DRAFT ONLY. 29/9/47. AVM:WM

State Electricity Commission of Victoria
BALLARAT TRAMWAYS

Traffic employees are required to be familiar with these instructions before qualifying to take up the duties of Motorman.

(Preliminary Draft)

(A) TRAM CAR EQUIPMENT (ELECTRICAL)

1. THE PATH OF THE ELECTRICITY THROUGH THE TRAM FROM THE TROLLEY WIRE TO THE TRAM RAILS.

From the wire via trolley wheel and trolley pole to the trolley base, thence to the lightning arrester and through the choke coil to the tram circuit breakers. From the circuit breakers to the controllers, and thence to the resistances and/or the motors. From the motors the current goes to the rails via the axles and wheels.

2. AUTOMATIC CIRCUIT BREAKERS.

These are inserted between the trolley and the controller. They open automatically when too much current is applied to the motor circuit. They are to be opened to cut the power from the controller before removing the cover from the controller front to avoid the risk of an electric shock.

3. CIRCUIT SWITCHES.

To switch the power on or off to electrical apparatus by hand. Make certain that the appropriate switch is in its "off" position before attempting to inspect or renew fuses, etc.

4. FUSES.

In circuits using lower power ratings, fuses take the place of automatic switches. They may be considered as a "safety valve", and will blow out and break the current if an overload is applied, due to fault, and thus protect the apparatus from damage or fire.

5. LIGHTNING ARRESTER.

This protects the tram equipment from damage due to lightning. A spark gap is provided for the lightning surge to jump across and go direct to the rails (earth).

6. CHOKE COIL.

This is used in conjunction with the lightning arrester. It acts as a block to lightning surges, and tends to cause

the discharge across the spark gap to the rails.

7. RESISTANCES.

These are used in conjunction with the controller, so that the ~~amount of~~ current applied to the motors can be applied gradually, and thus give gradual increases in speed from stop to full speed. They heat up when a current passes through them, and thus the period of power application must be limited. through the Resistances

8. CONTROLLERS.

Used in conjunction with the resistances to regulate the power applied to the motors by stages or notches. They also provide for the changing of the power circuits to the two motors from series to parallel, and also to enable a defective motor to be disconnected.

9. POWER IN SERIES.

The term used to describe the connection of motors or lamps in tandem. The current flows through one motor or lamp and then goes on to the next motor or lamp. The voltage applied is divided between each lamp or motor. Thus with two motors connected in series with 560 volts on the trolley wire, the voltage taken by each motor would be 280. This gives reduced speed, therefore trams start on series power.

10. POWER IN PARALLEL.

The term used to describe the connection of motors, etc., direct to the power supply. With two motors and 560 volts from the trolley wire, each motor has 560 volts applied, and thus full speed is obtained.

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11. NOTCHES ON CONTROLLERS.

There are four notches in each stage of series power and parallel power.

12. RESISTANCE NOTCHES.

The 1st, 2nd and 3rd notches in each stage are known as resistance notches. On the 1st notch the full resistance is used; on the 2nd a little less resistance, and on the 3rd notch still less resistance, till a small amount only is being used. As the resistance is being reduced, the speed of the tram increases.

13. RUNNING NOTCHES.

The 4th or last notch in each stage are known as running notches. They indicate full series or full parallel power, as the case may be. The resistances are not being used on these notches, and the power may be kept applied as long as necessary without causing damage to the equipment.

14. TIME ON RESISTANCE NOTCHES.

The period to dwell upon resistances must be sufficient only for the tram to accelerate to the corresponding speed. It is normally 3 or 4 seconds' duration.

15. TIME ON RUNNING NOTCHES.

Sufficient to maintain running schedules, and power should not be kept applied unnecessarily. Every advantage should be taken of opportunities to coast the tram. Power should be cut off well in advance of stops.

16. CUTTING ON AND CUTTING OFF POWER.

The controller handle should be moved cleanly and deliberately to each successive notch when applying power. This also applies particularly to the movement across the transition stage from full series. In cutting off, a clean and deliberate movement in one quick action is required.

