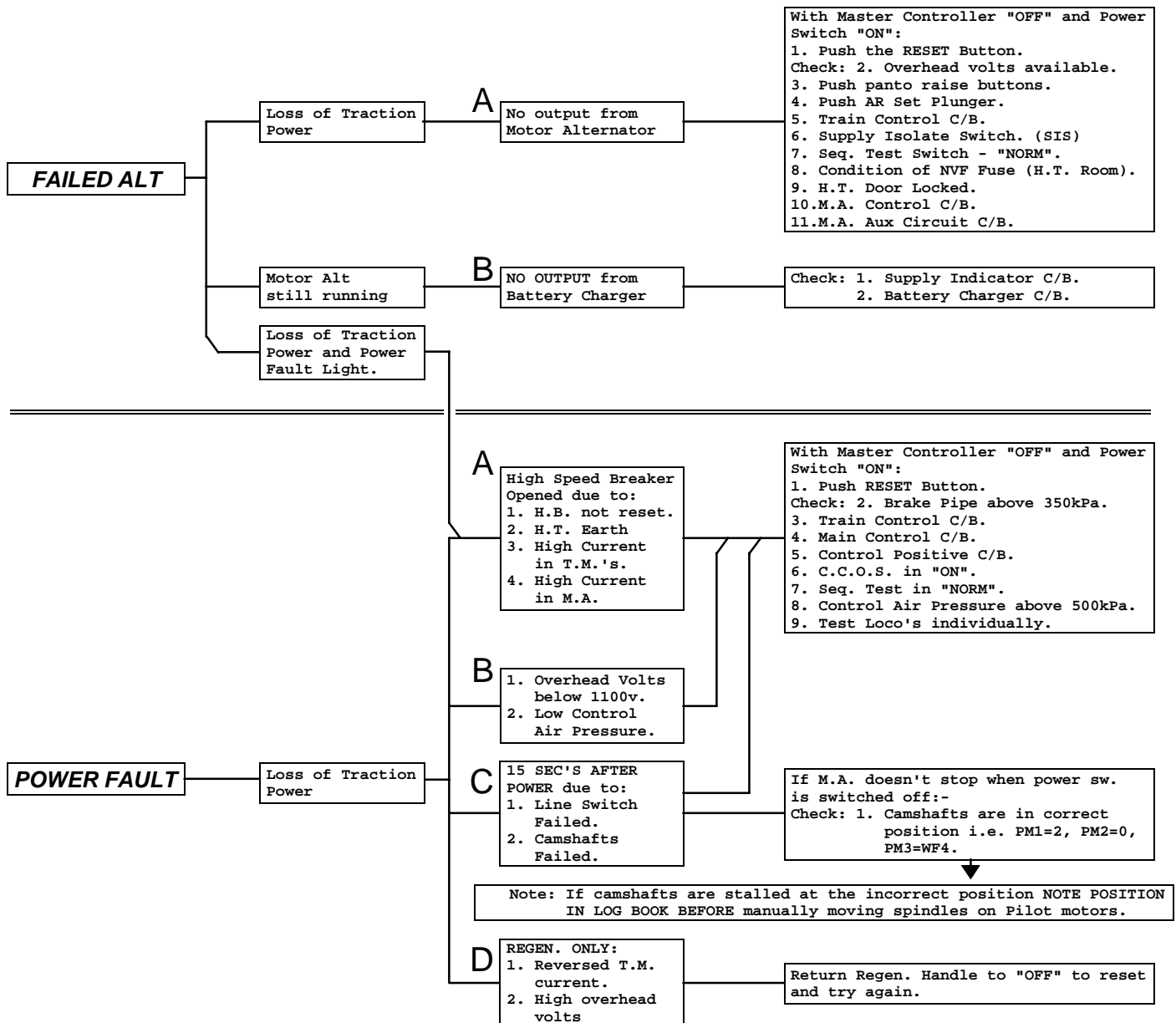
Faults a, b, c cause the high speed breaker to open and this opens the line switches which will also cause the fault indication to operate.

Faults d, e and f only cause line switches to open.

When the power fault indicator operates under power return the accelerating handle or regenerating handle to the "OFF" position and press the fault reset button.

In the event of the motor alternator stopping the Failed Alternator indication will function.

**NOTE:** There is a time delay of up to fifteen (15) seconds from the time the reset button is pressed until alarm ceases.



## Wheel Slip/slide Indication

The sonic alarm operates if either of the above occur.

In the event of a wheelslip the armature current is reduced to the affected wheel and automatic notching stops until wheel slip is corrected. The tractive effort should be reduced by easing the accelerating handle toward minimum position in notch 4 as well as operating the sander button if continual slipping is experienced.

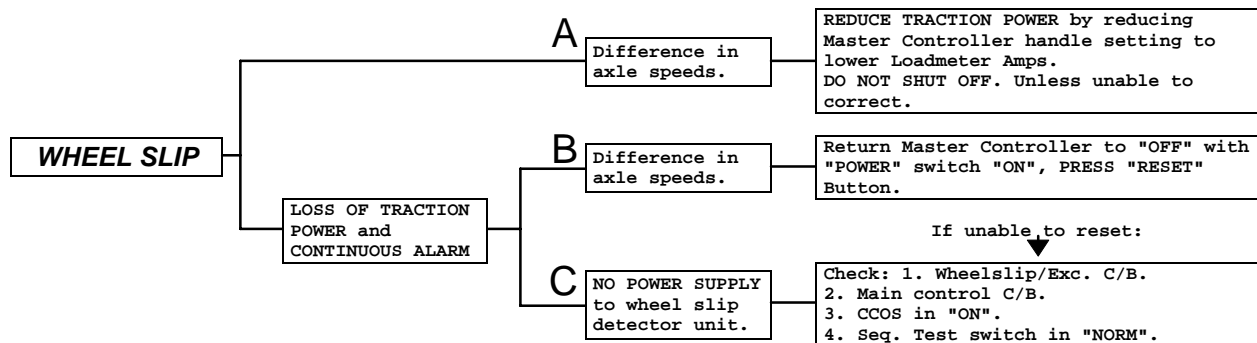
When operating in regeneration and wheelslide occurs the braking effort will automatically be reduced. When continual wheel slide is experienced, the regenerative handle position should be adjusted to correct the slide.

When the wheel slip/slide occurs during pneumatic braking no automatic correction is effected and braking effort should be reduced in conjunction with sanding.

