BRITISH RAILWAYS

Scottish Region

C.M.& E.E. DEPT. (Electric Traction Section)

68 DUNLOP STREET, GLASGOW.

BATTERY RAILCAR

GENERAL DESCRIPTION AND PROVISIONAL
OPERATING INSTRUCTIONS

8th March, 1958.

ABERDEEN – BALLATER 2 CAR BATTERY TRAIN

GENERAL DESCRIPTION AND OPERATING INSTRUCTIONS

GENERAL DESCRIPTION.

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PART I

GENERAL DESCRIPTION

SECTION (a) GENERAL.

The Battery Train consists of two light alloy coaches semi permanently coupled together, and designated Motor Coach and Driving Trailer. The batteries supplying the electrical energy are accommodated on the underframes, one half of the battery being carried under each car. It is, therefore, not possible for the Motor Coach to be operated alone, even for shunting purposes.

In addition to the normal screw couplings between the vehicles there are also three main power cables (440 v, 220 v interconnector and 0 v Negative), a 34 wire Control Jumper, a Heating and Lighting Control Jumper, the Air Compressor Power Jumper and the Air brake Train Pipe and Air Brake Main Reservoir Pipe.

It is not possible to couple the Brake Pipes to any other type of vehicle because of the Oerlikon system employed. The attaching of tail traffic to the train is also strictly forbidden.

The coaches are of the open saloon type with road motor omnibus style seating arranged to face the driving cab in each car. First class accommodation and a toilet are provided in the Driving Trailer Coach and a Guard's and Luggage Compartment in the Motor Coach.

The train is powered by two 100 KW (133 H.P.) Traction Motors geared one to each axle of the Motor Bogie which is immediately below the Guard's Compartment. The gear ratio is 13.81. Power is drawn from the batteries through the control equipment situated in a cubicle in the Guard's Compartment. The train may be driven from either cab, the controls in each being identical, the performance of the train being the same in either direction of travel.

Compressed air for braking, for the warning horns and windscreenwipers is supplied by an Air Compressor carried underneath the Driving Trailer, this being arranged to keep the two Main Reservoirs charged to full pressure.

A Motor Generator Set is provided on the Motor Coach driven at 440 volts from the Battery supplying power at 24 volts D.C. for train lighting and heating control.

The coaches are each heated by two Oil Combustion Heaters situated on the underframe, from which hot air is circulated throughout the vehicle. These heaters are controlled from panels in each driving cab.

The train is fitted with the Oerlikon Air Brake. A hand brake wheel in each driving cab operates the brakes on the bogie immediately below the driving cab. The hand brake is provided only for stabling purposes.

SECTION (b) BATTERIES AND MAIN POWER CIRCUITS

The battery consists of 216 cells connected in series. These are accommodated in wooden boxes, six cells per box. Three such wooden boxes are accommodated in each battery cradle of which there are twelve, six being carried under each coach. The cells in each cradle are permanently coupled together. The cradles are arranged with rollers which run on rails incorporated in the underframes of the coaches. This permits the batteries to be withdrawn from their normal position to facilitate topping up and inspection. When the battery cradles/

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cradles are pushed back into the running position they are automatically re-connected to the Power Circuit by an arrangement of copper blades on the battery cradles engaging fixed jaws on the coach underframe.

Four Main Power Cables run the length of the two coaches, two positive and two negative. These are connected at the outer ends of the train to the Charging Plug Sockets. These cables are also connected through the Positive and Negative ends of the battery. Connection is also made from the Main Positive and Negative Cables to the Battery Main Switch in the Control Cubicle in the Luggage Compartment.

In addition to the above cables there are two 220 volt cables which connect together the two halves of the battery on the two coaches. These 220 volt interconnectors are protected at both ends by main fuses.

There are thus six main cables passing between the two units, but these, however, are carried in three Large Jumpers each having four cores.

The four main battery fuses are accommodated in boxes on the coach underframes and are used for isolation purposes during maintenance and in certain specified emergencies.

The two Traction Motors are carried on the bogie underneath the Luggage Compartment of the Motor Coach and are connected to the batteries through the resistances and the control equipment.

Each motor drives one axle through a pinion fitted to the armature shaft of the Traction Motor and a gearwheel pressed onto the axle adjacent to one road wheel. The gear wheel and pinion are enclosed in a gear case.

To provide smooth acceleration and to prevent damage to the equipment, resistances are connected in the Motor Circuit, these resistances being carried under the Motor Coach Luggage Compartment. The two motors are connected in series during the first part of the acceleration, the resistances being automatically cut out in 22 steps. The motors are then automatically re-connected in parallel (this switching is in 4 steps) and the resistance re-inserted in circuit. The resistance is then automatically cut out again in 22 further steps.

The condition of both motors in series with all the resistance cut out is known as "Full Series", and is a running position on the controller, giving a speed of approximately 25 m.p.h. on straight level track. The next running notch on the controller corresponds to the condition of both motors in parallel and all the resistance cut out, and is known as "Full Parallel".

The final stages of acceleration are achieved by inserting resistance in the field circuit of the motors to reduce the strength of the magnetic field. This stage is known as "Weak Field" and corresponds to notches 4,5 and 6 of the controller each giving a definite running position.

SECTION (c) CONTROL EQUIPMENT

The main control equipment and most of that for the auxiliaries is housed in a cubicle in the Luggage Compartment of the Motor Coach. The principal items are as follows:-

(i) Battery Main Switch

This is located on the left side of the cubicle on the second shelf up and access is possible through a small door in the front of the front of the cubicle. The purpose of this switch is to isolate the power equipment, control equipment and auxiliaries from the battery. The Battery Main Switch is always closed, that is, switched on by hand. This is achieved by lifting up the lever with the black knob until it latches. The switch may be tripped by pulling down the black knob and tripping, or it can be tripped remotely from either driving cab.

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When the switch is tripped by hand all Main, Auxiliary and Control Circuits are disconnected from the battery. When the switch is remotely tripped by depressing the C.B. Trip switch in either driving cab, all circuits are broken except the 440 volts supply and the control current for the Motor Generator Set. After remote tripping the lever will remain in the set position until depressed by hand, which will finally disconnect the Motor Generator Set.

N.B. The Battery Main Switch cannot be tripped from either driving cab, unless the reversing key is in the Master Controller and placed either in the "Forward" or "Reverse" position.

(ii) Main and Field Weakening Contactors

This group of six contactors is located immediately to the right of the Battery Main Switch. The four right hand contactors serve as line switches to connect and disconnect the motors when applying and cutting off power. These contactors are provided with adjustable overload trips which open all four contactors should the current through one or both motors exceed a set value, thus protecting the electrical equipment against damage. A warning light is provided in each driving cab marked 'O' which indicates operation of the overload trips.

The contactors may then be re-closed by returning the Master Controller to the 'OFF' position and depressing the switch marked 'Overload Reset'. The warning light and reset switch are only operative in a driving cab when the reversing key is in the Master Controller and placed in the 'Forward' or 'Reverse' position.

The remaining two contactors in the group are the Field Weakening Contactors and serve to connect the resistances in the Field Circuits of the motors during the final stages of acceleration. They are not fitted with overload protection.