17. TRANSITION STAGE.

The section of the controller movement between full series and first parallel notch. In this stage the connections are being changed to motors from series to parallel, and the tram is temporarily being driven by one motor only.

18. REVERSING LEVER.

The reversing lever changes the direction of the current applied to the motors, and thus changes the direction of their rotation. The lever also provides a key for locking the controller to prevent its operation.

19. CONTROLLERS ON BOGIE TRAMS.

These controllers are Type GE.36 J.R., and have a ratchet switch incorporated at the bottom of the main drum. The

ratchet switch when cutting on picks up and completes a relay circuit which operates the line contactor. Any movement towards the "off" position of the controller handle trips the ratchet switch and breaks the relay circuit. The line contactor or automatic switch therefore opens each time the controller is cut to the "off" position, and it closes each time the controller is moved from the "off" position to the 1st series notch.

20. LINE BREAKER ON BOGIE TRAMS.

This is a small switch located on each platform, and corresponds to the automatic switch on the small trams. It controls the power circuit to the ratchet switch, and also includes a fuse to protect the relay circuit in the line contactor. This switch must always be opened before removing the controller cover.

21. LINE CONTACTOR ON BOGIE TRAMS.

This is placed under the centre drop section floor of the tram, and is an automatic switch which is operated by a relay circuit through the line breaker switch and the ratchet switch in the controller. The contactor closes when the controller is moved to the 1st power position, but any movement of the controller handle from any notch towards the "off" position automatically opens the contactor. The controller must then be returned to the "off" position before power can be re-applied to the tram.

22. SHORT CIRCUIT.

This defines a condition when electric current takes a short cut instead of through a normal circuit. In this condition a heavy flow of current occurs, and to prevent damage the automatic circuit breakers and fuses are used. For example, a fallen trolley wire contacting the rail is a short circuit, and would open the automatic breakers at the Power Station.

23. TRAM CAR MOTORS.

The stationary parts comprise the Field Coils and the Commutator Brushes. The revolving part is the Armature. The Carbon Brushes supply the electrical connection between the field coils and the armature.

24. MOTOR BEARINGS.

There are two bearings carrying the armature in the motor case, also two bearings carrying the motor case on the tram axle.

25. TRAM AXLES AND GEARS.

There are two bearings carrying the wheel axles in the axle boxes, and the power is transmitted from the motor to the wheels via the pinion wheel on the armature shaft and the gear wheel on the driving wheel axle.

26. TRAM LIGHTING.

There are two circuits of six lamps each on the single truck trams, and three circuits of six lamps each in the bogie trams. All the lamp circuits are in series. (Six 100 volt lamps).

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27. TRAM HEADLIGHTS.

The headlights are included in one of the tram circuits of six lamps, and the change of ends of the headlight is effected by a rotary switch near the lighting switch.

(B) LOCATION OF FAULTS:

28. PRECAUTIONS TO BE TAKEN.

First see that the switch controlling the apparatus to be inspected is in the "off" position. If uncertain, remove the trolley pole from the overhead wire to make sure.

29. SYMPTOMS OF MOTOR DEFECTS.

Tram runs jerkily and irregularly. Automatic switch opens violently. Smoke or fumes from the motors.

30. IF TRAM WILL NOT START.

First.	Check pole on wire.
Second.	Try the lights.
Third.	See that the automatic switch on single truck trams, or the line breaker switch on bogie trams, is properly closed or on.
Fourth.	Try controller at other end of tram. If a bogie tram, this would show a burnt out fuse in the line breaker switch at the other end, or a fault in the controller at the other end on all trams.
Fifth.	Open switch or circuit breaker and inspect controller to see that contacts are O.K. when handle moves forward.
Sixth.	Cut out No. 1 motor and try tram on No. 2 only.
Seventh.	Cut out No. 2 motor and try tram with No. 1 motor only.

Note: If no lights are obtained, the cause is either that the power is off the wire or the tram is on a dirty rail (earthed) and has no contact.

31. CUTTING OUT MOTORS IN WESTINGHOUSE T.I.F. CONTROLLERS.

This is effected by lifting one of the small catches in the top section of the controller drum marked "1" and "2". The finger is lifted from contact with the drum, and the catch then being lifted, holds the finger from making contact, and thus breaks the circuit of the motor concerned.