If a continual wheel slip/slide is indicated, check the wheel slip breaker and reset if tripped.

If wheel slip/slide indication still persists, check locomotive wheels for rotation. If all wheels are rotating and there is no evidence of other faults, the unit is to be isolated and considered a failure. It may be possible to clear section as a Light Engine (if a single unit) utilising the Emergency Light Engine Switch.

Details of the above are to be entered in the locomotive log book.



## Brake Cylinder Pressure Indication

The brake cylinder pressure indicator is provided to warn the Driver should the brakes inadvertently apply on the locomotive or on any trailing locomotive fitted with this switch in a multiple unit consist. The light is normally extinguished when the brakes are released.

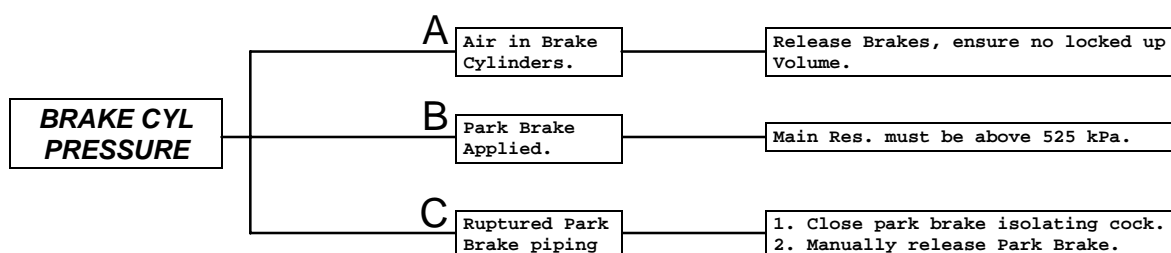
When pressure in the brake cylinder rises to 30 kPa, the switch closes and the indicator functions. Upon the pressure failing to 10 kPa, the switch opens, the indication is extinguished.

The brake cylinder pressure indicator is train lined through the jumper coupling and will function on all locomotives, when the brakes are applied on one or more of the locomotives in a multiple unit consist.

The indication will also shine with the application of a spring parking brake on either leading or trailing 86 class locomotive.

Should the indicator function when the locomotive(s) are being operated with the brakes released, immediate action is to be taken to release the brakes in accordance with current instructions. Check the spring parking brakes on all locomotive are off.

**NOTE:** This particularly applies in a multiple unit consist as severe damage can be caused to a trailing locomotive due to the brakes failing to release from a slight overcharge of the brake pipe. (Locked up volume)

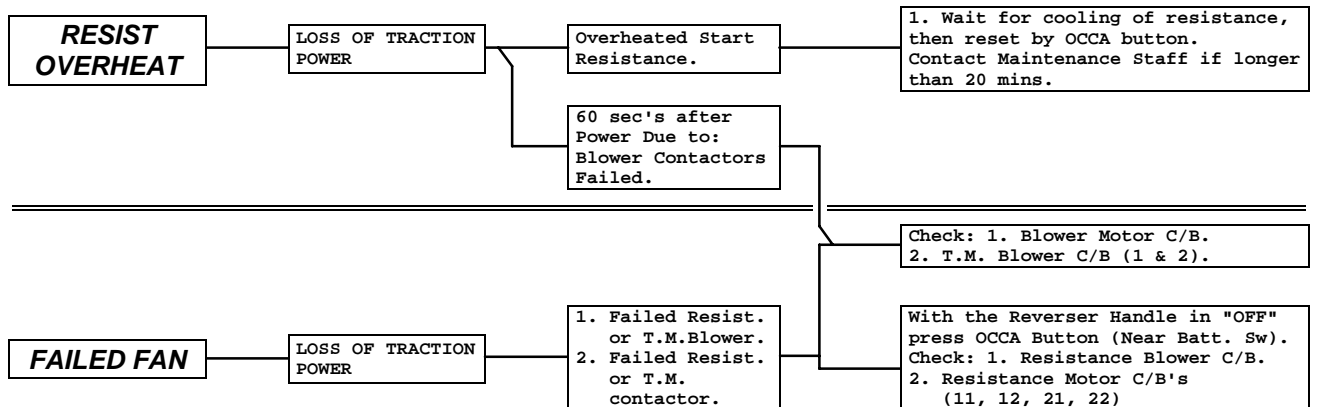


## Failed Fan Indication

Power circuit is interrupted automatically. The failed fan alarm will operate in the event of a resistance or traction motor blower fan stopped, due to a fan circuit breaker tripping or contactor failing to close.

Move the accelerating handle to the "off" position and check resistance fan and traction motor blower circuit breakers are not tripped.

When necessary reset a tripped circuit breaker and operate the OCCA reset button on the Auxiliary Low Tension panel in the machine compartment. The locomotive can operate as a light engine only, utilising the Emergency Light Engine Switch.



## Resistance overheat indication and alarm

Power circuit is interrupted automatically. The resistance overheat alarm will operate to indicate overheating of the resistances and under normal conditions should be able to be reset within a period of three (3) minutes by moving the accelerating handle to the "off" position and operating the OCCA reset button located on the auxiliary low tension panel in the Machine Compartment.

Should the resistor overheat circuit fail to reset after the reset button has been operated a number of times and a period of not more than Ten (10) minutes has elapsed, Maintenance Staff are to be contacted.

When the Resistor overheat circuit operates it is of the utmost importance that it is recorded in the log book with the operating current and the maintenance staff fully informed of the circumstances at the depot at the termination of the run.

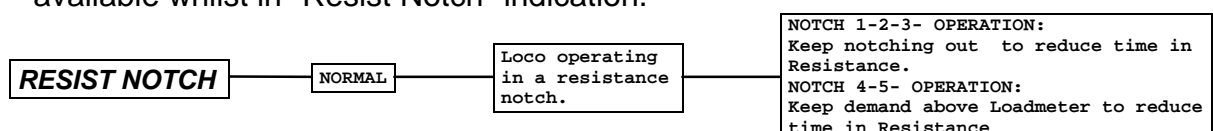
If the resistor overheat operates more than twice in starting, then arrangements are to be made to stow the train and remove the locomotive from service as quickly as possible.

**NOTE:** Overcurrent cancel acknowledgment (OCCA) reset button when operated resets the following:-

- (i) T.M.800A Latch light
- (ii) Resistor overheat fault.
- (iii) Fan Relay fault.

