DEPARTMENT OF RAILWAYS : MECHANICAL BRANCH

46 CLASS ELECTRIC LOCOMOTIVES

Operating Instructions

F. P. HEARD

CHIEF MECHANICAL ENGINEER

August, 1957.

Reprinted August 2003

HB 46OPER57.DOC

DEPARTMENT OF RAILWAYS : MECHANICAL BRANCH

46 CLASS ELECTRIC LOCOMOTIVES

Operating Instructions

F. P. HEARD

CHIEF MECHANICAL ENGINEER

August, 1957.

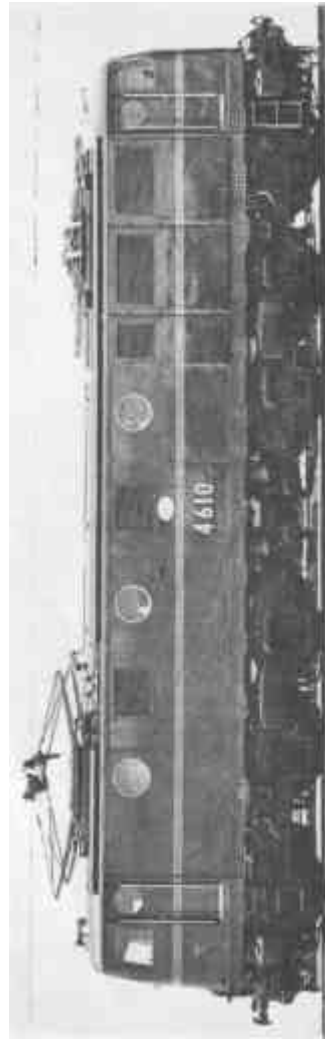


FIG.1. SIDE VIEW.

C O N T E N T S.

Page:

LOCATION OF ILLUSTRATIONS.

FIG.2. END VIEW.

GENERAL DESCRIPTION.

The 46 Class electric locomotives of which 40 are on order in Great Britain are a development from 4501 which was built as a prototype. Both types of locomotives have the same wheel arrangement and maximum tractive effort, but the 46 class has more powerful motors than the 45 class, and can maintain its maximum tractive effort at higher speeds.

The locomotive is illustrated in figures 1 and 2.

The driving position is illustrated in figure 3.

The 46 class electric locomotives will be used for hauling passenger and goods trains between Sydney and Lithgow when the electrification to Lithgow is completed in 1957.

General particulars are as follows:-

Voltage	1500 D.C.
Wheel arrangement	C + C.
Mass	111 tons.
Axle load	18.5 tons
Wheel diameter	45 inches
Bogie wheel base	14'0"
Total wheel base	41'0"
Length over buffers	54'0"
Overall width	9'9"
Height from rail level to pantograph, closed	14'6"
Tractive effort at 25% adhesion	62,000 lbs
Tractive effort at the one hour rating	40,800 lbs
Speed at the one hour rating	34.5 mph.
One hour rated horse power	3840
Continuous horse power	3480
Maximum speed	70 mph.
Low tension supply	120 volts D.C.

CAB.

The cab has a driving position at each end with comfortable accommodation for driver and

assistant driver. The cab ends are specially shaped to give an attractive appearance.

Between the two driving positions the locomotive houses control equipment, motor generator sets and traction motor blowers, and air compressors. The space between the centre longitudinals of the underframe is enclosed and forms an air duct for the traction motor ventilating air.

The underframe rests on the bogies through centre castings, side bearers, and bearers on the ends of the bogies.

The locomotive is well ventilated by louvres, and provided with circular windows. There is a passage from each driver's cabin to the machinery compartment in the centre.

BOGIES.

The bogies are one piece steel castings. On the outer ends of the bogies are mounted buffers and draw gear. The inner ends of the bogies are coupled together by a draw bar having spherical bushes at each end.

The inner ends of the bogies are aligned by a lateral control spring which is provided with an initial compression. Relative movement between the inner ends of the bogies increases the compression of this spring.

Centre castings are provided on the bogie transoms to take the centre castings on the underframe. The bogie centre castings can move laterally on a slide but are restrained in the central position by springs having initial compression.

The centre casting on one bogie is allowed a small amount of longitudinal movement to prevent binding on curves.

At the end of each bogie there is an end bearer mounted on rubber, and fitted with an

initial compression of the rubber. They align the bogies with the underframe and take the reaction caused by the tractive effort on the bogies. The springing on each side of each bogie is fully compensated. Each axle box is provided with a laminated spring and two helical auxiliary springs.

Axle boxes are of the single bearing self aligning SKF roller type.

TRACTION MOTORS.

There are six traction motors per locomotive, each rated at 640 h.p. at the one hour rating, and 580 h.p. continuously, at 725 volts. The motors have six poles, and are lap wound.

Armature bearings are of the roller type and axle suspension bearings are of the sleeve type. Pinions are of nickel chrome case hardening steel, and the gear wheel rims are of nickel chrome oil hardening steel. The gear wheel rims are mounted on the gear wheel centre through rubber bushes.

The traction motors are located laterally in the bogies by rubber bushed links. This relieves the ends of the suspension bearings of thrust.

The traction motor nose is mounted between rubber pads.

CONTROL EQUIPMENT.

The control equipment is arranged for the motors to be connected either six in series, two parallel circuits each of 3 motors in series, or three parallel circuits each of two motors in series. Five weak field positions are provided in each combination. Contactors are of the electro-pneumatic type.

Resistances are of strip metal type. They are provided with blowers which come into operation when the resistances are in circuit for over a prescribed time.

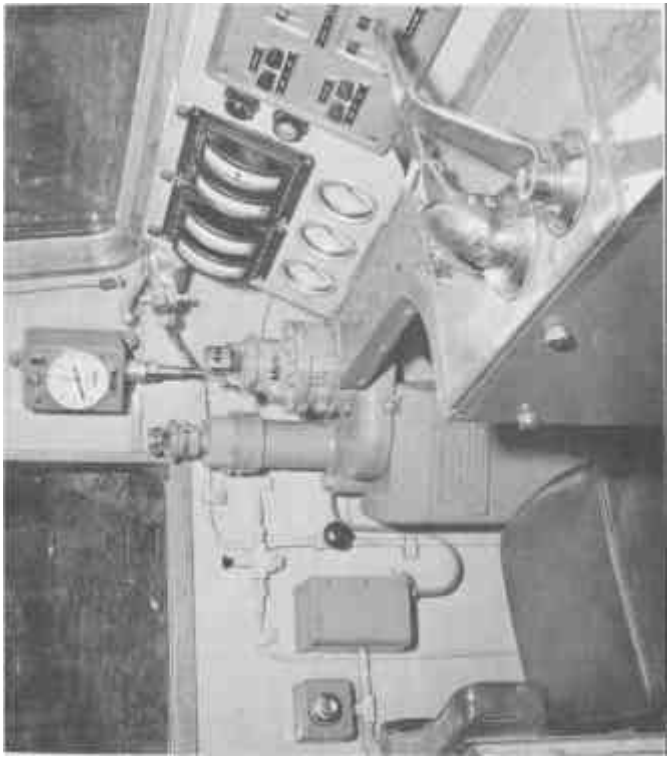


FIG.3. DRIVING POSITION.

Provision is made for regenerative braking in series and series-parallel.

The control voltage is 120 D.C.

There are two motor generator sets each driven by 1500 volt motors. One set includes a 120 volts D.C. generator which provides power for lighting and control and for battery charging. The other set includes a variable voltage generator which is used for separately exciting the traction motor fields during regeneration.

Each motor generator set also drives a fan which discharges into the air duct between centre longitudinals of the underframe and passes thence to the traction motors. Each motor is blown with 2500 cubic feet per minute.

The battery consists of 54 cells of the lead acid type with a capacity of 50 amp hours.

The two pantographs are of the double pan type. They are raised by air pressure controlled by electro-pneumatic valves operated from the driver's position. A hand pump is provided for use in the absence of air pressure.

BRAKE EQUIPMENT.

There are two air compressors, each having a displacement of 75 cubic feet per minute. Each is driven by a 1500 volt motor.

Brake equipment is of the Australian Westinghouse A-7-EL type. A diagram of the piping is shown in figure 23.

PERFORMANCE.

The locomotives are designed to haul 1100 tons at 35 mph on the rising 1/90 grades between Zig Zag and Newnes Junction, and 400 tons at 35 mph on the rising 1/33 grades between Valley Heights and Katoomba. Where grades and curves permit they can haul passenger trains at 70 mph.

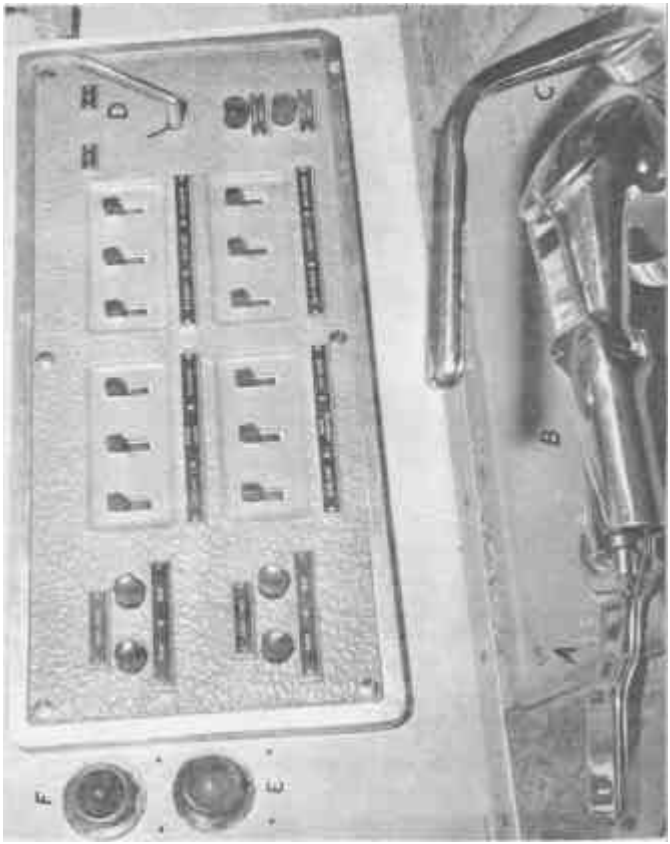


FIG.4. DRIVER'S SWITCH PANEL.

EQUIPMENT DETAILS.

WIRING DIAGRAMS.

Figure 17 shows the power connections.

Figure 18 shows the sequence of contactors.

Figure 19 shows part 1 of the control circuits schematically.

Figure 20 shows part 2 of the control circuits schematically.

Figure 21 shows the auxiliary control circuits schematically.

Figure 22 shows the lighting and power point circuits schematically.

Figure 24 is a locomotive diagram, showing the leading dimensions.

MOTOR COMBINATIONS.

Each locomotive is equipped with six M.V.272 traction motors which are axle mounted. Motors Nos. 1, 2 and 3 are on one bogie and motors Nos. 4, 5 and 6 on the other bogie.

The motors can be connected in any of three speed combinations by electro-pneumatic unit switches:

(1) Series - six motors in series.

(2) Series-Parallel - two parallel circuits each of three motors in series.

(3) Parallel - three parallel circuits each of two motors in series.

In each combination resistance is first included in circuit with the motors. It is cut out by moving the accelerating handle of the master controller from the off position to position No.20.

