7 Tracing Electrical Faults

7.1 General

Electrical faults can be divided into two categories, Supply System Faults, which affect all trains in the control area, and Train Faults, which affect only individual vehicles. This is distinct from faults arising from derailments where a combination of track and vehicle defects are the cause, which would not occur if only one or the other were present.

7.1.1 Test Equipment

The fault diagnosis procedures described in this section can be carried out using only a test lamp. A 12V 21W car lamp taking about 1.75A will be suitable in most cases. Use two in series for 24V systems. If, when placed across the power supply output, the lamp load causes the power unit protection to operate, reduce the lamp wattage. For example, the test lamp described above would cause a small commercial unit rated at, say, 12V 1A output to trip. A lamp rated at 12W would be suitable for this size of unit. (Figure 7-1)

Although not essential for tracing faults, panel mounted or portable meters will give more information about a fault than a test lamp as well as monitoring the system under normal operating conditions. Sections 1.12 and 1.13 deal with the installation of meters and interpreting their readings.

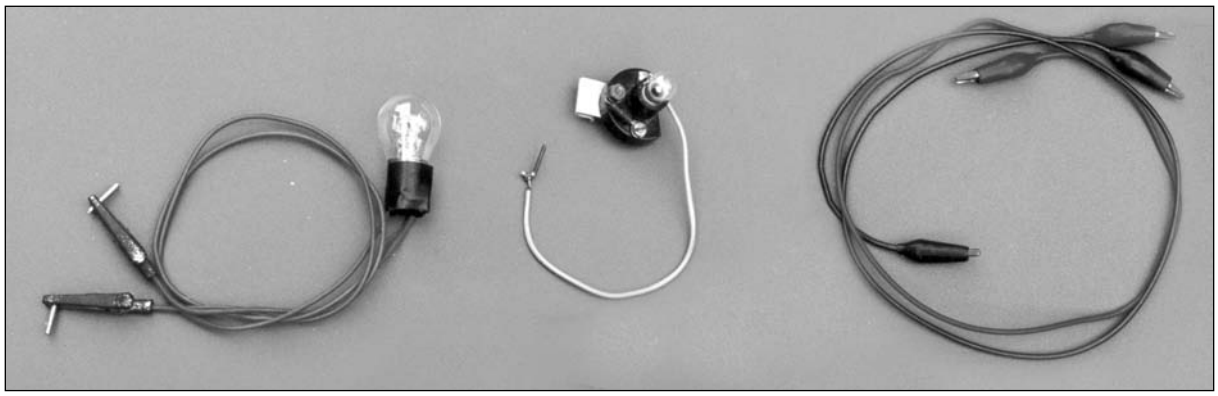

Photo 7.1 Test equipment. The lamp on the left is a 21W car lamp with approximately 400mm of cable and test clips. The short lengths of rod held in the test clips temporarily convert them into probes when checking circuits connected by block connectors. The centre test lamp is a torch bulb in a batten holder used for a quick check on track power when first setting up a portable test track or layout. One terminal is connected to a strip of aluminium by a 100 ohm resistor to limit the current through the bulb, while the other has about 70mm of lead terminating in a simple probe. The strip is roughly hook shaped, which makes it easy to place it in contact with one running rail while the probe is touched to the other. A useful item is a pair of jumper leads fitted with clips to bridge a faulty joint until repairs can be carried out.

7.2 Supply System Fault Diagnosis

7.2.1 Power Unit Failure

Mains Input

Possible cause	*Action*
Power not turned on or plug not inserted in socket.	Plug in and switch on.
Fuse blown in plug top due to: a) loose wires in plug. b) defective insulation in mains cable or primary/ secondary windings of transformer.	**WARNING** **Observe the safety recommendations set out in Part 8, Section 1.1. Contact with Mains Electricity can be Fatal.**

Voltage Output Low or Not Present

Possible cause	*Action*
Circuit protection operated - No Voltage a) Loose or broken wire in power unit. b) Defective reversing switch.	Depending on type: reset trip or replace fuse. If the cause is not obvious, e.g. previous derailment, apply power cautiously and carry out short circuit check. Panel unit - repair wire or replace switch as required. Sealed case unit, obtain professional assistance.

7.2.2 Open Circuit

Test lamp across rails does not light adjacent to the train

Possible cause	*Action*
a) Poor rail joint connection. b) Broken or poor soldered joint from rail to droppers. c) Wire loose or damaged in terminals between control panel and baseboards or between baseboards. d) Defective section switch on control panel.	Using the test lamp, work back along the track to the dropper connection and then to the section switch terminals. If the lamp lights along the track the fault is a) If it lights at the dropper connection the fault is b) If it lights at the intermediate terminals or section switch output the fault is c) If it lights at the section switch input the fault is d)

Test lamp across rails lights
This indicates a locomotive or rolling stock fault. Refer to Train Fault Diagnosis Section 7.3.

