



AUSTRALIAN RAIL TRACK CORPORATION LTD

This document has been adopted by the ARTC with the permission of the NSW Government and will continue to apply under the authority of the ARTC General Manager Infrastructure, Strategy & Performance until further notice

Discipline
Engineering Standard – NSW

Category
Signalling

Title
Signalling Control Systems

Reference Number
SCP 01 – (RIC Standard: SC 00 13 03 00 SP)

Document Control

Status	Date	Prepared	Reviewed	Endorsed	Approved
Issue 1 Revision 2	Mar 05	Standards and Systems	Standards Engineer	GM Infrastructure Strategy & Performance	Safety Committee
		Refer to Reference Number	H Olsen	M Owens	Refer to minutes of meeting 12/08/04

DISCLAIMER

Australian Rail Track Corporation has used its best endeavors to ensure that the content, layout and text of this document is accurate, complete and suitable for its stated purpose. It makes no warranties, express or implied, that compliance with the contents of this document shall be sufficient to ensure safe systems of work or operation. Australian Rail Track Corporation will not be liable to pay compensation in respect of the content or subsequent use of this document for any other purpose than its stated purpose or for any purpose other than that for which it was prepared except where it can be shown to have acted in bad faith or there has been willful default.

DOCUMENT APPROVAL

The technical content of this document has been approved by the relevant ARTC engineering authority and has also been endorsed by the ARTC Safety Committee.

DOCUMENT SUPPLY and CONTROL

The Primary Version of this document is the electronic version that is available and accessible on the Australian Rail Track Corporation Internet and Intranet website.

It is the document user's sole responsibility to ensure that copies are checked for currency against the Primary Version prior to its use.

COPYRIGHT

The information in this document is Copyright protected. Apart from the reproduction without alteration of this document for personal use, non-profit purposes or for any fair dealing as permitted under the Copyright Act 1968, no part of this document may be reproduced, altered, stored or transmitted by any person without the prior written consent of ARTC.

About This Standard

This document with its appendices, read in conjunction with the “Signalling Design Principles”, SDS 00 and standard specifications “Signalling Circuit Design Standards” SDS 25 and “Signalling Operator Interface” SCP 16 set out the ARTC basic signalling control design requirements and standard practices.

The “Signalling Design Principles” document takes precedence; however any perceived inconsistency between any of these standards documents is to be referred to the ARTC General Manager ISP or nominated Signalling representative for determination.

Document History

Primary Source – RIC Standard SC 00 13 03 00 SP Version 3.0

List of Amendments –

ISSUE	DATE	CLAUSE	DESCRIPTION
1.1	31/08/2004		<ul style="list-style-type: none">▪ Reformatting to ARTC Standard
1.2	14/03/2005	Disclaimer	<ul style="list-style-type: none">▪ Minor editorial change▪ Footer reformatted

Contents

1 GENERAL REQUIREMENTS	8
1.1 Signalling System	8
1.2 Contractor's Responsibilities	8
1.3 Design Applications	9
1.4 Drawing Standards	9
1.5 Event Logging	9
1.6 Train Describers	9
2 SIGNALLING SYSTEMS - MODE OF OPERATION: ROUTE CONTROL	9
3 ROUTE SETTING – General	10
3.1 BASIC OPERATION – PUSH BUTTONS/SWITCHES	10
3.1.1 Entrance - Exit Control System	10
3.1.2 One Control Switch System	10
3.2 Route Setting - Specific Example	11
3.2.1 Commence - Finish Control System	11
3.2.2 One Control Switch System	12
3.3 Operation of Points	12
3.4 Operation of Releases	12
3.5 Automatic Facility	12
3.6 Emergency Replacement	13
3.7 Alarms	13
3.8 Emergency Call-on Function	13
4 BASIC OPERATION - OPERATOR INTERFACE (OI)	13
5 SIGNALLING INDICATIONS	14
6 CONTROL AND INDICATIONS TO INTERLOCKING INTERFACE	14
6.1 Non-Vital Relay Interface	14
6.1.1 Entrance – Exit Controls	14
6.1.2 One Control Switch Controls	14
6.1.3 Entrance - Exit and One Control Switch Indications	15
6.2 Telemetry/Train Control Systems	15
6.3 Event Logger	15

7	SIGNALLING INDICATIONS/ALARMS - CONTROL PANEL/DIAGRAM OPERATION	15
7.1	General	15
8	INDICATIONS/ALARMS - OPERATOR INTERFACE (OI)	16
9	GENERAL DESIGN PRINCIPLES REQUIREMENTS	16
9.1	Power	16
9.2	Ground Frame and Releases	17
9.3	Points	17
9.4	Relays and Relay Circuits	18
9.5	Track Circuits	19
9.6	Signals	20
9.7	Shunt Signals	22
9.8	Intermediate Shunt Signals	22
9.9	Approach Locking (General)	23
9.10	Bi-Directional Signalling (Refer Sheets B01, B02, B03 in SDS 25)	23
	9.10.1 General	23
	9.10.2 Typical Circuit Design	24
	9.10.3 Protection of Maintenance Staff	25
9.11	Route Holding	25
9.12	Automatic Overlap Selection/Maintenance	25
9.13	Automatic Signalling (Refer Sheets : A01, A02, A03, A04, A05 in SDS 25)	26
	9.13.1 General	26
	9.13.2 Track Stick	26
	9.13.3 Train Stop Proving	27
	9.13.4 Country (A01)	27
	9.13.5 Metropolitan (A02, A03 in SDS 25)	27
	9.13.6 City (A04, A05 in SDS 25)	27
9.14	Circuits/Terminations	28
	9.14.1 Terminations	28
	9.14.2 Line Circuits	28
9.15	Half Pilot Staff's	28
9.16	Special General Design Rules for Centralised Traffic Control in Single Line Areas	28
	9.16.1 Crossing Movements	28
	9.16.2 Overlaps	29
	9.16.3 Outer Home Signals	29
	9.16.4 Home Signals	29
	9.16.5 Starting Signals	30
	9.16.6 Ground Frames at Crossing Loops	30
9.17	Interfacing Between CTC and Non CTC	31

9.18	General	31
10 ROUTE CONTROL SYSTEM - CIRCUIT DESCRIPTION		31
10.1	Control Panel Push Button Circuits	31
10.2	Control Panel Key Circuits	33
10.3	Route Setting	33
10.3.1	Route Lock Relays	33
10.3.2	Route Reverse Relays	34
10.4	Route Normalising	34
10.4.1	Manual	34
10.4.2	Passage of Train	35
10.4.3	Button Lights	35
10.5	Point Operation/Locking/Detecting	36
10.5.1	Point Lock Relays	36
10.5.2	Point Free Relays	36
10.5.3	Point Timer Relay	37
10.5.4	Point Lock/Detection Relays	37
10.5.5	Point Available Relays NWAR-RWAR	38
10.5.6	Point Overlap Relays	39
10.5.7	Point Detector Relays	39
10.5.8	Point Contactors	40
10.5.9	Point Isolating Relays	40
	10.5.10 Point Operation Under Route Setting Control (Refer to Sheet NO5 in SDS 25)	40
10.6	Route Stick Relays	41
10.7	Signal Operation	41
10.7.1	Lever Stick Relays	41
10.7.2	Signal Control Circuits (HR/UCR)	42
10.8	Approach Locking	43
10.9	Releasing Switches	44
10.9.1	Lock Relays	45
10.9.2	Release Switch NR	45

Appendices

- A Commence - Finish Flow Chart**
- B Commence - Finish Relay Status**
- C One Control Switch Flow Chart**
- D Signalling Circuit Design Standards**
- E Train Describer Signalling Inputs/Outputs**
- F Relay Interlocking: Event Logger Requirements**

1 GENERAL REQUIREMENT

This document with its appendices, read in conjunction with the “Signalling Design Principles”, SDS 00 and standard specifications “Signalling Circuit Design Standards” SDS 25 and “Signalling Operator Interface” SCP 16 set out the ARTC basic signalling control design requirements and standard practices.

1.1 Signalling System

The 'Signalling System' being a composite of Signalling Circuits, Signalling Data, and Signalling Equipment forms the basis of railway operational safety, therefore special arrangements apply in respect of their design.

The terms 'Signalling Circuits' and 'Signalling Data' are deemed to include all electrical circuits and software data associated with the Signalling Equipment including temporary works, stageworks and design necessary to interface the new works into the existing systems. The Signalling Equipment must fail in a predictable mode and this is to be taken into account when designing signalling circuits and data, thereby ensuring an intrinsically safe system.

The term 'Signalling Equipment' is deemed to include all equipment necessary to enable a signalling system to be engineered in accordance with the requirements of the specified track plan, specified control tables, specified performance, and specified standards.

The term 'Signalling System' relates to more than an aggregate of signalling equipment and includes in addition the conceptual and physical arrangements under which the equipment is operated and controlled.

1.2 Contractor's Responsibilities

The whole of the Signalling System shall be designed to operate safely and reliably. The Signalling System design shall meet the requirements of the following documents:

- (i) Specified Track Plans
- (ii) Specified Control Tables
- (iii) Particular Specification
- (iv) Standard Specifications
- (v) Signalling Design Principles

The typical circuit operations described in this standard Specification do not encompass every conceivable circuit design requirement. They are a representative selection, depicting the standards adopted by the ARTC.

They refer to typical circuit diagrams contained in ARTC's “Signalling Circuit Design Standards” manual SDS 25.

Typical data constructs for SSI interlockings are contained in the BR Specifications SSI 8003 and in the ARTC “SSI Data Preparation Guide Supplements” manual. Logic Equation Structures for Microlock and Westrace interlockings shall follow the ARTC “Signalling Design Principles” and “Signalling Circuit Design Standards.”

1.3 Design Applications

Signalling system designs shall take into consideration the long-term use of such designs by maintenance staff. Signalling equipment shall be designed and mounted for ease of access and subsequent removal for maintenance and replacement purposes. These considerations shall include but not be limited to the following examples. The design shall ensure that when twin relays or common power supplies are used, the removal for maintenance purposes or failure of the equipment shall not effect unassociated areas or routes etc.

1.4 Drawing Standards

Requirements with regards to drawing standards and presentation of designs are included in standard Specification SCP 06 Documentation and Drawings.

1.5 Event Logging

All signalling systems shall be fitted with event logging. Logging requirements are set out in Appendix F.

1.6 Train Describers

Where train describers are to be used, the list of signalling inputs and outputs required is set out in Appendix E.

2 SIGNALLING SYSTEMS - MODE OF OPERATION: ROUTE CONTROL

The ARTC has standardised on two basic operational control formats for relay based interlockings, these being:

- a) Entrance Exit Operation
- b) One Control Switch Operation

Unless otherwise specified in the Particular Specification relay based designs shall be based upon the Entrance Exit Operation philosophy.

Entrance-Exit and One Control Switch operation is achieved by either: Control Panel Push-buttons/switches, VDU Cursor Control, VDU Keyboard Control or a combination thereof in association with hardwired Control Panels and Indicator Diagrams or an Operator Interface (OI) incorporating VDU's with an Overview Indication Diagram or Video Mimic Panel.

Functions of an Operator Interface is described in the specification Signalling Operator Interface No. SCP 16

Where remote relay interlockings constitute part of the signalling system, a local emergency means of control may need to be provided in the form of a control panel fitted with pushbuttons and switches to facilitate the operation of all the signalling functions that would normally have been available from the main control centre.

The sequence of operations of a relay based 'Entrance - Exit' system is as indicated in the flow charts - Appendix A.

The sequence of operation of a relay based One Control Switch system is as indicated in the flow chart - Appendix B.

3 ROUTE SETTING – General

3.1 BASIC OPERATION – PUSH BUTTONS/SWITCHES

3.1.1 Entrance - Exit Control System

In this system, to set up a particular route a control command is operated at the entrance to the route and then another control command at the exit to the route. If the route is not locked out the route will set up and points will automatically be called to align with the route requirements.

Buttons shall be provided for all controlled signals operated from the panel. A button may act either as a commence button for entrance to a route or as a finish button at the exit of a route, or as both. The direction of travel shall be indicated by arrowheads on the buttons, the commence function being shown by a black arrowhead and the finish function by a clear arrowhead. Where a button acts both as commence and finish, separate arrowheads shall be displayed. Finish only buttons shall be provided where required.