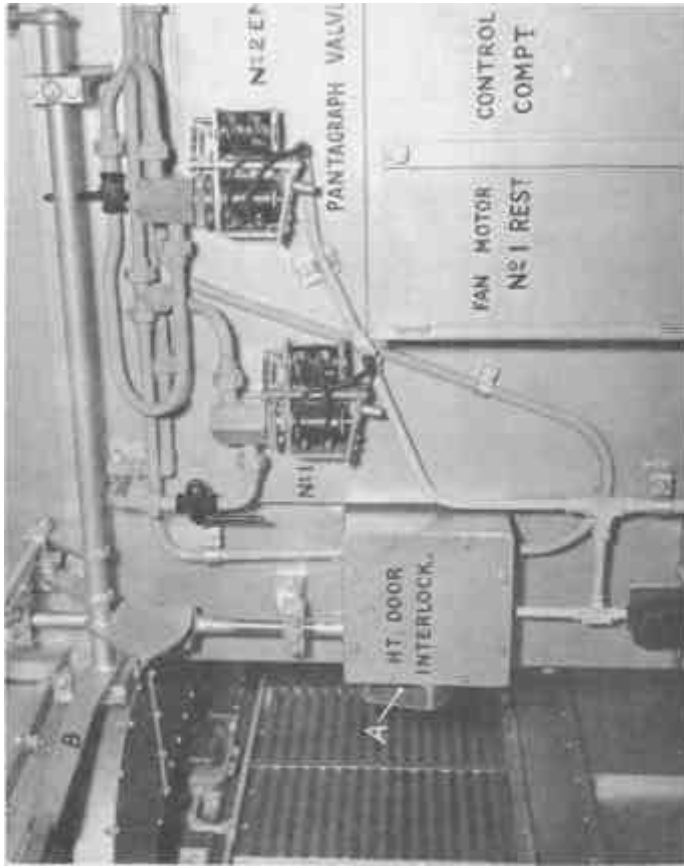


FIG.5. PANTOGRAPH VALVES & DOOR INTERLOCKING.

After all resistance has been cut out in each combination there are five stages of weak field.

MASTER CONTROLLER.

There is a master controller in each driving cabin. It has the following three handles which are shown in figure 4:-

REVERSING HANDLE. (A in figure 4).

This handle has three forward positions which are:-

Forward series,
Forward series-parallel,
Forward parallel.

It has two reverse positions which are:-

Reverse series,
Reverse series-parallel.

The reverse handle can only be removed when it is in the off position. It can not be moved to the off position unless the accelerating handle is in the off position.

ACCELERATING HANDLE. (B in figure 4).

The accelerating handle has the following positions:-

0 Off position.

1-20 Accelerating notches, commencing on notch 1 with all resistances in circuit with the motors, and ending on notch 20 with no resistance in circuit.

21-25 Weak field notches. These notches give higher running speeds than notch 20 which is a full field notch.

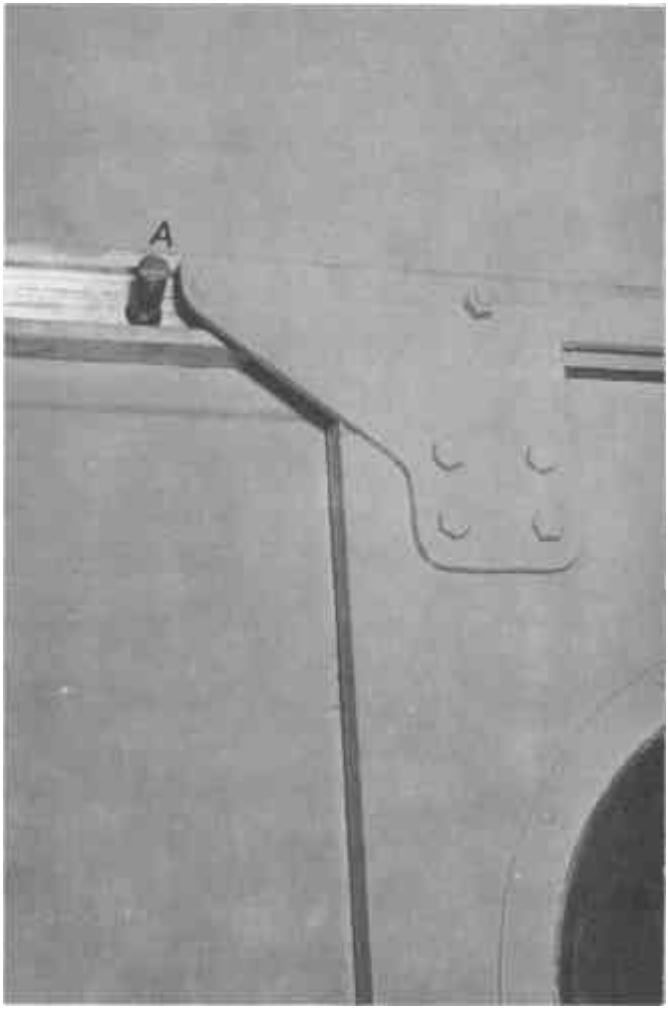


FIG.6. DOOR INTERLOCK BOLT.

REGENERATING HANDLE. (C in figure 4).

This handle is used for regulating the strength of the traction motor fields during regeneration and therefore the speed. It has the following positions:-

Mot - This position corresponds to the off position of the handle. The handle is always left in this position except when regenerative braking is taking place.

1-15 - In these positions the traction motors are separately excited for regeneration and the field strength is increased from position 1 to position 15. 1 is the highest speed running position and 15 the lowest speed position.

The regenerating handle cannot be moved from or to the motoring position unless the accelerating handle is in the off position.

Although regeneration is set up by moving the regeneration handle to any of positions 1 to 15 it does not actually commence until the accelerating handle has been moved to the first position. The accelerating handle should be steadily moved to position 20.

MAIN ISOLATING SWITCH.

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 the reverser handle on a knob in the opening shown at "A" in figure 5. In this figure the handle "B" is used for operating the switch and unlocking the H.T. compartment doors. In the position shown in this figure the doors are unlocked and isolating switch opened. This handle

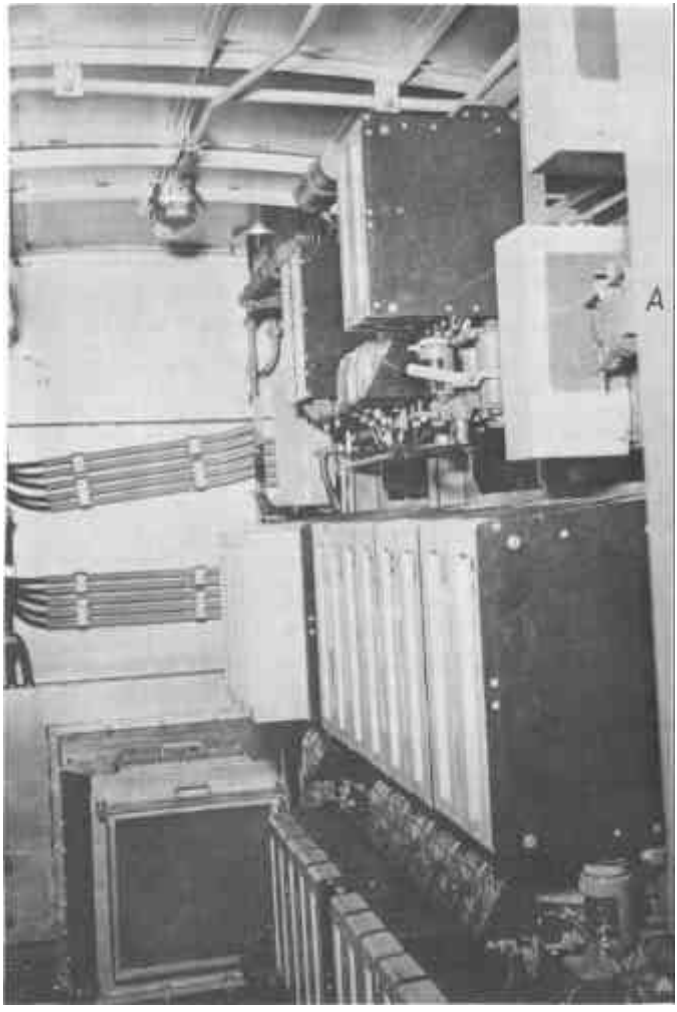


FIG.7. H.T. COMPARTMENT NO.1. END.

cannot be moved until the H.T. door interlock has been freed by lowering the pantographs.

The projecting bolt shown at "A" in figure 6 is operated by the handle "B" of figure 5.

CONTROL KEY SWITCH.

In order to obtain control current for the pantograph raise circuit, compressor control, and master controller it is necessary that the control key switch be closed. This switch is operated by the same key that operates the driver's cabin door. It is important that when locomotives are coupled together, with the jumpers inserted, only one key switch should be closed on all locomotives.

The switch is illustrated in the "On" position at "D" in figure 4.

OVERLOAD RELAYS.

In case there is a fault on the 1500 volt equipment, the locomotive is provided with overload and differential overload relays which can trip.

The overload relays are shown in figure 7 at "A".

When these relays trip on excessive current they cause the line switches to open.

The overload relays trip if excessive current passes through their coils. The differential overload relay trips if the amount of current flowing into the power circuit is different from the amount flowing out. This indicates a fault in the equipment. It is necessary to set the differential overload relay if the control switch has been switched off.

Overload relays are reset by pressing the "reset" button on the driver's panel. This button is shown in figure 4 immediately under the key switch.

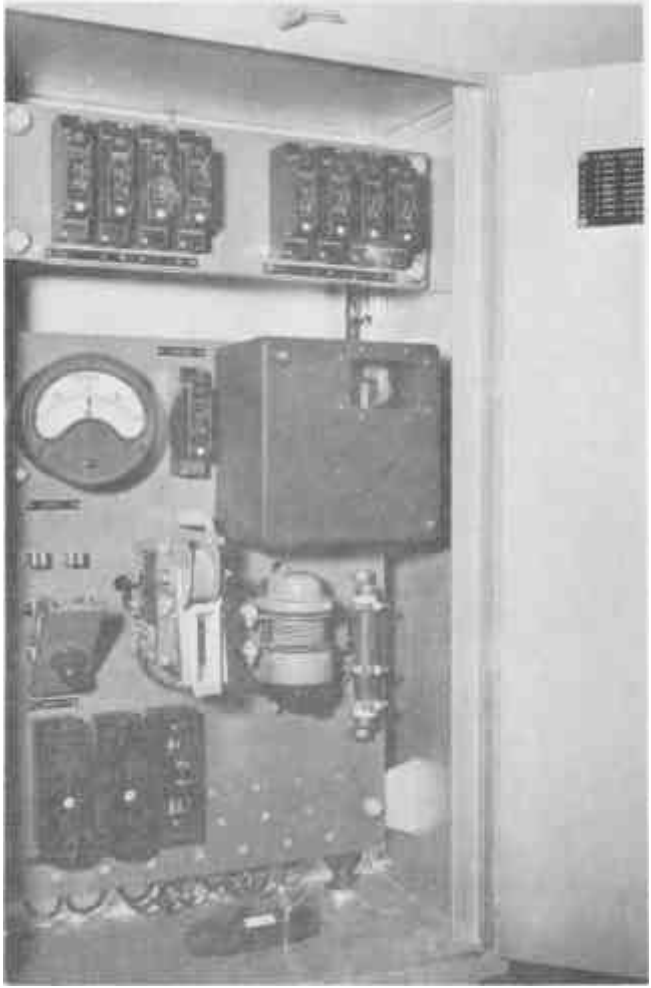


FIG.8. LOW TENSION PANEL NO.2. END.

They should not be reset more than twice in succession. Repeated resetting would damage the equipment and might start a fire.

OVERVOLTAGE RELAY.

This relay is required during regeneration and opens the line switches if the voltage which is being generated greatly exceeds the nominal line voltage. It is reset by pressing a push button on the driver's switch panel. This button is shown in figure 4 below the overload reset button.

Neither the overload relays nor the overvoltage relays can be reset unless the accelerating handle of the master controller is in the off position.

MOTOR GENERATOR CONTROL SWITCHES.

While the locomotive is in service it is necessary for both the motor generators to be running to provide ventilating air for the traction motors. Also the supply motor generator set must be running to provide 120 volt control current and keep the battery charged.

Each motor generator set is provided with a no current relay which makes contact if the machine is not running, and lights a yellow lamp in each driver's cabin, as a warning to the driver. This lamp is shown at "E" in figure 4.