(iii) Camshaft Contactor Group

This is the largest single item of control equipment and is located on the first shelf of the control cubicle underneath the Battery Main Switch. It consists of twenty Main Contactors and at the right hand end a group of auxiliary contactors. The twelve left hand contactors (Nos. 1-12) are operated by cams mounted on a shaft driven through a worm gear by a small motor at the left hand end of the assembly. These twelve contactors automatically control the acceleration of the train appropriate sections of the main resistances being inserted and cut out of circuit as the train speed increases, Nos.1 and 10 contactors serve to alter the connection of the motors from Series to Parallel.

Contactors 13, 14, 15, 16 are for reversing the direction of the train and are operated electro-magnetically by two coils, one forward and one reverse, actuated by the reversing drum of the master controller. As a safety measure to prevent accidental reverse of the train, the reverser is not thrown until a notch is selected on the master controller. The reversing contactors may be hand operated by the bar type lever at the right hand end of the assembly to which access is gained in service by a small door. The positions of the lever are marked "F = forward, R = reverse" with arrows indicating the resultant direction of motion of the train.

The last four contactors Nos. 17, 18, 19 and 20 comprise the Motor and Unit Cut Out Switch, and are hand operated by the lever carrying the black knob. This lever has five positions as follows:-

II	No. 1 motor cut out.	Only No.2 Motor driving.
I	No. 2 motor cut out.	Only No.1 motor driving.
F	Normal position.	Both motors driving.
A	Main and Control Circuits to Equipment isolated. No electrical equipment will function except the auxiliaries.	

P Testing position. The motors are disconnected but otherwise the complete control equipment may be operated for test purposes. When the lever is in this position a red warning light 'T' is illuminated in both driving cabs.

(iv) Traction Current Control Device

This is a special Motor Generator Set on a resilient mounting in the bottom left hand corner of the Control Cubicle. This machine is started automatically whenever power is applied to the train and is driven at 220 v from the battery. The Generator is specially connected to supply a varying voltage which is controlled by the current being taken by the traction motors. When the Traction Motor Current rises the voltage generated falls, and vice versa. This varying voltage is fed to the Camshaft Controller Motor. Thus the speed of rotation of the Camshaft, and hence the rate of acceleration of the train is regulated by the Traction Motor Current in such a way that automatic compensation for loading and gradients is obtained. The rate of acceleration (i.e. the traction motor current during initital starting) may be altered by adjustment of the resistances adjacent to the Current Control Device.

(v) Auxiliary Control Panel

This is located at the top of the Control Cubicle and carries the Voltage Regulator which automatically controls the output of the Motor Generator Set at 24 volts; also the Control Contactors; Compressor Contactor, Motor Generator Main and Starting Contactors, Increased Power Contactor and the Kilowatt Hour meter. The latter meter may be read through a glass panel in the front of the cubicle and measures the power used by the Traction Motors and Air Compressor.

(vi) Driver's Switch Panel

This is located in the end of the Control Cubicle remote from the Luggage Compartment partition, access being by a door, the key of which also opens the two small doors giving access to the Battery Main Switch and the Motor Cut Out Switch.

This panel carries the following items :-

440 Volt fuses for the Voltmeters, Motor Generator and Air Compressor.
Miniature Circuit Breakers for Traction Current Control Device, and Control Current and Subsidiary Miniature Circuit.
Breakers for Master Controller Supply, Indicator Lights, Air Compressor and Motor Generator Control.
Insulation Test Voltmeter with two-way switch.
Part Voltage Isolation Switch.
Battery Group Selector Switch.
Motor Generator Starter Push Button incorporating an Indicator Lamp.
Panel with five part Voltage Measuring Sockets.

(vii) Resistances

These are carried in a ventilated box on the underframe of the Motor Coach below the Luggage Compartment. They consist of two banks of cast iron grids, each divided electrically into nine sections, the various sections being connected by cables to the Control Cubicle.

(viii) Control Governor

Located at the bottom left hand side of the Control Cubicle is the Control Governor. This is a pressure switch which is connected to the Air Brake Train Pipe. Until there is a pressure of 55 lbs. per sq.inch in the train pipe the Governor will not close, which in turn prevents the Control Contactor from Closing, and thus prevents power from being applied to the train. If the train pipe/

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pipe pressure falls to 45 lbs. per sq. inch due to a full brake application, or operation of the Deadman's Valve, or other cause, the Control Governor will open, opening in turn the Control Contactor and cutting off power.

All the above Control Equipment located on the Motor Coach is remotely operated by the Driver's Controls at either end of the train. These controls draw current at 110 volts from the battery via the Part Voltage Isolation Switch and the Battery Group Selector Switch, and the Control Switch and Miniature Circuit Breakers. According to the position of the Battery Group Selector Switch the control current may be taken from any of the four quarters of the battery which give a voltage difference of 110 volts.

There are 34 control wires running the complete length of the train, connection between the coaches being made by a special jumper with a 34 pin plug. The latter fitting in a socket on the Driving Trailer Coach.

Drivers's Controls

(1) Master Controller

This operates all the Traction Motor Control Gear and also incorporates the "Deadman's" Device. It has two drums carrying segments which make and break connections between various fingers, thus energising various circuits according to the positions of the controller handles.

(a) Controller Reversing Key

The reversing drum is operated by a forked key which can only be inserted or removed with the reversing drum in the mid or off position. To select "Forward" or "Reverse" it is necessary to press down the round knob on top of the drum before the key can be moved. No action will take place in the Control Cubicle until the main drum is moved.

(b) Controller Main Handle

This is a hinged handle which must be kept depressed all the time the train is being driven in order to keep the "Deadman's" solenoid valve closed and maintain the Air Brake Train Pipe Pressure. If this handle is released (or if the Reversing drum is returned to the mid position), the air brakes will be fully applied after a delay of 8-10 seconds.

The Main Controller Drum has six positions as follows:-

0	=	Off	4	=	Weak Field (50%)
1	=	Inch	5	=	Weak Field (30%)
2	=	Full Series	6	=	Weak Field (20%)
3	=	Full Parallel			

The first notch "Inch" is not a running notch like the others, and must only be used for short movements at extreme caution. In this notch all the resistances are connected in circuit and will become overheated with consequent serious damage if the train is so driven fro more than a few seconds.

Should the controller handle be accidentally released while running under power, it is necessary to return it to the "Off" position before it can be depressed again to cancel the operation of the Deadman's device.

To enable the Motorman to cross the cab to observe signals and exchange single line tokens, etc. a push button is located near the off side cab door which may be depressed with the same effect as depressing the Main Controller Handle. There is sufficient delay between releasing the Controller Handle, or the push button to permit crossing the cab.

(II) Overload Reset Switch and Indicator Light.

A warning light marked 'O' is provided on each driver's desk which lights if the main contactors are tripped due to overloading. The overload trips may then be reset, by returning the controller to the 'OFF' position and depressing the switch marked 'OVERLOAD RESET' until the indication light is extinguished. The indicator light and reset switch are only operative when the reversing key is in position and 'FORWARD' or 'REVERSE' selected.

(III) Testing Indicator Light.

A warning light marked 'T' is illuminated in both driving cabs should the hand switch of the Camshaft Contactor Group be placed in the 'P' or testing position. This is an indication that the train will not move until the Cut out Switch has been reset in a running position.