32. CUTTING OUT MOTORS IN GENERAL ELECTRIC 36J. CONTROLLERS.

In the top left hand of the controller are two double throw switches. The top double pole switch controls No. 1 motor and the bottom, a single pole switch, controls No. 2 motor. To cut out either motor the switch is pulled out from the existing clips and turned over and pressed into corresponding clips normally not used.

33. STARTING NOTCH ON CONTROLLERS WHEN A MOTOR IS CUT OUT.

The Westinghouse controller starts motor on 1st parallel notch only, and uses the 5th, 6th, 7th and 8th notches only. The General Electric controller starts the motor on the 1st series notch only, and uses the 1st, 2nd, 3rd and 4th notches only.

34. DRIVING TRAM ON ONE MOTOR.

In view of the load imposed on one motor only, it will take longer to pick up the speed for each resistance notch, therefore a longer period on each notch should be allowed, to avoid overloading and consequent damage to the remaining motor.

35. HOT ARMATURE BEARING.

Cut out the motor in the controller, and send tram to the depot at once. The removal of power, and consequent load, from the defective motor is essential to prevent further heating and consequent melting of the bearing white metal.

36. TRAM EARTHED.

This occurs when tram is on a dirty rail, and thus contact between the wheels and the rail is broken. If the lights are switched on, or the compressor governor is closed, the tram is charged with electricity, and a shock may be sustained if a person touches metal work on the tram when standing on the ground.

37. TRAM EARTHED REMEDY.

Switch lights and compressor off. Pour water on the rail so that it will flow around the wheel. If on a grade, release the brakes so that the tram can roll to a clean rail position. If no water available, the point bar may be jammed behind a wheel on the rail, but the pole should be pulled down before doing this, to ensure that an electric shock cannot be sustained.

38. CONTROLLER JAMMED WITH HANDLE ON FULL PARALLEL NOTCH.

Knock out the circuit breaker or line breaker and stop the tram. With automatic brake, simply remove hand from the controller handle. May be due to finger out of position inside the controller.

39. CONTROLLER JAMMED AND TRAM TO BE TOWED.

If the controller is jammed in reverse to the direction in which it is to be towed, cut out one of the motors in the controller to prevent any braking action from the motors.

40. CAR LIGHTING FAULTS.

If all lights are out, try the spare fuse (switch off first). If one circuit only, it is a defective lamp or adaptor. Turn headlight change-over switch to identify the circuit, because if it is a headlamp it should light at the other end. Use spare lamp to trace faulty globe, but if a globe should be broken, make sure the lights are switched off before attempting to remove the cap from the lampholder. With the glass broken, the filament connections are exposed, and a severe shock would be suffered if touched by the hand.

(C) TRAMCAR BRAKING:

41. COMPRESSOR.

This is driven by an electric motor, and pumps air from the atmosphere into the reservoirs.

42. GOVERNOR.

This is an automatic electric switch which starts and stops the compressor motor at certain reservoir pressures.

43. GOVERNOR PRESSURE RANGE.

The governor starts up the compressor motor when the pressure has dropped to 60 lbs., and cuts out and stops the compressor motor when the pressure reaches 70 lbs.

44. COMPRESSOR OUT OF ACTION.

When it is known that the power is on the overhead wires, make sure that the compressor switch is "on" first; if so, switch off and replace the fuse with the spare carried.

45. MOTORMAN'S BRAKE VALVE.

This enables the motorman to pass air from the reservoirs to the brake cylinder in order to apply the brakes, and also to discharge the air from the brake cylinder in order to release the brakes. The centre position of the handle is the lap position, in which the handle is removable. In this position all air ports are closed. The movement of the handle to the right applies the brakes by transfer of air pressure to the brake cylinder. The extreme right position is the emergency position for quick and full transfer of the air pressure. Movement of the handle to the left of the centre lap position permits the air from the cylinder to be discharged through the exhaust and releases the brakes. The extreme left position is the quick release position used when starting the tram.