A route is set, and the signal leading over it cleared, by the signaller operating two commence - finish push buttons in sequence. The first button is at the entrance of the route and the second button at the finish of the route. The finish button is generally at the next signal applying to the direction of traffic being dealt with, but in the case of a route which leads into a section, siding or terminal road the finish button is located in the section, siding or terminal road.

Once the commence and finish push buttons have been pushed and registered by the system the route is able to set after checking that there is no conflicting route locking or that points, if not in the correct position (N or R), are available to operate to the correct position. Providing the line is then clear to the clearing point and the points have operated, the signal will exhibit a proceed indication.

If a conflicting route is set or points within the route are locked in the incorrect position for the route being called, it shall be impossible to call the route and it will be necessary for the signaller to again select the buttons when the conflicts become free.

To clear the next signal in line of route, the last button operated which represented the finish of the previous route is again operated and this time it acts as an commence button for the next route. A second button is then operated to locate the finish point for this route.

If it is required to cancel the route, prior to the passage of a train or prior to the establishment of the route, the commence button for the route has to be pulled, to restore the route to normal.

3.1.2 One Control Switch System

A route is set and the signal cleared by the signaller operating one of the discrete signal route push buttons.

The action of pressing the discrete signal route push button firstly causes the points in the line of route to operate to the required position if they are free to do so. The route is then able to set only after checking that there is no conflicting route locking or point locking. Providing the line is then clear to the clearing point, the signal will exhibit a proceed indication.

If a conflicting route is set, or points within the route are locked in the incorrect position for the route being called, it shall be impossible to call the route and it will be necessary for the signaller to again select the button when the route becomes free.

To clear the next signal in line of route its discrete route button has to be operated.

If it is required to cancel the route, prior to the passage of a train or prior to the establishment of the route, the route button, applicable to the route established or being established has to be pulled to restore the route to normal.

3.2 Route Setting - Specific Example

3.2.1 Commence - Finish Control System

The layout on sheet NO1 – SDS 25 shows a typical track layout, where a signal leads over more than one route, as in the case of No.3 signal, the various routes are designated 3A, 3B, reading from left to right. Thus No. 3A route leads to the Down Relief, No.3B route leads to the Down Main.

The method of clearing No.1 Route and No.3 (M)A route is as follows - Push Button No.1 and then Button No.3 (M) to clear No. 1 route. Push Button No.3 (M) again and then Push Button No.DR, this will set and lock 101 points reverse, if they were not already in the reverse position, and this in turn will lead to the clearing of No.3(M)A signal route.

When a subsidiary calling-on or shunt signal is provided on the post of a running signal, a separate button is provided on the control panel adjacent to the running signal push button. For example a separate button is provided adjacent to No. 3(M) button for use when a subsidiary move is to take place from No.3 signal. To clear the calling-on or shunt signal the subsidiary button is pressed as a commence button and a finish button is selected as for a running movement.

When a shunting signal exists within the entrance and exit points of a main route, the action of setting that main route will automatically clear the shunt signal. When the main route is cancelled by pulling the main commence button the overset shunt route will also require cancelling by pulling the shunt commence button. If the shunt route button is pulled after the train has passed the main signal the overset shunt route will not cancel until the approach locking requirements are satisfied. The inherent locking is however organised such that the main signal route locking ahead of the shunt signal is maintained and cannot be normalised, until certain other conditions have been met.

To clear the shunting signal for movements originating at the shunt signal the button at the shunt signal is pushed as a commence button and a finish button is selected in the normal manner.

3.2.2 One Control Switch System

The layout on sheet PO1 – SDS 25 shows the track layout at one end of a typical passing loop. Where a signal leads over more than one route in the case of No. 5 signal, the various routes are designated 'L' & 'M' (Loop and Main) respectively.

The method of clearing signal route No. 5L or No. 5M routes is by pressing their respective unique control buttons, this will set and lock 51 points reverse and normal respectively.

Cancellation of any established route is either by passage of the train or by the action of pulling the unique signal route control button.

3.3 Operation of Points

Points keys are provided in separate groups on the control panel and are provided to allow operation of the points without the necessity of setting a route. This type of operation may be required for maintenance purposes or under failure conditions or where it is required to hold a set of points in a particular position during route setting.

The points keys are of the rotary switch type and operate in three positions, left, centre and right. When route setting is being implemented the points key is placed in the centre position. If individual operation of the points is required the key is placed in the left hand position to set the points normal and the right hand position to set the points reverse.

The points circuit design is such that before the position of the points can be changed from normal to reverse the point key must be placed in the centre position until the points free light is exhibited, then the key can be moved to the desired position. This pause in the centre position is necessary to allow the point free relay to energise. The point free relay is provided to enable routes to be set under route setting conditions with the points lying in the opposite position to that required for the route being called. It also provides the additional function of non-storage operation of points, relying on the drop away time of the relay to cover the changeover between normal or reverse lock relays.

3.4 Operation of Releases

Release keys are located adjacent to the point keys on the control panel and are provided to allow an electrical release to be given to the lineside releasing switches, enabling the Annett key to be removed once the release has been accepted by personnel in the field.

The panel release keys are of the rotary switch type and operate in two positions, left and right. For giving a release the panel release key is turned to the 'Right'. For locking the releasing switch, the panel release key, is turned to the 'Left' position, its normal state position.

3.5 Automatic Facility

To enable a controlled signal or group of controlled signals to automatically re-clear after the passage of a train, auto buttons are provided. The action of pressing the auto button will ensure that the signal or predetermined groups of signals once selected to operate in the automatic mode will continue to re-clear subject to the conditions of the locking/track occupancy following the passage of each and every train to pass the signal/signals. The automatic buttons shall be ineffective unless all the individual applicable signal routes have been previously set in the normal manner. Cancellation of the automatic button command is effected by pulling the

automatic button, this returns all the applicable signals back to a fully controlled mode of operation. This action shall have no effect on the routes established or the aspects being displayed by the signal/signals at the instant the automatic button is pulled. The cancelling of an established signal route by the action of pulling its commence button whilst the signal is working in automatic mode, shall cancel the route for that particular signal and the automatic facility for that signal or group of signals.

3.6 Emergency Replacement

To enable certain fully automatic signals to be replaced in an emergency, E buttons are provided. The action of pulling the E button replaces the automatic signal to stop. The signal will continue to remain at stop until the E button is pressed. The signal then returns to a fully automatic signal.

3.7 Alarms

All alarms are cancelled by the action of pressing an alarm cancel button unique or common to a number of alarm/alarms.

For details of associated indications refer to Section 7.0

3.8 Emergency Call-on Function

To enable a subsidiary shunt signal to be cleared for emergency call-on moves when the first track past a signal is a failure, an emergency shunt button is provided. After setting the shunt route over the failed lever stick track circuit, the emergency shunt button is pressed allowing the subsidiary shunt signal to clear.

Cancellation of the signal shunt route or the action of pulling the emergency shunt button should cancel the emergency call-on function.

This facility should be limited to only one route of the interlocking at a time.

4 BASIC OPERATION - OPERATOR INTERFACE (OI)

An alternative to the use of commence - finish or individual push buttons to set routes is the use of a keyboard/ VDU Operator Interface (OI). The keyboard/ VDU OI shall provide the means whereby a signaller can set and cancel routes and perform all the functions that would normally be available on a standard entrance - exit or one control switch operating system. For more details refer to SCP 16 - Signalling Operator Interface Specification.

Unless otherwise stated the control functions associated with the OI based system shall perform in an equivalent manner to conventional control panels and shall not generally be more onerous to the signaller than the operation of a conventional control panel.

The keyboard/VDU Operator Interface shall interface to a relay based signalling system by means of a telemetry system.

5 SIGNALLING INDICATIONS

The signalling system is required to input the status of signalling objects into the Operator Interface as per appendix E. This is done by a telemetry field station for relay based interlockings.

6 CONTROL AND INDICATIONS TO INTERLOCKING INTERFACE

6.1 Non-Vital Relay Interface

6.1.1 Entrance – Exit Controls

Controlling the movement of trains through a particular area, involves the setting of routes or the operation of points or release keys. The signaller's direct action of pushing buttons to establish a signal route or turning a point key, registers with non-vital interface circuitry that a change of state to the vital locking is being requested.

The non-vital interface circuitry utilises a combination of BRB 930 series relays and cradle relays, the cradle relays being mounted on printed circuit boards.

The main function of the non-vital interface with regards to push button functions is to ensure that only one button function can be registered by the system at a specific instance, the system determining whether the button is acting as the commence or finish point of a route. The system also ensures that, once a second button has been registered a delay of one second is provided before both button interface functions are returned to their normal state. This time delay is provided to enable the vital route locking to become established. If the route is not available during the time period of one second then another attempt has to be made to establish the route. The system inherently eliminates pre-selection and storage of route commands, routes can only be established on call.

When the interlocking is remote from the point of control, control information is transmitted to the remote location via a Telemetry system providing one-shot (single time limited output) or continuous outputs. Button functions shall generally have two types of outputs, single time limited output such as (F)R and continuous output such as (FM)R at the remote location either directly interfacing with vital or non-vital logic. Point and release keys shall be continuous outputs at the remote interlocking directly interfacing with vital logic or non-vital logic. Key positions are required to provide continuous outputs to maintain vital relays in an energised state. Button and other key functions shall directly follow the command actions of signallers as required by the signalling system.

Where a telemetry link is provided to a remote interlocking an emergency local control panel is to be provided as a direct link into the non-vital locking as a back up for telemetry system failure unless the telemetry system achieves high availability through redundancy.

6.1.2 One Control Switch Controls

When this system of control is utilised the non-vital interface is invariably remote from the point of centralised traffic control. All commands to the remote location are transmitted by a telemetry system.

The non-vital interface circuitry utilises a combination of BRB 960 series relays and cradle relays, the cradle relays being mounted on printed circuit boards.

With this system of control each signal route is provided with a unique button the action of pressing this button selects the unique route command which is transmitted to the remote location. The telemetry output for the route information shall be a one shot output being limited to a time period (nominally 2 seconds). Within this time period the route command must establish a hold up path in parallel to the telemetry output. This path can only be provided once the vital locking is such that the route can be established.

Point and release key commands are identical to those in the Entrance - Exit System and there is generally no time limit on the output of the telemetry system at the remote location.

Where a telemetry link is provided an emergency local control panel is to be provided as a direct link into the non-vital locking as a back up for telemetry system failure unless the telemetry system achieves high availability through redundancy.

6.1.3 Entrance - Exit and One Control Switch Indications

The logic necessary to generate the level of indications required by the operator to observe train movements and status of systems may require the combining of a number of vital functions. Where this is necessary the combining of vital functions is carried out in the interlocking. If the point of control is remote from the interlocking the indications are generally sent back to the point of control on a one to one basis. The vital or non-vital relay contacts representing the vital functions being used to generate the indications must be of the highest repeat level, thereby representing the status of all preceding levels of repeats and the master relay.

6.2 Telemetry/Train Control Systems

Signalling inputs to the Telemetry field station shall be in accordance with Appendix E.

Signalling outputs from the Telemetry field station shall be in accordance with Appendix E.

Where a Computer Based Interlocking system is used the system shall provide data on signalling status and accept Operator Interface controls in accordance with Appendix E.

6.3 Event Logger

Relay interlocking event logger requirements shall be in accordance with Appendix F. These indications shall be provided as part of the telemetry/ train control system interface when the event logger is integrated as part of the train control system.

7 SIGNALLING INDICATIONS/ALARMS - CONTROL PANEL/DIAGRAM OPERATION

7.1 General

All console and diagram indications shall be of the LED type and shall comply with the requirements of the Operator Interface specification SCP 16.

8 INDICATIONS/ALARMS - OPERATOR INTERFACE (OI)

Unless otherwise detailed in this specification, indications shall react to the system in the same manner and shall be provided for and be displayed in the same format as indications on conventional indication panels, as detailed in Operator Interface specification SCP 16.

The VDU based system should, as far as is practicable, follow present practice for signalling indications.

9 GENERAL DESIGN PRINCIPLES REQUIREMENTS

The signalling design shall comply with the Signalling Design Principles SDS 00 and the Signalling Circuit Design Standards SDS 25.