## Resistance notch indication

This indication functions on all units when the accelerating handle is opened and will continue to shine until all resistance is notched out of circuit by the automatic action of the camshaft, i.e., the light shines to indicate to the driver that resistance is in circuit and continuous operation of this light beyond a reasonable time period will require attention to determine the cause. Transition is not available whilst in "Resist Notch" indication.



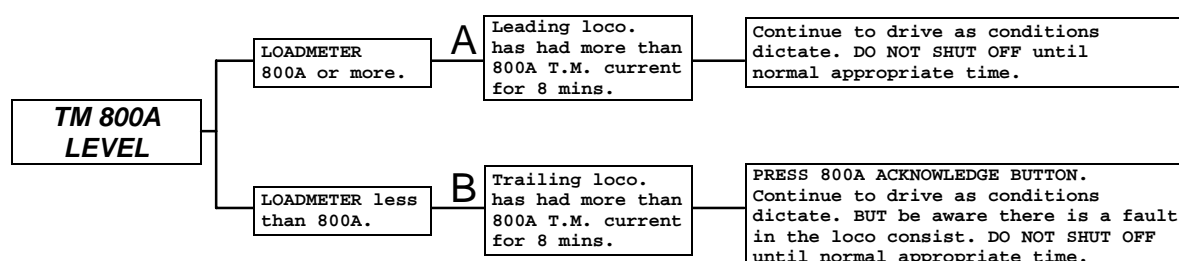
## TM800A - INDICATION - TRACTION

When operating the locomotive in excess of 800 amps for 8 minutes, the TM800A will appear on the annunciator panel. If the driver is aware that he has been operating the locomotive in the high amperage range, no immediate action is to be taken by the driver.

There will be no need to press the TM Overcurrent Acknowledge Button.

The TM800 amp indication will cancel when the accelerating handle is returned to "off".

However, when operating a double or triple unit consist and a TM800A indication appears with the leading loco. showing less than 800 amps on the Loadmeter, the driver should press the acknowledge button on the panel, which will light the red detection light in the machine compartment. This will enable the driver to identify the affected unit. After logging the defect in the locomotive log book, the red detection light should then be cancelled, by pressing the cancel (OCCA) button.



## TM800A - INDICATION - REGENERATIVE BRAKING

Same conditions apply in regen. braking as in motoring, in addition the traction motor current will automatically reduce to 750 amps.

## PANTOGRAPH CONTROL

The pantographs are raised by main reservoir air pressure when available. If air pressure is not available a footpump is supplied at each end of the locomotive and after pressing "Pan up" button or manually operating the "Pan Up" and AR set plungers, the respective footpump should be operated till the pantograph makes contact with the overhead wire the compressors commence to run and sufficient air is available to maintain contact between pantograph and contact wire.

**NOTE:** 8650 has an electric pantograph raise pump which operates when Main Reservoir air is below 200 kPa. To operate - Battery Switch "IN", place reverser handle to the OFF position and press the PAN UP Button, or manually set pantograph plunger and "Set" AR.

### A.T.C. (Automatic Train Control) on 8650

This locomotive is fitted with an Ericsson Train Control system. Additional equipment is located within the unit including a push button data field display unit immediately above the annunciator panels. Two computers are located behind the cab together with an air cock which is normally closed and sealed. The ATC circuit breakers in the circuit breaker cupboard are not to be touched. It is only during test trips that the air cock and circuit breakers are altered. A radar unit is located under the No. 1 end cab and is associated with the software to operate A.T.C.

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## STARTING A HEAVY TRAIN ON A STEEP GRADE

(Greater than 50% load on ruling grade)

There is only one way considered the most effective, of starting a heavy train on a steep grade, this is:-

Notches 1, 2 and 3 only must be utilised and any movement accidental or otherwise into the four zone, will jeopardize the successful starting of your train.

1. Ensure automatic brakes fully released throughout train.
2. Maintain independent brake fully applied.
3. Using notches 2 and 3, apply 600 amps to traction motors  
(0,1,2,3,2 pause, 3, 2 pause 3, 2)
4. Allow independent brake cylinder pressure to exhaust - do not depress.
5. Operate sands and remove another resistance utilising notch 3 then back to 2. (Sand - 2, 3, 2 pause)
6. Movement, although slow, should commence - if not, remove another resistance as in item 5. The locomotive has the capacity to produce in the vicinity of 1000 amps at this stage. Movement should definitely take place. If a slip occurs, re-insert a resistance by using notch 1 then return to notch 2.  
(Sand - 2, 3, 2 pause then possibly 1, 2 if slip occurs)
7. As amperage and movement stabilizes maintain an amperage of 800 - 900 using 2-3-2 or if necessary at times 2-1-2 to reduce amps when slipping.
8. It is feasible to be out of resistance by approximately 10 km/h and 800 amps on the load meter. As speed continues to rise, insert a weak field, again by using 2-3-2 to maintain amperage in the vicinity of 750 - 800 amps. Use weak fields in similar way to resistances to maintain this amperage until speed rises to 20 km/h.
9. Should a transition be required, place master controller to notch 5, pause, and move master controller back only far enough to indicate 800 amps on the demand meter. Under no circumstances return the master controller to 4 minimum!
10. When series-parallel resistance indicator extinguishes, the train is travelling fast enough to allow flexibility in your driving methods.

**NOTE:-**If notch 4 is selected at any stage during items 1 - 8, the load meter is likely to fall immediately to approximately 400 amps.

**TECHNIQUES FOR HEAVY GRADES**

1. Under normal circumstances Master Controller should be regulated to maintain 750 - 800 amps during heavy pulls at speeds above 20 km/h.
2. Dispose of one weak field at a time as speed falls and amperage rises above 800 amps.
3. If amperage exceeds 900 amps with no weak fields engaged, a lower Traction Motor combination may be required.
4. Watch for adverse short section of track (grease pots, wet rail in cutting etc.) and be mindful of tendency of wheel slip.
5. Listen for wheel creep or whine, watch amp meter and reduce traction power by reducing the number of weak fields (4 minimum).

