## Contents

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Foreword</td>
<td>vii</td>
</tr>
<tr>
<td>Preface</td>
<td>ix</td>
</tr>
<tr>
<td>Acknowledgements</td>
<td>xi</td>
</tr>
<tr>
<td><strong>1. Introduction</strong></td>
<td></td>
</tr>
<tr>
<td>1.1 Early beginnings</td>
<td>1</td>
</tr>
<tr>
<td>1.2 Development and diversification</td>
<td>2</td>
</tr>
<tr>
<td>1.3 The customer</td>
<td>3</td>
</tr>
<tr>
<td>1.4 The operator</td>
<td>3</td>
</tr>
<tr>
<td>1.5 Overall planning</td>
<td>4</td>
</tr>
<tr>
<td>1.6 Choice of route and level</td>
<td>5</td>
</tr>
<tr>
<td>1.7 Resources required</td>
<td>5</td>
</tr>
<tr>
<td><strong>2. Station Layout</strong></td>
<td></td>
</tr>
<tr>
<td>2.1 The customer and the design process</td>
<td>9</td>
</tr>
<tr>
<td>2.2 The need for standards</td>
<td>10</td>
</tr>
<tr>
<td>2.3 Objectives of station planning</td>
<td>11</td>
</tr>
<tr>
<td>2.4 Concept of speed and flow</td>
<td>12</td>
</tr>
<tr>
<td>2.5 Consideration of time</td>
<td>13</td>
</tr>
<tr>
<td>2.6 Planning normal operation</td>
<td>14</td>
</tr>
<tr>
<td>2.7 Demand Matrix</td>
<td>15</td>
</tr>
<tr>
<td>2.8 Capacity requirements</td>
<td>17</td>
</tr>
<tr>
<td>2.9 Ticket halls</td>
<td>18</td>
</tr>
<tr>
<td>2.10 Access and interchange</td>
<td>21</td>
</tr>
</tbody>
</table>
2.11 Stairs, escalators and lifts 22
2.12 Platforms 23
2.13 Footbridges and subways 24
2.14 Station canopies 25
2.15 Access for the disabled 25
2.16 The 'Downgraded' station 26
2.17 Planning for hazards 27
2.18 Staff accommodation 28
2.19 Designing for maintenance 28

3. Rolling Stock 31
3.1 Definition of railway rolling stock 31
3.2 Range of rolling stock 33
3.3 Evolution of steam 34
3.4 Advent of electric traction 37
3.5 Development of electric traction 39
3.6 Diesel traction 41
3.7 Evolution of wheel layout 42
3.8 Changes in locomotive maintenance 43
3.9 Carriages to modern carbodies 43
3.10 Carbody structures 46
3.11 Train performance on main line 47
3.12 Train performance on metros/light rail 47
3.13 Freight rolling stock 49
3.14 Engineering rolling stock 50
3.15 Manufacturing methods 52

4. Depots and Workshops 53
4.1 Proper maintenance of rolling stock 53
4.2 Maintenance considerations 54
4.3 Establishing a maintenance regime 54
4.4 Maintenance management 55
4.5 Balance between workshops and depots 56
4.6 Depot siting 57
4.7 Needs of the Maintainer 59
4.8 Basic requirements for depots 60
4.9 Performance indicators and audit

5. Track

5.1 Origin and development of railway track
5.2 Basic components
5.3 Track ballast
5.4 Materials for track ballast
5.5 Sleeper functions
5.6 Timber sleepers
5.7 Concrete sleepers (monobloc)
5.8 Twin block concrete sleepers
5.9 Steel sleepers
5.10 Rail fastenings
5.11 Rails
5.12 Rail wear
5.13 Desirability of removing rail joints
5.14 Introduction of track welding
5.15 Shop welding into long rails
5.16 Site welding into CWR
5.17 Rail stressing
5.18 Points, switches and crossings
5.19 Crossing design and manufacture
5.20 Points or turnouts
5.21 Driving, locking and detection
5.22 Conductor rails
5.23 Paved concrete track
5.24 Cast-in sleeper track
5.25 Floating slab track
5.26 Track installation and renewal
5.27 Day-to-day maintenance