9.1 Power

- a) The signalling power supplies and signalling circuits shall not be connected to earth. All circuits are to be kept earth free.
- b) Non-vital equipment, in general, shall not be connected in vital circuits except where specially approved. In approved cases, the non-vital selection shall be arranged outside the vital selection in the circuits and in the same leg of the supply for all cases. Non-vital cable shall not be connected directly to vital relays or vital power supply units and completely non-vital circuits shall be operated from a separate power supply unit. Non-vital equipment and cable shall be either isolated or double insulated from vital equipment racks and vital wiring.
- c) Power supplies voltages greater than the nominal 120 volts shall be suitably protected and conspicuously labelled at all termination points.
- d) Circuit design shall take into account the effects of power supply interruptions and shall be designed to prevent incorrect energisation of relays on restoration of the supply. Any loss of supply shall not endanger the proper operation of safeworking circuitry.
- e) The internal and external supplies for interlockings shall be capable of holding stick relays energised during power supply changeover conditions or during power supply resetting circuit breaker operating conditions. The unwanted application of approach or route locking shall be prevented in these situations. Particular reference is made to the NGPR circuits
- f) and the VNR circuits in the approach lock circuitry.

- Completely internal circuits in the main relay rooms shall be wired off separate internal supplies.
- g) Signalling relay circuit overload protection shall be provided by self-indicating 4 amp fuses or circuit breakers of approved types. Vital circuits are not to be loaded above 50% fuse capacity. Signal light operating circuit fuses shall be 4 amp rated and the main running lights shall be fused independently of auxiliary signals and marker lights.
 - h) The loading of point motor operating circuit fuses shall not exceed 60% of their rating.
 - i) Fuses and Circuit Breakers are to be rated for proper discrimination as well as protection.

- j) All circuits and busbars shall be individually fused with suitable ratings to afford discrimination.
- k) As far as practical circuits shall be individually fused. Related circuits may be combined only to the extent that failure of a particular fuse or circuit breaker will not result in unnecessary loss of equipment that could delay or further delay train running and/or fault finding and rectification.
- l) Diagram indication circuits may be connected together in groups using commoning blocks to load the group fuse (maximum four amps) or circuit breaker (maximum capacity five amps) to 75% capacity. The common side of the diagram relays shall also be to a commoning block.
- m) For all signalling equipment, two independent 120 volt 50Hz power supplies are required at each power supply location, and are referred to as the normal and emergency supplies.
- n) 50V supplies shall be derived from duplicated supplies, each supply being in its own housing. In the event that one channel fails a warning of such shall be transmitted to the main control centre and local relay room.

9.2 Ground Frame and Releases

- a) Where shunting frames are electrically released the circuit shall be so arranged that the release lever or the released equipment shall stand locked in the normal position.
- b) All facing points and points which act as traps shall be detected normal and locked before the signal box release can be restored to normal and shall be proved continuously in running signal controls.
- c) Signals protecting shunting frame connections shall require the shunting release proved normal.
- d) Prior to a release being given all relevant signals interlocked with the release are to be proved at stop and free of approach locking.

9.3 Points

- a) Points shall not be free to move until the tracks that directly or indirectly lock point movements, have been continuously energised for 1 second minimum.
- b) Pre-selection of signalling routes over points shall not be permitted. Points selection circuits shall be designed to be non-storage regardless of type of operation.
- c) Points motors/valves (excluding E.P. and clamplocks) shall be controlled by normal and reverse contactors of BRB 966-F4 type with heavy duty contacts.
- d) Contacts of point 'Isolating Relays' where applicable shall be in each point motor circuit, to control the point motor power supply. These shall be normally de-energised and located in the equipment housing where the point motor/s are controlled from. The circuit shall include one contact of the local track relays in preference to repeat relays. The isolating relay shall double switch the point motor circuit.

- e) Points contactors and IR relays are to be mounted adjacent to each other in the nearest location case, walk-in or relay room.

Back proving of both 'A' and 'D' contact stacks of the BRB 966-F4 relay shall be carried out.

The emergency on site operation of point machines will be made possible by the use of an emergency crank handle. When the points crank handle is removed from the Annett lock, the power supply to the point motor will be cut off and all signals interlocked with the points held at stop. This is achieved by cutting the detector relays and isolating relay circuits.

- h) A timing device shall be provided for all points to cut the feed to the point motor if its running time exceeds 300% of its normal running time. This timing device shall be re-set if the point control is operated to return the points to the other position.
- i) Where magnetic contactors are utilised in the machine, checking of the opposing lock relay should be performed in the detector circuit. In this case the ESML contacts should cut both the detector circuit and the isolating relay.

9.4 Relays and Relay Circuits

- a) Vital relays are to be to BRB Specification 930 Series. Relay bases and crimps to suit are to be of the Westinghouse design.
- b) Twin relays QNNAI and QBBAI or similar types to BRB Specification 966-F6 and 961 Series are restricted to UCR/NGPR/RGPR or RGKR/FZR or NKR/RKR or VNR/VRR or VCSR in vital applications.

In vital applications the relay pairs are to be restricted to use within the one signal and are to be logically arranged within the numerical grouping. It will not be permitted to utilise a "spare" half twin within one logical group for a non-related function.

Repeat relays of a relay that is in a twin relay case are not permissible.

Specifically, twin relays shall never be used for track relays, track repeat relays, signal control relays, route stick relays and other similar functions.

Any variation to the above will require specific approval.

Relay bases and crimps to suit are to be of the Westinghouse design.

- c) Cradle relays are to be in accordance with standard Specification SC 05 15 00 00 SP Non-vital Relays for Signalling Applications.
- d) Vital selection for signalling relays, if not wired in the same relay enclosure, shall double switch the relay.
- e) Unless the relay is inherently self-proving, the restoration of all time element relays shall be proved after every operation.
- f) Route stick and approach locking relays shall be proved in the de-energised position before the signals controlling them are permitted to display a proceed aspect.

- g) Qualifying stick relays shall generally be proved in the de-energised position before a signal which runs over the qualified track circuit area shall be permitted to display a proceed aspect.
- h) All line relays including level crossing control relays and track timers shall be proved in the de-energised position unless impractical. Care must be exercised in design whenever deenergised contacts of relays are utilised for reasons other than proving the relay state. In particular, if back contacts of track relays or repeat relays are utilised to release locking then no unsafe feature shall result if de-energisation of the particular relay is due to reasons other than the presence of a train. Such back contacts shall be as close as possible to the parent relay.
- i) Slow release relays and/or slow pick up relays shall be provided to prevent flashing signal indications, erroneous indications and premature releasing of route holding due either to changes in signal aspects or to irregular clearing of track circuits - particularly as a train passes over sectional insulated joints. The arrangements in these respects shall be discussed and agreed.
- j) Track circuit relays, signal operating control relays and point operating contactors shall normally be located near their respective track circuits, signals and points. Track repeat relays, signal normal repeat relays, point detection relays and releasing switch normal relays shall be housed in the main location along with the route interlocking and track locking relays.
- k) Indications for Mimic Diagrams, VDU's etc. are to be derived from the last repeat relay of any specific function.
- l) Stick relay contacts are always to be A1.A2 BRB 930/960 Series and in addition C1.C2 for BRB 960 Series.
- m) Track relays/feeds are not to be installed in Relay Rooms in D.C. electrified areas unless suitable isolation is provided that has been specifically approved. A separate enclosure is to be installed outside the Relay Rooms adjacent to the point of cable entry thereby allowing installation of track circuit equipment and suitable power and earthing requirements to be fulfilled.

In A.C. electrified areas requirements shall be given in the Particular Specification with regards to the installation of track relays/feeds in relay rooms.

- n) Bridge rectifiers for ECR units are to be mounted onto the back of the ECR relay base. The resistor unit is to be mounted on a blanking plate positioned adjacent to the ECR unit (for QSR3 type relay only).
- o) Where a vital relay circuit starts in an equipment location and picks up external circuit functions (contacts etc) all circuit functions shall double cut the circuit except where the circuit functions are contained within the same location as the coil of the circuit relay. See circuits in SDS 25.

9.5 Track Circuits

- a) Locking circuits shall utilise contacts of track repeat relays which have a minimum accumulative slow to pick time delay of 0.5 seconds.

- b) Track stick circuits shall be provided for all track circuits that act as replacement tracks for running signals or shunt signals.
- c) For any particular track circuit at an interlocking, if any track repeat relay should fail, then such fact shall be evident on the track indication diagram.
- d) At block joints the polarity/phase of adjacent track circuits shall be reversed, unless otherwise specified in the Particular Specification for example at adjacent track feeds.

9.6 Signals

- a) Lever stick circuits shall be provided on all controlled main signals and where specified in the Particular Specification on certain shunt and subsidiary signals.
- b) In cases where running signals are lever stick replaced, and it is a requirement that means be provided to enable automatic working to be introduced this is achieved by the operation of an additional button, ('A' button). A contact of the 'A' button follower relay is added to qualify out the lever stick contact.
- c) The operation of the 'A' button shall enable the signal to continue to work automatically until the 'A' button or the signal route button is pulled.
- d) Shunt signals shall not be subject to track control other than a lever stick track as a general rule. In some cases where regular shunting is required onto an occupied track a 'double' lever stick function shall be provided such that the signal can be re-cleared for a second train movement with the lever stick track circuit occupied.
- e) All running signals shall require all track circuits to be clear up to the overlap point beyond the next running signal.
- f) Generally all signals shall be replaced automatically by first wheel but in certain cases where called for in the specified control tables, last wheel replacement shall be provided.
- g) All main, subsidiary and shunt signals shall detect all points and ground frames over which they lead and any other points which physically prevent a conflicting movement (catchpoints in sidings and trap points whether in the section or the overlap). For the facing points over which the signals lead detection shall include both switches and the plunger.
- h) The circuit of route reverse relays of signals shall in general not include route holding or track control selection. These shall be provided in the UCR circuitry. The normal lock relay circuits shall not include locking other than the signal normal and not approach locked. Reverse lock relay circuits for releasing switches shall similarly not include route holding or track control which shall be included in the release switch operating circuit.
- i) Signal light operating circuit lengths shall be limited generally to 200m for 120 volt AC circuits in DC electrified areas and to 100m for 120 volt AC circuits in AC electrified areas unless particularly specified otherwise in the Particular Specification. For LED (Light Emitting Diodes) signals these lengths may be extended up to 1km when protection against induction is provided. In general all vital circuits within cabled areas shall be double switched and non-vital indication circuits shall be single switched
- j) Facing points in the overlap of a signal shall be held locked after a train has passed the outer signal if the alternate overlap is occupied or otherwise not free. Releasing to enable

switching of the facing points to an occupied overlap shall only be provided once the train has been proved to be at a stand by occupying the inner signal's berth track for a period of time with the inner signal at stop.

- k) Signal circuitry shall be designed for automatic normalising by train passage. Designs shall be in accordance with the ARTC's standard practice.
- l) Where there are no trainstops, a front contact of the 'A' track (the first track past the signal) shall be circuited in series with the proceed aspects, and a back contact of the 'A' track shall be circuited in parallel with the back contact of the HR relay in the Red Aspect.
- m) Double Head running signals shall have the active side of each light single cut with common returns for each head.
- n) Single head running signals shall have the proceed aspects double cut by the HR relay and the red aspect single cut on the active side. The proceed aspect also shall prove that the 1 st track past the signal is clear.
- o) Low speed lights shall be double-cut by the LSpR relay only.
- p) Calling-on, closing up and subsidiary shunt signal lights shall be double cut by their respective control relays.
- q) Position light and dwarf colour light shunting signals shall have the active side of each light single-cut with a common return for all lamps.
- r) Stencil type route indicators shall have the lights associated with each route single cut on the active side with a common return for all lights.
- s) Multi-lamp route indicators shall have the active side of all lamps single cut with a common return for all lamps which shall be of sufficient size to prevent excessive voltage drop.
- t) Where co-acting or indicator signals are required wiring shall not be such as to potentially cause incorrect lamp illumination should an open circuit occur.
- u) Designs shall include filament change over relays for SL35 12V, 24W + 24W lamps for all controlled or auto main line single and multi-head multi-aspect colour light signals. 'Filament fail' and 'lamp out' alarms for controlled and automatic signals shall be transmitted to the main control centre and the local relay room. The grouping of signals within these alarms shall be as specified in the Particular Specification, but in general they shall be grouped geographically with a maximum of fifteen signals within a group.
- v) The main signal lighting circuits shall be fused independently of auxiliary signals. Marker lights shall be separately fused.
- w) All single head or multi-head colour lights signals with incandescent lamps or LED lamps shall be provided with lamp proving.
- x) Single head colour light signals shall have circuits designed such that the red marker light shall be illuminated if the signal is at 'stop', or the main signal light in use is extinguished. In each case the signal in the rear shall not be able to show a higher aspect than 'caution'.