For the supply motor generator to be running it is necessary that the miniature circuit breaker in the low tension switch board and the motor generator two-way tumbler switch on one of the driver's desk panels should be closed.

The supply M.G. circuit breaker is No.1 in figure 8. The M.G. Tumbler switch is that labelled "motor generators" in figure 4.

For the exciter motor generator to be running it is necessary that its circuit breaker on

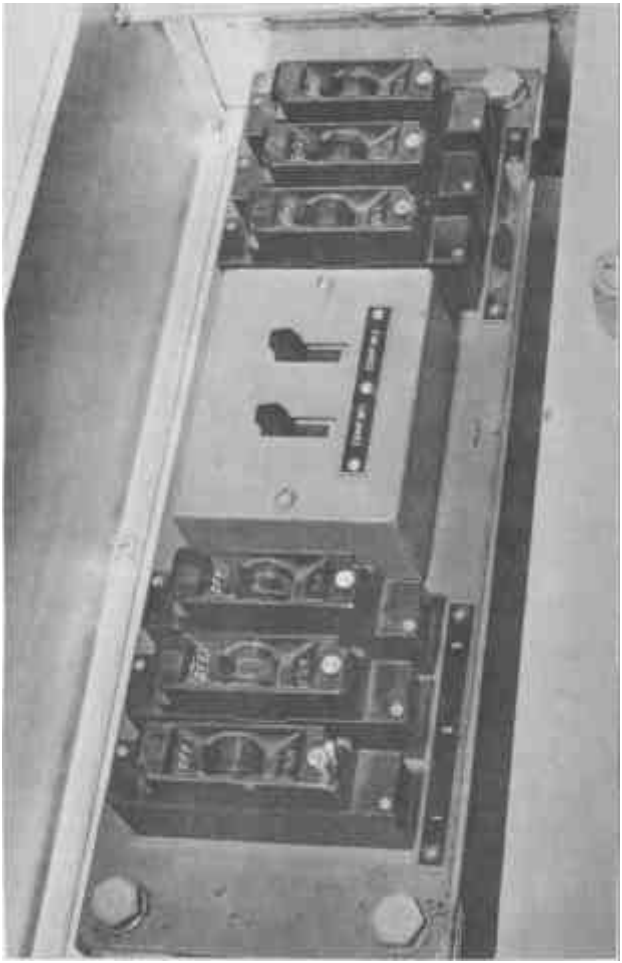


FIG.9. CIRCUIT BREAKER PANEL NO.1. END.

the low tension switch panel should be closed and the supply motor generator to be running.

The exciter M.G. circuit breaker is No.7 in figure 8.

AIR COMPRESSOR CONTROL.

For the air compressors to be running it is necessary that the control key switch be "On", the circuit breaker controlling them on the low tension switch panel and the compressor control switches on the same panel be closed. There is a separate control switch for each compressor so that either may be switched on while the other is idle. The normal operating condition is for both compressors to be switched on.

The compressor control circuit breaker is that numbered 3 in figure 9 and the two switches in the centre of this figure are the compressor control switches.

There is a compressor governor in the compressor control circuit. When main reservoir air pressure is built up to the pressure at which the governor is set, normally 125 pounds per square inch, the governor stops the operation of the compressors. When the pressure has fallen to 105 pounds per square inch the operation starts again.

The compressor governor is shown at "A" in figure 10.

PANTOGRAPH CONTROL.

The pantographs are raised by air pressure at 70 pounds per square inch from the pantograph and control reservoir. After the locomotive has been shut down for some time they are raised by air from the pantograph storage reservoir, or by a hand pump.

In the air supply from the pantograph and control reservoir there is an isolating cock which is connected to the interlocking mechanism

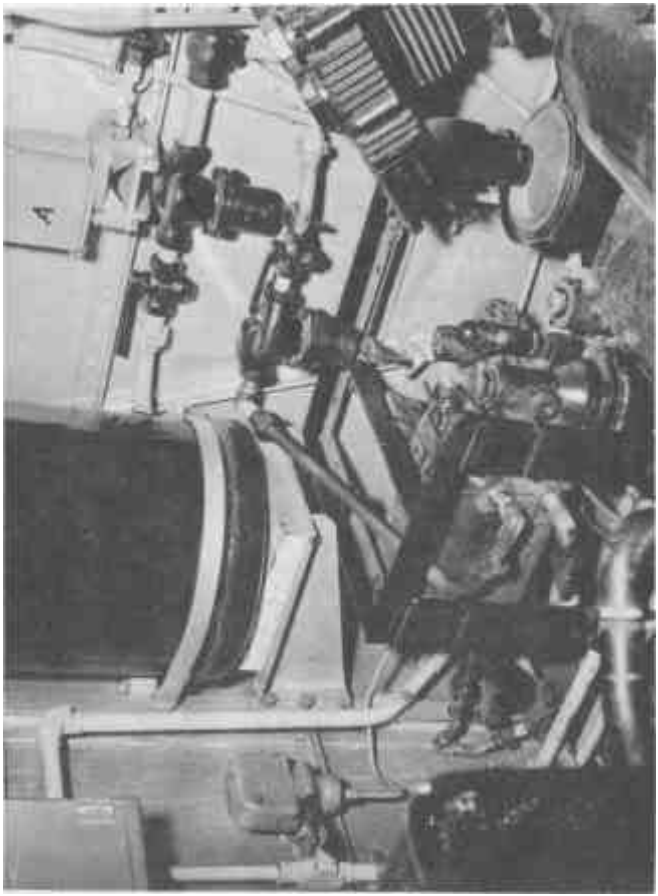


FIG.10. COMPRESSOR & GOVERNOR.

for the doors of the high tension compartments. This cock is enclosed in the H.T. Door interlock box illustrated in figure 5. This prevents the pantographs being raised until the doors are closed and locked. The air supply to the pantograph also passes through a three-way cock, illustrated at "A" in figure 11. The three positions of this cock are as follows:-

(1) In this position the handle is horizontal and the pantographs are connected via their electro-pneumatic pantograph valves to the pantograph air supply. This is the normal position of the cock while a locomotive is in service. See figure 12.

(2) In this position the handle points upwards and the pantographs are connected via their electro-pneumatic pantograph valves to the storage reservoir. In this position one of the pantographs can be raised from the storage reservoir by opening the storage reservoir wheel valve. See figure 13. The storage reservoir is shown at "A" in figure 15. This figure also shows the pantograph hand pump which must be used if the storage reservoir is depleted. The wheel valve is not shown in the figure but is to the right of the reservoir.

(3) In this position the handle is vertical pointing downwards. The storage reservoir is connected to the air supply so that it can be charged by opening its wheel valve. After charging, the wheel valve should be tightly closed to prevent loss of air. In this position the pantographs are lowered and isolated. See figure 14.

There are two pantograph electro-pneumatic valves, one for the control of each pantograph. Each valve is operated by two push buttons, "up" and "down" in each driving cabin. All front or all rear pantographs can be operated together if locomotives are coupled in multiple unit.

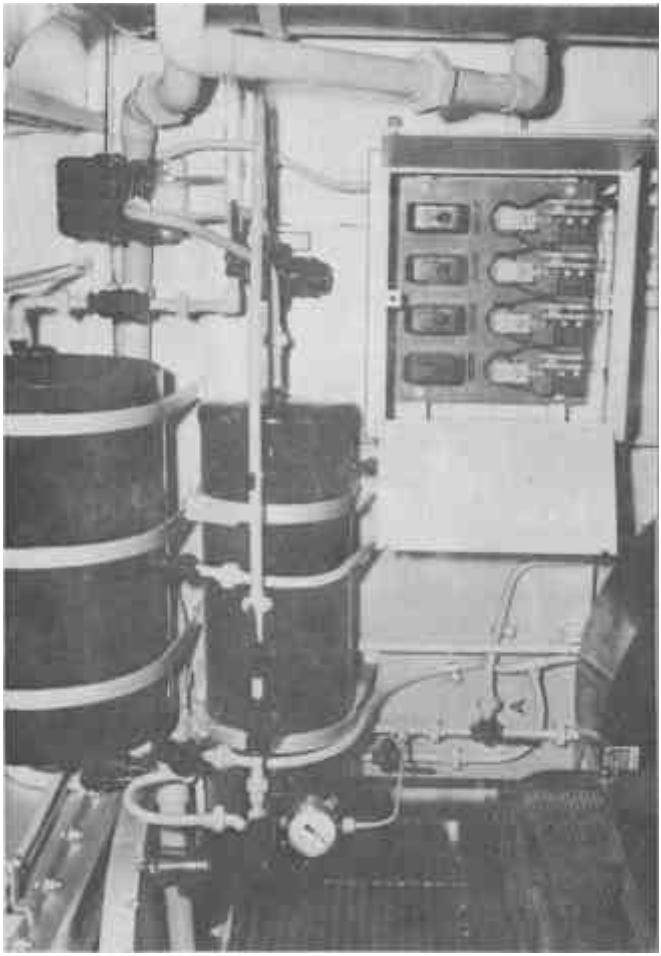


FIG.11. PANTOGRAPH & CONTROL AND TIMING RESERVOIRS.

These pantograph valves are shown in figure 5. This figure also shows the pantograph isolating cocks. In this figure the cock for No.1 pantograph is open, and that for No.2 pantograph is closed. The normal position is for both cocks to be open.

The pantograph push buttons are clearly shown to the left of the switch panel in figure 4.

CONTROL OF RESISTANCE FAN MOTORS.

The main resistances are ventilated by motor driven fans which start up after power has been on the main resistors for one minute. They keep running for three minutes after current has ceased to flow in the resistances. During some master controller operations the resistance fans will not operate, it is only when acceleration is unduly prolonged and during regeneration that the fans operate.

Operation of the fans is shown in each driver's cabin by a yellow indicator light which lights up when power is applied to the resistances and a fan is not running. As soon as all fans start running the light goes out.

The same lamp will shine as an indicator for the motor generators. It is shown at "E" in figure 4.

This light should not remain alight for more than one minute. If it does there is a possibility of the resistances becoming overheated.

HEATERS.

Each driver's cabin is provided with heaters, window heaters and a food heater. These are controlled by switches in the driving cabin. Their circuits are protected by circuit breakers on the low tension panel. These switches are shown in figure 4 and the circuit breakers in figures 8 and 9.

FIG.12. PANTOGRAPH THREE WAY COCK, SERVICE POSITION.

MOTOR CUT OUT SWITCH.

In case it is necessary to isolate a defective motor a motor cut out switch is provided. It is operated by the reverse handle of the master controller. Either 1, 2 and 3 motors can be cut out together, or 4, 5 and 6 motors together, or all motors on the locomotive can be cut out. This switch is shown in figure 16. It is in No.1 H.T. Compartment.

ISOLATING COCKS.

The isolating cocks provided in each locomotive are listed below together with the correct running position of each cock.

Brake valve isolating cock at driving end	open
Brake valve isolating cock at non driving end	closed.
One compressor governor isolating cock	open &) sealed)
One main reservoir isolating cock	open
Two pantograph isolating cocks	open
Two pantograph & control reservoir isolating cocks inlet and outlet	open
Three-way pantograph cock	handle horizontal (towards Corridor).
One switchgroup isolating cock	open
One time-delay reservoir isolating cock	open
One sander isolating cock	open
One distributing valve isolating cock	open & sealed.
One dead engine cock	closed
Two brake cylinder isolating cocks	open
All drain cocks	closed
Hose coupling cocks not connected to adjacent locomotive	closed.

SWITCHES AND CIRCUIT BREAKERS.

