



**A report of an Inquiry into the collision  
that occurred on 21 July 1991  
at Newton Junction**



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November 1992

Sir

On Sunday 21 July 1991, just before 10 pm, two suburban electric passenger trains collided violently head-on at Newton West Junction in the Scottish region of British Railways, killing both drivers and two passengers and injuring twenty-two other passengers.

I was appointed by the Secretary of State for Transport on 27 September 1991, under Section 7 of the Regulation of Railways Act 1871, to hold an Inquiry into the causes of the accident. Evidence was heard in public at the Central Hotel, Glasgow on 25-29 November 1991 and 17-21 February 1992. This is my report, together with my recommendations.

*D C T Eves*  
Deputy Director General

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**SUMMARY AND CONCLUSIONS**

1 The evening of Sunday 21 July 1991 was clear, dry and warm. Dusk was just falling when at 2156, the 2155 Newton to Glasgow train (number 2P55) driven by Driver Reginald McEwan, after leaving the Down platform at Newton Station, collided violently head-on with the 2055 Balloch to Motherwell train (2J66) driven by Driver David Scott, which was approaching Newton. The collision occurred at a combined speed of around 60 mile/h on the single track on the west side of the station, just west of No 23 Points (as shown in Figure 1 at the back of this report).

2 Sadly both drivers and two passengers, Mr Kenneth Meechan and Miss Tracey Donnachie, were killed. Twenty-two other passengers were injured, four of whom were detained in hospital until they had recovered sufficiently to return home.

3 Questions which required to be examined and answered (if possible) were:

- (a) Why did Driver McEwan start off from Newton into the path of Driver Scott's approaching train? Did he pass the starting signal at red?
- (b) Could there have been a wrong-side\* failure of the signalling? If so, did this open the integrity of the signalling system to doubt?
- (c) Was Driver McEwan misled by Signaller Dillon setting a route for his train, cancelling it when Driver Scott's late-running train approached, and failing to ensure that Driver McEwan knew that the signal had been replaced by contacting him as required by the rule book? Was there time for this to be done? If so, could this have accounted for Driver Scott's train first slowing at Signal M138 and then accelerating down the North Connecting line, as witnesses described, to meet Driver McEwan's train on the single-lead?
- (d) Could Mr Dillon have detected the impending catastrophe from information on his signalling panels showing the occupation of track circuits by trains? Would there have then been time for him to set a signal to danger in front of Driver Scott?
- (e) Could the provision of secondary devices have helped prevent or reduce the severity of such a collision?
- (f) Could the provision of Automatic Train Protection (ATP) have averted this accident?

\* Wrong-side failure: any failure of vital signalling equipment which endangers or has the potential to endanger the safe passage of trains, eg by causing a signal to display an aspect less restrictive than the proper one; or by preventing a signal from displaying a more restrictive aspect.

- (g) Had BR given sufficient attention to the risks of conflict at single-lead junctions\*, particularly when approached from a platform starting signal, in circumstances where it was known that drivers may pass signals at danger?
- (h) Why was Newton redeveloped to include single-lead junctions?
- (i) Should BR have applied to Newton the lessons of the similar accidents at Bellgrove and Hyde?
- (j) Was BR giving sufficient attention to the human factors involved in signals passed at danger (SPAD)?
- (k) Had the unreliability of the signalling affected the drivers' attitude towards the signalling?
- (l) Was driver training for remodelled layouts adequate?

4 This report addresses these issues. It concludes that on the balance of probabilities, Signal M145, the platform starting signal, was showing a red aspect when it was passed by Driver McEwan's train; that Driver Scott's train was signalled to proceed into Newton Station; that in the particular circumstances and the time available it was in reality, if not in theory, impossible to expect Signaller Dillon both to recognise the indication of impending catastrophe on his signal panels and to send radio messages to the drivers in time for them to stop their trains; and that the integrity of the signalling system at Newton was not in doubt though serious questions arise as to its local reliability and manner of installation. The safety and reliability of Solid State Interlocking (SSI) systems in general, of which the Newton system is an example, were considered at length and are not regarded as compromised.

5 That three very serious accidents have occurred in the recent past at single-lead junctions cannot be ignored. Accepting that single-track working has been a feature of railway operations since they began, and can be safely signalled on the basis of long-established principles, this report questions the total reliance that BR has placed in some higher risk situations on drivers' behaviour in observing signals, when there is a very substantial body of evidence of the number of signals passed at danger each year. In some circumstances, such as those where single-lead junctions are entered by trains leaving platforms protected only by the platform starting signal, the risks of head-on collisions are significantly higher. The accidents at Bellgrove, Hyde and Newton were similar in this respect.

\* A single-lead junction is a junction between two double-track railway lines where one line is reduced to a single track for a short distance leading up to the actual junction.

6 The Inquiry noted that after the Newton accident BR carried out a risk assessment of single-lead junctions and immediately identified ten locations, including Bellgrove, Hyde and Newton, where the risks were judged such that immediate steps were taken to provide additional protection. This action, while regrettably too late to prevent those accidents, is commended as likely in future to reduce the chances of a head-on collision at junctions following a starting signal being passed at danger (SPAD). The progress of this exercise and its methodology should be monitored closely by the Health and Safety Executive.

7 The Inquiry paid considerable attention to the human factors involved in managing health and safety on the railway. BR's action in commissioning in 1986 and since following up a major study of the causes of SPAD is welcomed. Particularly encouraging is their avowed intention now to look beyond the causes and find ways of mitigating the consequences, which have too often proved fatal for drivers and passengers of trains. ATP would have prevented the accident at Newton, and this Inquiry has reinforced the recommendations of others with regard to ATP.

8 The Inquiry also considered the effectiveness of the arrangements for emergency isolation of the traction power supply and protection of people involved after the accident; reviewed the management of the redevelopment of Newton Junction and the project management and commissioning of the signalling installation in the light of drivers' reports of malfunctions; considered the adequacy of procedures for briefing and training drivers faced with new layouts; and examined the possibilities of improved data recording. Recommendations are made wherever appropriate and are summarised at the end of the report.

## DESCRIPTION

### The trains

9 The units involved in the collision were unit No 037 (Mr McEwan's train), a Class 303 three-car electric multiple unit of late 1950's design, and unit No 203 (Mr Scott's train), a Class 314 three-car electric multiple unit dating from the late 1970s. Information about the maintenance of these trains and the damage sustained in the accident is given later in this report.

### The site

10 Newton Station lies about six and a half miles from Glasgow. It is a suburban station on the south east side of the city and was described by *Mr A Mackie, Movements Manager for ScotRail* as a focal point for services in the Strathclyde transport network, in the Lanarkshire suburban area. The station handles services on the Argyle line from the north side of Glasgow to Motherwell, and services on the Cathcart Circle lines from Glasgow Central which terminate at Newton.

11 There are two platforms, lying on two tracks known as the Up and Down Kirkhill lines. The Up direction is from Kirkhill to Newton. Just behind the station, on its north side, run the Up and Down lines of the West Coast Main Line, which carry InterCity locomotive-hauled trains, Regional Railways diesel trains from the Shotts line, suburban electric multiple-unit trains and locomotive-hauled freight trains. The Up direction is towards London.

12 There is a junction at the east, or Motherwell, end of Newton Station and another at the west, or Glasgow end. These junctions allow trains to transfer from one set of lines to another via the single South Connecting line at the Motherwell end, and the single North Connecting line at the Glasgow end. (The layout is illustrated at Figure 1.)

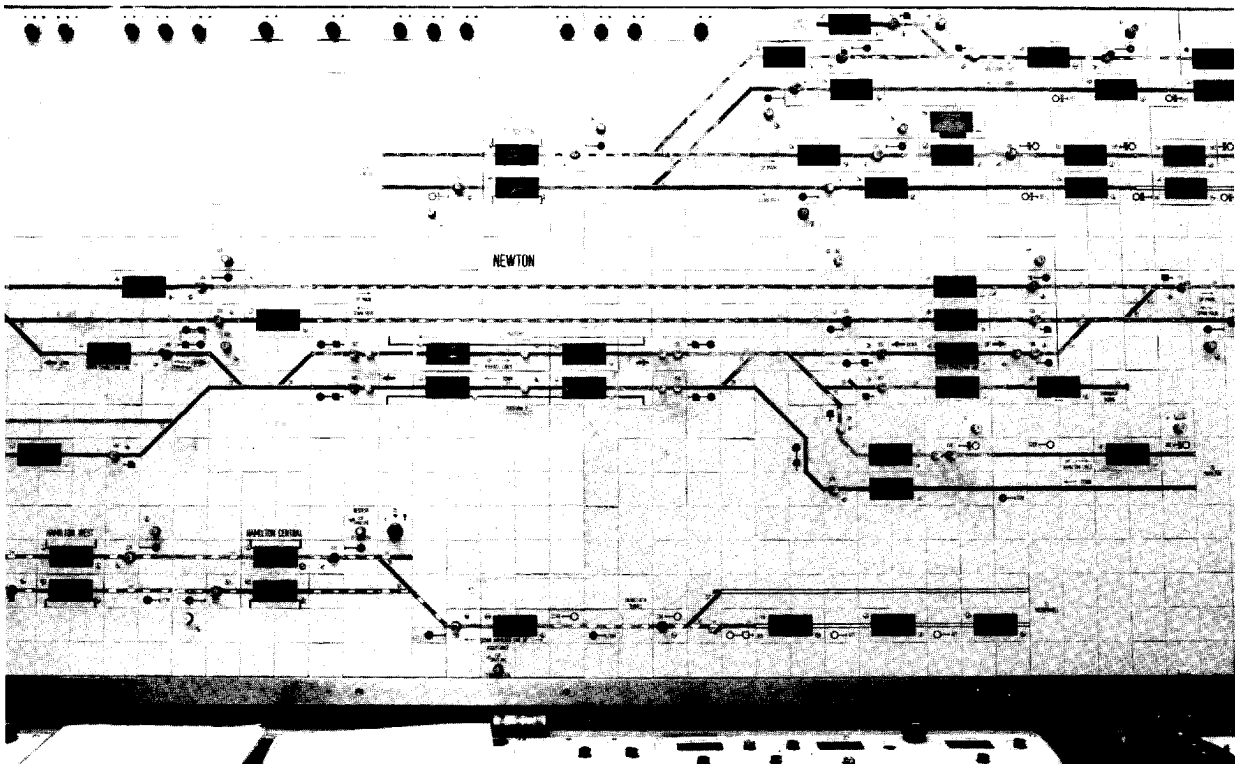
13 The layout and signalling had been substantially redeveloped and simplified not long before the accident occurred, in particular involving the introduction of single-lead junctions at the east and west ends of Newton Station instead of the previous parallel tracks. The commissioning of the new layout had taken place in two stages, Stage I on 9 June and Stage II on 23 June. It is stating the obvious, but it is clear that the head-on collision which occurred on 21 July would not have been possible under the previous double-track layout. The introduction of single-lead junctions at Newton was a major contributory factor amongst others in creating the circumstances in which this accident could occur.

14 Significantly, *Mr Simon Lane, Operations Manager of ScotRail*, stated on the second day of the Inquiry that *the double lines between the platforms at Newton and the Up and Down Kirkhill lines would be reinstated as a Stage 2 development at Newton*. This statement was well received.

### The signalling

15 Mr Mackie described the signalling in the Newton area, which is track-circuited throughout, as track circuit block consisting of three- and four-aspect colour-light signals controlled from the Signalling Centre at Motherwell, where six panel positions cover the area from Cambuslang to Gretna. The Newton area is covered by panel number one.

16 The control/indication panels are of the type which were standard on British Rail throughout the sixties and seventies. Entrance and exit buttons are pressed by the signalman at the start and end of the route he wishes to set. This action sets and locks the points and clears the signals on the route correctly if they are free to be so changed, and indicates this condition to the signalman. There are switches to operate each set of points individually if required, and an indication of the position of the points (normal or reverse) is provided by lights associated with the control switches. Should the points be in a position which does not correspond with the selected position a white 'out of correspondence' light is caused to flash. The route is indicated on the panel by a chain of white lights, and the



Signal panel display (see also Figure 5 at back of report)

signal aspects are shown red for stop or green for any proceed aspect. As the train proceeds along the set route the white lights turn to red as the track circuits are occupied. As the train advances, the signals are automatically replaced to danger behind it. The running number of each train, known as the train description, is displayed at each signal on a 4-digit display known as a berth display. The train describer system is controlled so that when a signal showing a proceed aspect is passed, the description steps forward to the next berth in the line of route, and the description and panel route lights are automatically extinguished behind the train. In the Newton area a condition for the train description stepping from a berth to the next berth is that the signal concerned must be showing a proceed aspect. Should a train pass a signal which is not displaying a proceed aspect the train description does not step forward and should remain illuminated in the berth vacated by the train.

17 The signalman is able to restore a signal to danger immediately on any route that has been set, simply by pulling up the entrance button. The route however, including the points, would be held locked for 120 seconds, during which the interlocking design prevents the movement of points or setting of a conflicting route. This feature together with the state of the train description was a significant factor in deducing the state of the signalling and points at the time of the accident.

18 The main features of the signalling systems at the time of the accident are shown in Figure 2. The buttons,

switches and lamps of the signalman's panel were connected by individual wires in a group of multicore cables to a Panel Multiplexer System in the equipment room on the ground floor of Motherwell Signalling Centre. The Panel Multiplexer equipment continuously scans the wires connected to the panel switches and converts their status, on/off, to serial data transmitted over a pair of wires to the Solid State Interlocking (SSI) central interlocking equipment located in another part of the equipment room. It also converts serial data received from the SSI into feeds to lamps on the signalman's panel.

19 The SSI implements all of the safety control and protection logic for the signalling system. Its operation is described in more detail in paragraphs 173 to 195.

20 Two SSI systems are provided to control the Newton area. Data links between the SSI central interlocking equipment and an equipment room at Newton are routed via PCM (Pulse Code Modulation) channels in the BR telecommunications network. Data are distributed from the Newton equipment room to the Trackside Functional Modules controlling points and signals via dedicated base-band local area networks.

21 The operation of the SSI system is monitored by the Technician's Terminal, which includes a data logger and a printer for fault messages. The Technician's Terminal is located in the equipment room at the Motherwell Signalling Centre.