**STARTING AFTER PULLED TO STAND ON HEAVY GRADES**

- AUTOMATIC BRAKES RELEASED. INDEPENDENT APPLIED
1. Using precise notch out mechanism (3-2-pause-3-2-pause etc), load Traction Motors to 600 amps, apply sand.
  2. Release Independent brake. Do not depress brake valve handle.
  3. Continue using precise notch out until movement occurs.
  4. If wheels begin to slip re-insert a resistance (2-pause-1-2-pause).
  5. Remove resistances slowly until Resistance Notch indicator light extinguishes.
  6. Continued use of precise method after Resistance light extinguishes enables weak field/s to be inserted or eliminated in similar manner to resistances.
  7. It is not possible to re-insert resistances after Resistance Notch light extinguishes.
- NOTE 1.: THE USE OF NOTCH 4 OR 5 IS NOT RECOMMENDED FOR STARTING ON HEAVY GRADES WITH MORE THAN 50% FULL LOAD.
- NOTE 2.: THE USE OF NOTCH 5 prior to the actual time transition is required only serves to considerably extend the duration of Resistance Notching, and in addition, weak fields will not be available until all resistances in 'Parallel' have been eliminated.

**STARTING A TRAIN ON NORMAL REASONABLY FLAT GRADES**

Under normal circumstances, movement will occur by stretching the train in notches 1, 2 or 3, then advancing the master controller into minimum 4.

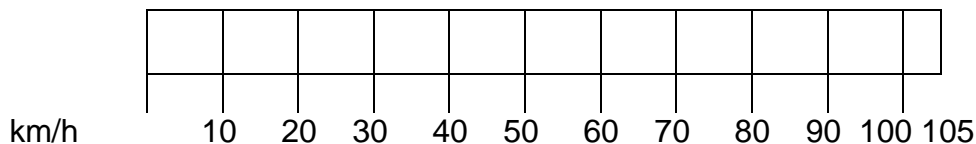
Further acceleration will occur as the master controller is advanced towards maximum, the demand meter must exceed the load meter for resistances to be eliminated. Use 600 - 800 amps on the demand meter as a guide.

**Parallel**

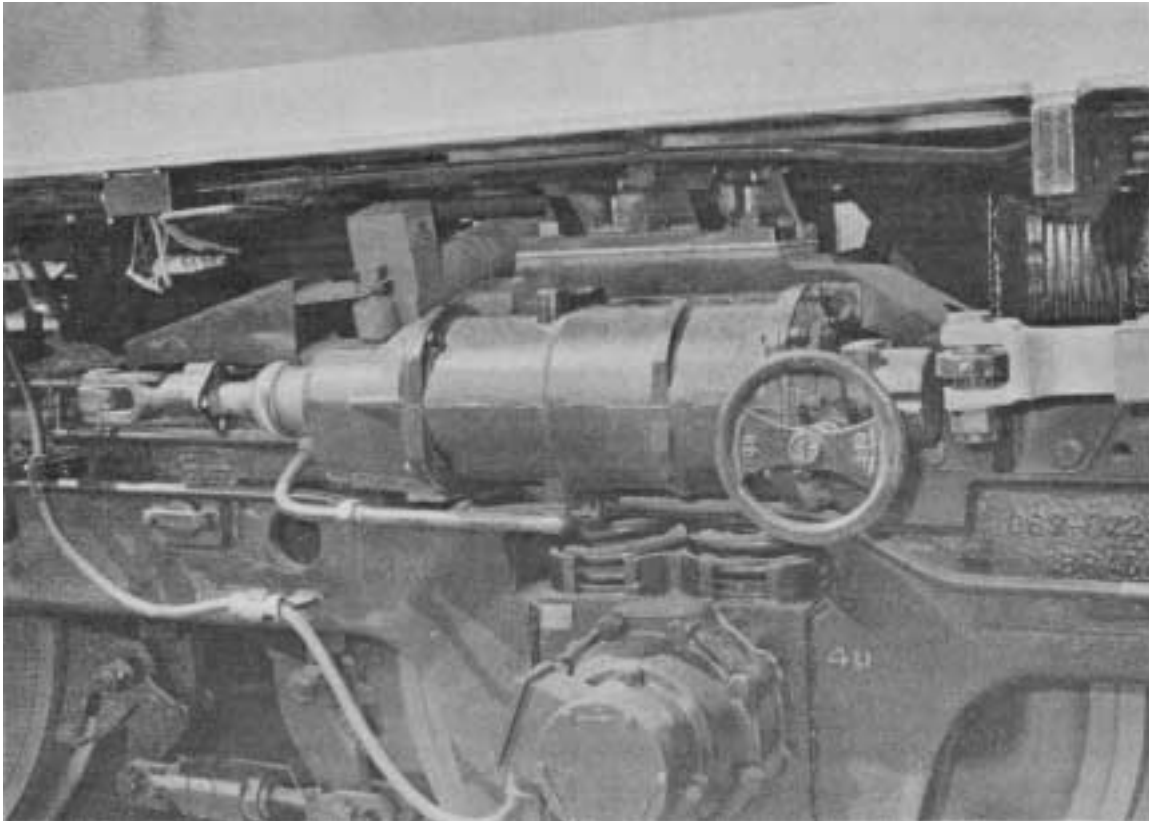
**Series-Par.**

**Series**

**Notch 1,2,3**



Notches 1, 2 and 3	range	0	-	20
Series	range	0	-	50
Series-Parallel	range	20	-	85
Parallel	range	32	-	105



### **Spring Parking Brake**

The locomotive is fitted with four spring parking brake units. The air pistons are connected to the Main Reservoir supply and are controlled by two park brake cocks, one mounted on the observer's desk in each cab.

When the Park Brake cock is in the ON position, the main reservoir pressure is prevented from flowing to the air piston assemblies and the springs will apply the brakes on the bogie. When the park brake cock is in the OFF position main reservoir air is allowed to flow to the piston assembly. This pressure acting on the piston, against the spring tension, releases the brakes. A gauge is provided to indicate if the parking brake is OFF. When it is ON the "brake cylinder pressure" indication will be displayed on the annunciator panel. In the event of loss of main reservoir pressure the spring parking brake can be released manually at each unit by turning the wheel anti-clockwise. An isolating cock is provided on each bogie, so that the parking brake may be isolated and manually released in the event of malfunction.