When a green aspect lamp is extinguished with the controls at clear (i.e. DR energised) the circuits shall be designed such that the signal is reverted to caution or 'medium' aspect, as applicable. In this case the signal in the rear shall not restrict its aspect by the lamp failure of the clear aspect, unless otherwise particularly specified.

- y) Where a yellow band of lights is provided in conjunction with a 3 aspect signal, lamp proving shall be provided to restrict the signal in the rear to caution, when all three lamps of the band of lights are extinguished.
- z) On double light colour light signals, lamp proving shall be provided to include one or both main running lights out. The signal in the rear shall be restricted to caution when one or more of the main running lights of the signal ahead are out.
- aa) When a Junction Repeater is used to provide advance warning of the route set on a turnout signal at a Junction, lamp proving shall be provided to restrict the signal indication to caution when more than 3 lamps of the Junction Repeater are extinguished and the signal in the rear shall be restricted to medium indication.

9.7 Shunt Signals

- a) In general subsidiary shunting signals, where the destination is at the running signal ahead, shall have the same in line route locking, route holding and releasing as the running signal on which it is fixed. Subsidiary shunting signals shall however have reduced overlap locking, being a nominal 100m.
- b) Subsidiary shunting signals reading up to another shunt signal may have different locking to the running route. The subsidiary shunt shall not overset shunt signals ahead.
- c) Where a shunt signal has more than one route or where the move is to the wrong road, route indicators shall be provided on shunt routes.
- d) A 100 ohm 60 watt resistor is to be provided in the "marker light" circuit of the shunt signal.

9.8 Intermediate Shunt Signals

- a) Where there are intervening facing ground signals within a running route, the running route shall have setting and locking and normalising circuitry as though the shunting signals were not there, except that the clearing of the running signal proceed aspect shall also be subject to the clearing of the intermediate shunt signal aspect. The shunt signal shall clear automatically when overset by the running route and approach locking applicable to the running signal shall be incorporated in the approach locking of the shunt signal. The shunt signal shall be held clear when a train has entered the running route until it has passed the signal itself except that it shall always be possible to place the signal to stop by pulling its own button.
- b) The route holding for the main route shall be carried out independently of the presence of the intermediate shunt signals.
- c) Should oversetting of routes be provided then the facility to set up the routes individually shall also be retained.

9.9 Approach Locking (General)

Approach locking shall be provided for all running and subsidiary and shunting signals controlled from the signal box. Generally signals at shunting frames shall not be approach locked. Approach locking shall only be effective after the signal UCR relay is energised or the signal is not normal.

Approach stick relays shall apply to each signal post separately and shall be initiated by the clearance of any of the signals on that post. The signal shall be approach locked once a driver has seen the signal displaying a proceed aspect or has seen an aspect of an approach signal which would indicate the signal is displaying a proceed aspect. In certain cases, eg. some accept signals, approach locking may be applied with signal clearance regardless of the approach of a train.

The approach locking shall be released as follows :

- a) By all approach track circuits required in the circuit unoccupied. OR
- b) When the train runs past the signal in the normal manner, by two track circuits ahead of the signal occupied, subject to the provision of a power off timing relay (POJR), or in the case of shunt signals by the first track ahead occupied. The POJR shall be de-energised whenever there is a supply interruption that would otherwise cause completion of the release path.

Where simplified automatic normalising of the release is incorporated into the design eg. O.C.S. circuitry, then this release path does not apply.

- c) By an automatic time release generally of 120 seconds (60 seconds for ground shunting signals) which will commence to operate when the signal assumes the 'Stop' position.

Approach stick relays shall be de-energised by the signal UCR relay and shall be proved in the signal HR circuit.

The releasing arrangements for approach locking shall be proved fully normal before the signal can clear.

Where shunting signals lead running signals the releasing arrangements for the shunt signal shall not reduce the releasing requirements for the running signals.

9.10 Bi-Directional Signalling (Refer Sheets B01, B02, B03 in SDS 25)

9.10.1 General

Normally, where 2 or more main running lines are provided, each of these lines is signalled for one direction only with automatic signalling provided in the section between interlockings.

However, it is sometimes required that one or more lines in multi-track areas be signalled for train movements in both directions.

The signalling provided for Bi-Directional lines in multi-track areas has the following features in addition to those for single line CTC installations.

- a) All signals opposing a signalled train movement through a section are at stop and must be proved to be at stop, before the starting signal is allowed to clear.
- b) Once the starting signal at one end of a section has cleared, it cannot be put back to stop by setting the route for the opposing starting signal at the other end of the section. This is done in the vital signalling circuits so that it applies when the interlockings are in local operation.
- c) Facilities are provided to aid in the protection of maintenance staff working near the track from train movements in the "wrong" direction.

9.10.2 Typical Circuit Design

The following describes the bi-directional operation for the down direction only on the Down Main.

781 and 792 are the Down and Up Starting signals for the section. (Neither the Up Main or points are shown to simplify the explanation of circuits).

If all track circuits are energised and all controlled signal routes are normal the intermediate Section control Relays (Down Direction - 785 SCR, 789 SCR and 791 SCR) for both directions will be energised.

The Section Control Relays controlling the starting signals for the section (DM DSCR and DM USCR) are de-energised when the route for the starting signal is not set.

If the previous train movement through the section was in the down direction the Up Signal Normal Relays DM UGNR(1), DM UGNR(2), DM UGNR(3) will be energised. If the previous train movement was in the Up direction the Down Signal Normal Relays will be energised.

When 781 route is set, 781 RUR will energise and allow DM DSCR to energise. (If the Up Starting signal at the other end of the section, 792, was already clear, DM USCR would be energised and 792 ALSR de-energised, thus preventing the Down Section control Relays from energising. 781 signal could not clear and 781 ALSR would remain energised as would the Up Section Control Relays and 792 would remain clear).

As back contacts of DM DSCR are in DM DGNR (1), the Down Signal Normal relays will de-energise, placing the up intermediate signal/s at stop and allowing the Up Signal Normal Relays to energise and the down intermediate signals to clear.

DM DSCR and DM UGNR (3) have front contacts in the controls of 781 and this signal will then clear.

As a train passes each intermediate signal in the section, the applicable direction stick relay energises (eg. 785 DDSR) allowing the previous signal to clear once its overlap is unoccupied.

The Half Pilot Staff Relay (1/2 PSR) contacts are included in the Signalling Normal Relay circuits rather than the Section Control Relay circuits so that an energised direction stick cannot allow a starting signal to clear when the half pilot staff is out at the other end of the section.

9.10.3 Protection of Maintenance Staff

A reliable method of inhibiting signalled movements in the wrong direction, which is guaranteed by the possession of a token is provided. The release of this token is under the control of the signaller. The token is held by authorised maintenance staff while working in the section.

To meet this requirement, special annett keys, normally locked in electric releasing switches, are provided. The releasing switches are controlled by the signaller and are interlocked with the section controls so that once a key has been taken from a releasing switch it is not possible to signal a down train on the up main or an up train on the down main in the section between interlockings.

The possession of any one of the annett keys for a section, therefore, ensures that trains can only be signalled in the normal direction on each line in the section.

9.11 Route Holding

- a) Route holding shall be applied between all signals and points or releasing switches (unless otherwise specified herein) that they interlock, generally between running signals and all signals they interlock and vice versa but shall not be applied where shunting signals interlock shunting signals or ground frames except where specifically indicated in the Specified Control Tables.
- b) The route holding shall be applied by track circuits between inner protecting signals and points unless impractical where the route holding shall be subject to signal clearance or to directional qualification. Over points the track circuits up to the fouling points shall always be included unqualified in the point lock relay circuits.
- c) Each route stick circuit shall include track circuits extending from the signal concerned to the required releasing point but not beyond the next signal of that type (running or shunting). The route stick relay shall be de-energised by the signal ALSR relay and shall be proved in the signal HR circuit.
- d) Cascaded Route Sticks shall not be permitted.
- e) The releasing arrangements for route holding circuits shall be proved fully normal before the signal concerned can clear. The releasing arrangements shall require the signal route normalised and the signal proved at stop. Completed timing for route release when provided shall be indicated by an illuminated red light in the diagram.
- f) The route holding for the main route shall be carried out independently of the presence of the intermediate shunt signals.

9.12 Automatic Overlap Selection/Maintenance

When a route, which has alternative clearance points is set by the operator and the clearance point of the existing path through the points is occupied by a train but the alternate path through the points is clear, the points will automatically operate to the alternate path providing they are free to move at the instant the route is set. If the points are not free to move when the route is set and they subsequently become free it is necessary to re-operate the route setting buttons or operate the points with the points key.

If the signaller wishes the points to remain in their existing position and not operate to give the signal a clear overlap he must place the points lever in the position corresponding with the point position, prior to operating the route setting buttons.

In those cases where the automatic selection of overlaps exceeds two, information will be supplied to the Contractor which will indicate which overlaps are to be automatically selected.

Facing points in the overlap of a signal shall be held locked after a train has passed the outer signal if the alternate overlap is occupied or otherwise not free. Releasing to enable switching of the facing points to an occupied overlap shall only be provided with the train proved stationary on the inner signals berth track for a period of time as defined in the Specified Control Tables and with the inner signal at stop.

9.13 Automatic Signalling (Refer Sheets : A01, A02, A03, A04, A05 in SDS 25)

9.13.1 General

Automatic signals are controlled by the position of trains on the track only. They show a proceed aspect when the track is unoccupied from the signal to a distance beyond the next signal. This distance is called the overlap.

The overlap point is shown on track plans by a small circle at the applicable track circuit junction. The name of the signal to which it applies is shown adjacent to this circle. This location is also referred to as the "clearing point" for the signal.

In general, higher indications than the basic proceed aspect (Low Speed or Caution) for an automatic signal are controlled by the lower aspects of the signal ahead.

The CIRCUIT DESIGN STANDARDS show the 3 basic forms of automatic signalling ie. - non-electrified country (A01), electrified outer metropolitan areas (A02, A03), and tunnels in the inner city (A05).

Combinations of these 3 forms occur in some areas. (eg. electrified areas with single light signalling - with or without train stops; areas outside tunnels with low speed signals).

9.13.2 Track Stick

The signal is proved to return to stop after the passage of each train by the track stick circuit. This is a circuit applied to the track relay or track repeat relay (PR) of the first track circuit in the signal section.

In this circuit, after the track relay has de-energised, the relays controlling the signal are proved down before the track relay (or repeat) can be energised again. As this track relay (or its repeat) controls the signal in the rear, any of the control relays of a signal failing to return to the stop position after the passage of a train will maintain the signal in rear at stop, causing the following train to come to a stand and then proceed under control for the next 2 signal sections.

For colour light signals, contacts of the relay (or repeat) of the first track circuit in the signal section, or contact on the VRR, maintain the signal itself at red if a signal control relay should stick up after the passage of a train.

The arm of an upper quadrant signal and the spectacle plate of a searchlight signal, where applicable, are also proved to return to the stop position in the track stick circuit.

9.13.3 Train Stop Proving

The train stop, where provided, is proved to return to the stop position after the passage of each train in a separate relay, VCSR. This relay directly controls the signal in rear, holding it at stop if the train stop fails to return to the stop position after the passage of a train.

When this happens the VCSR is energised when the train is one more signal section ahead. This is done by a contact of the signal control relay (LSpR or HR). This allows safe signalled passage of trains (with extended headway), reducing train delays due to train stop problems.

The VCSR is proved down in the track stick circuit.

The train stop is proved reverse before a proceed aspect is exhibited in the signal.

9.13.4 Country (A01)

This form of automatic signalling with single light 3 aspect signals is used mainly in nonelectrified areas. The example shown assumes the use of DC track relays with only 2 front contacts. The track stick is therefore included in a repeat relay circuit.

This signalling is also in use in some electrified areas with jointless track circuits. (eg. Gosford-Adamstown). Track repeat relays are not generally required in these areas.

Where train stops are also provided contacts of the VRR relay replace those of the track relay in the signal operating circuit.

9.13.5 Metropolitan (A02, A03 in SDS 25)

In the metropolitan area where closer headway is required, 2 light signals with 4 aspects are generally provided.