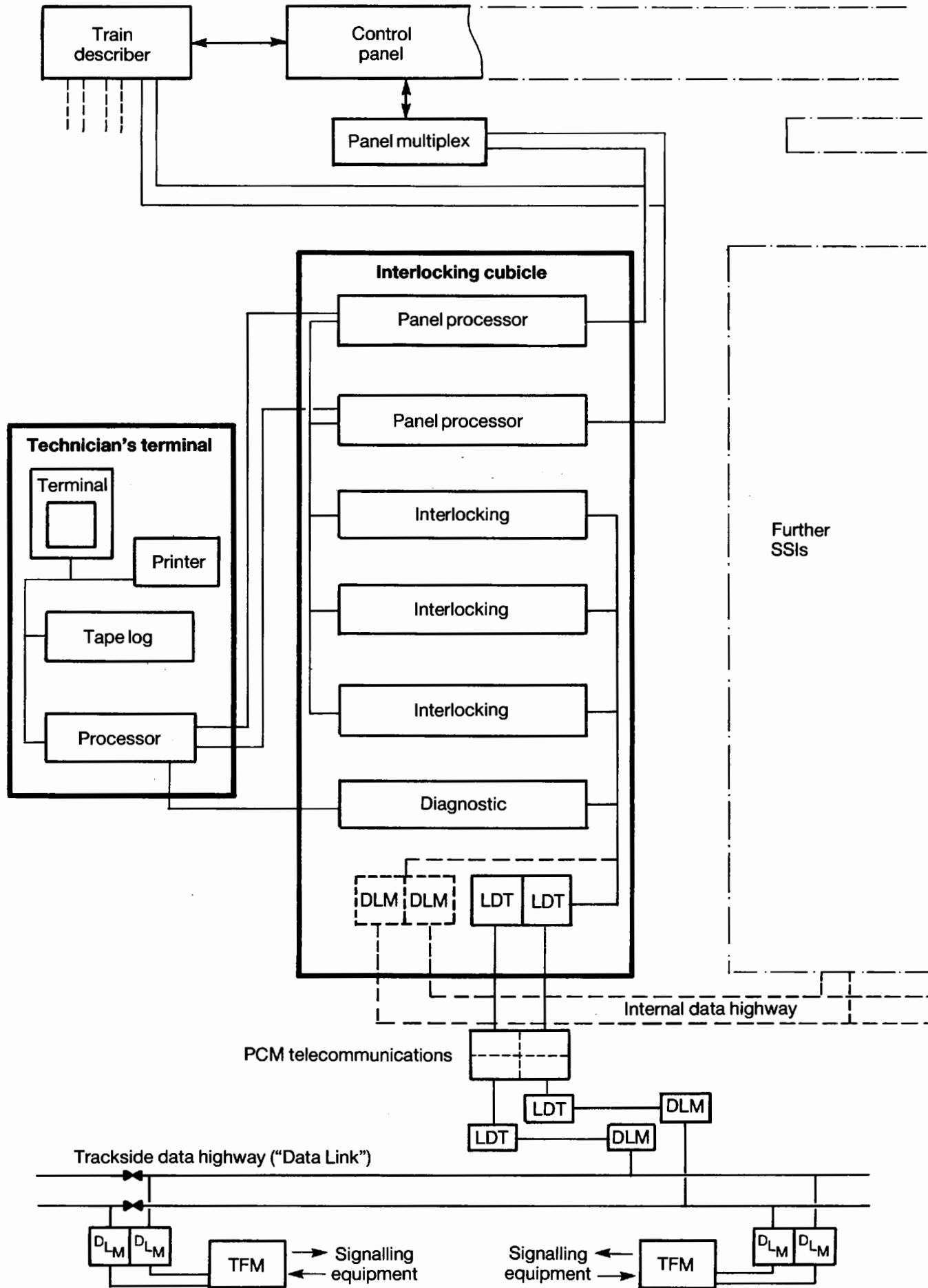


Figure 2 Principal features of the signalling system



Turnback sidings

22 The tracks in the Newton area are all electrified on the 25 Kv 50 Hz overhead catenary system, with traction current feeder stations and track sectioning cabins remotely controlled from a control room at Cathcart.

23 Drivers and signalmen may communicate with each other by using the telephones at signals or the radios provided in drivers' cabs. The radio system incorporates special features to facilitate the safe operation of driver-only trains. In order to ensure that instructions are not received by the wrong driver, the privacy of the speech link between the signalmen and the driver is guaranteed, and the train to which the signalmen is speaking is positively identified by means of a link between the train describer and radio system. The radio is required as one of the conditions for driver-only operation (DOO) of trains.

24 The performance of the signalling in the Newton area in terms of its safety and reliability is considered later in this report. Regrettably, the investigation of the accident was seriously hampered by the failure of the data logger in the Motherwell Signalling Centre to record the state of the signalling at the crucial moment.

#### The timetable

25 Mr Mackie explained that there are some 300 train movements daily through the Newton complex. During the week, services on the Cathcart Circle via Kirkhill, which terminate at Newton, are at half-hourly intervals, supplemented at peak periods by additional trains. There is also a half-hourly service from the Argyle line via the Hamilton Circle. Passengers from the Kirkhill line trains may transfer to the Hamilton Circle service at Newton to continue their journeys.

26 The pattern on Sundays is different. Every half hour, at 16 and 46 minutes past the hour, a DOO train from Glasgow Central arrives at Newton via *Kirkhill* and terminates on the Up Kirkhill platform. Passengers wishing to continue their journey may transfer from this service to a following service from *Balloch*, which then runs on to *Motherwell*.

27 Before the Balloch to Motherwell service arrives at Newton (at 20 and 50 minutes past each hour) the Kirkhill train which has terminated at Newton runs forward into a turn-back siding on the east side of the station (see Figure 1), and stops. The driver changes ends by walking through the train and then prepares for the return journey.

28 While the Kirkhill train is waiting in the turn-back siding, the *Up Balloch to Motherwell service* arrives from the West Coast Main Line via the North connecting line into the Up platform and stops. This train then leaves Newton via the South connecting line and rejoins the Main Line.

29 The *Down Motherwell to Balloch service* arrives via the South connecting line at the Down platform at 23 and 53 minutes past each hour, and stops. It then rejoins the West Coast Main Line via the North connecting line and proceeds towards Glasgow. Passengers may disembark from that train at Newton to join the Kirkhill train, which then comes out of the turn-back siding and enters the Down Kirkhill platform. This train leaves at 25 and 55 minutes past each hour for Glasgow Central, returning as it came via the Kirkhill line.

30 On Sunday 21 July four train movements were thus scheduled to occur at Newton within a nine-minute period. While this is by no means exceptional at British Rail locations, *at the time of the accident certain trains were running late, a significant factor amongst several that contributed to the circumstances of the accident.*

## EVIDENCE

### Ticket examiners, guards and passengers

31 *Mr W McKinnon, Assistant Ticket Examiner, was working on Mr McEwan's train at the time of the accident. He told the Inquiry that his duties were to sell and check tickets and to assist passengers. He had been examined on the BRB Rule Book to the extent that his duties required and passed. He said that he never operated the doors, there was no bell on a DOO train to which he had access with which to signal to the driver and he would not give any other kind of indication to a driver that a train should start.*

32 On 21 July his duty involved five or six return journeys, between Glasgow and Newton. His train was driven by Mr McEwan on three occasions, the first two of his duty and the last. He knew Mr McEwan as a workmate and considered that there was nothing unusual about his demeanour on the day of the accident.

33 All the journeys were normal, except that on the last occasion after arriving in the Up platform at Newton either on time or a little early, the train went into the turn-back siding and came back into the Down platform as soon as the driver had walked to the other end. Mr McKinnon estimated that they had been in the turnback siding for only two minutes. It was certainly the quickest turn round of the day. On other journeys they had waited several minutes in the siding until it was nearly time to depart for Glasgow, so spending very little time on the Down platform. But on this last occasion the train waited instead for three or four minutes in the Down platform before leaving.

34 He and Driver McEwan had changed ends as usual by walking through the train in the turn-back siding and Mr McKinnon remembered telling him as they passed that he had altered the destination indicator and changed over the lights for him. On the earlier journeys while his train was in the siding for perhaps five or six minutes he thought the trains to and from Motherwell had passed. On this last occasion he had no recollection of other trains passing, although he thought they could have done so without his noticing them, because he was concentrating on his cash.

35 As the train left the siding he was travelling in the rear coach, at the back. When it stopped in the Down platform he was opposite a door in the building just to the Motherwell side of the booking office door. This, he thought, would have placed the driver's cab 15 to 20 feet

from the platform starting signal (M145). The train's doors were open. He was sorting his money and had only looked out to see if any passengers were joining the train; he remembered noticing a man with a dog.

36 Mr McKinnon told the Inquiry that he had not signalled in any way to the driver and the departure was entirely normal, although perhaps a little late. Soon after leaving the platform he felt heavy braking, and knew there was something wrong. Next it was "like an explosion and we ground to a halt". He estimated that this was some 20 seconds from the time the brakes went on. Thinking there had been a derailment, he went forward to see if the passenger he had seen boarding the train was all right. He told the man, who said he felt dazed, to stay where he was while he tried to get to the driver's cab through the train. This proved impossible because of the damage so he went back, opened a door and stepped out, to realise that there had been a head-on collision with another train. Mr McKinnon saw that the guard of the other train was already using a telephone and so he helped clear a way for the emergency services and helped those passengers who were mobile out of the coaches. He had not tried to use a track circuit operating clip. He did not notice the aspect of the signal at the end of the platform, M145.

37 *Mr J McMahon, Guard of the 2044 Balloch to Motherwell train, had been a guard for 11 years and knew the Newton area well, although the journey on the train involved in the accident was only the second he had made over the junction in that direction since the resignalling. He said that when he and Driver Scott boarded the train at Dalmuir the headlight and both marker lights were illuminated. He was travelling in the rear cab. The train was running some ten minutes late and the driver telephoned him to say that there was a power fault. Later in the journey the driver telephoned at Clydebank to say that he had rectified the fault. Mr McMahon thought they had made up four minutes of the lost time on the approach to Newton.*

38 He knew that after leaving Cambuslang Station there was an automatic signal before reaching Signal M138 which protects the junction and which can be seen from a distance. He believed he could distinguish between a train being under power, coasting and braking and he felt that the train slowed down slightly approaching M138 and was coasting. He inferred from this that the signal was against the train.

39 Mr McMahon knew that the junction speed was 50 mile/h and that a temporary limit of 40 mile/h had been imposed for two years before the resignalling. He thought the train was travelling at about 30 mile/h or maybe more when it began to coast. He had assumed that the signal had cleared because the train then accelerated and he felt no braking before the shock of the collision knocked him over.



Down Kirkhill platform showing Signal M145

40 After the collision Mr McMahon tried to get to his driver. He could not get through the front coach, so he returned to the rear cab, collected his equipment and went to the telephone at Signal M146. He spoke to the signalman on the telephone and then to the supervisor, telling the latter that there had been a serious accident on the single line at Newton and that they required the over-head power supply switched off and all the emergency services immediately.

41 *Assistant Ticket Examiner J Tervet*, was on the same train. He had served on the railway only since 1 April 1991. His duties were commercial and at the time of the collision he was at the back of the train, having passed through it once and returned. He confirmed that the train was running late and that after Cambuslang it seemed to slow down and then draw power again, and carried on until the collision. He could not say where this was but made an estimate that it was two or three minutes before the collision. He looked out after the collision and saw that his guard was on the telephone and so he attended to the passengers.

42 *Driver D Slivinski* was travelling off duty on the 2055 train from Balloch as a passenger in the centre

coach with his family. He was an experienced driver with eleven years' service, based at Motherwell, and was familiar with the route and the type of EMU in which he was travelling. In the new driver training scheme he was a 'minder driver' and for this task he had undergone a week's training at the Rutherglen school. (After newly selected drivers have received their basic training they gain experience and driving practice with a minder driver from their home depot).

43 After leaving Cambuslang one of his family exclaimed that the train was slowing down. Having established where they were, he replied that they "must be waiting on the road coming off, the signal, for the junction". He was quite sure that there had been no brake application, that power was taken again and the train was still under power when the collision occurred. He was unable to estimate for how long the train had been slowing down or had taken power before the collision.

44 His understanding of the speed restrictions that applied was that before the resignalling they were 70 mile/h on the main line and 55 over the junction, and were now 80 or 90 on the main line with 50 over the junction and 40 for going into the station.

45 He mentioned that another possible reason for shutting off power in the area was the presence of a neutral section in the overhead line equipment just before the train reached the junction, although he agreed that the train had begun to slow down before it would have been necessary for the neutral section.

46 Regarding the remodelling of the Newton area, Mr Slivinski told the Inquiry that he had received and signed for a *signalling notice*\* issued to drivers with a track plan for the new layout at Newton in June 1991. He had not found this notice as easy to follow as the usual weekly or monthly notices because it was more complex but once he had seen the track and signal layout it fell into place. He was not aware of what other drivers felt about the document. He had driven over the layout in the course of three days' duties (although his duties did not include trains using the turn-back siding).

47 Mr Slivinski was "not too happy" about single lead junctions because of train speeds over them and what could go wrong. He considered that it was not a safe kind of working, because of the risk of meeting another train head-on. He referred to Barncluith Tunnel between Hamilton Central and Motherwell as a similar layout but which had catch points and a sand-drag so that a train overrunning a signal would be derailed and slowed. He said that if there had been such points at Newton the accident would not have happened. He agreed that there was a gradient approaching Barncluith Tunnel and that the layout was 20 years old and designed at a time when freight train braking was not as good as it was now, but he still appreciated the safety value.

48 *Mrs M Hanlon* was a Conductor or Guard who was acting solely as a Ticket Examiner on the day of the accident. She travelled on a DOO train driven by Driver McEwan for two round trips between Glasgow and Newton earlier in the day. She had known him for five or six years and felt she knew him quite well, describing him as "a quiet man". She met him at the start of their duty in the bothy at Glasgow Central; he seemed his usual self and he drove normally and consistently.

49 She travelled in the rear coach. The trains seemed to her to be running normally that day although she was unable to say if they were early or late. The only remarkable thing that had occurred was on the first journey; when the train arrived at Queens Park the burglar alarm was sounding. Driver McEwan had spoken on the intercom to her about this and said that he would report it at Crosshill, which he did. On the second occasion when they changed ends at Newton they chatted and she remarked on the speed with which the alterations had been carried out at Newton, because that was the first time she had seen them. Mr McEwan had agreed with her about the speed but had added that

he was worried about the "main signal" because "if the signalman gave anybody the wrong signal they would be in on top of them". She was not sure to which signal he was referring but knew that it was "down the platform end" and took it to be "the main signal for us to depart". She was sure he was concerned about an accident and not about the train being delayed, although he referred to the signalman doing something wrong.

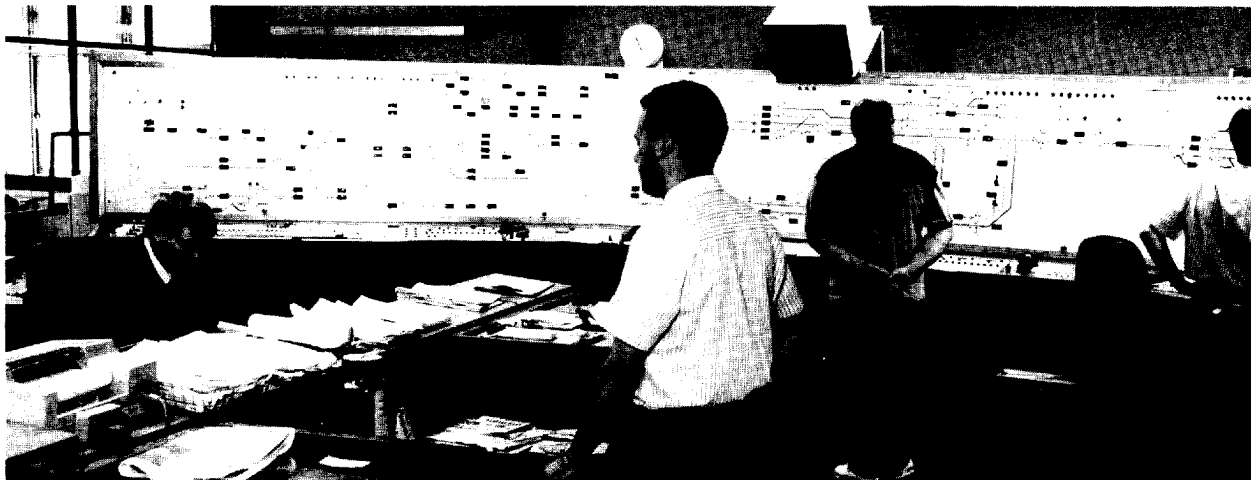
50 She was unable to say for how long they had remained in the turn-back or at either platform on the two occasions that day at Newton, although she agreed that the normal time at the platform would be no more than a minute and the majority of the time would be spent in the turn-back. Nor could she remember if any trains had passed while they were in the siding. She said that while they waited in the Down platform the doors were open and were closed just before departure. The rear of the train where she was sitting was, she thought, at the booking office door. At a station Driver McEwan tended to stand at his window. Mrs Hanlon said that she never, when working as a Ticket Examiner, gave a bell or hand signal for the train to depart nor closed the doors.