6. Earthworks, Drainage and Fencing

6.1 Stability of earthworks
6.2 Short term considerations
6.3 Long term considerations
6.4 Slips
6.5 Detection of movement 94
6.6 Dealing with embankment slips 95
6.7 Dealing with cutting slips 97
6.8 Drainage of the track bed 98
6.9 Sand blankets 99
6.10 Side or cess drains 100
6.11 Centre drains 100
6.12 Drain cleaning 101
6.13 Ineffective drains 102
6.14 Railway fencing 102

7. Bridges and Structures 105
7.1 Early railway structures and materials 105
7.2 Modern welded steelwork 108
7.3 Reinforced concrete structures 111
7.4 Prestressed concrete 113
7.5 Bridge reconstruction 116
7.6 Brick and masonry structures 119
7.7 Examination of structures 120
7.8 Structural maintenance 122
7.9 Strength assessment 122

8. Tunnels and Tunnelling 125
8.1 History of tunnelling 125
8.2 Cut-and-cover tunnels 126
8.3 First tunnel shields 127
8.4 Modern tunnel shields 128
8.5 Differing ground conditions 129
8.6 Construction methods 129
8.7 Tunnel linings 130
8.8 Vertical and sloping shafts 132
8.9 Tunnel inspection and maintenance 133

9. Electrification 135
9.1 Electricity as a form of motive power 135
9.2 Generation of electricity 136
9.3 Railway electrification systems 136
9.4 The AC system connection of supply 138
9.5 AC feeder points 138
9.6 AC overhead equipment 139
9.7 Earthing on the AC system 140
9.8 Electrical interference 141
9.9 DC low voltage systems 141
9.10 AC power distribution for DC systems 142
9.11 DC power distribution 143
9.12 Effects of electrification 144
9.13 Inspection and maintenance 145

10. Signalling and Train Control 147
10.1 Early history of signalling 147
10.2 Modern signalling 149
10.3 Track circuits 150
10.4 Point operation, locking and detection 151
10.5 Interlocking 152
10.6 Minimum headways 153
10.7 Home and distant signals 154
10.8 Subsidiary signals 154
10.9 Two aspect colour light signalling 155
10.10 Three aspect colour light signalling 156
10.11 Four aspect colour light signalling 157
10.12 Transmission based signalling 159
10.13 Proof of safety and safety standards 160

11. Systems and Communications 163
11.1 Getting things done! 163
11.2 Human processes 164
11.3 Good feedback 164
11.4 Interface between operation and engineering 166
11.5 Interface between operation and the user 166
11.6 Railway systems pyramid 167
11.7 The railway signalling system 168
11.8 The public address system 169
11.9 Telephones and radio 170
11.10 Closed circuit TV 172
11.11 Equipment operation and maintenance 172

12. Lifts, Escalators and Pumps 175
12.1 Vertical transportation 175
12.2 Development of early lifts 175
12.3 Development of escalators 176
12.4 Passenger flows to and from escalators and/or lifts 177
12.5 Achievable flow rates for modern lifts 178
12.6 Flow rates on escalators 179
12.7 Types of escalators 180
12.8 Compact type escalator 180
12.9 Semi-compact type escalators 182
12.10 Heavy duty public service escalators 182
12.11 Typical HDPS escalator dimensions 184
12.12 Types of modern lift 184
12.13 Application of lift types 185
12.14 Safety risks and human factors 185
12.15 Inspection and maintenance 186
12.16 Pumps 186

13. Ventilation and Draught Relief 189
13.1 Is ventilation a problem on railways? 189
13.2 Movement of air 190
13.3 Deciding on exhaust or pressure 191
13.4 The ‘piston’ effect 192
13.5 Design and operation of tunnel fans 192
13.6 Smoke in tunnels 193
13.7 Draught relief 194
13.8 Maintenance and inspection of fans 195

14. Future Trends 197
14.1 Engineering ‘full circle’ 197
14.2 The trend towards broader vision 199
14.3 The trend towards local accountability 199
Contents

14.4 Increasing Information Technology 200
14.5 Improved interchange between transport modes 201
14.6 A move towards design for Maintenance 202
14.7 Trends in comfort standards 202

15. Conclusion 203
15.1 Retrospect 203
15.2 Postscript 204

Subject Index 205