7.2.3 Short Circuit

A short circuit will cause the power unit protection to trip.

Locating the Fault

- Insert the test lamp in to the circuit at the power unit or controller output and turn the controller full on. (Figure 7-1a) If the lamp flashes and the protection trips, the fault is in the power unit or controller. If the fault is elsewhere the lamp will light, its brilliance depending on the resistance of the short.
- Open the switch of the section on which the train is standing.
- If, when the switch is opened, the short disappears, first check that the train is not bridging sections of the opposite polarity then lift it off the track and reclose the switch.
- If the fault does not reappear the fault is in the train. Replace each vehicle one by one. If the short reappears, the fault is in the last vehicle to be replaced. Refer to Train Fault Diagnosis Section 7.3.
- If, when the switch is opened, the short persists, the fault is not in the section on which the train was standing. Isolate the sections one by one until the faulty one is found. If the fault persists when all sections are isolated, the fault is in a part of the circuit between the power unit and the control panel which remains live.

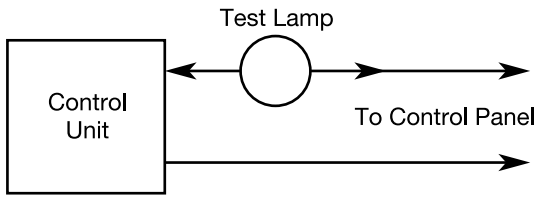

Figure 7-1a

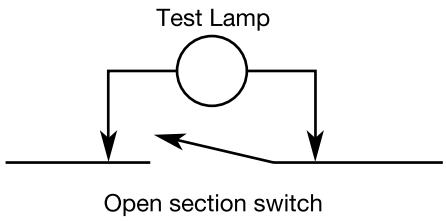

Figure 7-1b

Short circuit between control panel and track

Possible cause	*Action*
a) Metal object, e.g. tools, coins, etc., bridging rails b) Rail gap closed up due to rail movement in chairs or a rise in room temperature. c) Frayed or bare wire touching an adjacent wire in the harness or at a terminal strip. d) Bare wire in contact with metal at opposite polarity.	Open the switch feeding the fault and connect the test lamp across its terminals. (Figure 7-1b) The lamp will light initially but will extinguish when the fault is found. Examination of the track will usually find it but, if it does not, progressively disconnect the wiring, starting remote from the switch, until the lamp goes out.The fault will be in the last area to be disconnected.

Short circuit between control unit and control panel

Possible cause	*Action*
Faults similar to c) and d) above in the connections to the control panel.	With the test lamp connected at the controller output (Figure 7-1a), check wiring progressively as described above.

7.2.4 Check for Partial Short Circuit

Insert the test lamp into the circuit at the power unit or controller output as described above and shown in Figure 7-1a. Remove all loads and energise the system. If the test lamp glows proceed as for locating a full short circuit.

Note: On large outdoor railways there may be some current leakage particularly when the track is wet. This is unavoidable and the power unit should be capable of supplying the system without unacceptable voltage drop. On some large systems leakage currents of up to 1/2A have been noted.

7.2.5 High Circuit Resistance

Locating the Fault

- If all trains slow down significantly as they travel away from a track supply connection with the controller on a constant setting, the fault is in the supply system.
- If a particular locomotive slows down as it proceeds away from a supply point it is drawing too large a current for the supply system. This could be due to a motor fault or because it is fitted with an old type motor having a high current consumption.
- If all trains do not respond to the controller as expected there could be a high resistance between the power unit and the track feeder connection. With series resistance control units a partial short can show the same symptoms. If this is suspected test as described in 7.2.4 above.
- If a locomotive performs poorly irrespective of its position on the track the locomotive is defective.

Using an Ohmmeter or a portable multimeter is the best method of tracing high resistance in the supply system but a test lamp can give some indication of its presence. (Refer to Section 1.13 for information on high resistance).

The procedure is initially to remove all load from the system and connect the test lamp clips across the power unit output. Set the controller to the full speed setting and then move the test lamp clips progressively along the circuit. There will be a gradual reduction in brightness due to voltage drop in the wiring and rails but if it is excessive refer to the table below for possible causes. A sudden decrease in brightness will reveal a local fault that needs attention.