51 *Mr G Farrish* had been a driver for 34 years, the last 28 at Glasgow Central. He was on duty on both 20 and 21 July. On Sunday 21 he was booked on to do six return trips to Newton on Driver Only Operated trains of Class 303. He described the speeds approaching Newton and the procedure on arrival at Newton. He thought that on each of the four journeys he completed before the collision they could have spent 3-4 minutes in the siding, during which time the other trains would have passed, although he did not notice them. He would have stopped at the Down platform about 1 or 1½ coach lengths from Signal M145. On that day, although passing over the Automatic Warning System (AWS) magnet before coming to rest at the platform, he did not have to cancel the AWS horn because the signal was green each time. He agreed that if a driver did have to cancel the AWS a reminder existed on the AWS indicator in the cab.

52 Mr Farrish described the way in which he would bring the train from the siding to the Down platform, having first set the identity of the radio *area* into his radio equipment\* before leaving the siding. At the platform the doors would either be open or set for passenger opening and he would then set the signal *location*, M145, on the radio. He described how at the time for departure he would look out to make sure the platform was clear and that there were no passengers still boarding, check the signal, close the doors, take the brake off and apply power. He said that the Class 303 accelerated quickly and could be travelling at 35-40 mile/h by the time it reached the single line.

\* Appendix 1.

\* Described in more detail at paragraphs 289 to 295.



Signalling room indicating desks and panels

53 Mr Farrish had been on holiday for the first two weeks in July and so had only been over the new layout at Newton three or four times before the day of the accident. Asked for his comments on the layout and signalling, he said that he did not like it at all because he thought it was unsafe and unrealistic with four lines converging into the one single line. He had discussed it with colleagues and friends before the accident and they all "felt uncomfortable". Comparing it with the layout at Glasgow Central, he pointed out that speeds there were only 15 mile/h, which allowed drivers a lot more time.

54 He thought that it might have helped to have had a chance for *route learning* before driving over the new layout. (This view was strongly supported later in evidence to the Inquiry by Mr J Carrigan, a driver and ASLEF representative). All they had received was the *notice*. It was made more difficult because they were not driving through Newton while the redevelopment work was going on and so could not see the changes being made. He felt however that despite only having the notice he was able to carry out his duties competently. He recalled receiving pamphlets concerning signals passed at danger (SPAD) but he could not remember the details.

#### Characters of the drivers

55 Mr A Burns, Depot Manager, Operations, at Glasgow Central, stated that Driver McEwan was a dedicated driver with an unblemished record throughout his 43 years of service. There was no doubt about his skill and competence, and no concern over his fitness to drive, either physically or mentally. He had never passed a signal at danger. Mr Burns described Mr McEwan as a gentleman, and said that he was always clean and tidy, always at work on time and dedicated to safety.

56 Mr V Sweeney, Senior Traction Inspector at Yoker, described Driver Scott as a very conscientious and competent driver about whose driving abilities he had no

concern whatsoever. He had entered service with BR as a traction trainee in 1983, graduated to driver's assistant in that same year, and became a relief driver in 1988.

57 He had a particular interest in health and safety at work, having applied his talents as a communicator and a graphic designer to design COSHH posters.

#### Signalling staff

58 Mr George Gardiner was the *signal-box supervisor* on duty on 21 July at Motherwell Signalling Centre. He had a complement of three signalmen on duty, Mr Dillon, working panels Nos 1, 2 and 3 and two other signalmen, one working panel No 4 and 5 and the other panel No 6. Mr Gardiner's shift had commenced at 1500 and, apart from a problem that he considered to be of a minor nature at Signal M166 which could not be set to show a proceed aspect, there had been no recorded failures in the Newton area. He had not been informed of any failures when he relieved the early shift supervisor, although on previous shifts he had experienced problems associated with the train describer equipment failing to carry descriptions forward with the progress of trains. During the course of his shift problems were experienced with a remote control failure between Law Junction and Lanark Junction, which required the attention of the signalmen controlling panel Nos 4 to 6. The general train service he described as running between two and four minutes late.

59 Mr Gardiner described the position of his desk as situated centrally within a semicircle of indication panels. To observe panel No 1, which covered the Newton area, he had to swing around to his left. He witnessed the shift changeover at about 2130, when Mr Dillon relieved Mr McCormack on panel Nos 1 to 3. He explained that Mr Dillon had three panels to observe, each between 12 and 14 feet in length and each with a considerable amount of detail. However, for the traffic levels at that hour Mr Gardiner considered one man to be adequate to cover the panels.

60 It was his practice to observe the passage of trains whenever his duties allowed. When he last observed panel No 1 before the accident, train 2J65 (the Motherwell to Balloch service) was approaching the Uddingston area. He attended to other matters until his attention was drawn to panel No 1 by the sounding of alarms associated with the traction power supply and the solid state interlocking equipment for the Newton area. After collecting a pen and a piece of paper he went to panel No 1, some 12 feet distant from his desk, with the intention of noting the panel indications.

61 At this time Mr Dillon was directly in front of the supervisor's position pouring a cup of tea. Mr Gardiner described panel No 1 as still being within Mr Dillon's view and that Mr Dillon was facing the panel but he considered that his attention was not on it. He described how as he left his desk Mr Dillon was immediately behind him.

62 Mr Gardiner saw that the No 1 panel indications showed a route set for train 2J66 from the North connecting line through Newton Up platform to the Up Main Line. The signalled routes set were M146 to M156, M156 to M166 and M166 to the West Coast Main Line. He observed that all points in the line of route were indicated as correctly set and detected, with the exception of 24 points which were flashing, indicating out "of correspondence". The train description for 2J66 was in the berth display at Signal M156. The train description for train 2P55, the service from Newton to Kirkhill, was in the berth display at Signal M145. All points switches were in the route setting or centre position. He recorded the details on a piece of paper and used this to prepare his report the following day. He admitted that this paper had not been retained. However, he was certain as to the accuracy of his report which detailed the panel indications. He deduced from the indications present that train 2P55, which should have been standing at Newton Down platform, at signal M145, had moved forward.

63 Some two minutes after the alarm indications had been received a caller who identified himself as the guard of train 2J66 contacted the signal-box from a line side signal post telephone. Mr Gardiner took this call and was advised that a serious accident had occurred. He was requested to call the emergency services. He advised the emergency services by telephone and then returned to No 1 panel. He noticed that Signal M166 on the South connecting line had been returned to danger and he instructed Mr Dillon that while he was to provide protection to the area he was not to alter signalling associated with the area of the collision.

64 The electrical control room at Cathcart had contacted the signalling centre to report the tripping of overhead traction power supplies on sections MN5 and MN6. Having completed obtaining information from No 1

panel and having established contact with the emergency services, he contacted Cathcart control room, he estimated about four minutes after the accident, and requested that they did not restore power. Ten minutes after the accident he was contacted by Cathcart control room, who informed him that they intended to initiate isolation procedures associated with the overhead traction power supply. Mr Gardiner took no further part in the isolation arrangements.

65 Mr Gardiner's experience of the Sunday pattern of train movements in the Newton area was for a train from the Kirkhill lines to terminate in Newton Up platform and then run into the turn-back siding. When traffic was operating normally, movements to and from Motherwell went past through Newton Up and Down platforms. Following this, the movement to the Kirkhill lines from Newton would be signalled from the turn-back siding into the Down platform at Newton, ready to depart. *This sequence of movements normally took about nine minutes to complete.* Signalmen were not required to consult him if late running or other circumstances required the timetable pattern of movements to be altered.

66 As an experienced signalman Mr Gardiner considered that if the panel had been under observation the occupation of Track Circuit No 205 as a result of the movement of train 2P55 might have been noticed. However, the detail in the area required consideration and this might have taken some seconds. He thought his first reaction might have been that a track circuit failure had occurred and he might have waited for the berth track circuit to clear. He explained that one of the options available to a signalman observing such a situation and assuming that a signal had been passed at danger would have been the replacement of Signal M146 to danger. Any effect that this would have had on the movement of train 2J66 would have depended on its position in relation to the signal. Another option would have been to effect emergency radio communication with train 2P55. Again, this would have taken some seconds.

67 He described how if a route had been set up by the signalman and the signal had cleared then, in his experience, a signal would be returned to danger only in an emergency situation. Although the signal is returned to danger the route is held for two minutes. In those circumstances the BR Rule Book requires contact between the driver and the signalman to establish the reasons for the change before any attempt is made to set a new route. Returning a signal to danger would not affect the position of the points, which would be held until the two minute period imposed by the signalling equipment had elapsed. Mr Gardiner was able to say with certainty that Mr Dillon had not been in communication with Mr McEwan, the driver of train 2P55, concerning signals being placed to danger.

68 Mr Gardiner had heard about an incident at Signal M145 on 22 June but was not aware of the detail. (This incident involving Driver Munro is described at paragraphs 98 to 101).

69 *Mr John McCormack*, an experienced signalman, had been based at Motherwell Signalling Centre for about six and a half years and had frequently worked at No 1 panel. He described how problems had been experienced with the *train description equipment*, following the commissioning of the revised layout at Newton. The problems involved a train description being left behind by a train at an indication location (or signal berth display). This required the signalman to enter the train description into the berth to which the train had moved and then cancel the indication in the previous berth. He did not consider this to be serious as the phenomenon was well known in the signal-box and the system did not perform a safety function. He had experienced this problem at Signal M146 but not M145. He had never experienced a situation where the berth display moved ahead of the train.

70 On the day of the accident he had been rostered to work a late turn of duty which commenced at 1400. He described how during the course of his shift when he was working panel No 1, at about 2000 following an alarm from the SSI equipment, he had been unable to clear Signal M166 from the South connecting line to the Up Main Line. This fault had been reported to the signalling supervisor and the Signal and Telecommunications (S&T) Department and was rectified by 2100. He had experienced no other failures during his shift.

71 He confirmed how rail traffic in the Newton area was reduced in volume on a Sunday, and if traffic were running to time how, at hourly intervals, a series of four movements occurred over a nine-minute period just before the hour.

72 He described his usual practice as being to hold the Kirkhill train in the turn-back siding until near its scheduled departure time. Then he would clear Signal M163 to M145 and M145 to M143. This would usually result in M145 showing a proceed aspect while the driver approached it. He considered that it was the driver's responsibility to await the booked departure time. There were occasions when a proceed aspect might not be given at M145 and drivers would approach it at danger.

73 Mr McCormack described how, with a train standing at a signal with a proceed aspect, he would consider replacing the signal only in an emergency. Pulling up the route button for the signal would replace the signal aspect to red, but the signal equipment prevented points from moving and would hold the route, preventing other conflicting routes from being set, until

two minutes had passed. In these circumstances he would have to contact the driver and explain the situation to him. A cab radio facility available on terminating trains at Newton made communication with train drivers a simple procedure, as the drivers did not need to leave their train cabs to go to a telephone.

74 Although the timetable forms a guide for traffic movements he considered that unless there are specific rules to the contrary the signalman is permitted to regulate the traffic at his discretion.

75 Mr McCormack was relieved at about 2125 by Mr Dillon. He was unable to recall details of the routes set on the panel at the time of being relieved but remembered that there was nothing out of the ordinary and that trains were running within a minute or two of booked time. After a brief discussion with Mr Dillon he left the signal-box to make his way home. Although he was not booked to leave until 2200 this early relief was an accepted practice amongst signal-box staff.

76 *Mr Edward Dillon* was the signalman on duty at panel No 1 at Motherwell Signal Centre when the accident occurred. He was a relief signalman and had worked at Motherwell for about 18 months.

77 Being a relief man and required to interchange between panels, he was familiar with all the panels at Motherwell. On the day of the accident he had previously worked a night shift, which finished at 0700 on 21 July. Mr Dillon considered himself to have taken adequate rest by the time he took up duty again at about 2130. Although not rostered to commence duty until 2200 he agreed that it was practice for the relieving night shift signalman to take up duty early.

78 He relieved Mr McCormack. The changeover was described as straightforward, there being nothing to report about the situation on the indication panel. No reference was made to technical problems that had occurred earlier. He thought that two trains might have been within his area of control but was unable to recall specific details.

79 Mr Dillon was to work three panels during the shift: in addition to panel No 1 covering the Newton area, he was to operate panel Nos 2 and 3. The geographical area of the railway controlled from these panels was from Cambuslang, about three minutes running time from Newton, to the outskirts of Motherwell, about ten minutes running time from Newton. The panels at Motherwell are arranged in an arc with the supervisor's desk approximately at the focus. Panels 1, 2 and 3 form the extreme left hand segments of the arc as viewed by the supervisor. Each panel is designed so that the control switches and buttons are within the reach of a man standing immediately before the panel. Mr Dillon would thus have had to move from one panel to another

depending on the movement of trains. When seated at No 2 panel the supervisor's desk would have been about six feet behind him.

80 Mr Dillon confirmed that there were four timetabled movements through Newton booked to occur in a space of nine minutes just before 2200. Assuming trains were running to the timetable, the usual sequence of movements would be as follows: on arrival at Newton a train from Kirkhill terminated and then moved into the turnback siding. The next movement would be a Balloch to Motherwell service which approached Newton via the Up West Coast Main Line and passed through Newton Up platform before re-joining the West Coast Main Line to complete its journey to Motherwell. Following this, a movement from Motherwell approached on the Down West Coast Main Line into Newton Down platform before rejoining the Down West Coast Main Line to complete its journey to Glasgow. The final movement in the sequence would be the arrival of the Glasgow Central service via Kirkhill from the turn-back siding, which would subsequently depart for Glasgow. It was frequently the case, when trains were running to time, that Signal M145 on the Glasgow end of the Down platform at Newton would show a proceed aspect when approached by a movement from the turn-back sidings.

81 On the night of the accident trains were not running to the timetable. Mr Dillon became aware that 2J65, the Motherwell to Balloch service timetabled to depart from Newton Station towards Balloch at 2153, was running approximately ten minutes late. Train 2J66 from Balloch to Motherwell was running about two minutes late. He described one of the duties of a signalman as the regulation of trains and he told the Inquiry that he had discretion in the event of delay to run trains out of course to provide an effective service. He gave consideration to the late running Motherwell to Balloch 2J65 and the effect this would have on Mr McEwan's train 2P55. If 2P55 were held in the turn-back siding it would have been delayed about 12 minutes. After considering the effect on a 30-minute interval service, he decided to break the timetable connection with the Motherwell to Balloch service 2J65.

82 It was Mr Dillon's intention to run train 2P55 ahead of 2J65 through Newton Station. However, he was aware that 2J66, the Balloch to Motherwell service, was due to approach Newton. He told the Inquiry of his decision to signal 2P55 from the turn-back siding into Newton Down platform with the intention of holding the train at Signal M145 to await its scheduled departure time. There was no communication via the radio with the driver of 2P55, Mr McEwan, to inform him of the revised arrangements. (Mr Worrall, BR Director of Operations, pointed out in subsequent correspondence that there was no requirement for such communication in the BR rules.) With 2P55 standing in the Down platform, Mr Dillon set a through route for 2J66 from Signal M138 via

the North connecting line and Signal M146 to Signal M156 on Newton Up platform. He then set a route from Signal M156 to M166 on the South connecting line and thence to the Up West Coast Main line. At the time these routes were set 2J66 was in his area of control at Cambuslang.