A contactor (VR) is provided to switch the motor current of electric train stops because of the limited current capacity of BRB 930 relay contacts. This contactor is not required for EP train stops as a solenoid only has to be switched.

The circuits shown assume the use of jointless track circuits.

9.13.6 City (A04, A05 in SDS 25)

This form of signalling is used in the tunnels of the City and Eastern Suburbs Railways.

In addition to the usual track circuit controls for signals and train stops, the train stops are used to check the speed of trains approaching Low Speed and Caution aspects; 27km/h for Low Speed and 48km/h for Caution. Certain signals, generally approaching platforms also have conditional clearing controls which check the approaching train at an even slower speed. Intermediate train stops are provided between signals in and approaching platforms to further control the train speed in close headway situations.

These additional train stop controls, along with the fact that all trains in the tunnels are fitted with trip gear, allow much shorter overlaps to be provided than otherwise would be possible and consequently trains can run at very close headways.

The circuits shown represent typical arrangements on the Eastern Suburbs Railway using jointless track circuits with Data Pickup Units (DPU) provided for some timing points. The DPU's give precise detection of train wheels and economy of equipment. All signalling equipment other than signals, train stops, cables and track circuit tuning units, is located in relay rooms at stations allowing easy access, for fault finding and maintenance, to equipment that need not be in the tunnels (eg. relays, power supplies, fuses, track circuit transmitters and receivers).

Further major renewals in the City Railway will follow these same principles.

The Caution aspect of a signal is normally controlled by the Low Speed of the next signal, the Medium aspect is controlled by the Caution of the next signal etc, however in some circumstances the overlaps for the different aspects require that this be varied and direct track circuit controls may be added to some of the higher aspect control relay circuits.

9.14 Circuits/Terminations

9.14.1 Terminations

All likely disconnection points for adjusting, isolating, or testing vital circuits shall be provided as link type terminals. Situations shall be avoided where the disconnection of wires and wrong reconnection could possibly occur, particularly with polarised circuits.

9.14.2 Line Circuits

All line circuits shall operate satisfactorily using 7/0.50mm conductors.

The total voltage drop for line circuits shall not exceed 10% of the nominal supply voltage.

Where extremely long or high resistance line circuits are unavoidable the contractor shall submit alternative supply methods for approval by the superintendent. Care shall be taken to ensure that the correct voltage is available at the coil terminals of EP valve magnets and other such solenoid equipment.

9.15 Half Pilot Staff's

Half pilot staffs shall be provided at the entrance of each single line section to facilitate pilot staff working of trains when starting signals fail.

9.16 Special General Design Rules for Centralised Traffic Control in Single Line Areas

9.16.1 Crossing Movements

Simultaneous entry of opposing trains into a crossing loop main line and loop line is not permitted.

The second movement into the crossing loop main line or loop line shall not be permitted until the first movement has proceeded clear and has been proved at a stand by a track circuit timing arrangement.

Similarly this type of movement shall not be permitted with shunting taking place at the crossing loop unless such a movement is protected by catch points.

9.16.2 Overlaps

The overlap of Outer Home signals shall extend to the Starting Signal in advance at the finish end of the crossing loop or as detailed in the Specified Control Tables.

The overlap of Home Signals shall extend to the opposing Home Signal.

9.16.3 Outer Home Signals

The following principles shall apply in general :

- a) The Outer home signals shall lock and hold all routes and power operated points. The route holding is to be released by time release occupation of the berth track circuit at the Home Signal.
- b) Ground Frame releasing switches in the route from the Outer Home shall be locked and route held. They will be released by occupation of a local track circuit at the ground frame points facing end. Ground frame releasing switches in the overlap shall not be route held.

9.16.4 Home Signals

- a) The home signal is to be fitted with a subsidiary green 'low speed' signal and stencil type route indicator.

Movements into the loop line are to be signalled using the 'low speed' aspect.

Movements along the main line are to be signalled by the main aspect when the Starting/Second Home signal in advance is cleared for entry into section.

Movements along the main line are to be signalled by 'low speed' aspect when the Starting/Second home signal in advance is not clear for entry into section.

Subsidiary shunt signals working in conjunction with the stencil route indicators are also fitted where sidings exist within either of the running routes and where shunting movements are required outside the home signal to allow for resetting of the loop points before setting back.

- b) The Home Signal, when cleared for the main line, shall set and lock (but not route hold) the points at the other end of the loop in the reverse position if no opposing Outer Home signal is provided to prevent an opposing train approaching the opposite loop Home Signal, unless the Starting/Second home signal is set for entry into section.

When an opposing Outer Home Signal is provided and the Home Signal is set for the main line, the points at the far end of the loop (and catch points when provided) will be set locked and held in the normal position. Route release will be by a short time release on occupation of the berth track to the Starting/Second Home Signal in advance or by a long time release of up

to 5 minutes which caters for short trains which may not draw forward far enough to occupy the Starting/Second Home Signal berth track circuit.

Overlay track circuits are not favoured as berth track circuits unless it can be shown that their cost and reliability is favourable in comparison to conventional track circuits with glued insulated rail joints.

- c) The Home Signal, when cleared for the loop line, shall set and lock (but not route hold) the points at the other end of the loop in the normal position if no opposing Outer Home Signal is provided unless the Starting/Second Home Signal is set for entry into section.

If an opposing Outer Home Signal is provided and its route is set these points shall be set and locked normal and route holding shall be provided by the Outer Home Signal.

Shunt signals shall be provided on the finish signals from crossing loops where Starting Signals and Outer Home Signals are provided.

The running route of these finish signals shall set the Starting Signal route into section simultaneously and the finish signal shall not clear until the Starting Signals is at clear. Starting/Second Home Signals shall not clear until the section control relay has been energised for 10 seconds.

No shunt routes are to be fitted to Outer Home Signals or Starting Signals.

Approach tracks to the loop distant signals, shall be arranged such that approach locking of the home signal is applied at a point not less than 600m or sighting distance, whichever is the greater from the distant signal.

Opposing starting signals at opposite ends of single line sections must effectively lock each other over fail safe circuits, as must signals for entering single line sections from intermediate sidings. Non-vital locking for such signals may be provided at the Control Centre in addition to any vital locking.

9.16.5 Starting Signals

Starting signals (or any home signal which requires the section control) shall not clear until the section control relay has been energised for 10 seconds.

9.16.6 Ground Frames at Crossing Loops

- a) Ground Frames located between the Home Signals shall be released by an Annett key obtained from an electrical releasing instrument which will be operated from the main signal box.

These releases are not subject to direct track locking but will be indirectly locked by approach locking applied by protecting signals.

In certain cases the electrical release instrument will be strategically placed to provide a time interval between taking the release and operating the ground frame.

Route holding is not applied to these ground frame releases.

- a) Ground frames located outside the protection of the Home Signals but within the limits of controlled signals shall be route held by running routes but not by shunt routes.
- b) Ground frames at intermediate sidings in single line block sections will be released by a key from an electric releasing switch.

The release will be operated subject to either:

- (i) The whole block section being unoccupied with the section entering signals at stop and not approach locked, or
- (ii) The train must have occupied a short (30 metre) track circuit immediately ahead of the points.

Where a signal is specified to be provided for departure from the siding which will show proceed when the siding points are reversed, providing the section is clear and entering signals are at Stop. The traincrew operates a pushbutton to control the signal.

Emergency release of ground frames shall be accomplished for each ground frame by use of an Annett key secured in an Annett lock located in an approved position. Removal of the key shall place all signals in the interlocking at stop and the key may then be used to operate the ground frame.

9.17 Interfacing Between CTC and Non CTC

- a) Before a signal can be cleared to send a train from a CTC crossing station to a non-CTC station, or vice versa, controls must be operated by the signalmen controlling both areas.
- b) It should be noted that locking between CTC and non-CTC areas shall be carried out in a vital form over the section controls.
- c) Rotary contacts will be required on mechanical starting and accepting levers at the non CTC stations.

9.18 General

- a) The normal and reverse conditions of a given function shall be separately wired and indicated. It is not sufficient to assume, for instance, that a function is reverse if it is not normal. A separate channel for each condition shall be provided in remote control and indication systems.
- b) Large proving rings shall be avoided. For push button set up circuitry separate proving rings shall be provided for each signal operator control area.
- c) Machine in use and finish indications shall be provided for each proving ring.

10 ROUTE CONTROL SYSTEM - CIRCUIT DESCRIPTION

10.1 Control Panel Push Button Circuits

The number of push button interlocking rings is dependent on the number of signal operator areas on the control panel. A minimum of one per operator area is required.

Panel buttons work in two positions, with spring return to the centre position. Each button is fitted with two contacts, one of which is normally open and only made when the button is pushed (F), and the other one which is only opened when the button is pulled (FM). All functions are accommodated using the (F) and (FM) contacts.

Relays are operated by the contacts as follows : The (F)R relay repeats the push contact; the (FM)R relay repeats the broken when pulled contact.

The (F)R relay contacts are used to operate (R)PR relays. Each (R)PR relay is wired over a front contact of its own (F)R relay and a back contact of every other (R)PR relay. Thus interlocking is provided between every (R)PR relay operated from the control panel so that only one (R)PR can operate at a time. Contacts of (R)PR relays are used to operate the CeR commence relays and FnR finish relays.

When a button is pushed to select the commencement of a route its (R)PR energises and providing that no other button has been pushed a contact on the (R)PR closes the circuit for the commence relay CeR. A front contact of the CeR then energises the machine in use relay MUR. The MUR energised opens the pick up circuit for all CeR's and this determines that the next button to be pushed will function as a finish button. The CeR for the button operated is held energised by a stick circuit which includes a front contact of the finish timing relay FnJP2R, back contacts of its own (N)R relay and its own front contact.

When the next button is operated to define the finish point of the route to be cleared, its (R)PR is energised and because the MUR is up, the finish relay FnR, for that button will energise and is held energised by a stick circuit which includes a front contact of the finish timing relay FnJP2R, front contact of the MUR and its own front contact. A circuit is provided for the MUR via a front contact of FnPR, the finish relays repeat relay, to prevent the MUR from dropping out if a finish button is held for longer than one second. (This would change the button from a finish to a commence action).

Contacts of the CeR and FnR relays in series are utilised to select the required route by closing the negative side of the route RUR/NLR circuits and providing all locking conditions are satisfactory the route will set and lock.

The commence relay CeR and the finish relay FnR, remain energised for only approximately one second after the finish relay has operated, long enough to allow the route RUR to energise. Once energised the route reverse relay (RUR) remains held in that position even though its circuit is opened when the CeR releases by a stick circuit which includes a front contact of the (FM)R relay and its own front contact. This sequence provides the non-storage feature of the controls. That is, if the route is not capable of being set within one second of the signaller operating the finish button, his action is not registered and he must operate the buttons again when the route is free.

The method of obtaining the one second timing period is as follows. When a finish relay FnR energises, its front contact completes the circuit to the finish repeat relay FnPR and a back contact of the FnPR opens the circuit to the finish timing relay FnJR. FnJR/FnJPR/FnJP2R are slow release relays and approximately one second after the FnPR has energised the FnJP2R opens its front contact to break the holding circuit for the commence relay network (CeR) and the finish relay network (FnR).

A stick circuit is provided to hold FnPR energised until FnJP2R is de-energised. This ensures that if the finish button is released before FnJP2R has dropped, that FnJP2R will still release and cancel out the CeR and FnR functions.

When the commence relay releases and the finish button has been released the MUR releases, the FnJP2R energises and all button relays are in their normal position ready for another route to be set or for another attempt to be made to set the same route.

10.2 Control Panel Key Circuits

Panel keys are normally fitted into either two or three contact positions namely: left and right or left centre and right. The position that the key is turned to allows a continuous voltage to be present through that contact position to control follower relays.

The most common application of keys are:

- a) Point key, three positions
- b) Release key, two positions

Each point and release has a separate key. The point keys are normally turned to the centre position, thus allowing route setting using the panel push buttons to be achieved. As soon as the key is turned to the left or right of centre a command is issued to a set of points, calling them normal or reverse respectively. Once the left or right key position has been selected it is impossible to route set over that set of points unless the points happen to be in the correct lie for the route.

The operation of the points by key is therefore only normally used during testing, maintenance or under some failure conditions that may require the points to be key operated to inhibit route setting.

Release keys are normally set to the left position being the locked position. The action of turning the key to the right or free position allows a command to be issued to the releasing switch thereby allowing the release key to be extracted.