Lamp	***Possible cause***	***Action***
Lamp dims at section switch output.	Check terminal connections.	Clean or replace switch.
Lamp dims at connection to track.	a) Feeder wire too small. b) Wiring has high resistance joints or connectors.	Increase wire size or run wires in parallel. (See Section 1.11 Output Cable Size) Re-solder defective joints. Tighten connector screws. Clean plugs and sockets.
Lamp bright at track connector but dims as it is moved along the track	a) High resistance rail joints. b) Dry soldered joints in track connections. c) Dirty rails.	Fit bonds to rail joints or install additional feeders along the section. Re-solder defective joints.
Lamp dimmer than expected when directly connected to the power unit or controller output.	Power unit fault. a) A rectifier going open circuit will reduce the voltage to about half the nominal value. A rectifier short circuit is rare but will result in zero voltage at the output and severe overheating of the transformer. b) Some electronic controllers have a high output volt drop at full speed setting.	a) Obtain professional assistance. b) Either increase the input low voltage or replace the controller.

7.2.6 Loss of Control

Train	*Possible cause*	*Action*
Train runs at full speed when power is switched on, regardless of the controller setting	Solid state controller semi-conductor overheated due to overload and rendered permanently ON	Professional repair required or replacement unit.
Train does not start until controller is moved to full on and then suddenly runs at full speed.	Burnt out resistance controller	Professional repair or replacement unit.

7.3 Train Fault Diagnosis

Train faults can be separated into short circuits caused by rolling stock defects and locomotive faults that are more complex. The latter can occur in the construction of the locomotive or in the motor itself.

7.3.1 Rolling Stock

Defect	*Possible cause*	*Action*
Short circuit	Wheels touching rails of opposite polarity at a section gap.	Either a driving problem or section in advance selected incorrectly at the control panel. (See also Section 7.4, Some Case Histories).
External short circuit 2-rail	Short circuit path via couplings and/or buffers to adjacent vehicle that has body live to the opposite polarity.	Preferred solution - all vehicle underframes constructed to be electrically dead or by fitting insulated wheelsets. Alternatively, be aware of those that are not and run with insulated sides the same way round.
External short circuit 3-rail	a) Over long coupling links dragging on centre third or stud contact studs. b) At pointwork, incorrectly adjusted skates and pick-ups making random contacts with running rails.	a) Adjust to correct length. b) Check parallel action of stud contact pickups. Outside third pickups may be tilting and contacting the running rail at the non-operating end.
Internal short circuit	a) Wheel rims touching body or brake gear (most likely on curves). b) Stud, or three rail, pick-up movement bringing it into contact with frames.	a) Shorts between wheels and frames can be prevented by covering the contact areas with insulating tape, insulating paint or a thin layer of araldite. b) Adjust movement or protect contact area with an insulator as in a) above.

7.3.2 Locomotive

Defect	*Possible cause*	*Action*
Internal short circuit.	a) Loco pick-ups damaged and touching frame. b) Collector shoes of three-rail locomotives or stud contact skates shorting to the frame or final drive gear. c) Loco internal wiring damaged and wire contacting frame or body. d) Breakdown of epoxy resin wheel rim insulation.	Bench repairs required. Wheel rim insulation can sometimes be restored by cleaning but if this does not remove the short the wheelset must be replaced.

Locomotive runs erratically. Single motor locomotive has poor performance in one direction only. Multi-motor diesel or electric locomotive repeatedly accelerating and decelerating when running in one direction.	Worm on one motor too far up the shaft. Clearance in the thrust bearing is allowing it contact the motor endplate in one direction causing intermittent high friction.	Bench repair. Move the worm slightly down the shaft.
Locomotive stalls in one direction only.	Fold up type gearbox end plate bends and locks up the worm gear.	Stiffen or replace gearbox.
Locomotive either stalls or runs slowly on full power.	a) Drive gears misaligned and binding. b) Drive axles and, in the case of steam outline models, outside motion tight and binding. c) Excessive weight has been added to improve adhesion. An increase in drawbar load causes locomotive to stall instead of slipping.	Bench repairs required. For c) reduce adhesive weight until locomotive slips when held still under full power. Alternatively, fit a more powerful motor or lighten locomotive. (See Part 3, Section 1.4)
Locomotive does not run when power is applied.	a) Loco pick-ups dirty or broken b) Connection from pick-ups to motor broken c) Drive gears misaligned and jammed (can occur on curves due to excessive sideplay). d) On steam outline models, outside motion loose and locking up. e) Dirty loco wheels or rails. f) Wheel lifted off rails; connection broken.	Bench repairs required. e) Carry out cleaning procedure f) Obstruction in flangeway. (See also 7.4, Some Case Histories)

7.3.3 Motor defects

The following actions assume that the motor internals are accessible for repair. Otherwise a replacement motor would be required.