83 At about this time he turned from the panels and went to a position in front of the supervisor's desk, where he poured himself a cup of tea. Mr Dillon maintained that he could still see the panels; he did not consider pouring tea a significant distraction, given that a signalman is not required to observe every movement of every one of a number of trains that he might have under his control.

84 Mr Dillon described how he had started to make his way back to the panel when he saw track circuit indications on the North connecting line merge and heard the alarms associated with the signalling equipment. He described how Cathcart and Glasgow Central signal-boxes were advised not to send further trains and how protection was applied by collaring signal buttons and applying red strips to the panel to indicate that the lines were blocked. Signal M171 was already at red for the approaching Motherwell to Balloch train 2J65. During the time that he was applying protection he was aware that the supervisor was speaking by telephone with the guard of train 2J66 about the collision. Shortly after this he was involved in a telephone discussion with the driver of train 2J65, which was now standing at Signal M171.

85 Mr Dillon was shown and asked to comment on a video of the panel indications at Newton which showed their state some hours after the accident. He was able to confirm that the contents of the video differed from the indications shown immediately following the accident as, by the time the video had been recorded (at about 0530 on 22 July), a number of engine movements had taken place to do with the recovery of undamaged rolling stock. In the absence of signalled routes these movements would have required points to be individually set by turning the point switches from a central position to the lie of the points required.

86 Mr Dillon was asked if, when the route for Mr McEwan's train 2P55 had been set from Signal M163 in the turn-back siding to Signal M145, the route from Signal M145 to M143 had been set and a proceed aspect displayed. It was suggested that having decided to release 2P55, he might have set the route from Signal M145 to M143 before realising that 2J66 was approaching and subsequently, to allow the passage of 2J66, might have replaced Signal M145 to danger. He was adamant that at no time had a route been set from Signal M145 to Signal M143.

87 Given that Driver McEwan's train 2P55 waited in the Down platform for longer than two minutes, it was suggested that it would have been possible for Signal

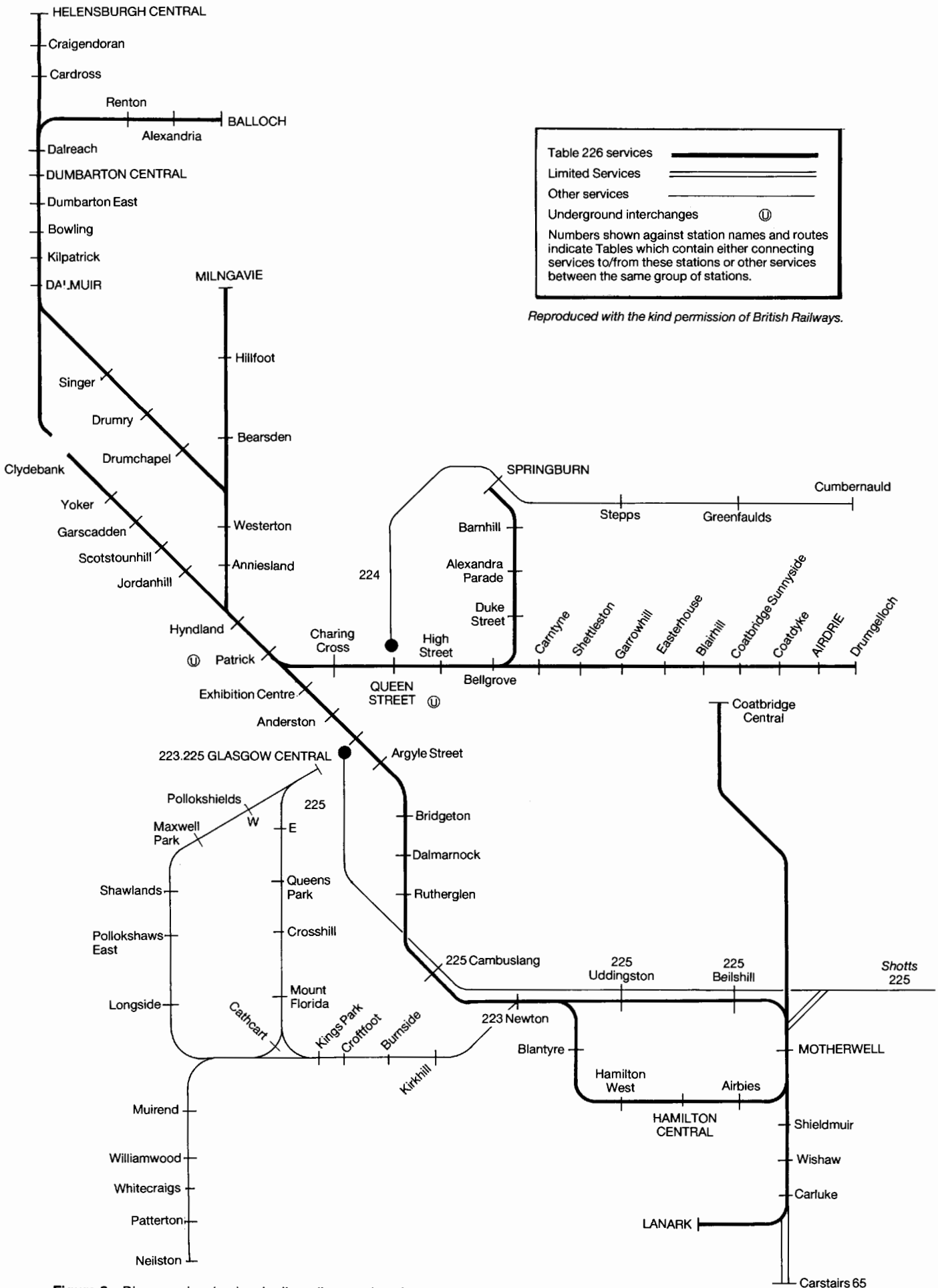


Figure 3 Diagram showing local railway lines and stations

M145 to have been at green when 2P55 entered the Down platform from the turnback siding, and to have been put back to red when Driver Scott's route was set, as the two minute lockout would have expired. That would not have been inconsistent with Mr McMahon's and Mr Slivinski's recollections of 2J66 slowing at Signal M138, if that had been before a proceed aspect was shown allowing Driver Scott to proceed down the North connecting line.

88 Mr Dillon confirmed that if a signal has been cleared and is then replaced to danger the interlocking makes it impossible to set any conflicting route until a period of two minutes has expired. However, he would have been required to make contact with the driver (to make sure that the train would not move) and he would not have set routes or moved points until he had made contact; at no time had he made contact with Mr McEwan. Setting of a route from Signal M145 to Signal M143 would set No 22 points normal; the position of the points would not then be altered by cancelling the route and No 22 points would be track-locked by Track Circuit No 169, which was occupied by the trains and collision debris. He said it would not have been possible to change the position of these points after the accident.

*Comment*

89 A calculation carried out by Mr C Law, HM Inspecting Officer of Railways, based on the available evidence of the time which train 2P55 spent in the turn-back siding, in the Down Kirkhill platform at Newton Station and of its departure (estimated from the time of the collision) confirms that time was available for a route to have been set from Signal M145 and then cancelled, and then allowing for the two minute time-out period to release the approach locking, for a route to have been set for Driver Scott's train from Signal M138 into the Up platform at Newton. Setting a route from Signal M145 to Kirkhill would have set all three sets of points, Nos 24, 23 and 22, normal. The fact that after the accident points No 24 were found reverse and run through, and No 22 were found reverse, is consistent with a route not having been set to Kirkhill.

90 The circumstances in which a signaller may observe the indications of a train passing a red signal were discussed with Mr Dillon. He considered that it was impossible for a signaller to watch all trains on the track diagrams at all times. He thought it unlikely, unless he was observing a particular train, that he would notice a track circuit becoming occupied ahead of a signal.

91 In the course of Mr Mackie's evidence (paragraphs 285 to 295) it became clear that the first indication to appear on the panel at Motherwell of Driver McEwan's train passing Signal M145 would have been the illumination of two red indicating lamps in the section of track on the single tile showing Track Circuit 205, the

Track Circuit immediately following Signal M145. The seven red indicating lamps for Track Circuit 207, the berth track circuit, would have remained alight until the rear of the train had passed the signal, and the train description, perhaps the most prominent indication of train position, would not have stepped forward.

92 However, it has been estimated from the performance characteristics of a typical Class 303 unit that Driver McEwan's train would have started to move from the platform about 32 seconds before the moment of collision. The front of the train would have passed Signal M145 about 20 seconds before the collision. Because of the response time of the signalling system, Track Circuit 205 would not be indicated as occupied until between 1 and 3 seconds after the train had passed the signal. Thus there may have been as little as 17 seconds between the time that the movement of Driver McEwan's train could have been observed by Mr Dillon and the moment of collision.

93 It has also been estimated from train performance characteristics that Driver Scott's train would have passed Signal M146 about 13 seconds before the collision. Because of the reaction time of the signalling system, and the need for Driver Scott's train to have been far enough back from the signal-box for him to see a change of aspect, Mr Dillon would have had to replace this signal to danger at least 15 seconds before the moment of collision in order to have been able to prevent or mitigate the accident. This would have required Mr Dillon to have reacted decisively in not more than 2 seconds from the first indication that Driver McEwan's train had passed the signal, which cannot realistically be regarded as humanly possible.

94 Mr Dillon described the emergency procedure for making contact with a train on the radio. This involved a keyboard operation to enter the train running number and a period awaiting response of the equipment. He estimated that the procedure would take of the order of 10 seconds. He accepted that if he had been watching that particular train and had realised what had happened it might just have been possible to take steps to contact trains or replace signals to danger.

95 If Mr Dillon had attempted to transmit an emergency radio message, the 17 seconds available would have had to encompass his own reaction time, the time needed to select the train identity on the radio system, the time to establish the call and speak to the driver, the driver's reaction time, and the time required for the train's braking system to have a significant effect on the speed of the train. It must be regarded as very doubtful as to whether anything could have been achieved to significantly mitigate the force of the collision in the time available.

96 Mr Dillon was asked to recall an incident that occurred on the 22 June 1991 when a train passed Signal M145 at danger. He confirmed that he was the signalman on duty and described how at that time the connecting lines to the main lines were not yet open to traffic and all traffic was passing by the Kirkhill lines. Mr Dillon was adamant that Signal M145 had not been cleared and therefore could not have been replaced to danger as the driver approached it, although he recalled the driver contacting him from a signal post telephone to report a signal irregularity after allegedly seeing a proceed aspect.

97 Mr Dillon told the Inquiry that he had not personally experienced problems with train descriptions failing to step forward with the passage of a train. He was aware of a problem associated with No 22 points but did not know the details. He had not experienced any technical problems with the equipment at Newton following re-commissioning of the revised layout.

#### **Incident at Signal M145 on 22 June 1991**

98 As mentioned in Signalman Dillon's evidence, there had been an incident involving Signal M145 and a DOO train just a month before the fatal accident at Newton. The matter had been the subject of a BR investigation, which found that the driver, Mr Munro, had passed Signal M145 at danger. Mr Munro refused to give evidence during the public Inquiry, as his legal advisers were concerned that he might lay himself open to prosecution. However, it was regarded as important that the Inquiry should have information about another event involving Signal M145 and a limited immunity from prosecution for the driver was obtained from the Lord Advocate on 10 March 1992. Mr Munro was accordingly interviewed by Mr E McNamee, HM Inspecting Officer of Railways, HSE, on 10 April 1992.

99 Mr Munro told Mr McNamee that he had been passed as a driver only on 15 April 1991. After joining the Glasgow Central drivers he had six-weeks route learning over the area manned from Glasgow Central, including a week on the old Newton layout, which was subsequently closed. On 2 June 1992 he received a Special Notice Permanent Way and Signal Arrangements - Newton Resignalling.\* He received no other instruction about Newton from management or minder drivers. He first drove through the Newton area on 16 June 1991 after the commissioning of Stage I on 9 June, and completed several trips that week. On Saturday 22 June 1991 (the day before the commissioning of Stage II of the resignalling) he drove a train from Glasgow Central to Newton and then waited for about ten minutes in the waiting room for a train from Motherwell, which he was to take over and drive as the 1911 Newton to Glasgow Central train. He boarded this train in the Down platform and set up the radio in the usual sequence: Area 21 (it was showing 17) train description, and 0145 signal. After

about 20 seconds, he was accepted into the system. He could not remember what the AWS indicator showed but recalled the train being half-way down the platform past the AWS magnet. He looked at Signal M145 before closing the doors and again just before leaving; he said that it was showing green, and he was convinced that it was definitely green when he left Newton Station. But he realised something was wrong when he saw No 22 points set for the Up Kirkhill instead of the Down Kirkhill line; he applied the brakes. He had also heard a noise around No 24 points but assumed this was a stone thrown at the train, a not unusual event. In fact, the point blades had been forced apart by being run through in the trailing direction.

100 The BR internal report on the incident is dated 25 June 1991. It says that Driver Munro stated when interviewed that he was sure that Signal M145 was displaying a proceed aspect, but that he then stated during questioning that he failed to observe the signal, and could not give a satisfactory reason as to why.

101 The report makes the following observation:

"After closing the doors Driver Munro carried out his setting up procedure whilst the train was on the move and therefore failed to observe the danger aspect being displayed on Signal M145, and passed said signal at danger without authority. Driver Munro became aware that something was amiss when he passed through number 24 points in a position set for the Up Kirkhill line, and stopped his train in advance of said points."

#### **The conditions of the trains**

*History of the units involved immediately prior to the accident*

102 Mr Alexander James Thompson, Fleet Maintenance Engineer at British Rail Shields Depot, described the maintenance procedure and investigation systems when faults are reported on rolling stock by drivers. He outlined a system of initial reporting via Regional Control Office, and a system of Driver Report Logs contained in the units so that supervisors in his Depot can instruct staff on the remedial action required.

103 Questioned at length on the state of the two units involved in the incident, he presented the Defects Record of both units. The Class 303 unit No 037, apart from minor problems regarding lights, pantograph and one interlock switch involved in door closing, had exhibited no major faults in the last few weeks before the incident. The Class 314 unit had accrued a series of reports of intermittent power faults which on at least one occasion had proved to be inaccurate. A brake problem on this unit had been reported on 1 July 1991: but this was a difficulty in

\* Appendix 1 Signalling Notice.



The wrecked trains at Newton

releasing the brake rather than applying it and an effective repair had been carried out at the Depot to the circuit involving the brake release. No other faults of safety significance had been reported for either unit involved in the collision in the two weeks previous to 21 July 1991.

*Testing of the remaining vehicles recovered from the accident*

104 The leading vehicles of both trains were almost completely destroyed in the collision and had to be wrenched apart for the recovery of casualties, thereby making detailed examination of the drivers' cabs and their controls almost impossible. Mr Thompson described the testing of the two vehicles from each train still in running condition after the incident. The only significant fault found was during one test with the Electro Pneumatic Brake Unit on the driving trailer taking longer to release than called for in its specification. No other significant problems were discovered during extensive tests following the collision. Only one Automatic Warning System indicator (from the Class 314 unit) had been recovered but Mr Thompson explained that the evidence displayed on an AWS indicator after a collision was not regarded as reliable, especially if the mechanism had become detached from the unit.