### **PREPARATION**

1. In the event of any equipment being found "cut out" unless labelled "Not to be used", or in the absence of a relevant entry in the Log Book, such equipment must be "Cut In".
2. If any authorised employee be at work on an electric locomotive at the time when the driver arrives to commence testing operations, and if such work is likely to affect the electrical or air equipment, the driver must not proceed with the testing operations on the locomotive concerned, or cause the locomotive to be moved, until the work has been completed and all danger discs removed from the departure end of the locomotives.
3. When an electric locomotive is stabled at a depot, the procedure outlined for stabling must be carried out by the stabling driver, unless instructed not to do so by the Operations Supervisor.

On arrival at locomotives ensure the brake cylinder and main reservoir isolating cocks are open. Enter locomotive and peruse the log book, then commence preparation from No. 1 end.

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## No. 1 End Cab

### The following items are to be checked:-

1. Parking brake is applied.
2. Check the accelerating handle, regenerative handle are in "off". Reverse lever in "Isolate" and removed.
3. Driver's brake valve cut off in "OUT" MU2A valve in "trail" position.
4. All switches on driver's and observer's stand not required are turned off.
5. Fire extinguisher charged and sealed.

Proceed to machine compartment

Check the following:-

- (a) Auxiliary air cock open.
- (b) Horn change over cock correctly set.
- (c) Panto. isolating cock open.
- (d) Kit and spare globes.
- (e) Battery ammeter for accuracy.
- (f) Close battery switch.
- (g) Sequence test switch in "NORMAL".
- (h) CCOS - switch "ON".
- (i) Emergency light engine switch in "NORMAL" and sealed.
- (j) S.I.S. - switch ON.
- (k) CMS1 and CMS2 - Compressor switches ON.

**WARNING:** An electrical cabinet housing 415V equipment is located next to the Auxiliary low tension group cabinet. Enginemen are warned against opening this electrical cabinet while the pantograph is in the raised position or motor alternator operating.

- (l) One 20 amp and one 10 amp spare fuse located next to the HT door interlock.
- (m) Level of sand in the sand boxes.
- (n) Ensure high tension door interlock properly locked.

## No 2 End Machine Compartment

1. High tension door isolating cock.
2. Sand magnet valves isolating cock.
3. Level of sand in sand boxes.

## No. 2 End Cab.

- (a) Spring parking brake is off, Fire extinguisher charged and sealed.
- (b) Driver's brake valve cut out valve in "OUT" MU2A valve in "trail".
- (c) All switches on driver's and observer's consoles not required are turned "off".
- (d) Insert reverser handle in "Isolate" position and move to centre position.
- (e) Press pantograph raise button. If no main reservoir pressure is available the pantograph is raised by using a footpump (one each end of the locomotive).  
In case of insufficient brake pipe air pressure the alarm will sound and the Power fault indicator will shine because the high speed breaker will not close until 350 kPa brake pipe pressure is attained. The Failed Alternator indication will also shine.
- (f) Check line voltage is normal 1100 - 1700 V DC

**NOTE:** If the line voltage is less than 1100V the high tension machines will not operate.

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With main reservoir fully charged to 700-800 kPa open brake valve cut off cock and MU2A valve and test brake as follows:-

Press Overload Reset Button (ORB) which should cause high speed breaker to close, Power Fault Light and Failed Alternator indications to be extinguished also alarm buzzer to cease sounding.

When the motor alternator commences to run 415V 50 Hz three phase power will be fed to the control and auxiliary circuits.

1. The independent brake valve is to be in the "application" position and the automatic brake valve in the "release" position. The brake valve cut off valve set at "IN" and MU valve in the "lead or dead" position on the brake pedestal being tested.
2. Check the main reservoir, brake pipe and equalising reservoir pressures. The brake pipe and equalising reservoir pressure should be 500 kPa. The main reservoir pressure 700 to 800 kPa.
3. Place the independent brake valve in the "release" position. The flashing light is to be acknowledged, whilst the brake test is being carried out.
4. Place the automatic brake valve in the minimum reduction position and note that a minimum reduction of 50 kPa takes place in the equalising reservoir and brake pipe pressures. The brake cylinder pressure should rise to between 70 and 105 kPa.
5. Release the engine brakes with the independent brake by depressing the handle in the "release" position until a full release of brake cylinder pressure is obtained.
6. Place the auto brake valve in the "service application" zone and reduce the equalising reservoir and brake pipe pressure by 75 kPa. Note that the regulating and relay valves function and the brake cylinder pressure increases.
7. Conduct a power and sand test, (notch one must be selected to obtain sand). Place brake valve cut off valve in the "out" position, check the brake piston travel is within required limits and sands are working correctly. Note that the brake pipe pressure has not seriously reduced or increased with the brake valve cut off valve set in the "out" position.
8. **Regenerative Brake Test.** Place the reverser in the "forward" position, and set brake valve cut off valve in the "in" position. Move the regenerative handle to the braking position. Note that minimum brake cylinder pressure releases. When the brake cylinder pressure has released, reduce the brake pipe pressure to below 250 kPa. Note that the locomotive brakes re-apply. Move the regenerative handle to the "off" position.
9. Place the automatic brake valve handle in the "release" position. Note the brake pipe and equalising reservoir pressure is restored and the locomotive brakes release.
10. Fully apply the independent brake and check the brake cylinder pressure rises to 325 kPa. Move the accelerating handle to position 1. Note the load meter reading indicating that the pneumatic control switch has closed. Move the accelerating handle to the "off" position.
11. Place the automatic brake valve in the emergency application position. Note that a heavy reduction occurs in the brake pipe and equalising reservoir pressure.
12. Move the automatic brake valve handle to the "release" position and note that the flow meter functions correctly.
13. Place the independent brake valve handle in the "release" position without depressing handle and note that the brake cylinder pressure releases.
14. Open emergency cock at base of pedestal and check that brake pipe is quickly and considerably reduced in pressure.

## 15. Maintaining feature check

Close emergency cock and fully recharge brake pipe.

Place auto brake valve handle in service zone and reduce brake pipe pressure by 70 kPa. Leave handle in this position.

Open emergency cock slightly to vent brake pipe and note that brake pipe pressure remains constant at the reduced level.

## 16. While the brake test is being conducted, the cutting in and out point of the governor is to be checked.

Lower and raise pantographs to ensure correct operation.

Set switches as required.

Isolate brake equipment.

Place reverser handle in "Isolate" and remove.

Alight from locomotive cab on driver's side.

Examine front of locomotive, checking all air cocks are closed and air hoses properly secured to dummy couplers. Check automatic coupling in good condition and operates correctly also jumper coupling in good condition and properly secured.