Once the key has been taken the key can again be turned to the left position without affecting the release instrument. Only when the key is re-inserted into the releasing switch does the release once again become locked.

10.3 Route Setting

10.3.1 Route Lock Relays

Each route in the interlocking from signal to signal or from signal to section, siding or terminal road has a route reverse relay to set points and clear the entering signal and a normal lock relay which proves the route normal and is used in locking conflicting routes.

Each set of points is controlled by a normal lock relay which operates them to the normal position and a reverse lock relay which operates them to the reverse position.

The interlocking in an installation is carried out between the various route normal lock relays and point lock relays as required.

On operation of control panel buttons to set a route, the route reverse relay is energised, providing the interlocking is free. The route reverse relay contacts then set all necessary point lock relays which in turn operate the points to line up the route. With point detection indicating

that the points are in their correct position and providing that the track circuits concerned are clear the signal control relay (UCR) energises over contacts of the route reverse relay.

10.3.2 Route Reverse Relays

Route RUR and NLR circuits are electrically interlocked with each other. Thus 3NLR back contact is in series with 3RUR operating coil and 3RUR back contact is in series with 3NLR operating coil.

The route reverse relay requires the route normal lock relay release coil to be energised to enable it to be energised.

The sequence of operation for the route lock relays is as follows:

Assuming that 3(M)ANLR is up and 3(M)ARUR down the next operation will be to pick up 3(M)ARUR. When 3(M)ARUR positive side circuit is complete CeR and the button relays 3(M)CeR and DRFnR are energised, 3(M)ANLR releases coil circuit is completed and 3(M)ANLR will drive down making its back contacts. When 3(M)ANLR back contact closes, the circuit to 3(M)ARUR operating coil is complete and 3(M)ARUR picks up closing its front contacts. 3(M)ARUR relay negative side of the circuit now provides a stick path over its own contact a back contact of the 3(N)R and a front of 3(FM)R.

The Interlocking between other functions and No. 3 route is carried out in the positive side of 3RUR in accordance with the requirements of the control table. One of the requirements for No. 3 route is that No. 101 points are normal or free to go normal. If No. 101 points are normal 3RUR is energised over 101NLR contact. If No. 101 points are not normal but are free to go normal, 3RUR is energised over 101 WZR contact. The WZR or points free relay detects when points are free to be operated to the next position and its use in parallel with point lock relay contacts as in 3RUR circuit is the basis of the route control system. Once a route reverse relay has been energised over a point WZR contact, a contact of the route reverse relay is used to set the points to the next position. Thus a contact of 3RUR will be used to energise 101NLR.

The route NLR when energised is used to release conflicting routes and points and proves that :

- (i) The signal has returned to stop.
- (ii) The signal is not approach locked.
- (iii) The route RUR is de-energised and is therefore not capable of setting points or clearing the controlling signal.

The route RUR when energised proves that the route NLR is de-energised and ensures that all conflicting routes and points are locked or available prior to the route setting.

10.4 Route Normalising

10.4.1 Manual

The remaining button relay the (N)R is associated with normalising of a route.

The (N)R relay controls the normalising of the appropriate route reverse relays and the energising of the normal lock relay (NLR) for example 1(N)R, 1NLR circuit. When No. 1 button is pulled 1(N)R is energised, 1(FM)R relay dropping by the action of pulling the button.

1(N)R is then stuck up over the back contact of the route 1NLR which is to be normalised and contacts of 1 CeR, and its own contact. The stick circuit will maintain 1(N)R energised until the route NLR circuit is completed by the signal returning to stop and the approach stick energising. The push button can be released immediately after it has been pulled. Once the route NLR has energised, its circuit is opened by the (N)Relay dropping and it is held in the energised position by its magnetic latch.

The CeR de-energised contact in the (N)R stick circuit permits a signal to be recleared, if required, after it has been cancelled but the route has not normalised due to approach locking.

A back contact of the (N)R relay is wired in the stick circuit of the relative CeR relay and this allows a button which has been incorrectly pressed as a commence button to be cancelled by pulling.

10.4.2 Passage of Train

Automatic normalisation of routes by passage of the train shall be incorporated into the system design. It is necessary to provide additional circuitry to facilitate the normalisation facility for a route.

In addition to the (N)R and the ALSR circuits being the active constituents in route normalisation an additional relay the TZR is required to ensure that intermittent insulated joint failures do not provide for the false release of a route.

The TZR introduces a third track condition being the signal berth track, this being required to be proven as having been occupied and cleared prior to allowing the (N)R to energise. Providing the signal is not in Auto Working the TZR for 3 signal is energised over a back contact of its (A)SR, 3AT and 1BT occupied. It is then held energised over a contact of itself and the back contact of 1(A)SR and 3AT. As soon as the train passes the signal and 1BT clears a path is provided for 1(N)R to energise providing 3ALSR has energised in conjunction with 3TZR being energised. If no berth track exists such as in the case of No. 6 signal then because of the restricted speed of the train movement it is acceptable to substitute the TZR circuit with the SR circuit. The SR being de-energised in association with the stick track clearing and the ALSR being energised is sufficient to enable the (N)R to energise.

10.4.3 Button Lights

Button knobs are made of clear perspex and are arranged to enable a white light to be shown through them. When a button has been pushed as a commence action a flashing white light is exhibited. When a finish button is pushed and it is a finish button for a route originating at the commence button previously operated and track and locking conditions are favourable, the normal route lock relay is de-energised and the light in the commence button becomes steady white. If the finish button operation is not successful the flashing light in the button knob is extinguished.

When a route has been set the button light remains illuminated until the route is normalised. When the button is pulled and the route has normalised the button light is extinguished.

If the route is not normalised when the button is pulled due to approach locking being applied the button light remains illuminated until the approach locking is free when the light is extinguished.

The circuit for No. 1 button lamp is initiated, when 1 CeR is operated, No. 1 white light is flashed via a contact of the FEKR until 1NLR is de-energised. The flashing supply is opened by the NLR dropping allowing the FEK2R to energise. The 24V active supply being connected via the FEK2R front contact to give a steady white light.

When the route is normalised the route NLR is no longer energised. If approach locking is applied when the button is pulled 1NLR drop contact will remain made to maintain the light in No. 1 button until the approach locking is released.

10.5 Point Operation/Locking/Detecting

10.5.1 Point Lock Relays

Point normal and reverse lock relays are electrically interlocked with each other. Referring to No. 101 lock relay circuits, it will be seen that each lock relay operating coil is wired through a back contact of the other and that the release coil of each relay is tapped off the operating coil of the other relay. Before either relay can make its front contacts the other relay is released and proved down. Thus before a point lock relay circuit can be energised to drive the points to the next position the lock relay for the existing position is proved down ensuring that all routes which lead over the points in their present position are locked before the points can move.

101NLR (Refer sheet NO5 IN SDS 25)

In the positive side of the circuits are NLR contacts of routes which require No. 101 points reverse (and hence must be normal before No. 101 points can drive normal) and track locking requirements. In this case its 3(M)A and 3(S)A routes and the track locking is provided by the local point track 3ATR.

In the negative side of the circuit are RUR contacts of all routes which set 101 points normal in series with a contact of 101(C)R which repeats No. 101 lever in the centre position. An alternative path is available for use when the points are to be operated normal under lever control via 101(N)R contact which is a repeat of No. 101 lever normal contact. The routes which can set No. 101 points normal are Nos. 3(M)B and 3(S)B.

101RLR (Refer sheet NO5 IN SDS 25)

In the positive side of the circuit, are NLR contacts of routes which require No. 101 points normal and therefore, when set, must prevent No. 101 points from driving reverse, and track locking requirements. The routes which lock 101RLR are 3(M)B and 3(S)B. Track locking requirements being provided by local point track 3ATR.

10.5.2 Point Free Relays

The WZR or points free relay taps off the interlocking and track locking portions of both 101NLR and 101RLR in its positive leg and over a contact of the centre position of the point switch (C)R in its negative leg. Moving the point switch away from the centre position to the Normal or Reverse position ensures that the points are locked in either of these respective positions. When 101NLR is energised the WZR is connected to the 101RLR circuit, thereby detecting if the points are free to go reverse and when 101RLR is energised the WZR is connected to 101NLR circuit, thereby detecting if the points are free to go normal. Thus the WZR relay when energised indicates if the points are free to operate to the next position.

The WZR is used to convey this information to the route RUR circuits which are allowed to energise if the required point lock relay is energised or if the points free relay is energised.

The point free relay is a slow release relay so as to prevent the RUR from dropping out during the operation of the point lock relays under route setting conditions.

The WZR relay in conjunction with the transient nature of the button controls provides for non-storage operation of the points under route setting or key operation. If when the route buttons are pushed to establish a route, the point lock relays are not in the correct position or the points are not free or available to be operated to that position as indicated by the WZR relays during the one second period that the button relays are energised, it will be necessary to operate the buttons again when the points become free or available. If a train were passing over points within the route in question the security of the points is dependent entirely on the track relays remaining down whilst occupied by the train. Therefore, if the track relay should bob during the one second which the button relays are energised the points would commence to move under the train. To guard against this event track repeat relays are made one second slow operating so that local tracks in the point circuit must be clear for one second before the points become free to operate to the next position.

10.5.3 Point Timer Relay

A point timer relay 101 WJR is provided to ensure that the tracks have been free for a length of time to cover track bob. The WJR is a slow pick-up relay, which together with the slow pickup track repeats provides a two stage timing facility before the points are free to move. The WJR is tapped off the point lock relay circuit and a contact of it cuts the WZR.

10.5.4 Point Lock/Detection Relays

The two remaining relay circuits tapping off the point lock relay circuits are the point normal and reverse lock and detector repeat relays 101NLKPR and 101RLKPR. Contacts of these relays are used in signal control circuits to provide proof that the detection and lock relays are in their correct position and that the operation of a route RUR has locked out the point lock relay for the movement to the next position before a signal can clear.

101NLKPR taps off 101NLR circuit so that it includes all dead locking which prevents No. 101 points from driving normal, in this case 3(M)ANLR, 3(S)ANLR, and detects, 101NLR energised, a front contact of 101NWKR and proving contacts of 101 WZR, 101 WJR and 101RLKPR. The proving contact of 101WZR is most important and its function is as follows.

With 101NLR up when route 3(M)B is called for, the release coil of 3(M)B NLR is energised when the 3(M)CeR and DM Fnr button relays are operated and when 3(M)B NLR makes its back contact 3(M)B RUR is energised. When 3(M)B NLR opens its front contact the circuit to 101 WZR over 101NLR contact is broken and 101 WZR drop contact makes to allow 101NLKPR to energise and complete 3(M)B HR circuit. Thus before No. 3(M)B signal can clear proof is obtained that 101RLR circuit is opened and therefore, No. 101 points cannot be operated to the reverse position.

Wiring of 101NLKPR over 3(M)A, 3(S)A contact in this case, provides a continuous check in the signal controls of all signals which require No. 101 points normal, that conflicting routes which require No. 101 points reverse are normal. Thus if No. 3(M)S, 3(S)A route should be falsely energised whilst No. 101 points were normal, 101NLKPR would drop and open circuit

any signal control relay which happened to be up for a movement through the points in the normal position.

101RLKPR taps off 101RLR circuit and performs similar functions to 101NLKPR being utilised in signal control circuit which lead over No. 101 points in the reverse position.

10.5.5 Point Available Relays NWAR-RWAR

(Refer sheets N10 and N11 in SDS 25)

Point available relays are provided to allow a route to set over two or more points one of which will not become free to operate for that route until one or more of the other points has responded to the route.

The point available relay detects all the functions which dead lock the points, thereby proving non-conflicting locking.

Contacts of the point available relay are utilised to by-pass the point WZR contact in the route release relay circuit and so allow the route reverse relay to energise. The route reverse relay then operates the points in sequence to line up the route. The action of the route reverse relay energising will cause the points WZR relay to de-energise, it is therefore essential that the NWAR/RWAR relay coils are of a slow release nature to eliminate back feed in the NLR/RLR coils and to support the WZR in maintaining the RUR during point sequencing.

The point available relays are proved de-energised in the relative point lock and detector repeat relays. The NWAR determines that the points are available to operate to the normal position and is proved down in the RLKPR. The RWAR determines that the points are available to operate to the reverse position and is proved down in the NLKPR.