*The crash worthiness of the two trains involved*

105 Mr A James, Regional Railways Structures Engineer, from the Railway Technical Centre, Derby, personally examined the trains the day after the accident. He

described the mechanism of impact and the capabilities of rolling stock to withstand collisions of the severity involved in this incident. The Class 303 unit was of 'Mark 1' design with an end load capability of 200 tonnes at the buffer coupler position. The Class 314 unit had been designed to the standards agreed by the UIC for intermediate connections with 150 tonnes at the buffer coupler position, 40 tonnes at 350 mm above the coupler centre line and 30 tonnes at the waist and cantrail level. Although these figures were for intermediate connections he believed that the cab ends would have strengths of similar order built into their design.

106 With colleagues of the Research Department of British Rail, he had examined the main structural members of the two vehicles severely damaged in the collision and they had reached the conclusion that the combined impact velocity was between 55 and 69 miles/h. It was apparent from other tests regarding the closing speeds that the collision impact velocity could have been as high as 76 mile/h but in his opinion the speed quoted from their tests was more realistic.

107 Mr James explained that the difference in buffer heights between the two units was some 85 mm, thus enabling the Class 303 unit to override the buffer area of the Class 314. From his observations of the vehicles involved, it appeared that this was the mechanism of destruction during the collision. He remarked however that with the speeds involved in this case an override was inevitable, even if a difference in level had not existed.

108 Mr James referred to design considerations in plans to provide a crumple zone of one metre in the ends of coaches and at every intermediate connection to improve crash worthiness, although he felt that over the last 15 years the design practice had demonstrated that the rolling stock performed very well in accidents. This report has nothing further to say with regard to crash worthiness, as it was apparent that the investigation of the collision damage to the rolling stock involved at Newton added nothing to the conclusions of the Report\* by Sir Anthony Hidden's Inquiry into the accident at Clapham on 12 December 1988.

### Emergency isolation procedures

109 Mr George Wallace, who acted as the Incident Officer, and was the first senior ScotRail official to reach the site of the incident on 21 July 1991, told the Inquiry of his concerns with respect to the emergency services and safety procedures for the isolation of the electrical supply to the 25 Kv overhead line equipment (OLE).

110 When he arrived on site at approximately 2220 he approached the officer in charge of the fire brigade activities. Told that the power was off, according to the information this officer had received, he decided to check with the supervisor and was told that the power was off on MN5 and 6. This indicated to him that the Emergency Isolation had not been established although the British Rail 'Working Instructions for AC Electrified Lines' BR29987 clearly called for all circuits to be isolated by a message for an Emergency Isolation. Mr Wallace then made this request, although it was not possible to isolate the bare feeders running alongside the main line.

111 Isolation Diagram No SC/WCML/C/2.04† clearly shows the circuits in the Newton area. From this it can be established that the initial information supplied to the emergency services only referred to the OLE on the Up and Down Kirkhill lines, together with half the North and South connecting lines. Mr Wallace told the Inquiry that with the limited initial isolation induced voltages could present a risk to the safety of the Emergency Services personnel. Since some of the wreckage was close to the main line, the fact that the main line circuits were still energised at 25 000 volts created a major hazard during rescue operations.

112 Mr William Dorran, the Electrical Control Room (ECR) Operator at Cathcart Control on the night of the incident, told the Inquiry that at no stage in conversations with the ScotRail Control at Glasgow was he asked to provide an Emergency Isolation. He

received a request from Motherwell Signalling Centre at 2230 that Mr Wallace had asked if the power was off on the main line. Mr Dorran asked if this were a request for Emergency Isolation and as a result opened the main bus coupler at Motherwell Feeder Station, thus effectively isolating all the area around the Newton incident. The Inquiry was provided with a copy of the Control Room Log containing this information.

113 Mr Dorran explained that his action still did not isolate the bare feeders mentioned above, since this could be effected only by manual switching on site. He believed that a more effective system would be to install motorized, not hand operated, switches as appropriate to isolate similar bare feeders.

### Comment

114 The Inquiry received a de-briefing report from Strathclyde Fire Brigade which, in the Log, indicates that the officer in charge on site was informed by the Railway Control Room at 2219 that the power was isolated. This is a matter for concern since, as described above, effective isolation did not take place until 2230, some 11 minutes later. And although an Emergency Isolation had been carried out in accordance with the British Rail Rules, induced voltage from the live bare feeders alongside the main line could still have presented a problem. It would appear that the correct messages were not passed between Motherwell Signalling Centre and Cathcart Electrical Control, creating a potentially dangerous situation for rescue personnel. *The isolation of bare feeders requires further clarification and attention by BR.*

115 At the Inquiry a suggestion was made that an indication of a signal passed at danger should be made immediately apparent to the ECR operators. Since the slightest interference with the signalling system (for example, vandals damaging a signalling circuit) would, if the system were adopted, possibly result in all power being disconnected from a large area of at least 15 geographical miles (which could involve upwards of 60 miles of railway) the safety of passengers would not best be served by this system. The system at present in use relies on effective communications between signal-boxes, traffic control and electric control.

116 It is clear from the evidence of Mr Gardiner and Mr Dorran that an emergency isolation of the electric traction power supply was not at any time formally requested. The power supply was fortuitously disconnected by the action of the protective circuit breakers as a result of contact with the live overhead equipment during the impact of the crash. In the absence of positive instructions the electrical control operator decided on his own initiative to implement an emergency isolation. In any event, the isolation could not be complete.

\* Reference: Report of the Inquiry into the Collision at Clapham Junction on 12 December 1988.

† Appendix 2.

117 Recommendation 81 of Sir Anthony Hidden's Report deals with the provision of communication links to ensure that the signalman is able to take full responsibility for ensuring that the area surrounding an accident is electrically isolated. It is clear that in this case although communication links were available they were not used effectively. *It is recommended that BR should review the effectiveness of their procedures and ensure that they are strictly followed to secure protection against electrical hazards in emergencies. The procedures should ensure that all electrical hazards in the area of an emergency are identified and isolated, to avoid repetition of the exposure to live bare feeds as occurred at Newton. They should also ensure that positive confirmation of an isolation is obtained before any persons on site are allowed to approach equipment which might otherwise be live.*

118 *BR should also consider reinforcing the verbal communication between signalmen and electrical controllers with a system providing a visual indication or printed confirmation of the status of the electric traction supply.*

#### Testing of the signalling

119 The testing of the signalling system which formed part of British Rail's investigation of the accident consisted of four main phases:

- (a) Mr Waugh and Mr Carfrae examined and tested the signalling equipment on site at Newton.
- (b) Mr Cassells performed a functional test of the overall system from the signalman's panel to the lineside signals and points.
- (c) A copy of the geographical data in the interlocking at Motherwell was checked and tested on a simulator system.
- (d) The signal module controlling Signal M145 was examined and tested at the BR Technical Investigation Centre at Crewe.

120 *Mr L Waugh, Signalling Maintenance Engineer (West Coast Main Line)* is in charge of the faulting and maintenance of signalling over an area which includes the Motherwell control centre; a post he had held for three years at the time of the accident. He told the Inquiry that at about 2215 on the evening of 21 July 1991, Mr Aitchison, his assistant, telephoned him at home about an accident at Newton. Mr Waugh said that he made sure that the duty Technician Officer had been instructed to take details of the positions of the points, signals and routes, together with all other indications in the immediate vicinity of the accident from the panel at Motherwell Signal-box. Having done this, he left immediately for the Signalling Centre, arriving at about

2240. He stayed at the Control Centre for about 20 minutes, during which he checked the indications on the panel himself and arranged for a Mr McKendrick to remove the data logger tapes from the data logger and to take them to Charles Street for analysis. He told Mr McKendrick to report back on the findings as soon as possible.

121 Mr Waugh then left Motherwell for Newton. He arrived there at about 2310 and was the first Signalling Engineer on site. He deduced from what he saw on site that the two trains had met head-on and that both trains had derailed to their right in the direction of travel. He observed the state of the signalling and points on site and noted that Signal M145 was at red, Signal M146 was out since it was approach lit, and Signal M156 was at yellow with a left-hand route indication. No 24 points had been run through by the train coming from the Down platform line at Newton which had forced the points over when they had been set in the reverse direction. He looked at No 22 points on site and confirmed that they were lying reverse. He checked the sighting of Signal M145, to determine whether the view of the aspect by the driver of a train approaching it would have been obscured or whether such a driver could have been confused by other lights or any other factors in the area. He found nothing untoward in the sighting of the signal.

122 Mr Waugh said that he initiated the testing of the lineside signalling equipment to ensure that it was to an acceptable standard. He said that the cables were tested to ensure that there had been no breakdown of insulation between the wires; that there had been no connections between the power supply busbars and earth and that the wiring of the relevant location cases and the equipment fed from these cases was correct and sound. The results of these tests confirmed that the lineside signalling was sound and fault-free. He also arranged for the Signal Module which had fed Signal M145 to be removed and handed over into police custody for transport to the Technical Investigation Centre at Crewe for further examination.

123 Mr Waugh confirmed that all the old wiring had been removed before the accident although a temporary cable had been run from the location which feeds Signal M145 to the old Newton Signal-box. He explained why this cable was necessary. Prior to the recent re-signalling of Newton, the control of the area was achieved using a Remote Control System between Motherwell and Newton and Uddingston; Newton taking one half of the link which was shared with Uddingston, the remote control equipment being housed in Newton old relay room. With the re-signalling, the power supply to Newton old relay room was disconnected and while it was not necessary to maintain the Newton Remote Control System, the disconnection caused the Uddingston area to go into fault. It was found, therefore,

that it was necessary to provide a power supply to feed the old Remote Control System in the old relay room and this power was taken by temporary cable from the location.

124 Mr Waugh stated that the cable was removed on 23 July 1991. Prior to its removal, full tests were carried on the system to ensure that there were no wiring errors and that the presence of the cable did not affect the signalling. These tests were repeated after it had been removed.

125 Asked about the data logger tape, Mr Waugh said that to determine the results of the tape's initial analysis he decided to go to Charles Street and progress the analysis of the tape himself. Information on the tape showed that Signal M145 showed a proceed aspect at the known time of the accident but further analysis proved that the data on the tape had not been recorded on the day of the accident, the fault to No 24 points (loss of detection due to run through) was not identified and traffic movements were recorded for a time when it was known that all movement had stopped because of the accident.

126 Mr Waugh considered that the availability of the data logger tape was invaluable in an accident investigation exercise such as the one he was undertaking on 21/22 July 1991. He told the Inquiry that the data logger was not reliable, failing on several occasions. The tapes left for use with the system by the commissioning team were not of the correct type and the type of tape which was in use at the time of the accident was considered unreliable. Further evidence about the data logger was given by Mr Newing, see paragraphs 374 to 378.

127 Although suffering from a terminal illness, *Mr R Carfrae* attended the Inquiry to give evidence. He said that he was Maintenance Engineer (Signalling) responsible for the maintenance of signalling equipment throughout ScotRail, a post he had held for one year at the time of the accident. He had had no involvement in the Newton resignalling scheme although some of his staff may have been involved at the time of the commissioning. He had heard about the accident at approximately 2220 on 21 July 1991 from Mr Calderbank, his immediate superior, who subsequently told him that he (Mr Calderbank) would attend site and that Mr Carfrae should go to his office on the following morning, on standby. During the course of the following morning Mr Carfrae was directed by Mr Nelson, the Signal and Telecommunication Engineer, ScotRail, to go to site to relieve Mr Waugh and lead the post-accident testing. Mr Carfrae said that the testing carried out on the lineside equipment, cabling, circuitry and power supplies did not reveal anything to cause concern or which might have resulted in a wrong-side signalling failure. He further said that the indication lights on all

the Trackside Modules gave the correct indications. While he had no reason to doubt that the Newton area signalling was satisfactory, the installation had not been formally accepted by the maintenance organisation. He was aware that it had not been inspected by the Signalling Maintenance Engineer and that there was a shortfall in documentation but he said that the unreliability of the data logger and the fact that some minor work had yet to be done to satisfy the Signalling Maintenance Engineer was the basic reason behind the delay in assuming responsibility.

128 He considered the training of the maintenance staff was not adequate but stressed that the system was maintainable by using the Technical Support Team as a back-up where necessary.

129 Mr Carfrae was aware of the signalling irregularities which had occurred at Newton and said that he was satisfied that every instance of a signal irregularity had been fully investigated.

130 *Mr D Cassells* is a Testing Engineer for the Signalling Department of ScotRail with some 20 years' experience in testing work and certificated to carry out interlocking tests. On the night of the accident he was working at Airdrie. When he heard about the accident he went to Newton to offer assistance, arriving there at about 0330 on 22 July 1991. He reported to Mr Calderbank, the senior S&T officer on the site, who requested that Mr Cassells carry out an interlocking test of the Newton interlocking.

131 Mr Cassells told the Inquiry that he formed a team of Mr J Balavage, to validate the tests using the control tables, and Mr J Call, to simulate operations using the keyboard in the relay room. Mr Cassells commenced testing by doing a full correspondence check with the assistance of a person out at the site of the points and the signals he was testing. This was done by the tester going to the control room at Motherwell and turning the point switches or operating the route setting, watching the indications on the signalman's panel and checking with the man on the ground which point blade was closed and which was open or, in the case of signals, checking that the aspects of the signals shown correctly reflected the routes set and the indications on the panel. Having confirmed that there was correspondence between the panel and the outside equipment, he went on to do a full interlocking test on Signals M146 and M145, testing that points could not be moved when a route had been set over them, that conflicting routes could not be set and that the routes could not be set unless the points were unlocked and available to be set for the new route. The route holding was also tested, simulating train movement, and the approach locking was tested to ensure that a route was not released immediately a signal had been put back to red. Mr Cassells tested the system from first principles with Mr

Balavage checking the items tested and marking them off on the control tables.

132 As an additional test a train was simulated as moving from the main line, in an Up direction into the Up platform and at every change of state of trackside function an attempt was made to set Signal M145 to a proceed aspect. Mr Cassell stated that he could not fault the Newton interlocking and he was confident that the interlocking was sound.

133 Mr Cassell's testing was witnessed by *Mr R Short* and *Mr E McNamee* of HM Railway Inspectorate, HSE.

134 A copy of the SSI geographical data for Newton, the significance of which is explained by Dr Cribbens' evidence at paragraphs 196 to 200, was checked and tested in a simulator by the BR signalling design office at York. The process used was as described in paragraphs 197 to 199. The York design office was chosen as having had no previous involvement in Newton, and the tests were witnessed by *Mr C Law* of HM Railway Inspectorate, HSE. No errors or irregularities were found.

135 The copy of the data tested at York was verified as identical with the data used in the SSI equipment controlling the signalling at Newton by comparing it with the contents of a memory device (EPROM) extracted from the central interlocking cubicle at Motherwell. The comparison was witnessed by Mr Law.

136 The signal module controlling Signal M145 was taken to the BR Technical Investigation Centre at Crewe for examination and testing. Extensive tests, witnessed by *Mr Law* and *Dr A Wray* of HSE, did not reveal any fault or irregularity in the operation of the module.

137 In conclusion, thorough and comprehensive testing of the signalling system did not reveal any defects or irregularities which might have caused or contributed to the accident.