Pass down the side of the locomotive, examine brake shoes and rigging, springs etc. Check that brake cylinder and spring parking brake isolating cocks are open, sands flow adequate and sandpipes set to rail, main reservoir isolating cock open, and compressor oil level is correct.

Examine the condition of battery circuit fuses.

Enter cab at No. 1 end, carry out instructions as previously detailed in No. 2 cab, lower and raise pantographs to ensure correct operation. Lower leading pantograph if it is not required.

Set required tail and number lights.

Check red flags, detonators, headlight, windscreen washers, wipers, marker gauge and interior lights.

At departure end, set up for operation and release hand brakes.

## DRIVER'S, SPARE AND EMERGENCY EQUIPMENT

The following equipment shall be carried on 86 class electric locomotives:-

### Driver's Equipment

2 Cases of 12 detonators. One in each cabin.

2 Red flags (in flag cases). One in each cabin.

### Tools

1 spanner

1 pin punch

1 chisel

1 hammer

1 screw wrench

1 brake pipe hose - 25 mm

1 brake pipe hose - 32 mm

Spare fuses 1 x compressor 20 ampere

1 x no volt 10 ampere

2 fire extinguishers (charged and sealed)

1 spare "WB" light

1 continuity tester

1 coupling chain

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## ISOLATING COCKS

### Below the Footplates

1. Two main reservoir pipe cocks at each end of the locomotive.
2. One brake pipe cock at each end of the locomotive.
3. Two sets of No. 3 control and No. 4 independent release cocks, at each end of the locomotive.
4. Two brake cylinder isolating cocks, left side.
5. Main reservoir isolating cock, left side.
6. Two parking brake isolating cocks, left side.
7. Main reservoir automatic drain valve cocks under the locomotive body.

### In the cab

1. Brake valve cut off valves, one on each brake pedestal.
2. Brake pipe emergency cock adjacent to the brake pedestal.
3. M.U. valves for isolating independent brake, one on each brake pedestal.
4. Refrigerator isolating cock, on side panel of refrigerator in each cab.

### In the Machine Room

#### Bulkhead behind No. 1 Cab.

1. Pantograph isolating cock No. 1 end.
2. Auxiliary air equipment No. 1 end.
3. Door interlock and auxiliaries No. 1 end.
4. Auxiliary air equipment No. 2 end.
5. Compressor governor.
6. Control air reservoir.

#### Bulkhead behind No. 2 cab

1. Pantograph isolating cock No. 2 end.
2. Vigilance control penalty valve. (sealed)
3. Flange lubricator. (currently isolated and out of use)

### Machine compartment corridor

1. High tension door interlock.
2. Two spare high tension fuses. One 20 amp and one 10 amp.
3. Sander magnet valves and isolating cocks.

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## CHANGING OPERATING STATIONS (Changing Ends)

The following procedure is to be adopted when changing operating stations.

1. Fully apply the independent brake and place M.U. valve in the "trail" position. Move the independent brake valve handle to the release position and remove the handle.
2. Reduce the brake pipe pressure by placing the automatic brake valve in the handle out position reducing the equalising reservoir and brake pipe pressures by 200 kPa, move the brake valve cut off valve to "OUT" position.
3. Accelerating and regenerative brake handles are to be in the "off" position and the reverser handle placed in the isolate position and removed. The motor alternator will stop when the reverser handle is moved to the "Isolate" position.
4. The Power switch is to be turned "off".
5. The driver is to remain at the control stand being vacated with the automatic brake valve in the "handle out" position.

6. The observer is to proceed to the stand being cut in, fully apply the parking brake, insert the independent brake valve handle, place the M.U. valve in the "lead or dead" position, release and fully apply the brakes.
  7. The driver is to observe that the brakes have released and applied and not less than 300 kPa is indicated on the brake cylinder gauge, and remove the automatic brake valve handle.
  8. Proceed to the control stand being cut in with the automatic brake valve and reverser handle, insert the automatic brake valve handle and reverser handle then place the brake valve cut off valve at the "in" position.
  9. Move the reverser handle from the isolate position, turn on the power switch and press the fault reset button to restart the motor alternator. The failed alternator indicator and sonic alarm will operate for approximately thirty (30) seconds due to it being necessary for the alternator output to exceed a predetermined voltage before the alarm ceases.
- NOTE:** When the reverser handle is moved to the isolate position, the high speed circuit breaker trips, which stops the alternator.
10. The brakes are to be tested in the normal manner and the observer is to release the parking brake under the driver's supervision.

## **AMALGAMATION AND DIVISION OF UNITS**

### **Coupling the locomotive**

The automatic coupler head is to be placed in position laterally by the observer, guard or shunter, to ensure that it is lined up correctly for the connection to be made. This is particularly necessary when the operation is being carried out on a curve in order to avoid damage to the couplers when being connected.

To alleviate the possibility of damage being caused through couplers not being in the correct position, the driver must bring the locomotive to a stand one metre from the vehicle to which it is to be coupled, so that the observer, guard or shunter may be satisfied that the coupler head is correctly aligned.

The procedure is essential and must be strictly adhered to when coupling 86 class locomotives to vehicles or locomotives fitted with automatic couplers and buffers, for example the buffers may foul the control pipe fittings on 86 class locomotives.

### **Coupling of Units for Multiple Unit Operation**

1. When the unit is prepared, place in position and secure with the independent brake in the application position, parking brake to be applied.
2. (a) Note the brake pipe and brake cylinder pressure.  
(b) Accelerating and Regenerative brake handles to be in the "off" position.  
(c) Move the reverser handle to the "isolate" position.
3. On trailing units:-
  - (a) Move trailing unit onto the leading unit and engage the automatic couplings. Test pull to ensure that they are properly coupled. Secure the automatic coupling locking catch in position.
  - (b) Reduce the brake pipe valve cut off valve in the "out" position.
  - (c) Remove the automatic brake valve handle in the "handle out" position. Place the M.U. valve in the "trail" position and remove the independent brake valve handle in the release position.
  - (d) (i) Accelerating and Regenerative brake handles to be in the "off" position.