The various switches and miniature circuit breakers are located as follows:-

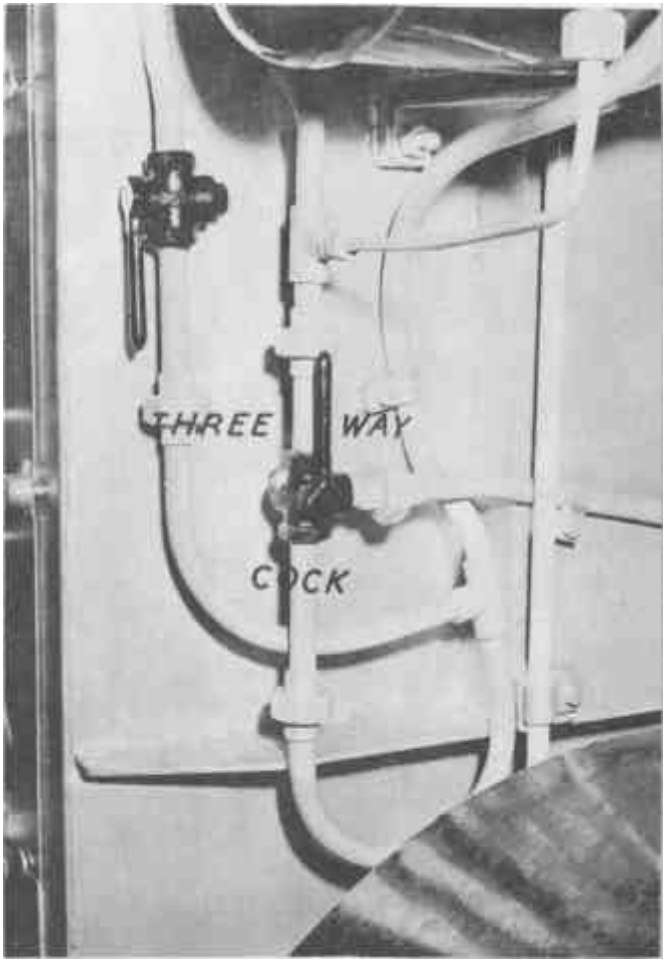


FIG.13. PANTOGRAPH THREE WAY COCK, RAISING FROM STORAGE RESERVOIR.

In No.1 H.T. Compartment.

Motor cut out switch.
Main H.T. isolating switch.
Compartment light switch.

In No.2 H.T. Compartment.

Compartment light switch.

In L.T. Cubicle (Back of No.2 Cab). (See figure 8.)

Battery isolating switch.
9 - Miniature circuit breakers (M.C.B's) for:-
Voltage Regulator.
Supply M.G.
Head & Marker lights.
Cab & Compartment lights.
Corridor lights.
Sanding.
Locomotive Brake.
Exciter M.G.
Cab heaters.

In each driving cab.

Control key switch.)
Motor generator switch)
Headlight switch)
Pilot light switch.) On driver's
Instrument light switch) switch panel.
Food heater switch) See figure 4.
Cab heater switch)
Window heater switch)
Cab light switch)
Marker light switches)

In No.1 Cab only. (In cupboard on back wall).
See figure 9.

Compressor switches.
6 - Miniature circuit breakers for:-
Control main.
Head and Marker lights.
Compressor
Control

FIG.14. PANTOGRAPH THREE WAY COCK, CHARGING POSITION.

Food heater
Cab heater.

In Corridor. (Adjacent to each cab door).

Corridor light switch.

In Machinery Compartment. See figure 11.

8 - Resistance Fan M.C.B's (4 in each of two cupboards on H.T. Compt. walls).

Outside of locomotive.

4 - Handlamp socket switches (2 each side on underframe).
2 - Pantograph isolating switches (1 each end of roof).

To operate locomotive lights the battery isolating switch must be closed, together with the lighting M.C.B's. Individual groups of lights are then controlled by their respective switches as required.

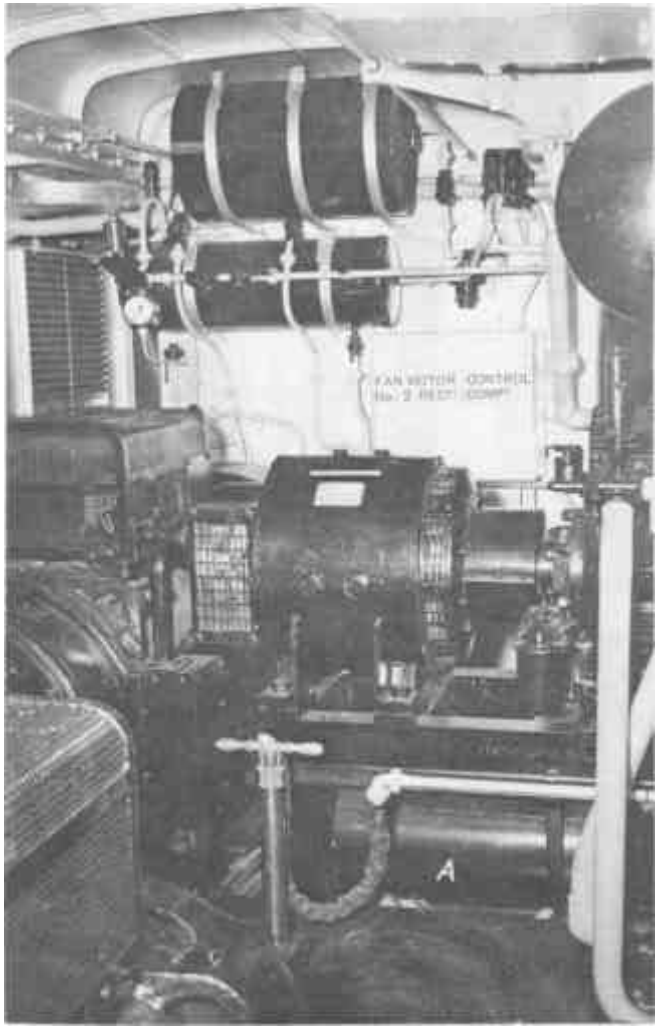


FIG.15. MACHINE COMPARTMENT.

PREPARATION AND STABLING.

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 tablets removed from the departure end of the locomotive.

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 Shed Chargeman.

PREPARATION.

1. Obtain Driver's Daily Report Sheet, Reverser Key and Control Key. On arrival at Locomotive observe that both pantograph isolating switches are closed. Peruse Depot Officers Certificate and commence preparation at No.2 end.

2. Enter cab and see that Hand Brake is "On" and locked.
   Check that all L.T. Circuit breakers are closed and place battery switch to "In" position.
   Switch on light to prove Battery fuses.
   Battery switch to be placed to "Out" position before L.T. fuses are renewed.
   See all switches on Driver's switch panel are up and "Off".
   Switch Cab and Corridor lights "On" if required.
   See that Driver's Brake Valve Isolating Cock is closed.
   See that No.2 H.T. Compartment door is closed.

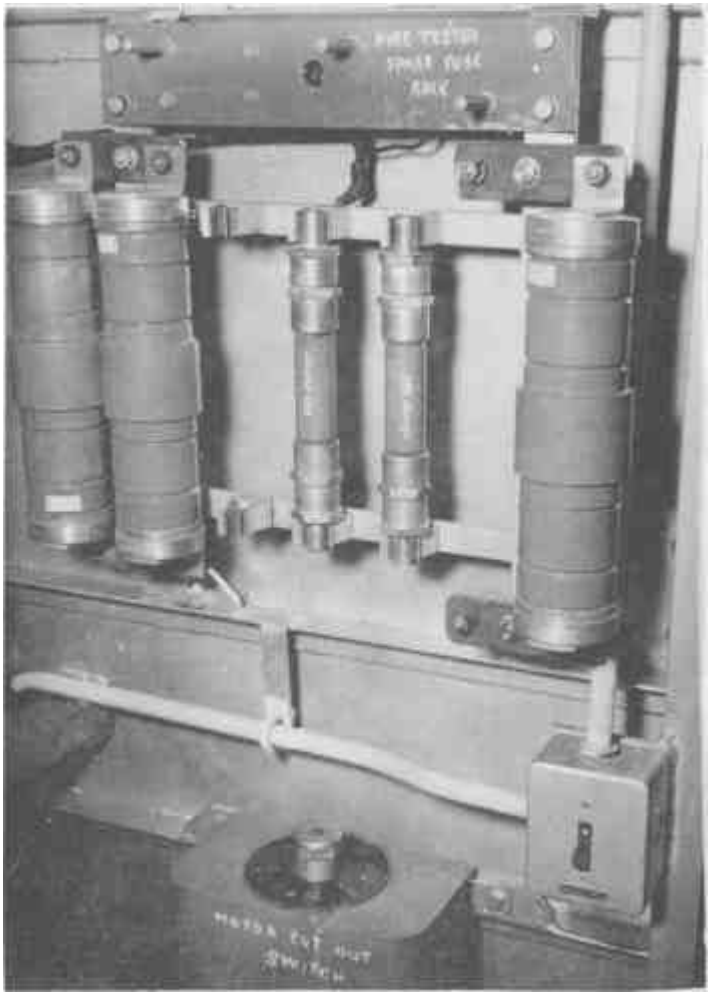


FIG.16. MOTOR CUT-OUT SWITCH AND SPARE H.T. FUSES.

3. Pass through locomotive to No.1 end and unlock it.
   Check that all L.T. circuit breakers are closed and compressor switches are up and "Off".
   See all switches on Driver's switch panel are up and "Off".
   See Driver's Brake Valve isolating cock is closed.
   Open door of H.T. Compartment.
   See motor "Cut Out" switch in No.1 H.T. Compartment is in "All in" or relative position as shown in Log Book.
   Check spare H.T. fuses and check that required H.T. fuses are in circuit. Close No.1 H.T. Compartment door.

4. Return to Machine (centre) compartment.
   Check that Fan resistance circuit breakers are Down and closed.
   Check spare equipment in compartment:-
      3 Control Jumpers - A. B. & C.
      2 Air hoses - brake pipe, main reservoir.
      3 Bogie Hoses - Main reservoir, Brake cylinder, Sanding.
      2 1/2" hose couplings.
      1 Fire extinguisher.
      1 Hook stick.
   Spare light globes:-
      1 Head Light Globe 120V, 250 watt.
      2 Interior " " 120V, 60 watt.
      2 Marker " " 120V, 40 watt.
      2 Pilot " " 120V, 15 watt.
   Check that seal is on the spare equipment locker.
   See that Main Reservoir, pantograph and control reservoir, fan time delay reservoir, switch group, sanding relay, and pantograph isolating cocks are open and, that Main Reservoir to Distributing Valve Isolating Cock and Compressor Governor Isolating Cocks are both open and sealed.
   The Dead Engine cock must be closed, the handle pointing to the brake pipe connection on the distributing valve.
   Place the door locking lever down and lock H.T. switch with reverser key (two movements).

Enter No.l end cabin, insert control key in switch and switch "On".
Press pantograph button to raise pantograph and press button to lower leading pantograph.
If main reservoir gauge shows 50 lbs. the pantograph can be raised with the three-way cock in "Horizontal" position.
If main reservoir is less than 50 lbs place the three-way cock in "Up" position and open wheel valve of storage reservoir. If after opening wheel valve pantograph gauge shows less than 50 lbs and pantograph does not rise, close wheel valve and operate hand pump until pantograph makes good contact with the overhead wire.
Proceed to No.1 end and note line voltage on volt meter and then switch on both compressors.
Return to centre compartment and keep pumping until main reservoir pressure is 70 lbs. Then move three way cock to horizontal position and close wheel valve if not already closed.

5. Go to departure end.
Then switch "On" supply generator. (Exciter Generator will start up automatically when Supply Generator is up to Speed).
Check all spare equipment in departure end cabin including, fire extinguisher, hand lamp, red flags, detonators and "Tail Disc No.l end", "Spare L.T. fuses No.2 end".
Test head, pilot, marker, gauge and interior lights and set required Head and Marker lights.
Test whistle, windscreen wipers and raising and lowering operation of both pantographs.
NOTE: Before lowering or raising pantographs the motor generators and compressors must be switched off.

Open Driver's Brake Valve isolating cock and test independent and automatic brake valves in the following manner:-

NOTE: During the following tests the "Cutting in" and "Cutting out" points of the air compressor governor should be checked. Any irregularities detected should be reported, and this also applies to incorrect pressures or adjustments that are noticed on other tests.