### Reliability of signalling

138 *Mr Mackie*, *Mr Waugh* and *Mr Simpson* all gave evidence that the reliability of the new signalling in the Newton area had been unsatisfactory. On a number of occasions this unreliability had led to the display of unexpected signal aspects, a cause of serious concern, especially to drivers. *Mr Brady*, *Mr Gordon* and *Mr Menzies* gave evidence of such incidents, and evidence of other incidents was taken by HMRI Inspecting Officers in the form of written statements from witnesses.

139 The continuing unreliability led to the setting up on 12 September 1991 of a technical investigation team headed by *Mr D Wells*, a Senior Applications Engineer

from the Signals and Telecommunications Department of British Railways Board, whose findings largely explained the poor performance of the signalling system, and led to severe restrictions being placed on the operation of the Newton layout pending the implementation of remedial action. Mr Wells' investigation is described at paragraphs 160 to 169.

140 *Mr Mackie* expressed considerable disappointment in the reliability of the installation at Newton compared with other recent installations of the same type. He was concerned at the large number of reports of signals reverting to more restrictive aspects in front of drivers, and also at incidents of spontaneous movements of points. He did, however, state that he was satisfied with the safety of the system.

141 *Mr Waugh* (recalled), who as Signalling Maintenance Engineer was in charge of faulting and maintenance for the area including Motherwell and Newton, said that the number of faults at Newton following commissioning was higher than he would have expected for a system of that sort. He explained that some of the failures were of a type to be expected on a new installation, such as points detection faults which could be caused by the settling of new track. He referred to the failure of SSI lineside modules as a problem, especially at Signal M166.

142 He described an incident on 25 June 1991 where *No 22 points at Newton* had moved to the opposite position to that in which the signalman had set them by means of the individual control switch on his panel. This had occurred because of a contact between two cores in an electrical cable in Motherwell relay room and a metal cover on a cable duct. The cable concerned ran from the disconnection frame in the relay room to the panel multiplexer system. Mr Waugh emphasised that the interlocking would however have prevented the movement of the points if the track over the points had been occupied or if a route had been set through the points.

143 *Driver P Brady* described an incident on 22 August 1991 when *Signal M138* changed from red to yellow and subsequently to green as he approached it. After passing this signal he found the next signal, M146, displaying a red aspect. He made an emergency brake application and reported the incident to the signalman at Motherwell, using the telephone at Signal M146. He consulted the guard on his train, who said that he had also seen a green aspect displayed by Signal M138.

144 The technical investigation of this incident was carried out by Mr Waugh, who said that he treated it as a wrong-side failure of Signal M138. He could find no defect in Signal M138 and its associated wiring. Interrogation of the data logger tape from Motherwell showed that at the time Driver Brady's train passed

M138 it was being commanded to display a yellow aspect.

145 The SSI signal module controlling M138 was sent to the BR Technical Investigation Centre at Crewe, where a comprehensive test failed to reveal any defect.

146 In another incident, *Mr I Gordon, Project Manager for the Newton Scheme*, stated that he was standing on the Down Kirkhill platform at Newton on 14 June 1991 as a train was moving from the Up Kirkhill platform to the turn-back siding when he noticed *Signal M154* change from red to single yellow for 4 or 5 seconds and then back to red again. He could not be sure whether the train was within the turn-back siding when M154 cleared, although a re-enactment of the sequence of events made two months later appeared to show that it was.

147 The signalman on duty on a relevant part of Motherwell panel at the time of that incident, *Mr S S Menzies*, denied that he had touched the controls of M154. There had been a signal technician at work replacing a lamp in the panel indication for M154, but Mr Menzies stated that he had been observing him all the time, and that the technician did not push the button to clear M154.

148 Mr Waugh had organised the testing of the signalling system following the incident reported by Mr Gordon, although due to absence on holiday he himself did not take part in the actual testing. He had been under the impression that M154 had probably been

cleared as a routine test by the technician changing the panel lamp, and so the technical investigation concentrated on establishing that M154 could not clear when it was not safe for it to do so, ie it could not have cleared before the train was inside the turn-back siding.

149 *Mr J A Simpson, Signalling Performance Engineer for ScotRail*, stated that it was his responsibility to monitor and collate reports of all signalling failures occurring in Scotland, and in addition to control the process of management of safe and wrong-side failures. He explained that signalling technicians were required to fill out fault report forms which his section collated and entered into a national computerised data base, called FRAME.

150 In addition there was a special procedure for managing wrong-side failures and dangerous incidents, summarised by the flow chart in Figure 4.

151 In a written statement to an HMRI Inspecting Officer Mr Simpson had provided a list of signalling irregularities reported for Newton from the commissioning of the new signalling up to late September 1991, which forms the basis of Table 1 of this report. The majority of the irregularities were reported by drivers, with a small number being reported by signalmen. All of the incidents had been investigated, but only four of them had been categorised as wrong-side failures to be subjected to the processes in Figure 4, including the incident at Signal M138 reported by Driver Brady and the movement of No 22 points described by Mr Waugh.

**Table 1** Signalling irregularities reported

<i>Date</i>	<i>Signal No</i>	<i>Report</i>	<i>Cause</i>
25/6		No 22 Points had moved of own accord from reverse to normal, but indicated reverse on panel.	Cable fault
25/6	M130	Signal reverted from Green to Red then back to Green as train approached.	Surge arrester faulty
30/6	M133	Signal changed from YY to Red when train 50 yards from signal. Train overshot signal by approx 3 coach lengths - signal reverted to YY.	No fault found
6/7	M146	Signal reverted from Green with route indicator to Red as train approached.	Faulty push button
8/7	G879	Signal indication changed from Single Yellow to Red then back to Single Yellow in face of train.	Slack link
8/7	G879	Driver advised signal sequence received as follows: M137-Green, M133-YY, G879 Red.	Slack link
11/7	M171	Signal indication changed from Green to YY with next signal (M159) showing Green.	No fault found
23/7	M175	Signal aspects alternating between Green and Single Yellow as train was approaching.	Suspected signalman error
24/7	M181	Signal aspects changing randomly.	37 points detection intermittent

(continued over)

27/7	M179	Signal aspect changed from Single Yellow to Green then back to Single Yellow, then Green as train was approaching.	Not reported to S & T
28/7	M156	As train approached, signal aspects changed from Green (no route indicator) to Red and then to Green with route indicator. (Signalman no knowledge of incident.)	Faulty M166 module
28/7	M156	Signal aspect changed from Green to Red and then back to Green as train approached.	Faulty M166 module
29/7	M156	While train was stationary at signal, aspects changed from Red to Green then Single Yellow	Faulty M166 module
4/8	M178	After passing AWS magnet (correct signal received), signal aspect changed from Green to Single Yellow then returned to Green.	No fault found
11/8	M156	As train approached a signal, aspects changed from Green (with route indicator) to Red, back to Green (with route indicator) then Red.	Faulty M166 module
18/8	M159	Signal displaying Red on approach. Train stopped and while Driver on telephone, signal aspects changed from Red to Single Yellow, then to YY, then Green and back to Red.	Not reported to S & T
18/8	M165	After being stopped at signal, the sub.signal cleared (with route indicator 'D'). It then returned to danger, then the main signal cleared to Green (with route indicator showing 'D').	Signalman's error
18/8	M156	As train approached the signal, aspects changed from Green (with route indicator) to Red back to Green (with route indicator).	Faulty M166 module
19/8	M133	As train approached signal displayed YY. It then changed to Red, remained so for several seconds, then changed to YY.	Not reported to S & T
22/8	M146	M146 displaying Red aspect with previous signal M138 displaying Green.	No fault found
25/8	M156	As train approached, signal aspects changed. from Green to Red before reverting back to Green	Faulty M166 module
26/8	M145	Signal reverted to danger. No apparent reason. No train involved.	Faulty push button
8/9	M156	While train stationary at signal, the aspects changed as follows (all with route indicators) - Y, YY, G, R, Y, YY, G, R, Y.	Faulty M166 module
8/9	M166	As train approached, signal reverted to danger.	Faulty M166 module
8/9	M137	As train approached, signal changed from Green to Single Yellow, then reverted to Green.	Inadvertent result of S & T test
9/9		No 19/20 Points moved of own accord.	See D Wells' report
9/9	M156	Signal aspects changed as train approached.	Faulty M166 module
10/9	M156	Driver of 2F38 reported signal displaying two White lights on H Indication (shunt to M161).	Signalman error
10/9		No 19 Points moved of own accord.	See D Wells' report
12/9	M138	Signal reverted to danger. All TCs flashed on/off	Panel multiplex fault
13/9	M170	Signal reverted to danger and M148 auto-button cancelled out.	Panel multiplex fault
13/9	M147	Signal reverted to danger as train approached.	Suspected power transient
21/9	M171	When train approximately 10 feet from signal, aspects changed from Single Yellow (with route indicator) to Red.	37 points lost detection
23/9	M171	As train approached, signal changed from Single Yellow with route indicator, to Red then reverted to Single Yellow with route indicator.	37 points lost detection

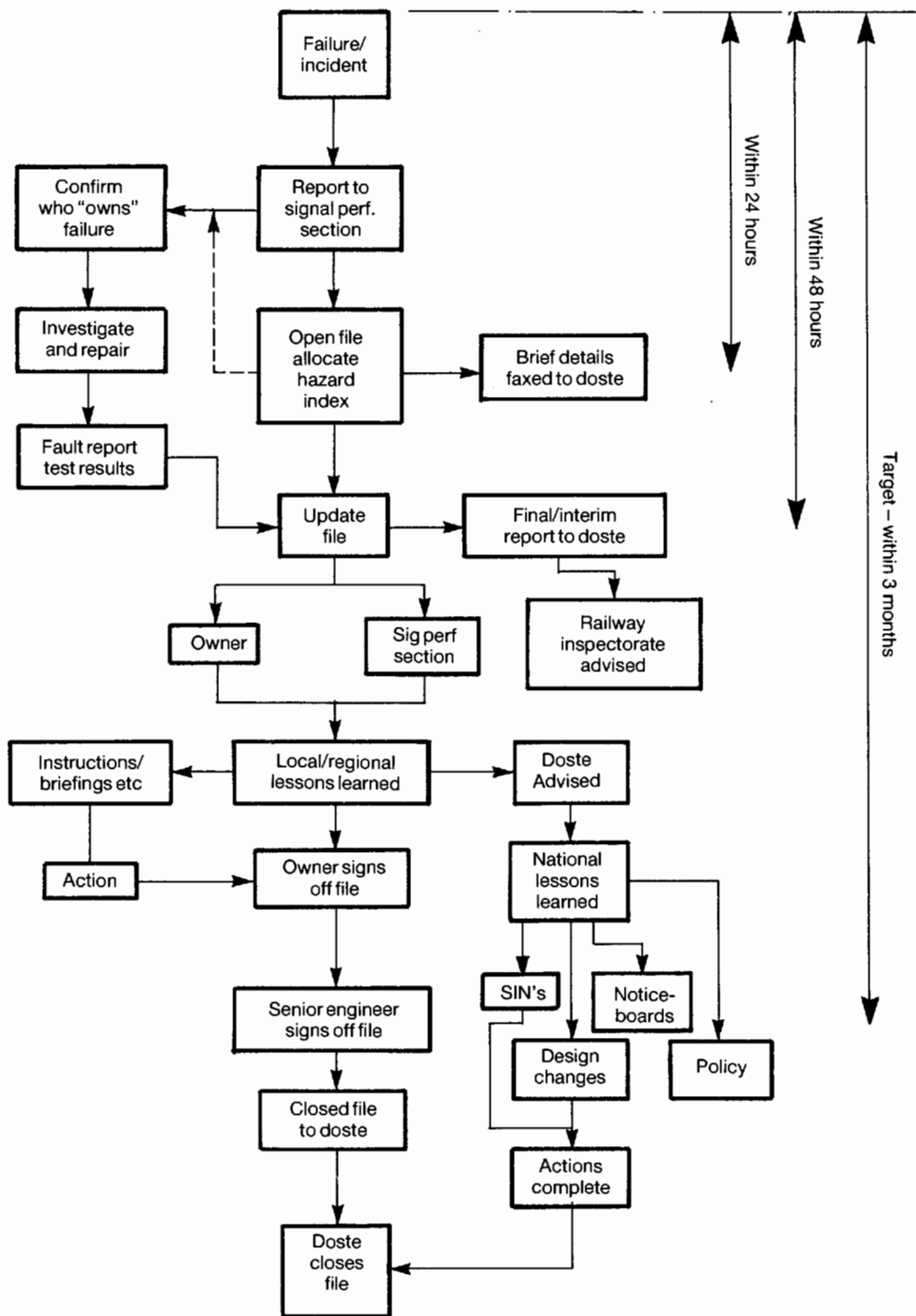


Figure 4 Process for managing wrong-side failures and dangerous incidents (Engineers Handbook H004)

152 Mr Simpson explained that a significant proportion of the incidents listed in Table 1 were due to a small number of technical defects which had each manifested themselves on several occasions before they had been correctly identified and rectified.

153 A series of failures occurred at *Signal M166* associated with problems of high initial current when the SSI module controlling the signal was required to operate in a flashing mode. Depending on the relative phases of the mains supply and the flashing cycle when a flashing signal aspect was first demanded, a larger than normal current could occur, due to the low resistance of the cold lamp filament, triggering the self-diagnostic feature of the module to force the module into its most restrictive state, ie holding the signal at red, in accordance with the fail-safe design philosophy. This caused the signals leading up to M166 to revert to correspondingly restrictive aspects.

154 As the fault occurred randomly, and was a feature of the design of the equipment rather than a failing of an individual unit, it had taken a considerable time to diagnose and rectify.

155 Another series of failures had occurred on 24 June 1991 resulting in *Signal M128* changing aspects, the changes always being to a more restrictive aspect. This was traced to a faulty line protection device which was allowing interference from the electric traction system to corrupt messages on the signalling data link, with the result that when the signal module controlling *Signal M128* could not recognise a valid message it correctly returned the signal to danger.

156 Further failures had been caused by a slack link in a lineside cable causing *Glasgow Central Signal G879* to revert to red, as a consequence of which the Newton signals leading up to it had appeared to a driver as displaying an incorrect sequence of signal aspects.

157 In addition to the driver's reports of irregularities listed in Table 1, there was a large number of failures identified from the signal technician's fault report form. Table 2, based on information prepared by Mr Simpson for Mr Wells' report (paragraph 160), shows how the performance of Newton compared with other SSI installations at the equivalent period of their life, immediately following commissioning.

158 On 10 September 1991 it was reported that *No 19 points* had moved of their own accord. Later *No's 20 and 37 points* were also reported as having moved. In each instance no trains were signalled and the points were free of interlocking controls. However, coming as the culmination of the events listed in Table 1, these failures resulted in a decision to disconnect and clamp all points in the Newton area, and Mr Wells' special investigation team was set up to get to the bottom of the irregularities.

**Table 2** Faults during first two months in use

<i>Scheme</i>	<i>SSI</i>	<i>Non SSI</i>	<i>Total</i>
Oxted	9	55	64
Dorchester	5	49	54
Millerhill	21	18	39
Tweedmouth	102	279	381
Alnmouth	62	369	431
Morpeth	62	146	208
Newton	68	78	146

Relating these failures to failures/interlocking cubicle (NB the number of interlockings are shown in brackets and the failures are expressed to nearest whole numbers).

		<i>SSI</i>	<i>Non SSI</i>	<i>Total</i>
Oxted	(1)	9	55	64
Dorchester	(1)	5	49	54
Millerhill	(1)	21	18	39
Tweedmouth	(5)	20	56	76
Alnmouth	(4)	15	92	107
Morpeth	(5)	12	29	41
Newton	(2)	34	39	73

Included in the figures for Newton are failures which may not be shown for other installations ie single causes resulting in multiple failures have been counted with the multiple failure counts. Also, telephone and other telecomms failures have been included.