(iv) Resistance Indicator Light

There is a third indicator light marked 'R' on each driving desk. This light is illuminated whenever the Camshaft is in a position between two running notches, i.e. when resistance is in circuit with the Traction Motors. During normal acceleration this light will flash on and off in sequence with the motion of the Camshaft. Should the 'R' light remain illuminated for a prolonged period, i.e. half minute, it indicates that the train due to conditions of load or gradient will not automatically accelerate until the next running notch has been reached, and that a state of balance has occurred in the Control Equipment. This situation can be remedied by depressing the switch marked "INCREASED TRACTIVE EFFORT" until the 'R' light is extinguished. This permits the Traction Motors to take a slightly higher current than during normal automatic acceleration, and thus accelerate the train and permit the Camshaft Controller to reach the next running position. The momentary contact switch is provided for sinming the 'R' light during night running.

(v) Circuit Breaker Trip Switch

This switch is only operative with the Controller Reversing Key in position and "FORWARD" or "REVERSE" selected. When depressed momentarily the switch trips the Battery Main Switch and cuts off all Traction Current, Compressor Current and Control Current (excepting that for the Motor Generator Set). It is, therefore, a means of shutting down, all electrical equipment on the train with the exception of the Motor Generator Set and should only be operated in emergency or when stabling the train.

(vi) Voltmeter

A Voltmeter is provided on each driver's desk which measures the Traction Voltage available at the battery. It also serves as an indication to the Motorman that the Battery Main Switch is closed.

(vii) Ammeter

An ammeter is provided on each driver's desk which measures the current being drawn from the battery by the traction motors.

(viii) Speedometer

There is a Speedometer on each driver's desk which is electrically driven from the leading axle at that end of the train. The Operation of the Speedometers is completely independent of all other equipment.

SECTION (d) AUXILIARIES

(i) Air Compressor

This is a two cylinder compound pump, driven directly by a 440 volt motor/

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motor, the two machines being mounted as a unit on three point rubber suspension underneath the Driving Trailer Car. The Compressor draws air in through a strainer and delivers it through two containers of anti-freeze and the check valve into the two Main Reservoirs under the same car.

The Air pressure in the reservoirs is controlled by the Compressor Governor. This is a pressure switch located on the equalising pipe between the two Main Reservoirs. It is set to close the compressor contactor and start the compressor when the reservoir pressure falls below 85 lbs per sq. inch and to open the Compressor Contactor and stop the Air Compressor when the reservoir pressure rises to 100 lbs. per sq.inch.

The Compressor Governor draws its current from a Miniature Circuit Breaker on the Driver's switch panel. Closing of the Compressor Contactor connects the Compressor Motor to the battery through the Compressor Fuses and the Battery Main Switch.

(ii) Motor Generator Set

This consists of a 440 volt motor driving a 24 volt generator, both machines being housed in the same casing and mounted on the underframe of the Motor Coach. The 24 volt generator supplies current for train lighting and the controls and fans of the oil combustion heaters.

The motor generator is started by a push button on the Driver's switch panel. This closes the motor generator contactor, the control current being drawn through a Miniature Circuit Breaker on the switch panel. When the motor has run up to speed, and is generating 24 volts, the Starting Contactor is automatically closed, cutting out the starting resistance. A green indicator lamp then lights inside the starter push button, which may then be released.

The output of the Motor Genrator Set is automatically maintained at 24 volts by the Voltage Regulator in the Control Cubicle.

SECTION (c) HEATING

Heating of both coaches is by means of two Smith's Oil Combustion Heaters. These are mounted on the underframes of the vehicles and are automatic in operation, being controlled electrically from a pair of switch panels on each driver's desk. Each pair of switch panels controls only the heaters on the same coach. Control current at 24 volts is taken from the Motor Genrator Set through the 24 volt main fuse and the 24 volt distribution box.

Diesel ful oil is carried in a tank near each heater, and is burned in a special chamber in the body of the heater. An electric fan passes air around this chamber so that it becomes heated and then circulates it through ducting into the passenger saloons. One heater in each coach is arranged to draw fresh air from outside the train through a filter whereas the second heater re-warms and re-circulates air from inside the coach. The control switches are provided with four positions:-

(1) OFF (2) HALF HEAT (3) FULL HEAT (4) COLD

The heaters must lalways be started by turning the appropriate switch to the 'FULL HEAT' position. This lights the electric glow plug in the heater combustion chamber and starts a time switch. After a fixed delay the time switch automatically starts the electric motor driving the fuel pump and fan. The glow plug ignites the fuel oil and the heater starts. A special flame detector thermostat then operates and keeps the fuel pump and fan running. Should the glow plug fail to ignite the fuel oil the fan motor is automatically shut down. After a short period due to the non-operation of the flame detector thermostat. A second attempt to start the heater must then be made by returning the/

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the control panel switch to 'OFF' and thence back to 'FULL HEAT'. When the heater functions correctly the glow plug is automatically switched off after theoil is ignited.

There are two indicator lights on each control panel. One indicates that the glow plug is alight and the second that the fan motor is running.

After pre-heating the train, particularly in moderately cold weather, the heaters may be switched to 'REDUCED HEAT' which reduces the fuel oil supply and slows down the fan motor. During hot weather the heaters may be switched to 'COLD' which runs the fan motor without opening the fuel valve or lighting the glow plug, and thus circulates cool air through the coach.

Failure of the Motor Generator Set or blowing of 24 volt main Fuses will cut off the 24 volt control and fanmotor supply to the heaters which will be shut down. After rectification of the fault the heaters must be individually restarted.

N.B. To avoid overloading the Motor Generator Set and the 24 volt circuits, not more than two heaters must be started simultaneously. The second pair of heaters must only be started after the glow plugs of the first pair are extinguished.

SECTION (f) LIGHTING

The coach lights, together with the instrument panel, classification and destination indicator lights are supplied at 24 volts D.C. fro the Motor Generator Set carried under the Motor Coach. The Motor Generator Set output passes through the main 24 volt fuses to the distribution box, where the individual lighting circuits are fused. The passenger saloon lights on both vehicles are controlled by 'ON' and 'OFF' push buttons and a two-way 'ON' and 'OFF' switch. The push bottons control only the lights on the same coach wereas the switch controls the lights on the whole train.

The lights in each driving cab and one light in the Guard's Compartment are controlled by separate switches.

The classification lights, destination indicator lights, and instrument panel lights are controlled by a separate switch panel in each driving cab.

SECTION (g)BRAKE EQUIPMENT

The train is fitted with automatic air brakes of the 'oerlikon' type. These cannot be coupled to the brakes of any other vehicle on British Railways.

Air from the main reservoirs is taken to the Driver's Brake Valves via the Main Reservoir Pipe. This runs the length of the two coaches and is distinguished by the red painted coupling hose cocks.

The train pipe is also connected to the Driver's Brake Valves and leads to a triple valve on each vehicle, the purpose of which is to control the pressure of air in the Brake Cylinderin accordance with the positions of the Driver's Brake Valve Handle.

The Train Pipe is charged with air via the Driver's Brake Valve when it is in the 'RUNNING or 'FILL' positions.

Also connected to the train pipe are the Deadman's Valve, Guard's Valve, Passenger Communication Valves and Duplex Pressure Gauges in the Driver's Cabs and a single pressure gauge in the Guard's Compartment.

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Associated with each triple valve are a control reservoir and an auxiliary reservoir. The reason for the control reservoir is to provide an increase in volume to a chamber of the triple valve to make it more sensitive to changes in train pipe pressure, whereas the auxiliary reservoir stores air for the brake cylinders.