TEST 1 - AIR PRESSURES.

With full main reservoir pressure and with both driver's brake valve handles in "running" position, check air gauges to ensure that correct air pressures are being carried. Main reservoir pressure should be governed within the limits of 105 to 125 p.s.i. - Brake Pipe pressure as necessary for the work to be performed and to be in accordance with that shown in Regulation 2, Clause (a), Sub-Clause (iv) of the Westinghouse Brake Regulations, Page 207, General Appendix Part 1 (i.e. Setting of reducing valve).

TEST 2 - MINIMUM REDUCTION FEATURE.

Move the automatic brake valve handle to "lap" position and check that the "minimum reduction" feature is operating.

TEST 3 - INDEPENDENT RELEASE OF AUTOMATIC BRAKE.

Move the independent brake valve handle to "quick release" position, to release brake application, and thence to "running" position.

TEST 4 - AUTOMATIC BRAKE VALVE - SERVICE OPERATION.

Increase the brake pipe reduction to 20 p.s.i. by means of the automatic brake valve and note the rise in pressure as shown on brake cylinder air gauge.

TEST 5 - REGENERATIVE INTERLOCK (a).

Before making the regenerative interlock test place the reverser key in forward series, press overload and overvoltage reset buttons, then place the accelerating handle in the first notch noting that a current reading is recorded on the ammeter. Return the accelerating handle and reverser key to the off position. With the auxiliary generator and the regenerative exciter running, reverser handle in forward series, place the regenerative handle in first position and with the accelerating handle also in the first notch, note that the air brake application releases.

TEST 6 - REGENERATIVE INTERLOCK (b).

Reduce the brake pipe pressure to zero, and check that the automatic control switch operates to cut out regenerative brake and that the air brake re-applies on the locomotive. Return the accelerating handle to the "Off" position.

TEST 7 - FLOWMETER TEST.

Return the automatic brake valve handle to "running" position and note that one hand of the Flow Indicator Gauge momentarily drops towards zero and then returns to the normal fully charged position, overlapping other hand.

TEST 8 - INDEPENDENT APPLICATION WITH REGENERATION.

Place the accelerating handle in the first notch.
Move the independent brake valve handle to "slow" application position and check that a brake application is obtained and that the setting of the reducing valve (45 p.s.i.) is correct and leave handle in this position.

Move the accelerating handle to the "Off" position, the regenerative handle to "MOT", and reverser key to "Off" position.

TEST 9 - DISTRIBUTING VALVE SAFETY VALVE.

Reduce brake pipe pressure by 20 lbs. with the automatic brake valve handle in "service" Position and check that the distributing valve safety valve lifts when 55 p.s.i. brake cylinder pressure has been obtained. Release brakes by returning both brake valves to "running" position.

6. Move reverser key to either Forward or Reverse Series position.
Test Sanding device.
Move Reverser key to "Off" position and remove key.
Make application of the brakes in slow application position with Independent Driver's Brake Valve, close D.B.V. Isolating Cock and remove both D.B.V. handles.
See that Hand Brake is applied and alight from cabin.
Examine front of locomotive, checking all air cocks are closed and dummy couplers in correct position.
See auto. coupler is in good order and jumper receptacle lids properly closed.

7. Pass along "Off" side of locomotive.
Examine brake shoes and riggings, springs etc. and see that Resistance Compartment doors are closed and securely fastened.
Check that Air Brake Cut Out cocks are open, sand boxes full and working correctly and Brake piston travel between 3-1/2" and 5".

8. Enter rear end cabin and carry out instructions as previously outlined in Clause 5.
Note that air pressures indicated on the air gauges do not materially differ from those indicated at the other driving compartment.

Set required Tail lights and release Hand Brake if applied.

9. Examine rear and "On" side of Locomotive as outlined in clause 6 and 7.

10. Enter departure end cab.
Open Driver's Brake Valve Isolating cock, release Hand Brake and lower leading Pantograph if not required.
Insert Reverser Key in Master Controller in readiness to depart.

11. Apply power in first notch "Forward" and "Reverse" and see that operation is correct.

NOTE: Blown H.T. fuses are to be placed in box provided in No.1 H.T. Compartment and blown L.T. fuses left in bottom of Battery Switch cupboard, No.2 cabin.

OPERATION PROCEDURE.

ACCELERATION IN SERIES.

To start a train or light engine the following actions are necessary:-

(1) The control key switch must be in the "On" position.
(2) Place the reverser handle on the Master Controller and move it to series forward or reverse as required.
(3) Press the overload reset button.
(4) Release the brakes.

The accelerating handle can then be moved to the first position and after a pause to the second position and so on.

If the locomotive is light it should move in the first position. If on the other hand a heavy train is attached it may be necessary to go to the 6th or 7th position to get the train moving.

After the train has started to move the accelerating handle should be moved step by step to position 20. The peak current measured on the ammeter should not exceed 1000 during notching. Peak currents in excess of 800 amperes will probably require the use of sand to prevent wheel slip. Another notch should not normally be taken until the current drops below 850 amperes.

After the accelerating handle has reached position No.20 it can be left in that position if no higher speed is required. Generally this speed will be insufficient and it will be necessary to pass to the next combination, in accordance with the following description:

TRANSITION FROM SERIES TO SERIES-PARALLEL.

The controller handle positions at the end of the previous acceleration are:

Reverse handle in "forward" "series".
Accelerating handle in position 20.

To change into the series-parallel combination the reverse handle is moved from "forward" "series" to "forward" "series-parallel".

The accelerating handle is then returned to notch 1 with the button on the end of the handle depressed. The button on the end of the handle prevents the controller handle going to off, during transition.

No change takes place until the accelerating handle is returned to notch 1. As soon as this happens transition to "series-parallel" takes place with all resistances in circuit. The handle should then be advanced step by step to position 20 as before.

TRANSITION FROM SERIES-PARALLEL TO PARALLEL.

If a higher speed than is obtained in the series-parallel combination is required, tran-

sition to parallel should be made. The reverse handle should be moved to "Forward" "parallel" position and the accelerating handle returned to No.1 position. This will make the transition to parallel with all resistances in circuit. The accelerating handle should then be moved step by step up to notch 20 as before.

WEAK FIELD NOTCHES.

There are five (5) positions of the accelerating handle after notch 20. In these positions the fields of the traction motors are weakened which increases the locomotive speed.

These notches should be used if a higher speed than can be obtained in full field is required, and if the next higher motor combination will give too high a speed.

Weak field notches should not be used at less than the speeds shown below:-

Combination:	W.F.Notch.	Minimum Speed.
Series	1 to 5	12 m.p.h.
Series-parallel	1 to 3	22 m.p.h.
Series-parallel	4 and 5	30 m.p.h.
Parallel	1 to 3	35 m.p.h.
Parallel	4 and 5	50 m.p.h.

RUNNING NOTCHES.

Positions 20 to 25 of the accelerating handle are running notches, and the handle may be left continuously in any of these positions. It should not be left continuously on any of positions 1 to 19, as in these positions resistances are in circuit with the traction motors and they are not designed for continuous operation. (An exception to this instruction is given under series regeneration).

REVERSING.

The reverser handle should never be thrown to reverse while the locomotive is moving forward, nor to forward while the locomotive is moving in reverse. The locomotive should be stopped before a change in the direction of the reverser handle is made.

WHEELS SLIPPING.

Wheel slip relays operate a lamp and buzzer in each driver's cabin if a wheel slip of over 7 m.p.h. occurs. The lamp and buzzer also operate during transition from series-parallel to parallel.

Wheel slips should be quickly corrected by the use of sand and by the accelerating handle being moved back until the slip stops.

In weak field a slipping speed high enough to burst an armature can be attained if these notches are used below a speed prescribed on page 24.

REDUCTION OF SPEED.

If on a rising grade it is necessary to reduce speed, the accelerating handle should be returned slowly to the off position, the reverse handle should be moved to a lower speed combination and the accelerating handle advanced to notch 20.

SECTION INSULATIONS IN OVERHEAD WIRE.

Section insulators in the overhead wire separate sections of the wire and there can be a difference of voltage between the two sides.

To reduce sparking at section insulators whenever practicable the locomotive should be coasted under them. Drivers should make a habit of switching off power while the pantographs are passing under section insulators.

REGENERATIVE BRAKING.

During regeneration the power generated by the motors is fed back to the overhead wire for use by other trains.

Regenerative braking is available in the series combination at speeds of approximately 15 m.p.h. and upwards.

Maximum retardation is available at 15 m.p.h., but above this speed the maximum amount of braking effort obtained falls off in inverse ratio to the speed. For instance at 30 m.p.h. the maximum braking effort obtainable is only half that obtainable at 15 m.p.h.

Regenerative braking is also available in the series-parallel combination at speeds of 30 m.p.h. and upwards. In this case full braking can be obtained at 30 m.p.h. and the maximum braking falls off in inverse ratio to the speed.

It should be noted that full braking effort can be obtained at only two speeds, namely 15 m.p.h. in series and 30 m.p.h. in series-parallel.

Operation at other speeds means a reduction in the amount of braking obtainable.

The maximum loads which can be braked at a steady speed on different grades without overheating the traction motors, or danger of wheel sliding are as follows:-

Grade.	Load which can be braked in series at 15 mph or series-parallel at 30 mph.	
1/33	580	tons.
1/40	760	tons.
1/60	1250	tons.
1/80	1850	tons.
1/90	2150	tons.

WHEN REGENERATIVE BRAKING SHOULD BE USED.

The regenerative brake is designed to maintain an approximately constant speed when descending grades and it should be used for this purpose. If rapid deceleration or a stop is required the automatic air brake should be used.

As the regenerative brake is applied only on the locomotive care must be taken to avoid sudden application or release which would impart a shock on the train.

OPERATION OF MASTER CONTROLLER IN REGENERATION.

If the speed is between 15 and 30 m.p.h. place the reverser handle in "forward" "series".

If the speed is above 30 m.p.h. place the reverser handle in "forward" "series-parallel".

Place the regeneration handle on a notch corresponding to the speed.

The following table shows the position of the reverser handle and regeneration handle for various speeds:-

Approx m.p.h.	60,	40,	30,	26	30,	20,	15,	13
Combination	Series-parallel				series			
Regen. notch	1,	5,	10,	15	1,	5,	10,	15

The proper position of the handle is indicated by the reading of the motor voltmeter which should approximately balance with the line voltmeter.

As soon as the regeneration handle has been placed in the appropriate position the accelerating handle should be moved steadily round to No.20 position.

The regeneration handle should then be moved to suit the speed and braking effort required. Movement of this handle should always be effected slowly.

Movement towards notch 15 increases braking effort and movement in the opposite direction decreases it.

TO SWITCH OFF.

When it is desired to switch off regeneration the regeneration handle should be moved slowly until the armature current is zero. The accelerating handle should then be returned to the off position. The regeneration handle should then be returned to the motoring position.

If while regeneration is in operation it is necessary to make a rapid decrease in speed, the automatic air brake should be applied on the train. It is important that as soon as the armature current reads zero the accelerating handle should be returned to the off position. Otherwise the locomotive may take a motoring current.

CHANGE OF COMBINATION.

To change from series to series-parallel or vice versa in regeneration it is necessary to switch off, adjust the speed of the train with the air brake and commence regeneration again in the new combination.

CONNECTION OF REGENERATION WITH AIR BRAKE.

As soon as the accelerating handle is moved from the off position to commence regeneration, a regeneration interlock magnet valve on the distributing valve is energised. This enables an automatic air brake application to be made on the train without taking effect on the locomotive.

If, however, an emergency application of the automatic brake is made, the heavy reduction

of brake pipe pressure thus caused operates a pneumatic switch which cuts off regeneration, and thereby, switches off the regeneration interlock magnet valve, so that an emergency brake application is effective on the locomotive as well as on the train.

WHEEL SLIDING DURING REGENERATION.