The sequential operating requirements of points are listed in the control tables. No. 102 points are locked normal when the following conditions apply :-

No. 1 route has been set and No. 101 points are Normal or alternatively No. 1 signal route has been taken and No. 101 points are Normal - conditional dead lock.

Nos. 5B, 6 and 10 routes have been set or alternatively No. 10 signal route has been taken - dead lock.

102 RWAR shown on sheet N11 checks that all other functions which lock No. 102 points normal, except condition (a) are in the correct position.

Referring to 5A RUR circuit on sheet N09 - it will be seen that 102WZR contact is qualified by 102 RWAR contact.

In addition you will see that if 1 route has been set or the route has been taken it is necessary to prove that 101 points are reverse or free to go reverse. This is required to comply with condition (a) where before 102 points can be freed to go reverse 101 points must be driven reverse. It is therefore essential to prove this in the route locking. 102 RWAR contact allows the route RUR to be established in these circumstances when 102 points will be locked Normal after 1 signal route set or taken with 101 points Normal.

10.5.6 Point Overlap Relays

Overlap relays automatically set facing points in the overlap of a signal to give a clear overlap for that signal. When a route which has facing points in its overlap is set and the points are lying so that the overlap over which the signal would clear is occupied, but an alternate overlap is clear and the points are free to operate to that overlap, the overlap relay OLR, will energise and drive the points to that position. The controlling signal for the route then clears via the free overlap.

The circuits for No. 101 points OLR's are shown on sheet NO7 and contacts of the OLR relays appear in 101NLR, 101RLR circuits where they close the negative side of the circuit under route setting conditions. The OLR relays are proved de-energised in the respective LKPR circuits.

The OLR relays are only energised during the one second period that the button relays are energised and the drop away time of the associated capacitor resistance unit thus complying with non-storage requirements.

Protection against the OLR's causing the points to move if a track relay should bob under a train is obtained by wiring a contact of the relative point WZR relay in the OLR circuit, thereby ensuring that the points have been free for at least one second before they can be operated to another position.

If the points in the overlap of a route are not free to move to an unoccupied overlap when the route setting buttons are operated the route RUR will energise providing its requirements are met but the OLR will not be energised. Because of the transient nature of the button controls it will be necessary to either re-operate the buttons when the points become free or to set the points to the required position by operating the point switch. In these circumstances the route will establish itself but a proceed aspect will not be displayed.

101 NOLR

Drives No. 101 points normal when :-

No. 1 route is set, 3BT is clear and 3XT is occupied.

101 ROLR

Drives No. 101 points reverse providing they are free to operate when :-

No. 1 route is set, 3XT is clear and 3BT occupied.

In association with the NOLR and ROLR drives the points are correspondingly locked until such time as the occupied status of the tracks changes.

When 101 are driven normal 101 points are locked normal by the inclusion of a contact of 3XT in parallel to 1USR. This ensures that until such time as 3XT clears or 1USR energises by occupation of 1 BT for time the points remain locked Normal. Similarly when 101 are driven reverse, 101 points are locked reverse by the inclusion of a contact of 3BT in parallel to 1USR.

10.5.7 Point Detector Relays

101 normal and reverse detector relays, 101NWKR and 101RWKR are shown on sheet WOI.

Each detector relay is double switched by the switch machine detector contacts and proves the isolating relay and the opposite detector relay down and checks correspondence with the point contactor and lock relay. In addition an emergency switch machine contact (ESML) is added in the circuit to ensure that when the points are to be operated by hand crank both the NWKR and the RWKR are de-energised.

The detector relay is proved de-energised in the opposite point lock relay. For example 101NWKR is proved down in 101RLR and 101RWKR is proved down in 101NLR. With No. 101 points normal and to be driven reverse 101NLR contact is opened and drops 101NWKR, 101NWKR de-energised contact closes the circuit for 101RLR, No. 101 points then drive reverse.

Proving of the detector relay down before the points operate to the next position is necessary to guarantee the correct selections in selective overlap and conditional locking bridging, which are carried out by means of the detector relay contacts.

10.5.8 Point Contactors

The point contactors 101NWR and 101RWR are as shown on sheet W01, double switched by contacts of the relevant point lock relays.

101RLR is proved down 101NLR SHT NO5 up in 101NWR and 101NLR is proved down 101RLR up in 101RWR. If both lock relays should be up at the same time or if either lock relay is unplugged both contactor coils are open circuited.

Contactors are checked energised in their relative detector circuits and when the contactor is de-energised the detector relay circuit is opened and it in turn drops the relative LKPR relay, contacts of which break the signal HR circuits and maintain protecting signals at stop.

The point lock relays being magnetically latched and hence special holding circuits are not required for the contactors.

Contacts of the points contactors switch the points motor operating circuit.

10.5.9 Point Isolating Relays

Isolating relays prevent irregular operation of the points should the point lock relay or contactor be falsely energised whilst a train movement is taking place over the points.

The isolating relay checks that, facing signals are normal and not approach locked, and that tracks from facing signals to the points and the local tracks over the points are clear before the points can be operated to the next position.

10.5.10 Point Operation Under Route Setting Control (Refer to Sheet NO5 in SDS 25)

With No. 101 lever in the centre position, No. 101 points reverse and 101RLR up, panel buttons are operated to set No. 3(M)B route. Providing No. 101 points are free to operate to the normal position, 101WZR circuit is complete via 101RLR contact and the positive 101NLR circuit selection. The negative side to 3(M)B release coil is closed by 3(M)CeR and DM FnR contacts for a period of one second. The positive side of 3(M)BNLR release coil and 3(M)B RUR operate coil is complete via 101WZR contact because 101NLR is down. 3(M)BNLR releases and its drop contact closes the operate circuit for 3(M)BRUR. 3(M)BRUR front

contact completes the negative to 101RLR release winding and when 101RLR back contact closes, 101NLR operate winding is energised and 101NLR subsequently drives No. 101 points to the normal position.

10.6 Route Stick Relays

Route stick relays provide the means of ensuring that locking of routes against points or route against route is maintained during the passage of a train.

1USR

The pick up path is via 1 ALSR and 1 ATPPR, 1 BTPR contact, or alternatively 1 ALSR and 1BTJR contact. The holding circuit is via 1ALSR and 1USR contact. Where a signal has more than one route and the route stick requires to be exclusive to a particular route then a contact of the exclusive route NLR is added in parallel to the ALSR.

The addition of a timer contact around the stick contact enables the USR to be energised after the occupation of a specific track for a pre-determined period of time as stipulated in the control tables.

Route sticks that contain timed releases are primarily used for releasing points in the overlap of a route or opposing signals.

With reference to the layout depicted on sheet NO8 1USR is used for:-

Ensuring that 102 points remain locked in the overlap of signal No. 1 with 101 points Normal until 1BT has been occupied for time "T".

In 5A Route RUR circuit to ensure that when attempting to set 5A route, 101 points are either Normal or free to go Normal when a route from signal No. 1 has been set or the route has been taken.

With reference to sheet N12 to ensure that Release 102 is locked Normal after a route from Signal No. 1 has been set or the route has been taken until such time as 1BT has been occupied for time "T" with 101 points reverse.

Overlap maintenance on 101 points.

10.7 Signal Operation

10.7.1 Lever Stick Relays

The Lever stick relay (SR) is used to ensure that the control on a signal is returned to normal after the passage of a train. The circuit for 1 SR is shown on sheet NO7. When No 1 signal is cleared by operation of the panel buttons 1 SR is held energised VIA 1 ATPPR and 1 SR stick contact. On the passage of a train past No. 1 signal 1 SR is de-energised by 1 ATPPR contact opening. The relay will remain de-energised after the train has vacated 1A track until the signal control is returned to normal. A pick up path will then be generated via 1 ATPPR and 1 NR and/or INLR which will energise the relay. If closing facilities are provided or if the route can operate automatically an energised contact of 1(A)SR is connected in parallel with 1NR and 1NLR.

1 SR will then not require the signal control to be cancelled and 1 SR will follow 1 ATPPR. Energised contacts of 1 SR are included in No. 1 signal control circuits and after the passage of a train past the signal the SR contact prevents the signal from clearing again until the route has been cancelled and then the signaller can re-set the route by operation of the panel buttons. The (N)R contact in parallel with the route NLR contacts allows re-energisation of the lever stick relay should a power outage occur when a train is approaching the signal and the signal is showing a proceed indication. Under these circumstances the approach stick down would prevent energisation of the route NLR when the panel button was pulled and it would not be possible to energise the SR relay to re-clear the signal unless the timing period of the ALSR had elapsed.

10.7.2 Signal Control Circuits (HR/UCR)

These relays are provided to ensure that all locking/ detection and track conditions in the signal route have been fulfilled prior to allowing a command to be issued by the system allowing the signal to display a proceed aspect.

All main signals are to be provided with UCR's.

The UCR drops the NGPR and then the USR and ALSR relays which are then proved down in the outgoing HR circuit, in series with front contacts of the UCR. The UCR relays allow proving of internal relays whilst allowing 120V AC signal operating circuits to be wired from nearby locations via external HR relays. These short wiring runs for the signal operating circuit reduce the circuit exposure to AC induction.

With reference to 1UCR/1HR circuit on sheet NO6 the principle components of the signal control circuits are :-

- a) A front contact of 1RUR the controlling route reverse relay which responds to the button operation and checks that all conflicting locking is in the correct position and that if points are out of position they are free to be operated to the correct position.
- b) A front contact of all directly opposing USR's thereby proving no directly conflicting train movements are in progress.
- c) A front contact of 1 SR the lever stick relay which prevents the signal from automatically clearing again after the passage of a train.
- d) Front contacts of all tracks up to the next signal, 1ATR, 1BTR. (Running Routes Only).
- e) Front contacts of all overlap tracks and where necessary selection by the necessary point detection relay contacts, 3AT, 3BT, 3XT.
- f) Point lock and detector repeat relay contacts, LKPR's of all points within the route up to the next signal which require to be detected by the signal or which are interlocked with the route. There are no such points in the case of No. 1 signal, but referring to 3(M)UCR circuit, 101RLKPR being an example of detection of local points.

The LKPR contact inserts the following information in the signal HR circuit :

- (i) Proof that the points are in the correct position.
- (ii) Proof that the correct point lock relay is energised.

- (iii) That all routes which require the points in the other position and therefore conflict with No. 3(M)A route are normal.
- (iv) That the WZR is de-energised as a result of No. 3(M)A route clearing and this in conjunction with the route NLR being up becomes proof that conflicting routes cannot become reverse.
- (v) Proof that the opposite LKPR is de- energised.
- g) Points within the overlap of a route which lock the route, (usually trailing points), eg. No. 102 points in the case of No. 10 route must be checked in the signal HR circuit via the point LKPR contact to ensure that they have operated to the correct position, are locked in that position before the signal exhibits a proceed indication and to give continuous proof that conflicting routes through the points are normal.
- h) Conditional locking is checked in the HR circuit to ensure that points have operated to the correct position in response to a route having been called, before the signal can clear. In this instance since these points are only locked conditionally and it would be possible by the action of setting other routes to move the points thereby changing the point conditions, detection only is required. In 1HR the conditional locking would be 102 N with 101 N. To achieve this 101RWKR would be circuited in parallel to 102 NWKR thereby proving at all times points in the overlap are correctly positioned.

Note: If a signal route has a single set of facing points in its overlap then they are not required to be detected even at time of clearing.

In addition to the typical circuits other common functions proved in the UCR/HR circuits are :-

- a) Facing shunt signals if any in the route must be proved to be OFF.
- b) Approach release track circuits where applicable must be proved occupied on the associated timing- out features to have operated.
- c) Route lock release timing applicable to the route being established proved not to be effective at the time of clearing the signal aspect. (JR down)
- d) The approach locking and route locking must be proved to be in operation.

10.8 Approach Locking

Approach stick relays to be provided for all controlled signals with the exception of certain starting signals as specified in the Control Tables.

A signal shall become approach locked once a driver has seen a "Proceed" aspect or has seen an aspect at a previous signal which would indicate to him that the former signal is displaying a "Proceed" aspect.

Where very long sighting distances are involved, 600 metres shall be considered a suitable approach locking distance to the first warning signal.

When a train moves through the area in the normal manner the 1 st and 2nd track past the signal occupied plus a contact of the 'power off' relay in series prevents a delay in normalising No. 1 route. (Refer Path No. 2 below).