The pressure of air in the Brake Cylinders is shown on the single pressure gauge in the driver's cab of that vehicle.

The motor coach motor bogie has four 6" diameter brake cylinders whereas the three trailing bogies have one - 10" diameter brake cylinder each. There are two brake blocks to each wheel of each bogie.

The following is a description of the main items of Brake Equipment, and their respective functions:-

Driver's Brake Valve

This valve has seven positions as follows:-

(a) Neutral

The valve is inoperative in this position as it isolates the train pipe from the main reservoir pipe. The valve must always be left in this position when not in use, ie.e when driving the train from the other cab or when stabling.

To put the handle in the 'NEUTRAL' position the locking pin should be lifted and the handle rotated in a clockwise direction as far as it will go and then released. The pin located behind a projection on the valve body, thus locking the handle.

(b) Fill

This position should only be used when a very quick release of the brake is required, and is mainly intended for use on long trains. The handle should not be left in this position for more than 15 seconds or the brake system will be overcharged.

This overcharge will be maintained in the system while the brake handle is left in the 'FILL' position, but will subsequently be dissipated when the brake handle is moved to the 'RUNNING' position.

(c) Running

When the brake handle is in the 'RUNNING' position the train pipe will be maintained at a pre-determined pressure which can be adjusted by the knurled knob or regulating cap on top of the brake handle. This train pipe pressure should normally be 70 lbs. per sq.inch and car should be taken that the brake valves in the two driving cabs are adjusted to give the same running train pipe pressure. Frequent adjustment is not necessary and should be avoided.

A ball catch positively locates the brake valve handle in the 'RUNNING' position.

(d) Set

With the brake handle in the 'SET' position a very light brake application will be made with a brake cylinder pressure of 8-10 lbs per sq.inch. No intermediate position between 'RUNNING' and 'SET' should be used as the triple valves are not sensitive over this range. Any anti-clockwise movement of the brake handle past the 'SET' position results in a positive brake application.

A ball catch locates the brake handle in the 'SET' Position.

(e) Full Service Braking

With the brake handle in this position the maximum normal brake cylinder pressure of about 57 lbs. per sq.inch will be obtained, corresponding to a drop in train pipe pressure of about 20 lbs. per sq.inch - i.e. a drop from 70 to 50 lbs. per sq.inch on the Train Pipe Gauge. Any intermediate position between 'SET' and 'FULL SERVICE BRAKING' will give a brake cylinder pressure proportional to the distance the brake handle is moved from the 'SET' position.

A ball catch locates the brake handle in the 'FULL SERVICE BRAKING' position.

(f) Re-Application

This position should NOT be used on the Battery train, as its use may cause a partial release of the brake. It is intended for use when the Brake is fitted to a locomotive, and is a means of permitting the driver to release the brakes of the locomotive while holding those on the train, thus stretching the train. The locomotive brake is then re-applied using this position of the handle.

(g) 'Emergency' or 'Quick Action'

With the brake handle in this position the train pipe is quickly exhausted to zero. pressure, the brake cylinder pressure rising to its maximum in the shortest time possible. Simultaneously the reservoir pipe is isolated from the train pipe, thus retaining full pressure in the main reservoir.

2. Deadman's Device

The Deadman's Device is located under the driving desk of the motor coach. It consists of a solenoid operated valve, which is connected to a train control line wired to both Master Controllers. If the Controller reversing Key is inserted in either driving cab, 'FORWARD' or 'REVERSE' selected, and the Master Controller Handle depressed, a current flows through the solenoid, Keeping the valve closed. Release of the 'Deadman's Handle' cuts off the current and allows the valve to open.

A timing reservoir is connected to the Deadman's Valve which gives a delay of 6-8 seconds before the valve opens the train pipe to atmosphere resulting in an emergency brake application. Depressing The Deadman's handle again within this delay period will cancel the operation of the Deadman's valve and prevent the brake application.

A button is also provided near the off side cab door, which when depressed will cancel the operation of the Deadman's Solenoid valve, thus permitting the Motorman to cross the cab within the limit of the 6-8 seconds delay.

3. Triple Valve

There is a Triple Valve on each coach, which controls the admission and exhaust of compressed air from the brake cylinders of that coach. The Triple Valves are actuated by changes in the train pipe air pressure due to operation of the Driver's or Guard's Brake Valves, or the Passenger Communication Valves.

Connected to each Triple Valve, in addition to the Brake Cylinders are an Auxiliary Reservoir and a Control Reservoir.

The Brake Cylinder pressure is controlled by the differences in pressure between the Control Reservoir and the Train Pipe, this in turn being dependent on the position of the Driver's Brake Valve.

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When the Train Pipe Pressure falls below that of the Control Reservoir air is fed from the Auxiliary Reservoir to the Brake cylinders applying the brake blocks to the wheels. The pressure built up in the brake cylinders isproportionnal to the difference in pressure between the Train Pipe and the Control Reservoir.

When the Train Pipe pressure is raised by moving the Driver's Brake Valve towards the 'RUNNING' position the Triple Valve vents air from the Brake Cylinders to atmosphere, releasing the brakes.

In the 'RUNNING' position of the Driver's Brake Valve, the Triple Valves connect together the Train Pipe, Auxiliary and Control Reservoirs which are thus maintained fully charged to the same pressure (70 lbs. per sq.inch).

A release lever is provided at the bottom of each triple valve to which cords are attached. These may be pulled to release the brakes manually if required.

4. Reservoirs and Reservoir Pipe

The output of the Air Compressor is led by means of a flexible pipe, through a drip cup (to separate any water) and a check valve into one main reservoir. This is connected by an equalising pipe to the second main reservoir. The second reservoir is connected to the Main Reservoir Pipe which runs the length of the train, and is connected in the dirving cabs to the Driver's Brake Valves and Duplex Pressure Gauges.

On the equalising pipe between the two reservoirs are situated the safety valve and the air connection to the Compressor Governor.

The Reservoir Pipe also supplies air to the driving cabs for the windscreen wipers and the Two Tone Warning Horns.

5. Train Pipe

The Train Pipe also runs the length of the train, and to it are connected the Driver's Brake Valves, Deadman's Valve, Duplex Pressure Gauges and Emergency Brake Valves, in the drivingCabs, the Guard's Emergency Valve and single pressure gauge in the Luggage Compartment and the Passenger Communication Valves.

The Triple Valves are connected to this pipe, and are operated by changes of pressure in it, thus operating the brakes.

6. Brake Cylinders

The brake Cylinders are single acting and push outwards during a brake application. Internal springs return the pistons to their original positions when air is released from the cylinders.

Each wheel of the motor bogie is separately braked, there being four - 6" diameter cylinders mounted on the bogie. The other three bogies each have one - 10" diameter cylinder operating all the brake blocks through a system of levers.

There is no mechanical brake connection between bogies. The air connection to each bogie is by means of a flexible pipe located near the bogie centres, all brake cylinders on each coach being connected to the Triple Valve and the driving cab Brake Cylinder Pressure Gauge on that coach. It should be noted that the Brake Cylinder pressure gauges on the two coaches are completely independent.

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7. Hand Brake

There is a Hand Brake Wheel in each driving cab, which supplies the brakes only on the bogie immediately below the cab.