The motor armature current should generally be kept at less than 700 amperes to prevent wheel sliding during regeneration. If wheel sliding occurs it is possible for the speed of the train to increase rapidly, so a close watch on the speed should be kept.

If wheel sliding occurs an immediate application of the automatic air brake should be made to check the speed. This will reduce the braking effort being exerted by the locomotive and stop the wheel sliding. At the same time the regeneration handle should be moved to reduce the amount of braking.

LOSS OF OVERHEAD POWER.

If overhead power is lost while a train is descending a steep grade an immediate application of the automatic air brake, sufficient to stop the train, should be made, and this application must not be released until power is restored and main reservoir pressure exceeds 105 lbs per square inch.

This instruction must be observed whether or not regeneration is in operation, as it is essential that the brakes be applied before main reservoir pressure has been depleted. The instructions on page 259 of the General Appendix Part I apply.

OVER VOLTAGE PROTECTION.

If the voltage generated by the traction motors exceeds 2050 volts the overvoltage relay will trip and cut off regeneration. Care should

be exercised in setting up regeneration not to allow the motor volts to greatly exceed the line volts before connection is made to the line by movement of the accelerating handle to notch 20.

If the overvoltage relay trips during regeneration an automatic air brake application should be made. The accelerating handle should be returned to the "off" position and the regenerating handle to the motoring position. The overvolt reset button should then be pressed after which regeneration may be commenced again.

The line voltage should not be allowed to exceed 2000 volts. It can be reduced by reducing the current regenerated, and if necessary using the automatic air brake to give the braking required.

START IN SERIES REGENERATION.

A train may be started in series regeneration from rest if on a falling grade.

The regeneration handle should be placed in notch 2, and the accelerating handle advanced notch by notch to position 20, and the regeneration handle adjusted as required.

The locomotive will take a motoring current to start after which on a falling grade a braking current will be generated.

A start in series-parallel regeneration from rest must not be made.

RESISTANCE IN SERIES REGENERATION.

In series regeneration the accelerating handle may be moved back as far as notch 12 to insert resistance in the motor circuit, this will allow of a slight increase in speed in this combination. This working does not apply to series-parallel regeneration.

PANTOGRAPHS.

Most wear on the overhead wire is caused by passage of current to the pantograph strips rather than by friction between wire and strips. It is therefore desirable at all times when hauling a train to operate with both pantographs raised. The current density at the pantograph strips is thereby kept as low as possible and the rate of wear on the overhead wire kept as low as possible.

When running light only the rear pantograph should be raised.

PANTOGRAPHS WHEN DOUBLE HEADED.

The overhead wire for the suburban area to the east of Westmead is too light to allow for four (4) pantographs being raised on two locomotives coupled together. Excessive lift of the contact wire would occur and there would be possible damage to pantographs at cross spans.

The overhead wire to the west of Westmead is of heavier construction and allows four adjacent pantographs to be raised.

Double headed up trains passing through Westmead must have the leading pantograph on each locomotive lowered. The driver should do this by first switching off power, then pressing the pantograph "front" "Lower" button on the panel on the driver's desk.

DOUBLE HEADING.

When double heading it is the normal practice for two locomotives to have jumpers inserted between them and for both machines to be controlled from the leading driving cabin.

Each locomotive is prepared as described in preparation instructions.

Each locomotive carries three jumpers and two 1/2" hose couplings. One set of these fittings should be inserted at the point of coupling. The couplings for the 1/2" hose are duplicated on each side, but a pair of hoses should be fitted on one side only. The brake pipe and main reservoir hose pipes should be coupled. The hose pipe cocks at each end of each hose pipe should be opened.

When uncoupling two locomotives the jumpers and the 1/2" hose pipes removed from the point of coupling should be placed in the locomotive not equipped with these parts.

CONTROL AND BRAKE VALVE HANDLES.

When double heading the control key switch, 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 the rear locomotive, the control key, and reverser handle should be removed from the equipment and placed on the bottom of the low tension panel at No.2 End.

AMALGAMATION: DUTIES OF DRIVER & OBSERVER.

1. Observer: Secure the stationary locomotive or locomotives by applying the hand brakes unless the stationary locomotive is attached to a train standing with brakes applied. Open the automatic coupler, signal the driver to ease up, and, when coupled, couple the main reservoir and train pipe hoses and open the four air cocks.

2. Driver: Obtain the three jumpers and two half inch air hoses from the hook in the passageway of the locomotive, hand them down to the observer on the ground, and alight from the locomotive. Hand the jumpers ('B' jumper first) and the air hoses to the observer at

foot plate level.

3. Observer: Place the jumpers and half inch hoses on the ground taking care to avoid dirt getting in to the ends, climb to foot plate level between the two locomotives, and receive the jumpers from the driver ('B' jumper first), and insert them in their respective receptacles. Place the half inch hoses in position on one side and open the air cocks.

4. Driver: Test the operation of the pantographs first from the leading locomotive then from the second locomotive, and release the hand brakes applied at the beginning of the amalgamation.

DIVISION.

Duties of Driver and Observer.

l. Observer: Climb to foot plate level, close the control and independent release pipe air cocks, remove the two half-inch hoses and hand them to the driver on the ground. Remove the three jumpers ('B' jumper last) and hand them to the driver.

2. Driver: Place the two half-inch air hoses and three jumpers on the ground taking care to avoid dirt getting into the ends. Enter the cab and receive the air hoses and jumpers from the observer.

3. Observer: After handing the air hoses and jumpers up to the driver, close the main reservoir and brake pipe cocks, uncouple the hoses, open the brake pipe cock on the stationary loco., and signal the driver to ease up to uncouple. When the locomotive is uncoupled, close the open brake pipe cock, attach the dummy couplers to the air hoses and to the control and independent release pipes of both locomotives, close the jaw of the automatic coupler, and secure the stationary

locomotive by applying the hand brakes.

4. Driver: When the locomotive is uncoupled, place the jumpers and air hoses on the hook in the passage-way of the locomotive not already equipped with these parts.

STABLING.

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

Close the driver's brake valve isolating cock. Leave the automatic brake valve handle in the running position and the independent brake valve handle in the lap position.

Apply the leading hand brake hard on and lock it.

Switch off the supply motor generator at the tumbler switch on the driver's desk.

Switch off compressors, heaters and lights.

Press both pantograph down buttons and lower pantographs.

Check that the pantographs are down by visual observation.

Turn pantograph three-way cock to the down position, opening the storage reservoir wheel valve and charging the storage reservoir. Close wheel valve tightly. Close the P & C reservoir inlet and outlet cocks.

Remove the control switch key and the reverser handle, walk around the locomotive and make sure there are no defective parts. Enter any defects in the Log Book.

When leaving locomotive open battery switch, make sure that all doors are locked and windows closed.

DRIVERS, SPARE AND EMERGENCY EQUIPMENT.

The following equipment shall be carried in each 46 class electric locomotive:-

DRIVER'S EQUIPMENT.

2 Hand lamps. One in each driver's cabin.
1 Tail disc. In No.1 cabin.
2 cases of 12 detonators. One in each cabin.
2 red flags (in flag cases). One in each cabin.

FOR COUPLING TO ANOTHER LOCOMOTIVE.

2 1/2" hose couplings. In No.2 End Corridor
3 Jumper couplings. In No.2 End Corridor.

TOOLS.

1 Spanner, hose M.R.& T.L.	)
1 " " Bogie M.R.	)
1 " " " B.Cyl.	)
1 " " " Sand	)In sealed box in
1 Pin punch 3/8"	)No.1 end corridor.
1 Chisel	)
1 Hammer	)
1 Spanner, fuse.	)
1 Inspection light & lead	)

SPARE AND EMERGENCY EQUIPMENT.

1 Air hose M.R. 3/4"	)
1 " " T.L. 1"	)
1 " " B.Cyl 1"	)
1 " " Sand 1/2"	)In open box in
1 Rope 40 ft.	)No.1 end
1 Light globe, headlight 250W.	)corridor.
1 " " interior 60W.	)
1 " " marker 40W.	)
1 " " pilot 15W.	)
2 Fuses, Main Aux. H.T. 150A	In rack in No.1 H.T. Compt.
2 " Gen H.T. 50A	In rack in No.1 H.T. Compt.

2	Fuses, Comp.	H.T.	18A	In rack in No.1 H.T. Compt.
1	"	Voltmeter	9.5A	In rack in No.1 H.T. Compt.
2	"	L.T. Gen & Battery	100A	On bottom of L.T. Panel No.2 end.

Spent H.T. fuses to be placed in box in No.1 H.T. Compartment.

Spent L.T. fuses to be placed in bottom of No.2 L.T. Panel.

1 Hook stick.	In No.1 end corridor.
3 Fire Extinguishers.	One in each cabin and centre compartment.

DEFECTS IN OPERATION.

The following are hints to assist in overcoming operating troubles which may be experienced.

FAULTS DURING PREPARATION.

1. Lights will not go on when M.G. is not running.

   a) Check that Battery isolating switch is closed.
   b) Check that miniature circuit breakers (MCB) are "On".
   c) Check Battery Fuses.

2. Pantograph will not go up.

   a) Check that H.T. doors are closed and completely locked.
   b) Check Control key switch is "On".
   c) Check that amber light on desk is showing.

      If not - Check that the lights work (See 1).
               Check that "Control Main" M.C.B. is on.
               Check that "Control" M.C.B. is on.
   d) Check that correct air pressure is available.
   e) Check that pantograph isolating cocks are open.

3. Line Voltmeters do not register.

   a) Check that pantograph is up (See 2).
   b) Check that roof switches are closed.
   c) Check voltmeter fuses (9.5 amps).

4. Compressors will not start.

   a) Check control key switch is "On".
   b) Check Voltmeter is reading (See 3).

      If motor generators are not running, and amber light is not showing, then:-

c) Check (i) that lights work (See 1).
(ii) "Control Main" M.C.B. is "On".
(iii) "Control" M.C.B. is "On"
d) Check "Compressors" M.C.B. is "On".
e) Check 18 Amp. Compressor fuses.
f) Check 160 Amp. Main H.T. Auxiliaries fuse.
If one compressor only will not start,
(i) Check 18 Amp Compressor fuses.

NOTE: The Compressors will not start if main Reservoir pressure is above 105 p.s.i. gauge.

5. Motor Generators will not start.

a) Check that Compressors will start (See 4).
b) Check that (i) "Supply M.G." M.C.B. is "On".
(ii) "Exciter M.G." M.C.B. is "On".
c) Check Switchgroup isolating cock is open.
d) Check 50 Amp Supply M.G. H.T. Fuse.

6. Exciter M.G. set only will not start.

a) Check that "Exciter M.G." M.C.B. is "On".

7. Cab, Food and Window Heaters.

a) Check that M.G. Sets are running, as otherwise heaters are not available.
b) Check the appropriate M.C.B.s.

8. Sanders will not operate.

a) Check that "Sander" M.C.B. is "On".
b) Check that Sander Isolating Cock is open.

9. Horns will not operate.

If main reservoir pressure is available, horns are defective.

FAULTS IN RUNNING.

Procedure when locomotive will not move or loses power when motoring or regenerating.

If on a steep falling grade bring the train to a stand by the automatic air brake.

Return master controller to "Off" position and set reverser key to FORWARD SERIES.

Check control key switch is in "ON" position, and reset over-load and overvolt relays.

Take Notch 1 on accelerating handle.

If motor ammeter reads, electrical circuits are now normal, and the locomotive can proceed.

If motor ammeter does not read, return accelerating handle to "OFF" and carry out the following checks to prove the locomotive supply circuits.

Check for	Supply is proved if:-	Action if no supply.
1. OVERHEAD SUPPLY	Line Voltmeter Reads or Motor Generators Operate or Compressors Operate.	Ensure Panto in contact with wire & Panto Isolating Switches closed. If these are OK await restoration of power.
2. BATTERY SUPPLY	Motor Generators Operate or Compressors Operate or Any loco lights Operate.	Check Battery Isolating switch closed & battery fuses O.K.