159 Following Mr Wells' initial findings, further restrictions were placed on the signalling at Newton pending longer term remedial action. These restrictions comprised the cessation of use of all points except No 24 points (hand operated on the instructions of the signalman) in the Newton area, the restriction of trains to three predetermined routes, the restriction of all signals to display either a red or yellow aspect only, and a 25 mile/h speed restriction throughout the Newton area. The last two precautions were taken to minimise the consequences of any further incidents of signals reverting to danger in the face of a driver.

*Mr D Wells' investigation*

160 The technical investigation led by Mr Wells discovered a number of factors which would largely account for the poor reliability of the signalling system, and in particular the irregular signal aspects reports by drivers and the spontaneous points movements. The principal factors were:

- (a) Damaged multicore cables in the panel circuits between the signalman's panel and the multiplexer system, which converts the operation of the signalman's push buttons and switches into a serial data stream transmitted to the SSI (Solid State Interlocking) equipment. It was the contact of

a metal plate with cabling in this area that caused the incident with No 22 points described by Mr Waugh.

- (b) There were faults in the electronics of the multiplexer and the panel processor of the SSI system.
- (c) The Panel Multiplexer and SSI equipment were not installed with sufficient regard to minimising the effects of electromagnetic interference from other equipment within the relay room.

161 Any of these factors could have been the cause of false commands being transmitted to the SSI system, resulting in the movement of points or the replacement of signals to danger.

162 These defects all existed at levels in the system above the safety interlocking processors. Consequently they could not have caused a signal to clear or a set of points to move if conditions on the track made it unsafe to do so. They could, however, adversely affect safety in circumstances where safety is determined by the signalman's actions rather than by the logic of the interlocking system. Such circumstances include the setting of points as part of the protection of staff and vehicles within an engineering possession, and the replacement of automatic signals to danger.

163 As a result of the investigation at Newton, BR realised that the software of the SSI system was too ready to respond to transient erroneous commands, and has developed a modification to reduce its susceptibility in this respect.

164 Several safety related discrepancies were also discovered by Mr Wells' investigation:

- (a) A number of test certificates had not been signed, yet the master test certificate had been signed; it should not have been when individual certificates were incomplete.
- (b) A decompilation check on the SSI geographical data had been omitted.
- (c) The seals on some of the modules in the SSI cubicle at Motherwell were missing.

165 Subsequent checks established that none of these procedural omissions had actually masked any real threat to safety in this case.

166 A further possible cause of signals at Newton being randomly replaced to danger was the high error rate on some of the data transmission links between Newton and Motherwell. *Mr D Newing, Team Leader of the SSI Application Support Team of British Rail Research*, who

was a member of Mr Wells' investigation team, explained that this was due at least in part to problems of interfacing a new type of bought-in pulse code modulation (PCM) transmission card to the custom designed SSI transmission modules. It had been observed that the high error rates were occurring only in the transmission of indications from Newton to Motherwell, and not in the transmission of commands from Motherwell to Newton.

167 Mr Newing had instigated tests on the electrical power supply to the SSI equipment at Motherwell and Newton, and had seen the results of similar investigations by Scottish Power. Neither series of tests showed signs of any problem with the power supply.

168 Mr Newing had also monitored the trackside data highway at Newton which runs out from the equipment room to the trackside equipment at each signal or set of points. The error rates were observed to be very low for a system in the environment of an electrified railway.

169 Mr Wells' report also identified a shortage of maintenance documentation which prevented the maintenance staff from performing their function effectively.

*Comment*

170 While it is considered that the shortcomings in documentation did not contribute to the causes of the accident, *Mr Wells' findings give cause for concern about the management of the installation of the signalling at Newton, echoing the concern expressed in the report on the Clapham accident. It is recommended that BR give the closest attention to improving this aspect of the management of safety.*

**Integrity of signalling control system**

171 It was important to establish the integrity of the signalling system, given the remotest possibility that Driver McEwan had been the unwitting victim of a wrong-side failure at Signal M145. The Inquiry considered evidence from expert witnesses and certain equipment was later subjected to independent testing by HSE's Research and Laboratory Services Division.

172 The signals at Newton are controlled from the signalling centre at Motherwell by means of an SSI system installed during the redevelopments. Although the functional testing carried out by BR following the accident had not revealed any irregularity in this system, the nature of the technology made it necessary to consider the design principle and standards on which the system was based in order to establish whether there was any reasonable possibility that it might have contributed to the accident.

173 Dr A Cribbens, Head of the Safety Systems Unit at British Rail Research, outlined the structure and principles of operation of the SSI system and described the principal safety features which are built into it. The SSI system may be regarded as consisting of *two main sub-systems*: first, the interlocking itself, located in the Motherwell Signalling Centre. The *interlocking* is a multiple processor system which implements all the logic necessary to generate safety commands for lineside signalling equipment. Second, the *lineside data cable and trackside functional modules (TFMs)*, which comprise a local area network. This network drives signals, points, and other signalling equipment according to command telegrams generated and sent by the interlocking, and transfers information back to the interlocking from track circuits, points, and other equipment.

174 A *network* internal to the signal-box provides communication between interlockings to enable information to be exchanged relating to adjoining signalling areas.

175 Dr Cribbens explained that there are *three main functional areas of the interlocking*: the panel processors; the interlocking processors; and the diagnostic system.

176 The *panel processors* comprise a duplicated processor system which handles the non-vital functions associated with the signalman's controls and indications. The processors are *duplicated for availability*, and the system will continue to function with no loss of performance with only one panel processor operational. In the case of a BR standard NX signalling panel, the panel processors communicate over serial data links with the panel multiplexer, which provides serial-parallel conversion between the serial data and parallel feeds to and from individual lamps, and from buttons and switches on the panel.

177 The *safety interlocking functions* are performed by *three multi-processor modules (MPMs) configured as a triple modular redundant system*.

178 The processors normally operate in *triplicate*, but if one processor fails the remaining two will operate as a *duplicate redundant system* until the failed processor is replaced, when the system reverts to triplicated operation.

179 Failure of two interlocking processors would result in a complete system shut-down, as this would remove any safety redundancy to protect against a fault developing in the third processor.

180 Dr Cribbens described the *vital output* of the interlocking processors as consisting of command telegrams transmitted to the trackside data links from two of the communication processors in each MPM. The

interlocking processors take turns to transmit one telegram each, although each interlocking processor calculates the content of every telegram. For each telegram the two non-transmitting processors monitor the outgoing message, checking the validity of each bit as it is sent, and either processor can inhibit the data links immediately in the event of a disagreement.

181 The *lineside sub-system* consists of up to 63 *trackside functional modules (TFMs)* all communicating with the interlocking over the trackside data link. Each module sets its outputs to correspond to the command bits in the telegrams sent out by the interlocking, and generates a reply telegram whose indication bits correspond to the states of the input contacts connected to the module.

182 There are *two types of TFM*: signal modules and points modules.

183 The *signal module* has eight outputs and six contact sensing inputs. The outputs switch 110 V AC for driving loads such as signal lamps, junction indicators, and transformer rectifier units feeding AWS magnets. The outputs may be switched in any combination demanded by the interlocking. All but two of the outputs are isolated by the module's redundancy management circuitry in the event of a failure. The remaining two have a permanent 110 V feed connected in the event of a failure to enable the red aspect of any signals fed from the module to be retained.

184 Safety is achieved through *duplication*, so *TFMs* contain two microcomputers which check each other using strategies very similar to those used in the interlocking processors, and independently check all the other vital functions of the track side module. The two microcomputers control electronic switches called *Triacs* which themselves control the vital outputs to signal lamps, point machines and so on. These vital outputs are independently checked by the two processors to make sure they are in the correct state at all times.

185 Power is supplied to the vital outputs through a *duplicated disconnection* mechanism (which is known as '*redundancy management*') which can be activated by either processor and whose ability to do its job is periodically tested. This mechanism also ensures that the red signal lamp is lit whenever disconnection has taken place for whatever reason. Should, for example, the output controlling a yellow signal lamp become illegally driven, the fault will be detected within a small fraction of a second - typically about one eighth of a second - power will be disconnected from it, and the red lamp will be lit. The interlocking will immediately be informed and will take any necessary protective action

186 A *periodic test* also confirms that the output checking circuitry is working properly and is capable of

detecting any fault condition which would be capable of interpretation as an illuminated signal.

187 The central interlocking and TFMs are connected to the data links by *Data Link Modules (DLMs)* which provide line driving and receiving functions for the baseband data links.

188 The data links, each of which consists of a cable containing a single screened twisted pair, are duplicated for availability, as are the DLMs. Each DLM can interface to up to six TFMs.

189 Longer transmission distances can be achieved by utilising channels in a *lineside PCM system*. A *Long Distance Terminal (LDT)* is used to translate the baseband data into levels and bit rates suitable for injection into the PCM system, and to translate the output of the PCM system back into the SSI baseband data format. The PCM link is used by 'long haul' data transmission to the drop and insert node nearest to the location of the TFMs, the baseband link still being used for local data distribution. The LDT is a *fail-safe duplicated processor* module which performs additional safety checks on the data as well as translating the data format.

190 *Additional protection* is provided by adding to the data the code which uniquely identifies the control centre with which it is associated and by sending each message twice, the second time inverted, and ensuring that both of these copies of the original message match when they reach the receiving end. This additional coding protects against misrouting in telecommunication systems, and also protects against the higher error rates which can occur (but normally do not) in this type of transmission system.

191 *The diagnostic processor*, which is another MPM in the interlocking cubicle, monitors the transmissions on both data links, interprets the status bits in the reply telegrams and identifies from the absence of telegrams any TFMs which have failed to reply. This diagnostic information is passed on to the Technician's Terminal Processor which translates it into 'user friendly' messages for the Technician.

192 The diagnostic processor also recognises all changes of state of the signalling information and passes these on to the Technician's Terminal to be logged on tape. A full record of the recent activity of the system is thus available on a tape which can be interrogated off-line in the course of investigating failures or incidents.

193 The operation of panel switches and buttons by the signalman is converted into a serial data stream by the Panel Multiplexer and fed to the Panel Processor Modules (PPMs), which decide whether these constitute a valid sequence and, if so, send a panel request code to the interlocking MPMs.

194 Dr Cribbens said that each interlocking processor maintains within itself *a complete record of the state of the signalling system*, which is continuously updated both as a result of its own actions and by messages received from trackside equipment. Part of the record is copied back to the panel processors to enable them to calculate what should be shown on the panel.

195 The interlocking processors respond to requests from the panel processors by checking the availability of routes, checking whether points are free to move, and so on. The conditions to be satisfied for any panel request to be implemented are contained in the 'geographic data' with which each interlocking processor is programmed to configure it to the specific signalling layout which it controls. If all conditions are satisfied an interlocking system sends commands to the trackside equipment to move points and change signal aspects.

196 The *geographic data* are written in a specially designed language which allows the signal engineer to specify his requirements using the established naming conventions of railway signalling. In each of the modules which make up the interlocking system there is a set of software which embodies the rules for interpreting the geographic data, and this operates on the geographic data and the internal record of the state of the system in such a way as to perform all the logical functions that the signal engineer has specified within it. The signal engineer has been provided with a suite of tools to enable him to prepare this scheme-specific database, to check its correctness and to help him undertake the functional testing of it, which is part of the scheme design process.

197 The data are *derived* from the signalling scheme plan and the control tables. They are *entered* by qualified signalling engineers into a computer-based system, which is called the *SSI Design Work Station*, and *compiled* into the machine *code*, which represents the database inside the SSI interlocking and other modules. The compiled code is *decompiled*, and turned back into a *copy* of the source code which the signal engineer generated in the first instance, and an *automated check* is made that these two sets of information are equivalent. The purpose of this check is to make sure that the data compiler has not introduced any errors.

198 A *manual check* is also made that the data which the signal engineer has written conform exactly with the requirements as specified in the signalling control tables. The object of this check is to justify every statement which appears in the geographic data, so that it is ensured that there are no statements missing, and that there are no statements in the data which do not have a purpose which is reflected in the control tables.

199 The *final check* on the accuracy of the data is achieved by loading the compiled data into a *simulator*

(which is in fact, effectively, an SSI system) connected to a number of display screens which allow the signal engineer to do a full functional test of all the interlocking functions against the control tables to ensure the database correctly reflects the requirements as expressed in the control tables.

200 There are *precautions* built in to the interlocking to make sure that it cannot be unintentionally loaded with an incorrect set of data. There is a code hard-wired into the connectors within the interlocking rack, and these must match up to a version number which is part of the geographic database. There is no other part of the system which is subject to any adjustment.

201 Considering the *design philosophy* of the SSI system, Dr Cribbens explained how it had been determined that the duplicate and triplicate processor configurations achieved an adequate level of protection against processor failure. The theoretical behaviour of duplicated and triplicated systems had been analysed and found to depend critically on the mean time to detect a failure. For SSI this time is very short, of the order of one second, resulting in very high theoretical intervals between wrong-side failures.

202 Dr Cribbens emphasised that there is no such thing as absolute safety, and it is impossible to prove that any complex system, whatever the technology used, is completely and absolutely safe. The essential difference between traditional technologies and those based, as SSIs, on redundancy principles is that, in the latter case, it is possible to be numerate about the probability of unsafe failure.

203 In calculating the probability of unsafe failure of SSI the calculations are based on *four crucial assumptions* of which the first two are decidedly pessimistic; in other words, they exaggerate the calculated probability of unsafe failure. The first assumption is that any failure, if it remained undetected, would result in an unsafe malfunction of the system; that is a quite pessimistic assumption.

204 The second assumption is that, the first failure having occurred, a second failure would cause both the first failure and itself to be undetectable, or would result in the system being unable to impose the safe condition. That is an extremely pessimistic assumption.

205 The two further assumptions need to be supported by rigorous analysis of the specification and design of the system. The third is that there are no specification or design errors which might cause an unsafe failure which the redundancy built in to the system cannot detect, or deal with in a safe way.

206 The fourth and final assumption is that failures of the redundant parts of the system are assumed to be independent of one another.

207 Dr Cribbens said that SSI had been subject to the most rigorous examination of both its specification and design. Based on those assumptions the calculated risk of unsafe failure of the interlocking is about one event in seven million years. Also, based on those assumptions, the calculated probability of unsafe failure of one trackside module is about one event in twenty million years. That means that for an interlocking system with 50 trackside modules the meantime between wrong-side failures would be expected to be in the order of 400,000 years, or two chances in a million in any one year.

208 Asked about *precautions against common mode failures*, Dr Cribbens answered that the most likely cause of two processors failing simultaneously is externally originating electrical interference. It is in fact most unlikely that such interference would cause identical failures in, say, two of the three processors of an interlocking, due to differences in the routing of wiring and so on. It is also very unlikely that such failures would leave those processors working sufficiently properly to satisfy all the built in safety checks of the system. However, as an added precaution, the design arranges that the three processors of an interlocking, or the two processors of a trackside module, run slightly out of step with each other. The timing stagger is not large, but it is large enough to ensure that interference entering from outside is very unlikely to cause the same type of disturbance in both, or all three, of the processors.