8. Emergency Brake Valves

An Emergency Brake Valve is provided on each Driver's Desk and also in the Guard's Compartment. Both are for the use of the Guard, that in the driving cab in an emergency, if the train is being propelled, when the Guard should ride in the leading cab.

9. Passenger Communication Valves

An emergency valve is provided on top of a handrail in each passenger saloon fro emergency use. When operated these completely exhaust the train pipe, with which they are in direct communication.

Addition to Section (d)

AUXILIARIES

(iii) Battery Cooling Fans

Two cooling fans are carried on both vehicles and are each driven by a 110 volt electric motor. Each pair of fans is carried in the same casing and rotate in opposite directions. They draw in air through a filter and circulate it through the battery compartment to cool the cells and rive off any gas.

The fan motors are supplied from the Battery group Selector Switch through fuses and a contactor. Al the fans start when the Master Controller Reversing Key is moved to forward or reverse or when the lids of a charging socket are lifted to plug in the charging cables.

The cooling fan contactor is interlocked with the Battery Charging plants sto that the D.C. circuit breakers of the latter cannot be closed, and charging commenced unless the contactor is closed.

PART II

BATTERY CHARGING

(a) General Description of Charging Plants

Battery charging facilities are provided both at Aberdeen and Ballater, the former being located at No. 1 platform and the latter at Canada Bank.

Power is taken from the North of Scotland Hydro-Electricity Board at 11,000 volts at Ballater and 6,600 volts at Aberdeen. The incoming cables are led to an isolator at each plant which is contained in a large steel cubicle, in which are also situated the consumption meters. These isolators are the property of the N.S.H.E.B. and are used when it is necessary to disconnect the charging plant for maintenance.

The isolator is connected on the charging plant side to the Oil circuit breaker which is the main switch for starting and stopping the plant. This is closed and tripped by hand and has an 'OFF' and 'ON' indicator in the small aperture at the front. From this circuit breaker the power is fed to the main transformer which steps down the voltage to that required by the batteries. The power is then fed at this voltage to the rectifiers, of which there are four in each plant, to change the alternating current to direct current. The direct current is then fed into the positive and negative charging cables through the D.C. circuit breakers.

The D.C. circuit breaker protects the batteries, as it will trip and cut off the charging current if the latter rises to too high a value. The D.C. circuit breaker is closed and tripped by two push buttons on the front of the rectifier cubicle. An orange indicator lamp is illuminated on the front of the cubicle to show when the D.C. breaker can be closed. This lamp goes on when the breaker is closed.

Each charging plant is provided with a special interlocking circuit which works in conjunction with the Interlocking circuit on the train. This ensures that the D.C. circuit breaker cannot be closed until the charging plugs are correctly inserted in the sockets on the train and locked, and the battery cooling fans on the train are running. This circuit is connected through a small pin in the positive charging plug.

The charging plants are entirely automatic in operation once the train has been correctly connected and the oil circuit breaker and D.C. circuit breaker have been closed. On a normal boost charge the charging current is initially limited to 600 amps by the regulating mechanism in order to prevent overloading of the rectifiers and overheating of the charging cables. As the battery becomes charged the output voltage of the charging plant is automatically stepped up until it reaches a maximum value, which can be adjusted by the maintenance staff to suit the demands made by the train service on the battery. The output voltage is then automatically regulated to remain at this value, the charging current gradually falling as the battery is recharged.

The output voltage and current are shown on a voltmeter and ammeter in a panel on the front of the rectifier cubicles.

The charging plant is then shut down by first tripping the D.C. circuit breaker. The oil circuit breaker may be tripped when the orange indicator light goes out.

Padlocks are provided on the oil circuit breaker and rectifier cubicle and these must be left locked when the plants are left unattended when charging is complete.

In addition, a wire enclosure with a padlocked gate is erected around the Ballater charging plant.

(b) Connection of the Charging Plant to the Train.

These instructions apply to both charging plants.

After bringing the train to rest in the correct position on the appropriate road, and applying the hand brake at one end of the train, the following procedure must be carried out in the order given.

(1) Unlock the battery charging socket covers at the appropriate end of the train and lift up. Observe that the battery cooling fans start up.

(2) Insert the two charging plugs in the correct sockets and lock by pulling down the lever at the side of the socket.

(3) Proceed to the charging plant and close the oil circuit breaker using the bar provided. The hinge down cover in front of the breaker should be unlocked and hinged downwards. The switch bar should then be inserted in its socket and lifted up to its fullest extent and then pushed down until the circuit breaker "latches in". The switch bar must then be removed, and the cover closed.

(4) Proceed to the rectifier cubicle and unlock the panel covering the D.C. circuit breaker push buttons. Wait until the orange indicator light goes out, and press the 'ON' push button. Observe that the D.C. circuit breaker closes and that the current rises to, but not above, 600 amps.

(5) If the charging plant is to be left unattended, lock the oil circuit breaker, rectifier cubicle panel, and the enclosure gate.

(c) Disconnection of the Charging plant from the Train.

These instructions are applicable to both charging plants.

(1) Proceed to the charging plant and trip the D.C. circuit breaker.

(2) Wait until the orange indicator lamp goes out. Trip the oil circuit breaker.

(3) Lock all padlocks.

(4) Unlock the charging plugs and remove from the charging sockets and place in the dummy sockets taking care that the charging cables are safely and correctly stowed.

(5) Close the charging socket covers, making sure both are securely locked. Close the train pipe safety cock and secure with the hook and chain.

NOTE:- Modified instructions regarding battery charging may be issued from time to time as various modifications are carried out to the train and the charging plants. Motormen should ensure that they are familiar with these instructions and also any that may be issued with regard to meters on the train.

PART XXI

OPERATING INSTRUCTIONS

SECTION (a) DUTIES OF MOTORMAN.

(1) Preparation of Train for Service.

After signing on and reading the notices etc., the driver must proceed to the train and carry out the following operations in the order given :-

	OPERATION	REASON
1.	Make sure that the charging plant is switched off and disconnected, and the cables etc. safely stowed away. If the train is still connected the motorman should disconnect in accordance with the instructions for operation of the charging plant.	
2.	The motorman should then proceed to the main control cubicle in the luggage compartment and with his private key unlock the small doors of the cubicle.	To gain access to the Battery Main Switch and Switch Panel.
3.	Close the Battery Main Switch by raising the lever with the black knob until it latches. Close the door.	To connect the main, auxiliary and control circuits of the train to the battery.
	The following operations are then carried out on the switch panel of the main control cubicle :-	
4.	Open the Battery Part Voltage Isolation Switch and withdraw the key. Insert same in the Battery Group Selector Switch and rotate through ½ turn. Replace the key in the Part Voltage Isolation Switch and close.	This operation transfers the 110 volt connections for the control circuits to a different quarter of the battery.
	N.B. Operation 4 must be carried out only once each day by the first driver.	
5.-	Close the Miniature Circuit Breaker marked "CONTROL SWITCH".	To connect the 110 volt supply from the Battery Group Selector Switch to the individual control current Miniature Circuit Breakers.
6.	Close the Miniature Circuit Breaker marked "COMPRESSOR CONTROL".	To make control current available to the Compressor Governor which will then start the Air Compressor if there is less than 85lbs per sq. in. pressure in the Main Reservoirs.
7.	Close the Miniature Circuit Breaker marked "M.G. SET CONTROL".	To make control current available for starting the motor generator set.