- 
- (ii) Place the reverser handle in the "isolate" position and remove.
4. Couple the brake pipe, main reservoir, No. 3 control and No. 4 Independent release air hoses and open the associated cocks.
  5. Note that the brake pipe and brake cylinder pressures build up on the air gauges to the same setting as on the leading unit.
  6. Supervise the insertion of the jumper couplings.
  7. The reverser and brake valve handles are to be suitably located in the No. 1 end driver's cab.
  8. On leading unit:-
    - (a) Test the operation of the pantographs.
    - (b) A check is to be made between the units to ensure that there is no leakage on the air hose connections.
    - (c) Release the parking brake.
    - (d) Move the reverser handle from the isolate position, operate powering switch to "on", press the fault reset button to restart the motor alternator.
    - (e) Proceed with normal operation.

### **Coupling for Multiple Unit Working - Observer's duties**

1. Upon preparing to couple the units, open and centre the automatic couplers to ensure they engage when brought together.
2. When the automatic couplers are brought together, wait until the driver test pulls the couplings to make sure that they are properly engaged, then secure the automatic coupling locking latch in position.
3. Couple up the brake pipe, main reservoir and one set of independent brake air hoses.
4. When driver signals, open the air hose cocks between the units.
5. Ensure the jumper heads are inserted correctly.

**NOTE:** In all cases where time is allowed for the turning of units and piloting locomotives to whistling out point, such duties must be performed by the observer.

## **MULTIPLE UNIT OPERATION - DIVISION OF UNITS**

When units are being divided in multiple unit working either in depots or at stations en route to suit traffic requirements, the following procedure is to be adopted:-

1. When the locomotives have been brought to a stand, they are to be secured with a full application of the independent brake and parking brakes are to be applied.
2. The observer is to remove the jumper couplings and secure in the dummy receptacles. Close the brake pipe, main reservoir and independent brake pipe air hose cocks and uncouple the air hoses.
3. *On the Trailing Unit:-*  
Place the automatic and independent brake valve handles in position. Move the M.U. valve to the "lead or dead" position and fully apply the independent brake. Place the brake valve cut off valve at the "on" position and move the automatic brake valve handle to the release position.

4. The observer will then ease the Driver up, disengage the automatic couplers and attach air hoses to the dummy couplers.
5. Two wooden chocks are to be located on each side of the No. 2 wheel of the stationary locomotive.
6. On leading locomotive, proceed with normal operation.

## **STABLING**

When the locomotive has been brought to a stand at the point of stabling the following duties should be carried out.

1. Fully apply the independent brake.
2. Reduce the brake pipe pressure by placing the automatic brake valve handle in "handle out" position, place the brake valve cut off valve in the "OUT" position.
3. The accelerating handle is to be in the "off" position, the Regenerative handle in the "off" position, the reverser handle placed in the "Isolate" position and removed.
4. Press Pan down buttons to lower pantographs.
5. Before leaving locomotive, open battery switch, close all windows and doors.
6. Parking brake to be applied. Enter all defects in the log book.
7. Chocks to be placed each side of No. 2 wheel.

## **POSITIONING OF CONTROLS FOR HAULAGE OF DEAD LOCOMOTIVES**

Should a locomotive fail and be left at a station, the qualified Driver, prior to leaving the unit must secure the locomotive by means of the parking brake and carry out normal stabling duties and leave the unit in order vide instructions relating to the haulage of the unit.

An electric locomotive of any type when required to be hauled dead must not be attached to a train unless a qualified Mechanical and Electrical Equipment Branch Technical Officer or Technician has certified to its fitness to be hauled. Where possible a Driver required to haul a "dead" locomotive, should contact the District Manager, Locomotives and Rolling Stock or other Technical Officer nominated, for clearance to do so.

The following procedure is to be adopted on the "dead" locomotive:-

1. Under normal operating conditions when the No. 3 control and No. 4 independent release air hoses can be satisfactorily coupled for multiple unit air brake operation.
  - (a) Air brake equipment is to be set up for normal multiple unit operation.
  - (b) Accelerating handle in the "off" position, regenerative handle in the "off" position and reverser handle removed in "Isolate" position.
  - (c) All switches to be turned "OFF" on the control stand, circuit breakers on the control panel to be left "ON". Battery switch open.
  - (d) vigilance control penalty valve to be closed.

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- (e) Main reservoir, brake pipe, No. 3 control and No. 4 independent release air hoses are to be coupled between the locomotives and associated air cocks opened.
  - (f) The brakes must be operative on the dead locomotive.
2. When the No. 3 control and No. 4 independent release air hoses cannot be coupled between locomotives fitted with 26L brake equipment, a competent employee, qualified for 26L brake operations must travel on the "dead" locomotive for the purpose of releasing the locomotive brakes, by depressing the independent brake valve handle when the brake pipe pressure is restored upon each release of the automatic brake from the leading locomotive.
- (a) Driver's brake valve cut off valves are to be in the "out" position.
  - (b) Automatic brake valve handle is to be placed in the "handle out" position and removed.
  - (c) At the brake pedestal being operated on the "dead" locomotive, the independent brake valve handle is to be carried in the release position and the MU valve placed in the "lead or dead" position.
  - (d) Powering handle in "off" position, regenerative handle in the "off" position and reverser handle removed in "Isolate" position.
  - (e) Main reservoir and brake pipe air hoses are to be coupled between the locomotives and associated air cocks opened.
  - (f) Brakes are to be applied and released from the leading locomotive and their correct operation checked on the "dead" locomotive before departure.

**NOTE:** When the main reservoir air supply is not available from the assisting locomotive the dead locomotive device is to be placed in the open position to charge the main reservoir on the "dead" locomotive. In addition to this, the parking brake on the "dead" 86 class will have to be isolated and manually wound off on both bogies (middle bogie 8650)

### **Hauling of Dead Locomotives from a Depot**

When a locomotive is being hauled "dead" from a depot it will be the responsibility of Depot Officers making these arrangements to ensure that the "dead" locomotive is correctly set up, the air brake equipment is properly positioned and connected for dead haulage and the brakes apply and release satisfactorily when remotely controlled from the hauling locomotive.

It is not necessary for the Driver of the train by which the dead locomotive is hauled between depots to be qualified for it, but, being qualified for the type of brake equipment with which it is fitted, he will be expected to effectively deal with any brake troubles occurring enroute.

### **Operation through Water**

Under no circumstances should the locomotive be operated through water that is deeper than 50 millimetres above rail level and speed must not exceed 3 kilometres per hour.