The circuit for 3ALSR is shown on sheet NO7 and the various circuit paths are as follows :-

Path No. 1

All approach track circuits energised.

Path No. 2

Allows for energisation of 3ALSR when a train runs past No. 3 signal in the normal manner and allows a release of approach locking should a long train stand with its rear on the approach locking tracks. To guard against a release due to an intermittent failure of 3AT track circuit, with either 3BT or 3XT due to a power outage and restoration, which will cause track circuits to drop and then pick up again, a front contact of a power off time delay relay is placed in the drop track release circuit (POJR). The POJR is wired directly across all the AC and DC supplies and does not make its front contacts until 30 seconds after the supply is restored.

Path No. 3 Stick circuit. Path No. 4

Energises the time release which allows release of the approach locking. When No. 3 panel button is pulled and providing No. 3 signal has assumed the stop position 3ALSR will energise on the pre-determined time of 120 seconds (60 seconds Shunt Routes).

The ALSR and the ALSJR relays are proved de-energised in the signal control circuit. (HR)

10.9 Releasing Switches

Releasing switches are located adjacent to the point switches and control the operation of the various ground frame releases.

The releasing switches are of the rotary switch type, coloured blue, and operate in two positions, left (normal) and right (reverse).

To release a particular releasing switch, all conflicting functions must be normalised and then the releasing lever must be turned to the reverse position. After shunting operations, have been completed and the releasing switch has been restored to normal, the release normal light will be displayed and the lever must then be turned to the normal position.

Two indication lights are associated with each releasing lever as follows :

Release Normal Light

The release normal light is adjacent to the normal position of the lever and exhibits a lunar white when the releasing switch is in the normal position. Once a release has been taken the switch can be returned to the Normal position. Until such time as the Release is put back in the field a flashing white light is displayed, this converting to a steady white light on the replacement of the release key in the Annett lock.

Release Reverse Light

The release reverse light is adjacent to the reverse position of the lever and exhibits a lunar white light when the lever is placed in the reverse position and all conflicting functions are in their normal positions.

If any conflicting points are not in the correct position when a releasing lever is turned from N to R but are otherwise free to be operated, the release reverse light will be illuminated and the points will be automatically set to the correct position.

If the points are not free the release SR relay prevents the call being stored.

If the reverse light is not displayed when a releasing lever is turned to the reverse position, this would indicate that a conflicting function may be reversed. The lever then must be restored to the normal position and other functions checked before the releasing lever is again reversed.

Release Switch

The electric release switch normal lock circuit is double switched by contacts of 101 RLR and includes any track locking or route holding requirements (in this case 17USR).

10.9.1 Lock Relays

Each electric release in an interlocking has a reverse lock relay which when energised completes the circuit to the release switch normal lock and a normal lock relay which when energised proves the release switch normal and is used in locking conflicting functions.

The release normal and reverse lock relays are interlocked with each other and operate in a similar manner to the route reverse and route normal lock relays.

Sheet N12 shows the relays for No. 102 releasing switch. Functions which lock the release 3B and 1 conditionally against 101 points are proved normal in the positive side of 102 RLR circuit, and the negative side of the circuit is closed when No. 102 release switch is placed in the reverse position to energise 102(R)R relay. In the example shown No. 102 release requires No. 101 points normal. When 102 release sets and locks 101 points normal 102SR relay is provided to ensure non-storage operation so far as 101 points is concerned.

102 NLR relay is energised when the releasing switch is normal and locked as indicated by Rel.Sw.B (NR) relay contact made and when No. 101 release lever is placed in the normal position to pick up 101 (N)R relay.

10.9.2 Release Switch NR

The Rel. Sw. NR relay detects the drop contact of the release switch normal lock and is double switched by the release switch rotary contacts in the normal position. Also included in this circuit is electrical detection of the points which are facing to running movements.

Front contacts of the Rel.Sw. NR relay are included in the UCR or HR circuits of conflicting signals, in this case No. 3(M)B together with contacts of the release NLR relay. The Rel.Sw. NR contact proves the release normal and the detection correct, the NLR contact provides protection against manipulation of the mag stick lock relays.

APPENDIX A

APPENDIX A

APPENDIX B

APPENDIX B

APPENDIX B

APPENDIX B

APPENDIX C

APPENDIX C

APPENDIX D

Australian Rail Track Corporation

**SIGNALLING
CIRCUIT DESIGN
STANDARDS**

BOOK OF

VERSION:

APPENDIX E

INPUTS TO TELEMETRY/TRAIN CONTROL SYSTEM AND OUTPUTS FROM TELEMETRY/TRAIN CONTROL SYSTEM

THE FOLLOWING INPUTS SHALL BE MADE AVAILABLE FROM THE SIGNALLING SYSTEM

- an input for each Track Circuit indicating the state of TKR.
- an input for each Track Circuit data pick up unit indicating the state of the TKR.
- an input for each Track Timer indicating the state of TJKR.
- an input for each Controlled Signal indicating the state of NGPR. (When no NGPR is provided then LSpR and/or HR with VNR shall be provided) #1.
- an input for each Controlled Signal indicating the state of ALSR.
- an input for each Controlled Signal indicating the state of RGKR. (Refer #1 NGPR).
- an input for each Controlled Signal (Main) Signal Route indicating the state of each (Main) NLR.
- an input for each Controlled Signal (Shunt) Signal Route indicating the state of each (Shunt) NLR.
- an input for each Automatic Signal indicating the state of (*HR).
- an input for each Automatic Signal indicating the state of (*VNR).
- an input for each set of Points, Catch Points and Slip Points indicating the state of NWKR.
- an input for each set of Points, Catch Points and Slip Points indicating the state of WZR.
- an input for each set of Points, Catch Points and Slip Points indicating the state of RWKR.
- an input for each set of Points indicating the state of NLR as required.
- an input for each set of Points indicating the state of RLR as required.
- an input for each Ground Frame releasing switch indicating the state of NLR.
- an input for each Ground Frame releasing switch indicating the state of RLR.
- an input for each Ground Frame releasing switch indicating the state of *NKR.
- an input for each Route (Shunt or Main) indicating the state of each RUZR.
- an input for each level crossing indicating the state of the XNR.
- an input for each level crossing indicating the state of the XR.

- an input for each intermediate trainstop indicating the state of VNR.
- an input for each intermediate trainstop indicating the state of VRR.
- an input for each designated Route or group of Routes (Shunt or Main) which can be made to auto reclear indicating the state of (A)SR.
- an input for each AC Power Supply indicating the state of Normal/Emergency Power Supply i.e. Total Power Failure - PSR.
- an input for each AC Power Supply indicating Normal Supply available.
- an input for each AC Power Supply indicating Emergency Supply available.
- an input for each AC Power Supply indicating the state of ELD KR.
- an input for each DC Power Supply (50V, 48V, 24V or 12V) indicating the state of DC Power Supply i.e. Single Channel Failure - PSKR.
- an input for each DC Power Supply (50V, 48V, 24V or 12V) indicating the state of DC Power Supply i.e. Total Power Failure - PSR.
- an input for each DC Power Supply (50V, 48V, 24V or 12V) indicating the state of ELD KR.
- inputs for Signal Lamps in the form of an indication for ECKR filament failure (possibly a group indication, indicating more than one Signal Lamp) and an indication for FCKR lamp failure (possibly a group indication indicating more than one Signal Lamp).
- an input for each Fire System indicating the state of Fire System Fail KR.
- an input for each Fire System indicating the state of Fire Alarm KR.
- an input for each Air Pressure System indicating the state of Low Air Pressure Alarm KR.
- an input for each Signalling Interlocking which can be placed into Local Control indicating the state of Remote Control.
- an input for each System area which can be placed into Local Control indicating the state of Local Control or closing.
- an input for each Direction Arrow indicating the state of UDKR.
- an input for each Direction Arrow indicating the state of DDKR.
- an input for each train ready to depart light.
- an input for each existing miscellaneous input that is presently fed to the signal box or control panel.

THE FOLLOWING OUTPUTS SHALL BE MADE AVAILABLE FOR THE SIGNALLING SYSTEM

- an output for each Controlled Signal feeding the (FM)R.
- an output for each dual Controlled Signal (Y)R.
- an output for each Signal Route (Main or Shunt) feeding the RSR.
- an output for each Finish (F)R not at a controlled signal
- alternatively if ring circuits are used in the signal interlocking an output for each Controlled Main Signal or Shunt Signal for the (F)R.
- an output for each Auto-Reclear Controlled Signal or group of signal feeding A(F)R.
- an output to cancel Auto-Reclear functions - A(FM)R (opposite sense)
- an output for each set of Points, Catch Points and Slip Points in the area of control feeding (C)R.
- an output for each set of Points, Catch Points and Slip Points in the area of control feeding (N)R.
- an output for each set of Points, Catch Points and Slip Points in the area of control feeding (R)R.
- an output for each an output for each Ground Frame releasing switch feeding (N)R.
- an output for each Ground Frame releasing switch feeding (R)R.
- an output for each emergency replacement of Automatic Signals EM.REP.
- an output to cancel each emergency replacement of Automatic Signals EM(FM)REP (opposite sense)
- an output for each maintenance call (FM) R (opposite sense)
- an output for each maintenance call (F) R
- an output for each alarm cancel
- an output for each staff release (F)
- an output for each staff cancel (T)
- an output for each reset control for any particular equipment that may be remotely reset
- an output for each controlled level crossing.
- Maintenance releases (xyz keys)
- Emergency shunt

APPENDIX F

INTERLOCKING: EVENT LOGGER REQUIREMENTS The event logger shall log the following:

INDICATIONS

All track circuits individually.

All signals ALSR, RGKR, NGPR.

All trainstops VNR, VRR

All routes NLR back contact.

All points NLR, RLR, WZR, NKR, RKR

All ground frames NLR, RLR, NKR, RKR.

All track timers TJR.

All Level Crossing XR, XNR.

Filament failures for each individual signal lamp is to be indicated. Lamp out failures for each individual signal lamp is to be indicated. All alarm and warning relays.

The status of each other signalling object that would aid in determining the sequence of events during a safety incident, or identifying the particular equipment involved in failures.

CONTROLS

Signaller push button relays.

Signaller points control switches.

Signaller ground frame release switches.

The event logger shall:

- Automatically start-up at power on.
- Check all configuration data on start-up and indicate a system fault if it is invalid.
- Continuously check that the software and real time clock are operating correctly.
- Log the date and time that the event logger starts operating or stops operating.

The state of each digital input shall be checked at least once every 0.25 seconds and logged with a input bit label name and a time and date stamp if it has changed.

The event log shall be maintained in a non volatile storage medium such as a hard disk drive.

The oldest event or oldest days log shall be automatically replaced by the next new event or the current days event log when the event log space is full. The event log shall be able to store at least the last 7 days (preferably 21 days) of logged events. The event logger shall use a IBM - compatible PC.

The following facilities shall be provided for the event logger:.

- a) Display all logged events starting from a given date and time and finishing with the most recent event. The user shall be able to pause, continue, and abort this display. The event logger must have the ability to view files on the screen without interrupting logging to the hard disk.
- b) Ability to download log files to 3½ inch 1.44Mb IBM formatted floppy disk without halting the logging function.
- c) Display time and date. The time stamps in the log shall have a resolution of 0.1 seconds.
- d) Set time and date.
- e) Ability to attach a name label to each input in the configuration data. This label on each input cannot be changed during normal operation
- f) Remote connection via dial up modem to allow downloading of log files and viewing of log files without interrupting the logging to disk.

Configurable items that can not be changed during normal operation are:

- Name and date of the permanent configuration data.
- For each digital input, its name.

HARDWARE INTERFACE

- a) The event logger shall use optically isolated digital inputs in accordance with Specification SPS 06. These inputs shall operated from a 24 volt nominal signalling power supply. Each input shall draw at least 5 mA. This is required to ensure reliable operation of the safety relay contracts.
- b) Digital inputs that monitor intermediate points in signalling circuits shall use Vital Indication Optoisolators in accordance with Specification SPS 07.

ENVIRONMENTAL

- a) The event logger shall perform as specified herein in ambient temperatures of 0 to 55 degrees Celsius and relative humidities up to 85% non-condensing.
- b) The event logger shall be protected against power supply and lightning surges.

RELIABILITY

The designed Mean Time Between Failures (MTBF) for the event logger shall be greater than 15,000 hours.