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	OPERATION	PURPOSE
8.	Press the push button marked "M.G. START" and keep depressed until the green light inside the button lights.	This closes the Motor Generator Contactor and supplies 440 volt current to the motor generator set. When this machine has run up to speed the motor generator set starting contactor closes, cutting the starting resistance out of circuit and lighting the green indicator lamp on the switch panel.
9.	Close the Miniature Circuit Breaker marked "MAST CONTROLLER".	This makes control current available at the driver's controls for operating the reverse and accelerating controls, and the deadman's device.
10.	Close the Miniature Circuit Breaker marked "INDICATOR LAMPS AND RESET".	This makes control current available at the driver's desks for operating the overload resistance and testing indicator lamps, and for operating the overload reset switch.
10a	Close the Miniature Circuit Breaker marked "TRACTION CURRENT CONTROL".	
11.	Test the insulation by placing the testing voltmeter switch first in the positive (up) position and then in the negative (down) position and observing the voltmeter reading in each case. Both readings should be zero or very low.	This operation measures the voltage between the positive and negative sides of all the battery circuits and the earthed metalwork of the coaches. As the electrical circuits are completely insulated there should be a zero reading of the voltmeter in both cases. Any slight leakage across the insulation will show as a reading on the voltmeter.
12.	Securely lock all cubicle doors.	To prevent possible interference with the electrical equipment by passengers.
13.	Proceed to the cab from which it is intended to drive the train.	
14.	Switch on the Oil Combustion heaters if required by turning the control switches to the "FULL HEAT" position. Observe that the glow plug indicator lamps light.	
15.	Check that the Air Compressor is pumping up the main reservoirs. When the main reservoir pressure reaches 70 lbs. per sq. inch insert the reversing key in the master controller. Release the brake valve handle from the "NEUTRAL" position and place in the "RUNNING" position. Place the reversing key in the "FORWARD" position and depress the Deadman's Handle. Check that the train pipe pressure rises to 70 lbs. per sq. in.	To test that the driver's brake valve builds up and maintains the correct train pipe pressure, and also that the Deadman's control functions correctly.
16.	Release the Deadman's handle and check that a full application of the brake is made after the correct delay by observing that the train pipe pressure falls to zero and the brake cylinder pressure rises to 55 to 60 lbs. per sq. in. Re-depress the Deadman's handle and observe that the train pipe pressure returns to 70 lbs. per sq. in. and the brake is fully released, with the brake valve in the "RUNNING" position.	To check the functioning of the Deadman's valve and that it makes a full brake application when the controller handle in this cab is released.

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OPERATION	PURPOSE
17. While keeping the Deadman's handle depressed make a full brake application with the Driver's Brake Valve and observe that the Brake Cylinder Pressure rises to 56-60 lbs. per sq. in. Return the handle towards the "RUNNING" position and observe that the brakes are gradually released. Finally return the handle to the "NEUTRAL" position.	To test the operation of the Driver's Brake Valve and the triple valves to make sure that a full brake application can be made from that end of the train and also that a graduated release can be obtained.
18. Test both notes of the warning horn.	
19. Check that the handbrake is applied.	To verify that it is safe to release the handbrake at the rear end of the train before returning to the driving cab.
20. Remove the Controller Reversing Key and proceed along one side of the train to the other driving cab, checking that all brake blocks are fully applied, and that charging socket covers, couplings, jumpers and hose connections are in order so far as can be seen.	
21. Enter the other driving cab and if required switch on the oil combustion heaters by turning the control switches to the "FULL HEAT" position. Observe that the glow plug indicator lamps light.	
22. Repeat 15 23. Repeat 16 24. Repeat 17	To test the functioning of the Driver's brake valve and deadman's device at the opposite end of the train, thus ensuring that all brake gear is in order.
25. Remove the Controller Reversing Key, place the Brake Valve handle in the "NEUTRAL" position and release the hand brake.	
26. Test both notes of the warning horn.	
27. Set the destination indicator and (electric tail lamp if required) switch on the destination indicator light and switch off all other lights.	
28. Check flags and detonators.	
29. Secure all windows and lock all doors.	
30. Proceed back to the first driving cab along the opposite side of the train, checking couplings, jumper connections hose connections, charging sockets etc.	
31. Set destination indicator and switch on destination indicator and correct classification lights.	
32. Check red flags, detonators and hand lamp.	
33. Place the Brake Valve handle in the running position insert the Controller Reversing key, move to the "FORWARD" position and depress the deadman's handle in readiness for the guard's test of the contuous brake.	

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SECTION (h) CHANGING ENDS. DUTIES OF MOTORMAN.

1. Place the Driver's Brake Valve in the "NEUTRAL" position.

2. Remove the Controller Reversing Key.

3. Switch off the classification lights, set the Destination Indicator, and switch off the cab lights and fan.

4. Secure all windows and lock all doors.

5. Proceed to the other end of the train, enter the cab, release the Brake Valve handle from the "NEUTRAL" position and insert the controller reversing key.

6. Set the Destination Indicator and switch on the correct classification lights.

SECTION (a) DISPOSAL OF TRAIN AFTER SERVICE - DUTIES OF MOTORMAN.

When the train is in the stabled position the following operations must be carried out in the order given :-

1. Make sure that the train is correctly positioned for connection to the Battery Charging Plant.

2. With the Controller Reversing Key still in the "FORWARD" position, operate the "C.B. TRIP" switch. — To test the operation of the emergency trip switch and to trip the Battery Main Switch, disconnecting all power circuits except the motor generator set.

3. Remove the Controller Reversing Key and place the Driver's Brake Valve in the "NEUTRAL" position.

4. Apply the handbrake.

5. Check that the heaters are switched off. — N.B. the heaters should be switched off at least 5 minutes before the train is finally stabled to allow the fans to run and cool the combustion chambers down to a safe temperature for stabling.

6. Switch off all Classification Lights, Destination Indicator lights, cab lights and fans.

7. Secure all windows and lock all doors.

8. Proceed to the other driving cab and apply the hand brake.

9. Repeat 4.

10. Repeat 5.

11. Repeat 6.

12. Repeat 7.

13. Proceed to the Control Cubicle in the luggage compartment and unlock the doors giving access to the Battery Main Switch and the Driver's Switch panel.

14. Depress the handle of the Battery Main Switch — to isolate the control circuits and the Motor Generator set from the Battery.

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15. Open all six Miniature Circuit Breakers on the Driver's Switch Panel. } To isolate all the control circuits from the Battery Main Switch in readiness for the next preparation of the train.

16. Lock all control cubicle doors.

17. If required, connect the train to the battery charging plant.

18. Report any defects by telephone to Kittybrewster Motive Power Depot.

PART IV.

DRIVING METHODS.

Section (a) GENERAL.

The aim in driving any electric train is to operate the booked service with the minimum consumption of electricity.

Any run can be divided into three parts of motoring, coasting and braking.

During the motoring period, the train is accelerated and energy is stored in the train, wheels and traction motors, which provide a flywheel effect and help to carry the train during the coasting period.

Energy stored in the train is destroyed when the brake is applied.

Section (b) OPERATION OF THE MASTER CONTROLLER.