Check for	Supply is proved if:-	Action if no supply.
3. CONTROL CIRCUIT SUPPLY	Compressors Operate or Unit switches Operate or Indicator Lamps Light.	Check Main and Control M.C.B's.
4. CONTROL AIR SUPPLY	Motor Generators Operate or Any Unit switch Operates.	Check all Isolating cocks on P & C Reservoir and Switch-group.

RESISTANCE FANS AND MOTOR GENERATORS INDICATOR LIGHTS.

There is an indicator lamp on each driver's panel for the resistance fan motors and for the motor generators. If this lamp is alight it indicates either that one of the motor generators has stopped, or that one of the resistance fans has stopped. If the lamp is alight when the accelerating handle is in the off position the indication is that one of the motor generators has stopped.

When double headed the indicator light shows whether a resistance fan or a motor generator on either locomotive is not operating.

When the accelerating handle is on notches 1 to 19 the lamp will normally light and stay alight for approximately one minute.

If it remains alight for more than one minute there is indication of trouble with the resistance fan motors or one of the motor generators. In this case:-

Check that both motor generators are running. Check that all eight fan circuits breakers on the low tension panels in the centre compartment are closed.

RESISTANCE FAN INOPERATIVE.

If both motor generators are running it is probable that one or more of the fan motors has stopped, and repeated accelerations will overheat the resistances.

Resistance should not be inserted during series regeneration.

The resistances are designed to stand two successive starts each taking five minutes without the fans operating.

If the fans are not operating and additional starts are required it may be necessary to wait for the resistances to cool down.

SUPPLY M.G. INOPERATIVE.

If the supply motor generator is inoperative, the ventilating air to the traction motors is greatly reduced and care must be taken to avoid overheating the motors. In such conditions the average motor currents must not exceed the following values:

700 amps for 30 minutes.
550 amps for 60 minutes.
450 amps for continuously.

If the load is such that the current exceeds these values the train must be placed in the first siding to avoid damage to the motors, and the locomotive worked light to a depot.

The regenerative brake and the resistance fans are inoperative.

EXCITER M.G. INOPERATIVE.

If the exciter M.G. is inoperative the average motor currents should not exceed the figures shown under previous heading.

The regenerative brake and resistance fans will be inoperative.

ONE COMPRESSOR INOPERATIVE.

The locomotive may be operated normally, but a close watch should be kept on the main reservoir pressure.

OVERLOAD RELAY TRIPPING.

Tripping of the overload relays will be indicated by lighting of the line switch indicator lamp, F in figure 4, a sudden loss of power, and zero readings on both ammeters.

The M.G. sets will continue to operate and the line voltmeter will register.

The accelerating handle should be returned to the off position and the overload relay reset button pressed. The accelerating handle can then be notched up again carefully.

The overload relays should not be reset more than twice in succession.

After the tripping of the overload relays the locomotive should not be operated beyond full series for 1 minute, nor beyond series-parallel for a further period of 5 minutes.

After the overload relays have tripped twice in succession and the load of the train is more than that shown below it will be necessary to obtain assistance.

GRADE.	LOAD.
1/33	175 tons
1/40	250 tons
1/60	350 tons
1/90	550 tons

If the load is less than that shown, Nos.1 2 and 3 motors should be cut out by setting the motor cut out switch to "1, 2 & 3 OUT". The overload relays should be reset, the reverser handle moved to series-parallel, and an attempt made to proceed in this combination.

Only the series-parallel position is effective with motors cut out. Regenerative braking is inoperative. The line switch indicator lamp is inoperative with motors cut out.

If the overload relays trip again, Nos.1, 2 and 3 motors should be cut in and 4, 5 and 6 motors cut out. The overload relays should be reset again and an attempt made to proceed in series-parallel.

If the overload relays trip again the locomotive is a total failure.

When double headed the line switch indicator lamp shows whether the overload relays have tripped on either locomotive.

INTERRUPTION OF OVERHEAD SUPPLY.

This will be shown by loss of indication on the line voltmeter. The line switches will open through the action of the no current relay which is de-energised on loss of line voltage.

Return the accelerating handle to the "OFF" position and when power is restored, as indicated by the line voltmeter, and main reservoir air pressure has been restored, notch up again in the normal manner.

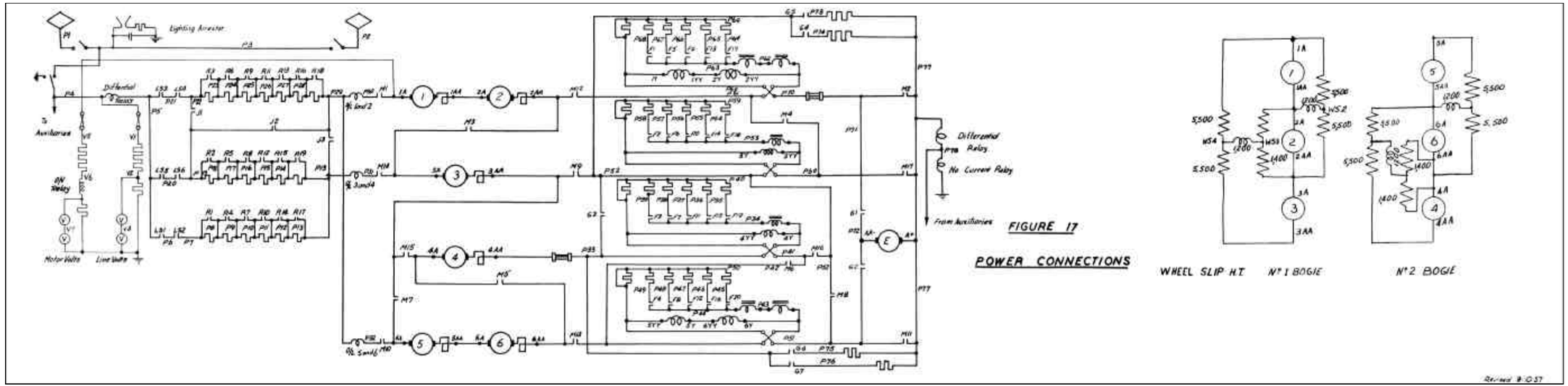
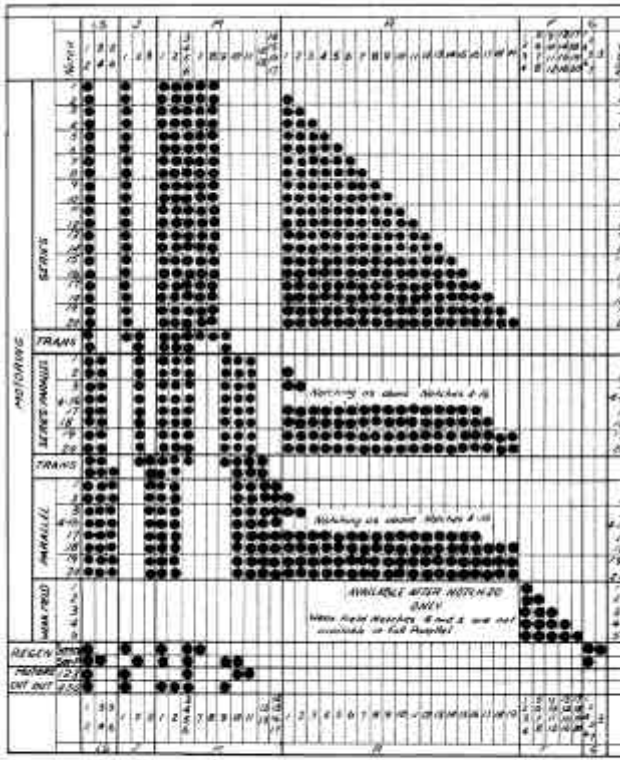


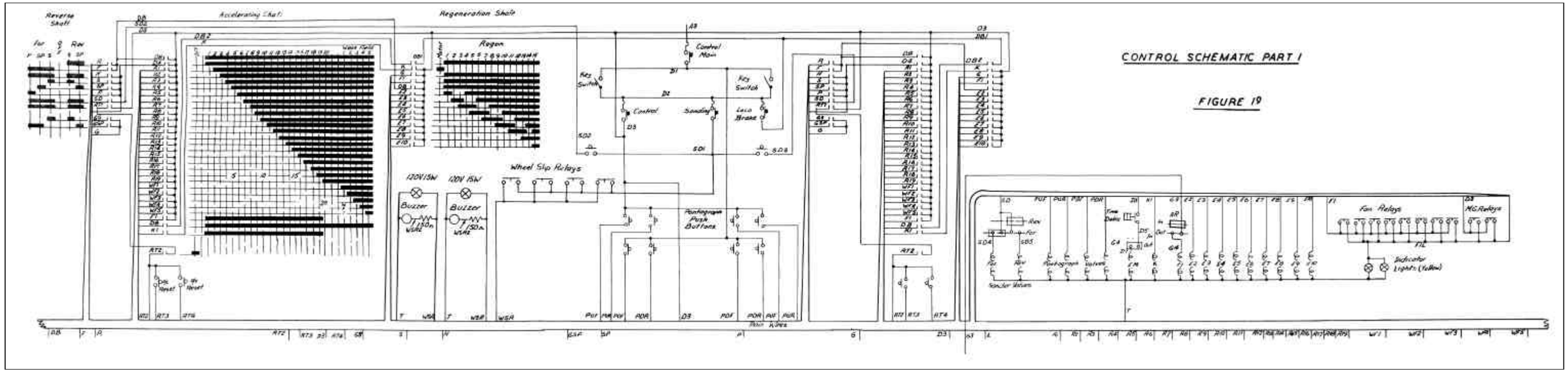
FIGURE 17

POWER CONNECTIONS



SEQUENCE OF SWITCHES.

FIGURE 18.