### **Multiple Unit Operation**

These locomotives can operate with up to five (5) other locomotives of the 86 and if necessary, 85 class type. Should one or more 85 class locos be utilised in multiple with 86 class loco/s, an 85 class must be marshalled leading when on a train. This does not include light engine running to or from a train, as light engine operation is in the series combination only.

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When in multiple with 85 class locos, the master controller (if using notch 4) must remain further than minimum to ensure the trailing 86 class resistances are removed.

The resistance notch indicator lights are not trainlined.

When using the 2-3-2 method, one weak field should be inserted on the 85 class to ensure the 86 class is fully out of resistance. Normal notching may take place after this.

When operating with multiple units, the normal practice is for all locomotives to have the jumper couplings inserted from the leading driver's cabin.

The locomotives are to be prepared as described in preparation duties.

Each locomotive is equipped with a 44 pin jumper coupling at each end and suitable air hose couplings. When the locomotives are coupled for multiple unit operation, both jumper couplings are to be connected between the locomotives. The brake pipe and main reservoir, No. 3 control and No. 4 independent release air hoses are to be coupled and all relative air hose cocks opened.

### **Control and Brake Valve Handles**

When operating with units in multiple unit consists, reverser handle, automatic brake valve handle, and the independent brake valve handle should be in position on the appropriate equipment in the leading driver's cabin.

In all other cabs in the locomotive consist the reverser must be removed from the control stands in "Isolate" position. Brake equipment cut out in accordance with instructions.

## **JUMPER COUPLING**

The locomotive is equipped with a permanently attached 44 pin jumper coupling and receptacle.

The 44 pin jumper coupling is removed from its dummy receptacle by turning a small wheel anti-clockwise to withdraw a threaded screw, thus releasing a locking clamp and freeing the jumper head.

When placing the jumper coupling in position its face must be located with the matching lugs in the receptacle. The locking clamp is then lifted upwards and secured in position with the small hand wheel being turned clockwise moving the threaded screw in to secure it.

These jumper couplings must be secured to the dummy receptacles and not left hanging loose as they are dangerous in this condition and can cause serious injury to personnel as well damage to the equipment.

When removing and inserting jumper couplings Reverse handle should be located in "Isolate" position to reduce possibility of injury and burning of contact points.

The receptacle is fitted with a shear pin designed to permit the jumper coupling to be released and avoiding damage to equipment in the event of train being parted. Particular attention should be paid to the shear pin during preparation and if defective should be rectified prior to departing from the depot.

At the present time, both jumper couplings are to be inserted, including when in multiple and trailing with 85 class electric locos.

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## JUMPER WIRING

<b>PIN NUMBER</b>	<b>FUNCTION</b>
1	Forward
2	Reverse
3	Powering
4	Run Up
5	Backward Transition
6	Regenerative Brake
7	Transition
8	Fault
9	TM 800A Level
10	Overload Reset
11	Pan Up No. 2 End
12	Pan Down No. 2 End
13	Brake Cylinder Pressure Indicator
14	Control Positive
15	Pan Up No. 1 End
16	Pan Down No. 1 End
17	Battery Negative
18	Pan Up/Down Indication
19	Control Positive
20	Sand Control
21	Sand Control
22	Compressor Synchro
23	Control Positive
24	
25	Control Negative
26	Control Negative
27	Wheel Slip Indication
28	Remote Supply
29	Remote Supply
30	Pattern Circuit Positive
31	Current Pattern Negative
32	Control Negative
33	
34	Battery Negative
35	Battery Negative
36	Notch Advance
37	Notch Hold
38	Notch Back
39	TM 800A Level Acknowledge
40	Resistance Notch Indicator
41	Powering Current Demand
42	Regen Brake Current Demand
43	Spare
44	Spare

## INDEX

Air Compressors	22	Manual Notching	27
Air-Conditioning	12	Manual Pantograph Isolating Switches	17
Alarms and Safeguards	30	Master Controller	26
Amalgamation of Units	43	Motor Alternator (M.A.)	20
Amp (Load) Meter	26	Motor Alternator Circuit Breakers	20
Amps (Max) Emerg L.E. Working	26	Motor Alternator Failure	31
Amps (Max) Train Working	26	Multiple Unit Operation	46
A.T.C. (8560)	35	Multiple Unit (with 85 Class)	46
Aux Low Tension Compt	15	No Volt Relay	23
Aux Low Tension Compt Diagram	16	Notch 1,2 and 3	27
Auxiliary Relays (AR)	23	Notch 4	27
		Notch 5	28
Battery Fuse Panel	21	Observers Switch Panel	11
Battery Switch	13 & 20	Operation through water	46
Brake Cylinder Pressure Indication	33	Overhead Voltages Varying	24
		Overload Relays	24
Changing Operating Ends	42	Overvoltage Relay	24
Circuit Breakers and Switches	14	Pantograph Control	35
Control Cut Out Switch (CCOS)	15	Pantograph Isolation	17
		Pilot Motors and Camshafts	18
Demand Meter	26	Power Fault Indication	31
Demisters	11	Preparation	38
Differential Current Detector	24	Refrigerator	12
Division of Units	44	Regenerative Brake	29
Driver's Desk	10	Resistance Blower Motors	19
		Resistance Notch Indication	34
Emergency and Spare Equipment	41	Resistance Overheat Indication	34
Emergency Light Engine Switch	15	Sanding	30
		Sequence Test Switch	14
Fan Failed Indication	34	Spare and Emergency Equipment	41
Fault and indication flow chart	5	Specifications	1
Fog Lights	12	Spring Parking Brake	38
Fuse Panel	21	Stabling	45
		Starting on easy grade	37
Generalised Traction Flow Chart	4	Starting on heavy grade	36
Haulage of 'Dead' Locomotives	45	T.M 800 Indication	35
Hauling 'Dead' Locos from Depot	46	Traction Motors	19
Headlight	12	Traction Motor Blowers	23
High Speed Circuit Breaker	18	Transition (Down)	28
High Tension Compartment	16	Transition (Up)	28
High Tension Compartment Entry	17	Vigilance Control	13
Hot Plate	11	Vigilance Control Isolation	13
		Voltmeter	24
Isolating Cocks	42	Wheel Slip	29
Isolating Vigilance Control	13	Wheel Slip Indication	32
Jumper Coupling	47		
Jumper Pin List	48		
Layout	2 & 3		
Load Meter	26		
Main Isolating Switch	17		