(i) While awaiting the starting signal, the reversing lever should be in the forward position, with the Deadman's handle depressed and the Brake Valve Handle in a position to give a suitable partial application of the Brake to hold the train. The "SET" position should be adequate in most circumstances. On receiving the starting signal, the Brake should be totally released, i.e. placed in the "RUNNING" position, and the Master Controller moved to Notch 4 unless maximum acceleration of the train is not required due to the proximity of speed restrictions or adverse signals. The train will then automatically accelerate until it reaches a balancing speed depending on the notch selected and the load and gradient.

During acceleration the "E" Indicator Lamp on the driver's desk will flash on and off indicating the operation of the camshaft controller. Should this lamp stay alight for a period of ½ minute or more, it indicates that due to a gradient or heavy loading the train will not accelerate sufficiently for the camshaft to reach a running position and that the main resistances are still in circuit with the traction motors. If the train is allowed to run in this state the resistances will overheat and serious damage will result. To avoid this the "INCREASED POWER" switch must be depressed until the train accelerates enough to cut out all the resistances. If, after depressing this switch for about 10 to 15 seconds, the "E" Indicator Light does not go out, the Master Controller must be moved back to the next lower notch. When the train has reached the required speed The Master Controller should be returned to the "OFF" position and the train allowed to coast. The Controller Reversing Key must be kept in the "FORWARD" position (or "REVERSE" if shunting) while the train is in motion, otherwise the Deadman's valve will operate, and an emergency operation of the brake will take place after 5 seconds delay.

(ii) Movement at Dead Slow Speed

When it is necessary to move very slowly or at extreme caution, the Master Controller should be moved to Notch 1. The train must not be moved for more than a few yards (½ minute under power) in this notch, otherwise the resistances will become overheated and serious damage will result.

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(iii) Wheel Slip.

Should wheel slip occur, the Master Controller should be returned to the "OFF" position. When the slipping stops, the controller should be notched up again gradually.

(iv) Starting on a Gradient.

When starting on a gradient, the train may move backwards if the brake is released before power is applied. In these circumstances, a start should always be made against a partial brake application.. In no circumstances, should power be applied when the train is moving under gravity or for any other reason in the opposite direction to that selected on the master controller.

IF POWER IS APPLIED AGAINST THE MOVEMENT OF THE TRAIN, SERIOUS DAMAGE WILL OCCUR TO THE ELECTRICAL EQUIPMENT.

(v) Reduction of Power.

If it is necessary to reduce power when running in notches 4, 5 and 6, the Master Controller may be moved back to the next lower notch. If it is required to reduce power when running in notch 3, the controller must be moved back to the "OFF" position before selecting Notch 2.

Section (c) BRAKE OPERATION.

(i) Normal Braking.

The highest braking rate consistent with passenger confort and rail conditions should always be used to save time. It should also be borne in mind that sudden changes in braking rate are more responsible for passenger discomfort than steady, high braking rates.

Whenever possible, all normal station stops should be made with a single full brake application. The Brake should be gradually released as the train comes to a stand, after which it should be held with the Driver's Brake Valve in the "SET" position. The "OERLIKON" brake is self-lapping in action, and after the Brake Valve has been placed in an application position no further action is then necessary by the Driver to maintain application at a steady rate. Unnecessary movement of the Driver's Brake Valve between the "FULL BRAKE" and "RUNNING" positions results in wastage of air from the auxiliary reservoirs, with consequent loss of brake power.

Any tendency for the train to stop short should be corrected by a full or partial release of the brake before too much speed has been lost. Although a second application is undesirable, it is better to do this than to cover the last few yards to the stopping point at walking pace, which will increase the running time considerably.

(ii) Deadman's Application

If the Deadman's handle is accidentally released, the train pipe pressure will be completely destroyed. The Brake Valve should be immediately placed in the "FULL BRAKE" position to avoid wastage of air. The master controller should then be returned to the "OFF" position and may then be fully depressed. The brakes may then be released by returning the Driver's brake valve to the "RUNNING" position after which the train may be re-started.

(iii) Emergency Stop.

To make an emergency stop the Driver's Brake Valve should be moved to the "QUICK ACTION" position and left there. No attempt should be made to release the brakes until the train has come to rest.

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(iv) Automatic Brake Communication.

Operation of the Passenger Communication valves, or any of the Guard's Emergency Brake Valves will completely destroy the pressure in the train pipe and has the same effect as placing the Driver's Brake Valve in the "QUICK ACTION" position. No attempt must be made to release the brake until the train has come to rest, or a broken coupling may result. The train must not be moved again until the brake is fully released.

Section (d) CONSERVATION OF THE BATTERIES.

Motorman should at all times drive the train in such a way that the consumption of electricity is kept as low as possible.

In general, this objectcan be achieved by :-

(a) Rapid acceleration of the train, i.e. by moving the master controller into a high notch as quickly as possible.

(b) The highest rate of braking consistent with passenger comfort.

It will thus be possible :-

(c) To run at a low maximum speed.

which in turn permits :-

(d) the maximum amount of coasting.

The timing of the service is arranged so that the train can coast for considerable periods, where the gradient permits, between station stops. These coasting periods also act as a reserve, as, if the train is running behind time, some of the loss can be made up by keeping power on past the usual coasting points. As soon as the train is running to the booked times, normal running should be resumed.

When running semi fast services, the points at which power is cut off must be found by experience. The total consumption of electricity will be less if power is applied for several short periods, rather than maintained for one long period, as the former method permits the maximum speed to be kept at its lowest.

It is particularly important to observe the above in the case of the battery train, due to the limited capacity of the batteries. Although these have sufficient reserve to perform a complete round trip between Aberdeen and Ballater without intermediate charge, it is essential that the battery be kept to as high a level of charge as possible. "Hard Driving" in addition only leads to extra brake wear and results in standing time at intermediate stations.

PART V

DEFECTS IN SERVICE

(a) Electrical Equipment

Each 440 volt and 110 volt circuit is protected by fuses which will blow, and break the circuit if the current passing is greater than the fuse rating.

The control circuits are protected by miniature circuit breakers which trip if the current passing is greater than the rated value.

The various fuses and miniature circuit breakers, and the effects of the fuse blowing, or miniature circuit breakers tripping are as follows:-

1. Fuses & Miniature Circuit Breakers.

These fuses are carried in boxes on the underframe on both coaches and may only be changed by authorised maintenance staff.

(i) Main 440 volt 700 amps	No power to Traction Motors, Air Compressor or motor generator set.
(ii) Main Negative 700 amps	- do -
(iii) Main 220 volt Interconnector & 700 amps (iv) (2 fuses)	- do -
(v) 440 volt Part Voltage 35 amps	Air compressor and motor generator set will not run. Control equipment will not work in one of the four positions of the battery group selector switch.
(vi) 330 Volt Part Voltage 35 amps	Control equipment will not work in two positions of Battery group selector switch.
(vii) 220 Volt Part Voltage 35 amps	Control equipment will work in two positions of the battery group selector switch. Main camshaft will not work in any position of battery group selector switch. Train will only run at very slow speed as the control equipment will not advance beyond notch 1.
(viii) 110 Volt Part Voltage 35 amps	Control equipment will not work in two positions of the Battery group selector switch. Battery cooling fans will not run.
(ix) 0 Volt Part Voltage 35 amps	Air compressor and motor generator set will not run. Control equipment will not work in one position of the battery group selector switch. Main camshaft will not work in any position of the battery group selector switch.
(x & xi) Main 24 Volt Positive and Negative 100 amps	Train lighting and heating, Headcode, destination indicator and instrument panel lights will not work.
(xii & xiii) Voltage regulator Positive & Negative 6 amps	Motor generator set stops when the starting push button is released.