CONTROL SCHEMATIC PART I

FIGURE 19

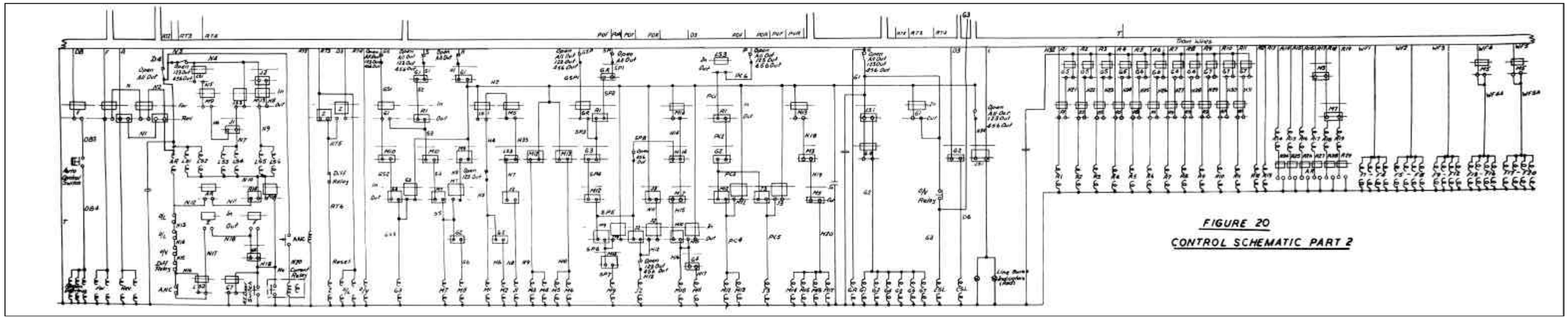


FIGURE 20

CONTROL SCHEMATIC PART 2

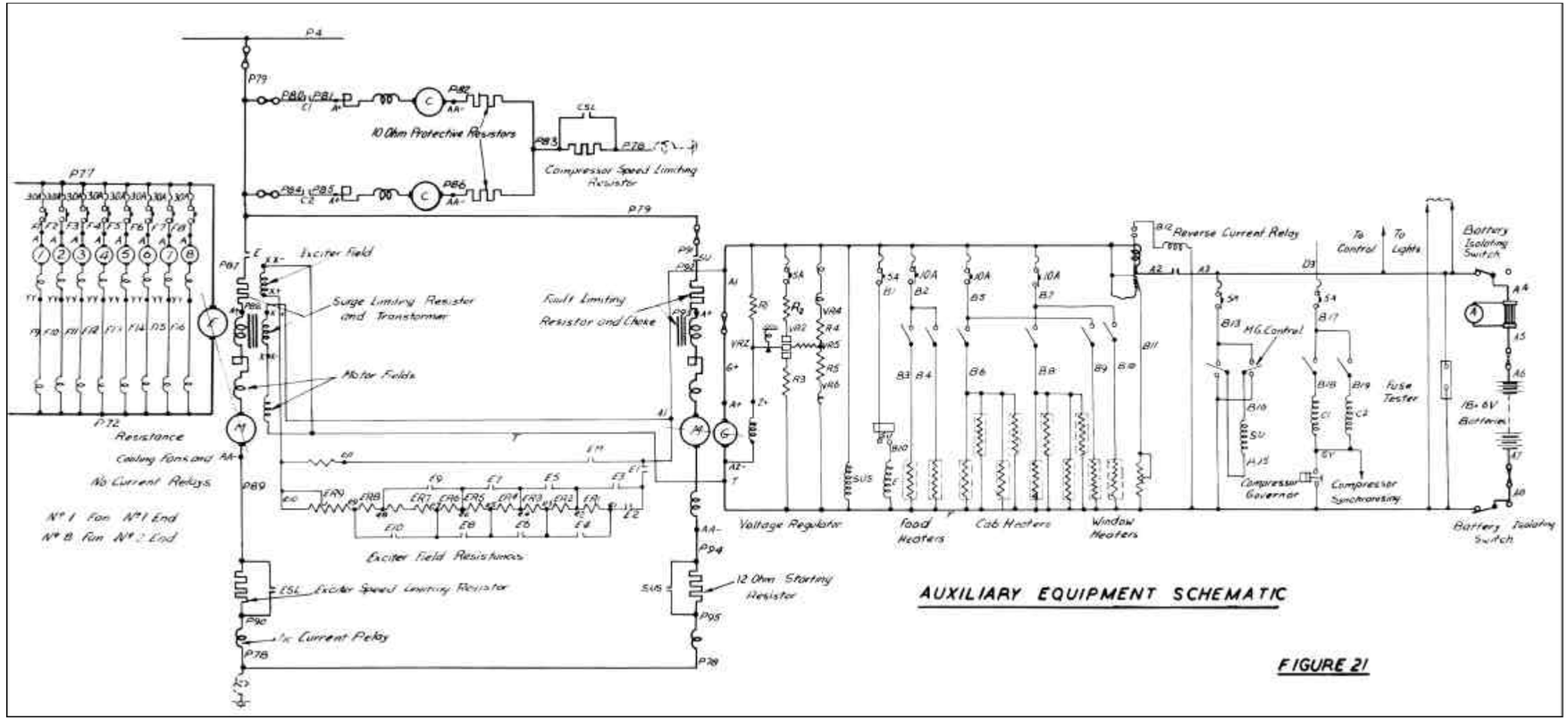
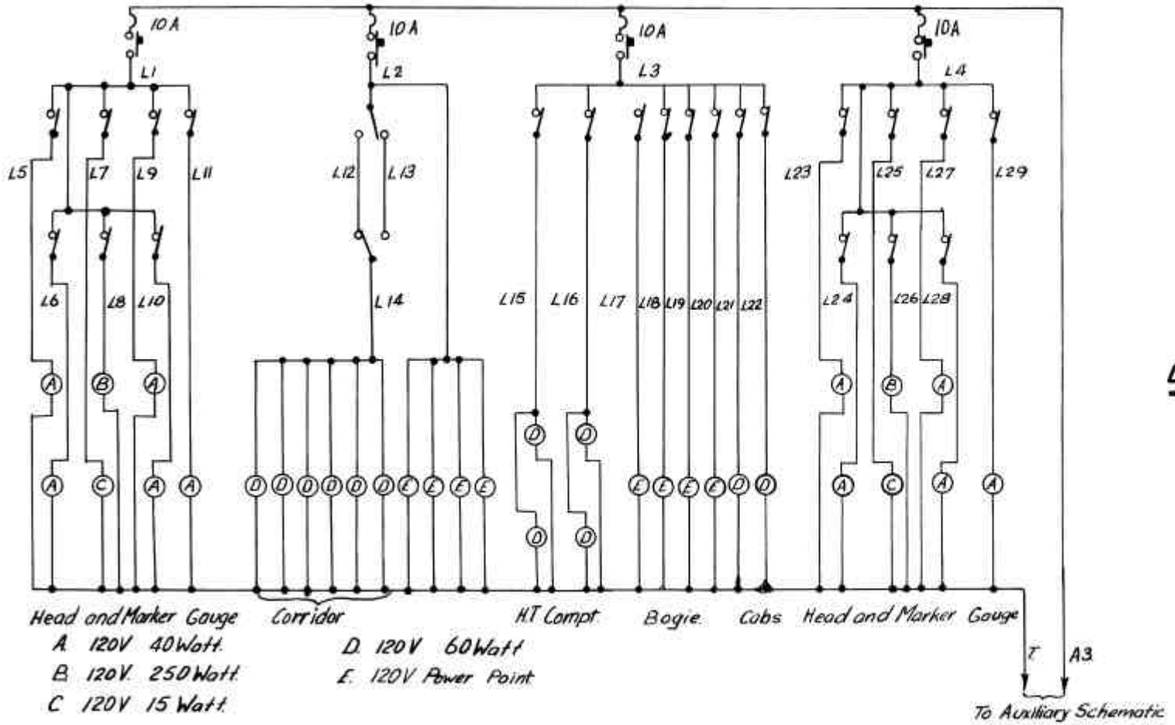
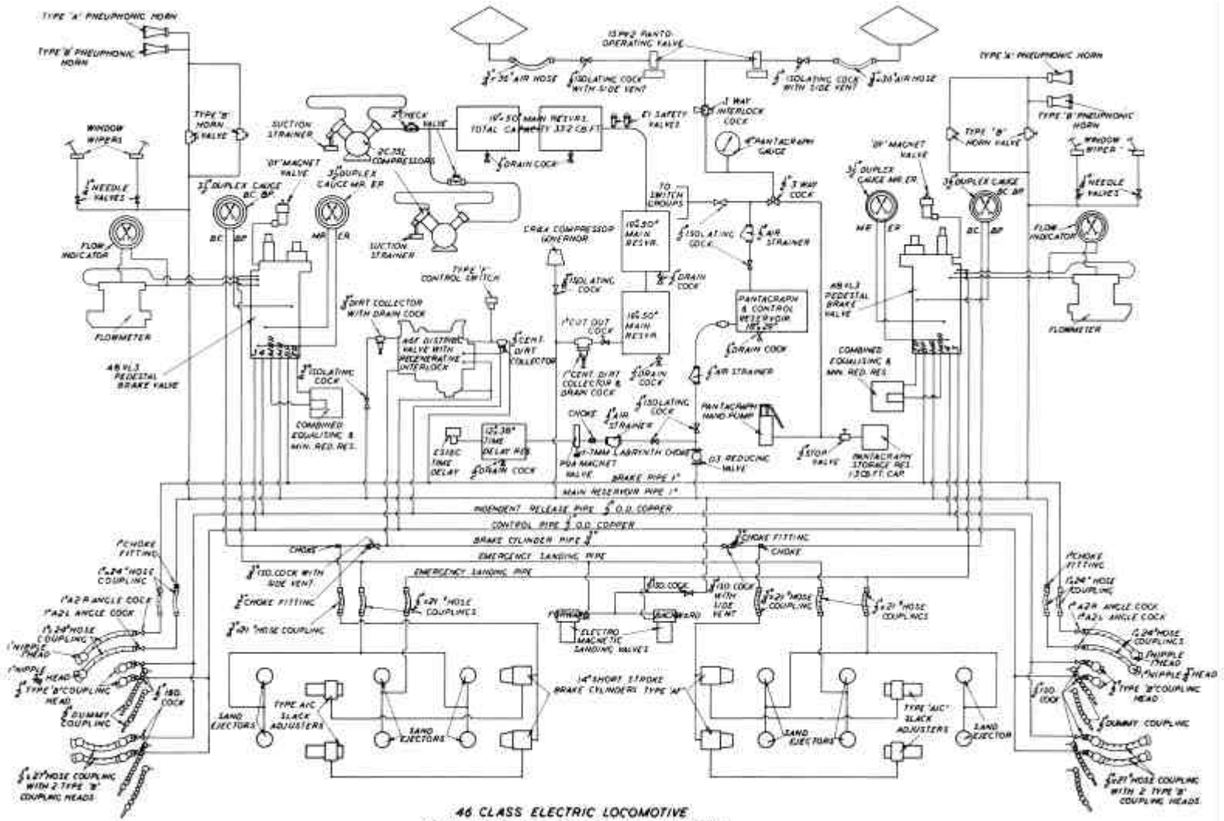

10 Ohm Protective Resistors
Compressor Speed Limiting Resistor
Exciter Field
Surge Limiting Resistor and Transformer
Fault Limiting Resistor and Choke
Motor Fields
Resistance
Cooling Fans and
No Current Relays
Nº 1 Fan Nº 1 End
Nº 8 Fan Nº 2 End
Exciter Field Resistances
Exciter Speed Limiting Resistor
12 Ohm Starting Resistor
Reverse Current Relay
To Control
To Lights
Battery Isolating Switch
M.G. Control
Fuse Tester
18 6V Batteries
Compressor Governor
Compressor Synchronizing
Voltage Regulator
Food Heaters
Cab Heaters
Window Heaters
AUXILIARY EQUIPMENT SCHEMATIC

FIGURE 21



LIGHTING SCHEMATIC

FIGURE 22



46 CLASS ELECTRIC LOCOMOTIVE
SCHEMATIC ARRANGEMENT OF AIR BRAKE,
AUXILIARY EQUIPMENT & PIPING

FIG.23. AIR BRAKE PIPING.

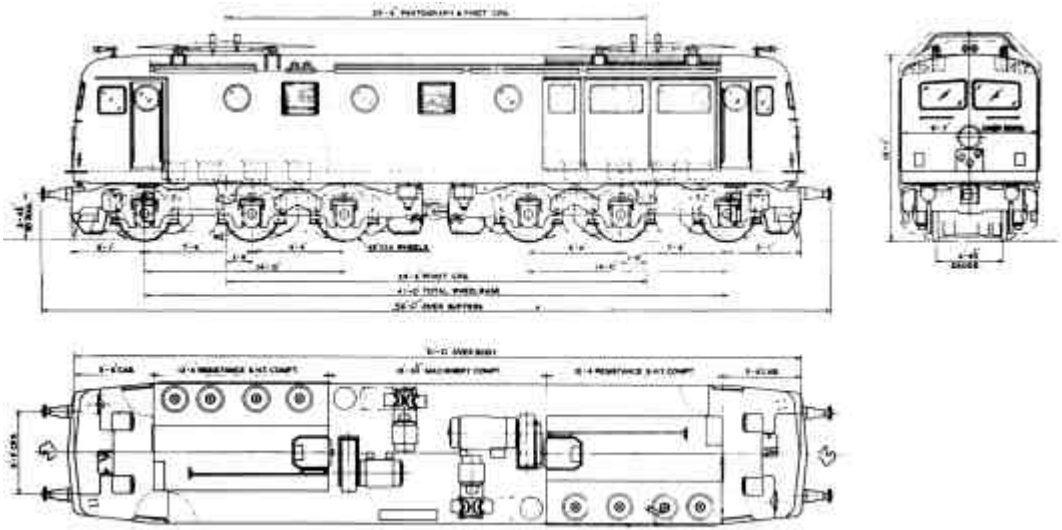


FIG. 24. LOCOMOTIVE DIAGRAM