Defect	***Possible cause***	***Action***
Locomotive speed low and drawbar pull weak.	Weak magnet - most likely in older open frame motors.	Check by running motor in no load condition. If motor runs freely but at apparently higher than normal speed and draws more than the usual no load current the possibility is a weak magnet. Remagnetising is possible on some types but replacement is usually required.
Motor does not turn.	Motor is open circuit or high resistance.	Examine brushes and renew if worn. Clean commutator and brushgear if accessible. If no improvement, armature is open circuit. Seek specialist advice regarding the possibility of repair.
Motor sparking at commutator.	Conducting dirt between commutator segments.	Carefully clean between the segments with a thin craft knife.
Motor runs roughly at below normal speed taking a large current with heavy sparking at the commutator.	Armature winding is short circuited or partially open circuit.	Replace motor.
Motor runs faster in one direction.	Commutator may have rotated on the shaft.	Seek specialist advice.

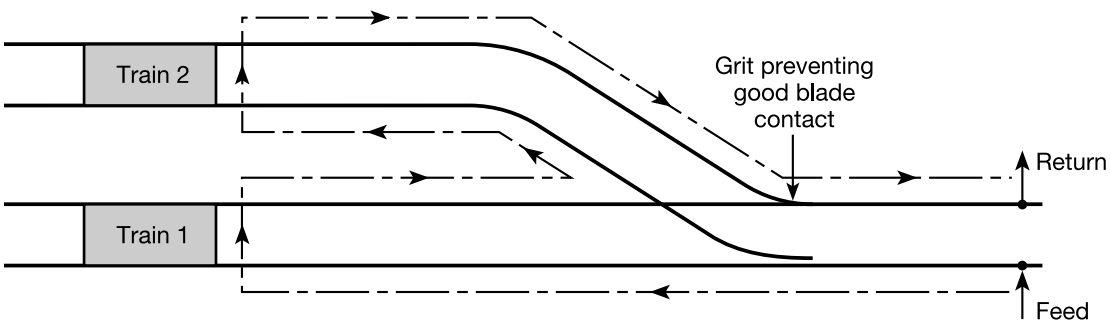

Figure 7-2 Backstairs or 'Sneak' Circuit

7.4 Some Case Histories

When a layout has been built, tested and operated successfully for some time, a fault can initially cause some confusion. By systematically checking as described above, most of the causes can be located. However, occasionally two or more faults can occur at the same time and these can troublesome to separate and identify. The following case histories may assist in highlighting some of the difficulties encountered.

7.4.1 Faulty pick-up.

A 4-4-0 locomotive running at a moderate speed on an oval test track kept stopping at the same point. A slight push would set it off again and it would run freely until the same point was reached. The track was examined and a slight dip in one rail was noted. The locomotive pick-ups were of the rim-scraper variety operating on the driving wheels only. When examined, one was found to be bent and out of contact with the wheel. As the undeframe was a rigid type, the single wheel still conducting on that side was lifted clear of the rail at the dip, breaking the electrical contact and stopping the locomotive.

7.4.2 Faulty micro-switch operation.

A locomotive approaching a trailing turnout came to a halt. A short circuit was noted and the locating procedure described in 7.2.3 was carried out. The short circuit no longer appeared so the locomotive was put back on the track and restarted. When it reached the same position, the section gap before the point crossing, the short reappeared. With the power on and the locomotive lifted off the track, a check using a test lamp showed that, although the turnout was correctly set, the crossing polarity was wrong. The crossing was fed by a tiebar operated micro-switch and an examination showed that the pad that pressed on the switch button had broken away and the switch was not being operated.

7.4.3 Backstairs or 'Sneak' circuit.

Two trains in adjacent sidings in a fiddle yard moved off together almost colliding at the fouling point when they were noticed and switched off. The turnouts had live crossings fed via the point blades and were used to isolate the sidings. (See also Part 8, Section 3.3.1). The blade that should have made an electrical contact with the stock rail was prevented from doing this by a fine piece of grit. As a result both locomotives were connected in series. Figure 7-2 illustrates the problem.

7.4.4 Flangeway problem

A six-coupled locomotive was being tested on a temporary piece of track which included a turnout. The turnout was a commercial product with an insulated crossing. As the locomotive passed over the turnout it stalled if driven slowly but was satisfactory at speed. Each time it stalled it was with the centre driver on the insulated crossing. A bench test showed that all drivers were picking up correctly and no fault was found. It was finally realised that the plastic crossing was a solid moulding and the flangeway was quite shallow. The flanges of the drivers were riding on the moulding and, as the frame was a rigid type, slightly lifting that side of the locomotive. When the centre driver reached the crossing it lifted sufficiently to break the contact of the other two drivers and, at slow speed, the locomotive was brought to a halt.

7.4.5 Feeder Failure

Locomotives on a large garden railway performed poorly over a long stretch of the main line. Checking the voltage at the controller output and on the track with no locomotives present gave similar readings. When a locomotive was placed on the track, the track voltage fell to below half the controller output voltage. The cause was eventually traced to a dry joint in the feeder connection to the track.