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Lighting and Heater Circuit Fuses

These are located in fuse boxes on the underframes of the coaches and in the heater control panels in the driving cabs. These fuses must only be changed by Carriage & Wagon Department Staff.

The following fuses are of the screw cap type and are carried on the Driver's switch panel in the control cubicle. They may be changed by motormen, spares being carried in the cupboard in the guard's compartment.

(i) & (ii) Measuring circuits 440 & 0 Volts 6 amps	Voltmeters on Driving Cab instrument panels, and insulation test voltmeter on driver's switch panel will not work.
(iii)&(iv) Motor Generator 440 & 0 Volts 15 amps	Motor generator set supplying lighting and heater circuits will not run.
(v)&(vi) Air compressor 440 & 0 Volts 20 amps	Air compressor will not run

The following fuses are contained inside the control cubicle and must only be changed by maintenance staff.

(vii)&(viii) Battery cooling fan Positive & Negative 6 amps	Battery cooling fans will not run. The train may run but the batteries must not be charged until the fuses are replaced.

The following miniature circuit breakers are located on the Driver's switch panel in the control cubicle and may be reset by the motorman.

(i) "TRACTION CURRENT CONTROL"	The traction current control device supplying the driving motor of the main camshaft controller will not run. The train will only move slowly with the control equipment in Notch 1.
(ii) "CONTROL SWITCH"	No control equipment will work. Train cannot be moved and air compressor, motor generator set and cooling fans will not work.
(iii) "MASTER CONTROLLER"	Power cannot be applied to the train. Deadman's brake application will be made.
(iv) "INDICATOR LAMPS & RESET"	Indicator lamps, O.T. & A. on the driving cab instrument panels will not work. Overload relays cannot be reset.
(v) "M.G. SET CONTROL"	Motor generator set will not start or run.
(vi) "COMPRESSOR CONTROL"	Air compressor will not work.

Blown Fuses

All traction fuses and auxiliary fuses carry a "tell tale" coloured button, which springs out of the fuse when it is blown.

Tripped Miniature Circuit Breakers

A miniature circuit breaker is tripped when the toggle is in the down position. The breaker is reset by lifting the toggle, when a red spot becomes visible.

2. Electrical Faults during Preparation

1. Air compressor does not start when the "Air Compressor Miniature circuit breaker is closed.	0 or 440 volt air compressor 20 amp fuses blown(replace). Control switch miniature circuit breaker not closed. Battery main switch not closed.

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	Battery part voltage isolation switch not closed. Any of four main 700 amp battery fuses blown. 220 volt part voltage 35 amp fuse blown. (try different position of battery group selector switch.) 0 or 440 volt part voltage 35 amp fuse blown.
2. Motor generator will not start.	0 or 440 volt motor generator 20A fuses blown (replace). Other causes as for air compressor.
3. Motor generator set starts but stops when the push button is released.	One or both voltage regulator fuses in 24 volt main fuse box blown.
4. Insulation test voltmeter shows a reading of more than 50 volts in either position of the test switch.	Short circuit in electrical equipment or battery circuits. Report to maintenance staff. Train may run if the excessive reading is only in one position of the test switch.
5. Heaters will not start.	Heater control fuse blown. Distribution fuse blown. Main 24 volt 100 amp fuse blown.
6. Heater indicator lamp does not light up before glow plug indicator lamp goes out.	Fuel oil has not ignited due to dirty glow plug. Return control switch to off and try to restart the heater.
7. Train pipe pressure will not build up with Reversing Key in position and "Forward" or "Reverse" selected and brake handle in "Running" position.	Deadman's solenoid valve coil not energised. "Master controller" miniature circuit breaker tripped. Battery part voltage 35 amp fuse blown.
8. Destination indicator lamps and headcode lights will not work.	Main 24 volt 100 amp fuse blown. 24 volt distribution fuse blown.

3. Electrical Faults during Service.

1. Train will not start	Overload relays tripped (Indicator lamp bulb may have burned out and thus no visual indication is given.) Insufficient train pipe pressure therefore control circuit governor will not close. Hand brake applied. Equipment and unit cut out switch in testing position (Indicator lamp may have burned out thus giving no visual indication).
2. Train only runs at very low speed and does not accelerate.	Control equipment will not run up beyond notch 1. Miniature circuit breaker "traction current control" tripped. 220 volt battery part voltage fuse blown. Traction current control device or camshaft motor defective. Brake dragging (Hand or air)
3. Overload Trip.	Press reset button with master controller main handle in 'OFF' position. If the relay trips three times in quick successions the defective motor should be isolated using the Equipment cut out switch. The train should only be driven on one motor until it can be taken out of traffic.
4. Failure of motor Generator set.	If this cannot be rectified, train can still be driven until it can be taken out of traffic. No lighting, heating, headcode or tail lamps will work.
5. Failure of air compressor.	If this cannot be rectified the train must be taken out of service.

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6. Power lost while motoring	"Master controller" miniature circuit breaker tripped. Overload trip. Battery main switch accidentally tripped. Battery main fuse blown (auxiliary machines will also stop.) One of the battery part voltage 35 amp fuses blown (try another position of the battery group selector switch).
7. Power cannot be re-applied after a period of coasting.	Main camshaft controller has not run back to the 'OFF' position. Traction current control miniature circuit breaker tripped. 220 volt part voltage 35 amp fuse blown. Traction current control device or camshaft driving motor defective.
8. Air compressor runs continuously.	Compressor governor stuck. Train can proceed until maintenance staff can rectify the fault. The compressor should be switched off at terminal stations using the "Compressor Control" miniature circuit breaker.

(b) Air Brake Equipment

1. Isolating Cocks.

Most items of air equipment can be isolated in the event of a fault. Isolating cocks are fitted as follows:-

(a) Main reservoir isolating cock which cuts off the main reservoir from the reservoir pipe.

(b) Brake Valve isolating cock which isolates the driver's brake valve from the main reservoir pipe.

(c) Triple valve isolating cock which isolates the triple valve, and hence the auxiliary reservoir and brake cylinder from the train pipe.

(d) Main reservoir and train pipe coupling cocks for isolating burst hoses etc. Normally open. No coupling hoses are provided at the outer ends of the train.

2. Defects in Air System during preparation and in Service.

(a) Burst hoses in train pipe.	The train will be brought to a stand. The coupling cocks on either side of the burst hose must be closed. The train must then be driven from the driving cab in the Motor coach. If this is not the leading cab, then the guard must travel in the leading cab in accordance with the operating instructions. The brake power will be reduced to one half of normal and the train must be driven with due caution at reduced speed.
(b) Burst hose in main reservoir pipe.	The train must be stopped and the coupling cock on either side of the burst hose must be closed. The train must then be driven from the driving cab of the Trailer car. If this is not the leading cab then the guard must travel in the motor coach driving cab in accordance with the operating instructions and be prepared to apply the brake using the emergency valve.
(c) Burst hose between triple valve and brake cylinders.	The triple valve isolating cock must be closed. The brake power will be reduced by half and the train must be driven with due caution at reduced speed.