46. AIR PRESSURE GAUGES.

Situated in each motorman's cabin to indicate the pressure in the air reservoirs. The importance of the motorman watching the gauge should be obvious, and should the pressure drop below 50 lbs., the hand brake must be used until the tram is taken from service, or the fault in the compressor electrical circuit is rectified, such as the replacement of the fuse.

47. HAND BRAKES.

This is the manual means of applying the brake shoes to the wheels. This is done by turning the hand wheel in a clockwise direction, and the brake can be locked on by means of a ratchet pawl operated by the right foot.

48. USE OF HAND BRAKE.

The hand brake must be used if the air pressure system is out of order, and cannot be rectified by the motorman. It must also be applied when a tram is to be left unattended on the road.

49. HAND BRAKE LINK WITH AIR BRAKE.

The air brakes are applied by the brake cylinder located at No. 2 end of single truck trams, therefore should the air brake be applied on these trams, the hand brake can only be applied also at the same operating end. On the bogie trams the brake cylinder is under the centre drop section of the body, and the hand brake can be applied to lock on the air brake at either end of the tram.

50. BRAKE EFFICIENCY.

The maximum braking effect is obtained when the pressure on the shoes will almost skid the wheels under conditions that give the greatest grip between the wheels and the rails, and the air brake has been designed to give this required effect.

51. DEGREES OF BRAKING REQUIRED.

The braking force required to stop a tram is proportionate to its speed and load; therefore a heavier application is required at faster speeds and also with greater loads of passengers. The same condition also exists on trams going downhill as compared with an up-hill gradient.

52. RAIL CONDITION AND EFFECT UPON BRAKING.

Since the distance required in which to stop a tram is dependent upon the grip of the wheels to the rails, it follows that the best results are obtained upon clean rails, and adverse results when rails are greasy.

53. GOOD RAIL CONDITIONS.

The best conditions occur when the rails are being washed by substantial rainfall, a dry rail not necessarily being a good clean rail.

54. BAD RAIL CONDITIONS.

These are experienced on such occasions as light misty rain on dry rails, and rails not thoroughly wetted, and particularly when leaves are present on the rails, or any substance such as oil, tar or bitumen, etc.

55. COUNTERACTION OF BAD RAIL CONDITIONS.

This is accomplished by the more gradual application of the brakes and the application of sand to the rails.

56. SANDING APPARATUS.

Sand is applied to the rail by depressing the sand valve foot punch. It is forced from the sand container by compressed air. It is the responsibility of motormen to see that the sand hoppers have plenty of sand, and that the apparatus is in good working order. Under conditions that render slippery rails likely, the inspection should be frequent.

57. TO PREVENT OR STOP WHEELS SKIDDING.

When slippery rails are known to exist, a light application of sand should be made before making the brake application. Should the wheels skid, the brake must be released for a moment to permit the wheels to turn, and with sand application, re-applied gradually to bring the tram to a stop. A greater distance must always be allowed in which to stop a tram when adverse rail conditions exist, because the brakes must be applied more gradually.

58. GREATEST DISTANCE REQUIRED TO STOP A TRAM.

The distance becomes greater when the following conditions are met, and correspondingly greater when they occur simultaneously :-

(a) When tram is heavily loaded.
(b) When the tram is travelling at faster speeds.
(c) When the tram is on a down grade.
(d) When the tram rails are slippery.
(e) When using the hand brake.

Also, a greater distance must always be allowed for when approaching any obstruction.

(D) FAILURE OF THE MECHANICAL BRAKES.

59. POSSIBLE CAUSES OF BRAKE FAILURE.

Air Brake. Since the air brake is dependent upon the supply of compressed air, and requires a minimum of 50 lbs. pressure for adequate braking, failure of the air supply due to electrical fault or break of a pipe line would put the air brakes out of action. The same mechanical levers and bars are used for both the air brake and the hand brake, and it therefore follows that the breakage or jamming of a lever or bar would render both the air brake and the hand brake inoperative.

60. TO STOP A TRAM IF BRAKES SHOULD FAIL.

This would be effected (in the case of the tram travelling forward) by applying one or two notches of ~~service~~ SERIES power