209 Concerning the *design correctness of the microprocessor chips*, Dr Cribbens stated that during the early part of development, the various options for the architectural design of the system were considered very carefully, and it was decided that the design would use identical subsystems incorporating identical processors. One of the reasons why this was felt to be an acceptable decision was that the processors which were used in SSI were relatively simple compared with modern microprocessors and are used in many millions in embedded control systems throughout the world. BR therefore felt it was justified to regard them as trusted components in the sense that their behaviour had been established as correct over quite a long period of use in very large numbers.

210 Dr Cribbens confirmed that the correct behaviour of the system depended critically on the correctness of the software, which had been the subject of very careful design processes and an extremely thorough validation carried out by BR's S and T engineers during development of the system.

211 He said that BR had considered *software diversity*. He told the Inquiry that diverse software is a rather contentious subject. It is philosophically attractive because, quite clearly, errors in the latter stages of software design are likely to be independent in diversely

designed system. However, two facts argued against that approach, the first being that the design has to have a single origin which is the specification for the software. It is well known that many, if not the majority, of errors which occur in software-based systems can be traced back to the original specification.

212 The second is that a number of experiments have been carried out in academic circles with the production of diverse versions of software, and it has been discovered that diverse design teams do actually make the same errors due to making the same misunderstandings about specification, or because they have the same cultural tendency to do things in the same way. Software diversity is not therefore as powerful a technique as it might seem, and it is an extremely expensive way of designing a system.

213 It has the further disadvantage that it makes it very difficult to produce a system which is as interactive between modules as SSI and, therefore, makes it very difficult to produce a system which has the degree of cross-checking contained in the SSI system, and the very short mean time to detection of failure.

214 Two methods had been used to demonstrate that the *coding arrangements* adopted for the SSI data transmission would give *adequate protection* against the risk of a corrupted message being accepted.

215 First, a theoretical study by a coding expert on BR staff concluded that the codes which were being applied would provide a very high level of detection of errors.

216 Secondly, the transmission system was tested at two sites: one was in a 25 kv AC electrified environment, which was chosen as being particularly bad from an electrical interference point of view, and the other was in a 750 V DC environment. The total duration of the tests was six years at both sites and, with no cable faults, in no case was the first level of coding defeated throughout that period.

217 The test system was operated for a period of about one month with a very severe cable fault deliberately applied. In that case, and only in the 750 V DC environment, the first level of coding - the Manchester coding - was defeated on two occasions. The second level of coding was never defeated.

218 BR had deduced from these results that the probability of the message being undetectably corrupted, even under the severe fault conditions, is about 1 in 10 to the power minus 26, which equates to once in about 10 to the power 14 years, or about 10 000 times the age of the universe.

219 Asked to consider the *possibility of a malfunction of the signal module controlling Signal M145* due to

interference from electric traction currents, Dr Cribbens pointed out that electromagnetic interference levels at Newton are comparatively low and, certainly, very much less than have been experienced at certain other sites where SSI is installed. It is known that very high levels can cause malfunction, but the module is extremely well protected, from a safety point of view, against these malfunctions. Four possible scenarios should be considered.

220 The first possibility is that interference causes an output to be energised for a very short time. This may or may not be detected within the module. It will not be sufficient to illuminate the signal lamp, and if it is detected within the module it is part of the module's fault tolerance that it will not do anything about it unless it persists.

221 Secondly, an output circuit might be damaged by electrical interference such that it becomes falsely energised; in this case, the fault is detected and the signal restored to red within a short time (150 milliseconds) and the fault is reported to the control centre.

222 The third possibility is that one of the two processors is disrupted. The response to this would be that the other processor would enforce an orderly, safe shutdown of the whole module. In addition to that, the disrupted processor is extremely unlikely to be capable of generating the coded signals which maintain power to the vital outputs, in which case it will also, by default, act to enforce safe output conditions. The output protection mechanism relies on the emission of special coded signals from both processors to keep it alive. If either of those ceases to be emitted it will enforce the safe shutdown condition.

223 The fourth scenario is that both processors are disrupted and, in this case, the output protection mechanism (which requires these coded signals from both processors) will operate within 140 milliseconds and disconnect all outputs except the ones connected to the most restrictive aspects.

224 Subsequent to the hearing of evidence in public, *Dr A M Wray*, of HSE's Research and Laboratory Services Division, carried out *tests on the signal module which had been controlling Signal M145* at the time of the accident. His report\* concludes that a wide range of interference tests, some at levels far exceeding those expected in practice, did not cause any observable effect that could have resulted in a wrong-side failure. In his opinion it is very unlikely that the signal would have displayed a wrong aspect as a result of electrical interference affecting the signal module.

\* Available from HSE.

225 As pointed out by Dr Cribbens, the *correctness* of the SSI software is crucial to the safety of the signalling system. Consequently HSE had retained *Dr P Bennett, Managing Director of the Centre for Software Engineering*, as an independent expert to assess the software design and development process used by BR. Dr Bennett advises various international standards bodies on the subject of safety critical systems, as well as being Chairman of the Institution of Electrical Engineers Safety Critical Systems Committee.

226 Dr Bennett and his colleague *Dr Finney* had held discussions with BR Research, the designers of SSI, BR Signal and Telecommunications, the evaluators and users of SSI, and Westinghouse Brake & Signal Company and GEC Alsthom Signalling, the manufacturers of SSI. He examined their approach and methods both in relation to what would have been good practice at the time that the system was developed and in relation to what would be good practice today given the development of standards that is taking place.

227 Dr Bennett explained that the validation process which took place in the late 1970s and early 1980s was based on the work of Prof Carré, which was an approach as good as any in common use in engineering at that time.

228 Dr Bennett had some reservations about the relatively loose way in which a formal life-cycle had been followed, and about the lack of formality in formulating system requirements. He also noted that the design and validation teams were not fully independent in that they both belonged to the same parent organisation, albeit from different departments of BR.

229 In relation to the organisation of the project, Dr Bennett said that the SSI development benefited from the advantage, unusual for a software development, of having a core team of people who were associated with the conception of the underlying ideas in the mid-1970s right up to the present time.

230 It had the further advantage that the parties collaborating in the development had distinct individual self-interests and so provided a diverse forum for assessment of the progress of the project, with the result that the exchange of information and review comment was open and effective.

231 In his written report\* to HSE, Dr Bennett concludes that:

"The SSI project has probably had the greatest amount of detailed scrutiny of the safety implications of the software before introduction than most projects being introduced at this time in

\* Available from HSE.

other industries. The technology is based upon an eight bit processor and the exhaustive examination approach which was undertaken was feasible where it may not have been with a more complex system and processor."

232 The report goes on to say:

"The probability of a signalling failure from SSI in a simple scheme such as Newton is very low, given the duration of the project, the continuity of personnel, the tools provided, and the operational experience of the system to date on other installations."

#### *Comment*

233 The relevance of the evidence on the safety of the signalling system to establishing the cause of the accident can be demonstrated by six crucial questions. These are set out below, with answers derived from the evidence set out in paragraphs 189 to 218 as well as some additional material.

*Question 1:* Could faults in the signalman's panel or panel interface have caused Signal M145 to falsely present a proceed aspect?

234 Dr Cribbens explained that one of the primary functions of the interlocking is to prevent any malfunction of the signalman's panel or panel interface causing unsafe behaviour of signals, points, or any other vital signalling equipment. Only valid panel requests are accepted by the interlocking, and these will be acted upon only if they do not conflict with routes already set and the state of track occupancy, and if all other conditions specified for that action in the interlocking data are satisfied.

*Question 2:* Could the central interlocking have generated a command to clear Signal M145 when an opposing move was taking place?

235 Mr Cassells gave evidence of the testing following the accident, when the interlocking functioned correctly and would not allow any opposing moves to be signalled.

236 A subsequent check of the geographical data, witnessed by *Mr C Law* of HM Railway Inspectorate, confirmed that there were no errors of logic not revealed by the on-site tests.

237 The malfunction of the data logger which resulted in a failure to record the behaviour of the system at the time of the accident should not be regarded as symptomatic of a defect in the interlocking itself. The data logger is part of a diagnostic system which is unable to influence the behaviour of the interlocking as it is only a passive receiver of vital data.

238 Dr Cribbens explained that a malfunction of the interlocking processors on the night of the accident was highly improbable, and Dr Bennett confirmed that the software design and development processes applied to the SSI system made the probability of a malfunction of the interlocking software very low.

*Question 3:* Could the command telegrams from the interlocking have been corrupted during transmission over the vital data link so as to produce a false command to clear Signal M145?

239 Dr Cribbens showed that the probability of the error detecting coding being defeated was extremely remote, even in the event of transmission line faults which introduce high levels of electrical interference. Mr Newing gave evidence that in fact the observed error rates on the trackside data links were very low.

240 Mr Newing had observed high error rates on the PCM data link between Newton and Motherwell. This was occurring only in the direction of transmission from Newton to Motherwell, and therefore was not relevant to the possible receipt of a corrupt message by trackside equipment. Dr Cribbens emphasised that in this case the relatively poor performance was the result of the long distance terminals rejecting pairs of PCM messages which did not match, thus representing the correct operation of yet another level of security coding.

*Question 4:* Could the signal module controlling Signal M145 have spontaneously set a proceed aspect on the signal?

241 The module was removed and tested at the BR Technical Investigation Centre, Crewe, the tests being witnessed by Mr Law and Dr Wray. No faults or irregularities were found.

242 Dr Cribbens' and Dr Bennett's remarks on the integrity of the system, quoted under Question 2, are equally applicable here.

243 Dr Cribbens emphasised how well the vital outputs are protected against false energisation. Even under permanent fault conditions an illegally driven output would be removed within an absolute maximum of 190 milliseconds. Assuming the signal was supposed to be red at the time, the red lamp would remain lit both during and after the fault.

*Question 5:* Could a fault in Signal M145 itself or its associated wiring have caused a false proceed aspect to be displayed?

244 The evidence of Mr Waugh and Mr Carfrae showed that no fault had been found when the signal and wiring were tested.

245 Dr Cribbens pointed out that for the wrong signal lamp to be lit in isolation would require a double fault in the external wiring. In other words, it would need a proceed aspect output connected to the red lamp, and red output connected to a proceed aspect. This seems an incredible situation bearing in mind the installation was shown to be correct. A single fault such as a short circuit between the red output and the proceed aspect, or any other source of current and the proceed aspect, would be detected by the module, which would disable its output interfaces very rapidly and force the red lamp to be lit, even if it could not prevent the proceed aspect from being lit. This would be immediately reported to the control centre, and would appear as a fault printout. No such printout was recorded.

*Question 6:* Could electromagnetic interference have caused the system to malfunction in an unsafe manner?

246 Dr Cribbens' evidence explained what would be the effect of severe electromagnetic interference on the SSI equipment. This was supported by Dr Wray's tests.

247 *Mr Newing*, in his evidence on *Mr Wells'* report, referred to experience of an earlier SSI scheme at Liverpool Street in London where severe problems of electrical noise had been encountered due to local circumstances. It had manifested itself as modules reverting to their 'red retaining' states. In this way fail-safe behaviour was maintained in spite of the presence of interference pulses of several thousand volts.

#### **Management of signalling safety and reliability**

248 During the design, installation, testing and commissioning phases of the Newton resignalling scheme the safety and reliability of the final product was the responsibility of the Signalling Works organisation, a part of the Department headed by *Mr K Burrage*, Director of Signal and Telecommunications Engineering for the British Railways Board. The work was carried out by the Glasgow Signalling Projects Office, headed by *Mr A Pinkstone*, Signal Engineer (Works) for Glasgow. The engineer on his staff responsible for the Newton scheme was *Mr R Genner*, Signal Engineer (Projects), who was in charge of the project-engineering and design group and was thus responsible for project engineering and overseeing the design of signalling schemes allocated to the Glasgow office from all parts of Britain.

249 Upon commissioning, maintenance of the safety and reliability of the signalling at Newton became the responsibility of *Mr R Nelson*, Signalling and Telecommunications Engineer for ScotRail. Mr Waugh and Mr Simpson (see the section on reliability of signalling) are members of his organisation.

250 Mr Genner explained that the Newton scheme was managed in accordance with the BR investment

regulations by a project manager, Mr I Gordon, assisted by a project team to which each of the interested departments nominate members. Mr Genner was nominated as the S & T project engineer on the team at the point where his part of the organisation was required to start implementing the signalling contribution to the project.

251 Prior to this, it had been the responsibility of a scheme development engineer to see it through the final stages of multi-option development. This is when engineers from various departments and representatives of business sectors look at a scheme and evaluate the various options that are available and determine which option to develop to its final implementation.

252 Mr Genner said that design work had started in December 1989 and that work had progressed to the point where, in early 1990, most of the equipment had been installed and tested by the manufacturers on site when the project was halted while the lessons of the Bellgrove and Clapham accidents were absorbed.

253 When work recommenced in February 1991 it was decided to restart the testing procedure from the beginning to take account of the revised standards and practices which had been introduced to comply with Sir Anthony Hidden's recommendations. The scheme was tested to Issue 1 of the Signalling Works Testing Handbook, which was issued in early 1991. This was in fact the first scheme that Mr Genner's team had tested to this newly-issued standard.

254 It may be recalled that neither the thorough testing carried out immediately after the accident nor Mr Wells' technical investigation revealed any defect which might have caused the accident, or any defect at all in the basic safety-critical signalling systems. This confirms that Mr Genner and his team substantially implemented what the BR standards perceived as a safe system, and that the signalling installation and testing did not contribute to the accident.

255 However, there were serious deficiencies reported by Mr Wells. With regard to the signing of test certificates (paragraph 164), Mr Genner said that there were a few omissions from the testing plan at the time of commissioning. At 0500 on the Monday morning before the final commissioning the tester in charge obtained oral assurance that the outstanding tests had been completed, but that the individuals had not been able to return to the central point to sign the certificate. As the omissions were minor and of a non-safety related nature, he took the decision, subsequently endorsed by Mr Genner, to let the commissioning proceed, rather than leave the railway to be operated under emergency procedures without the protection of the signalling system. *It is recommended that where contingencies*



Damaged wiring, Motherwell Signalling Centre

*arise such that the person in charge of commissioning judges it appropriate to proceed on the basis of incomplete test certificates, he must record the deficiencies on the master test certificate, and record his reasons for so doing.*

256 Asked about the damaged multicore cables at the Motherwell Signalling Centre (paragraph 160(a)), Mr Genner stated that the installation staff had reported difficulties in terminating these cables. The type of cables and the allocation of functions to individual wires within them made it impossible to terminate them to a satisfactory standard in the Motherwell equipment room. It was concluded that the testing had indicated that the wiring was correctly terminated. As it was on what BR call the non-vital side of the interlocking, it was decided that there was no reason to halt or postpone the commissioning. It was decided that the cable terminations should be re-engineered subsequent to the commissioning, and the preliminary design work had started but had been set aside following the accident. Mr Genner believed that the damage to the cable sheaths which was observed before commissioning was superficial, and he considered that the very poor appearance of the wiring as shown to the inquiry in a video was due to its having been disturbed in the course of investigating the movement of No 22 points described earlier.

257 The electronic system faults reported by Mr Wells (paragraph 160(b)) were identified only by the special

skills and testing equipment of his investigation team. It would appear that the normal precommissioning tests, even to the latest standards, were not capable of identifying such faults. Although in a part of the system classified by BR as non-vital, these faults could affect safety-related functions such as emergency replacement of signals or holding of points to protect engineering possessions. They are also likely to have been responsible for much of the unreliability which was a cause of concern to drivers and public. *It is recommended that BR should ensure that its testing techniques and commissioning procedures are appropriate to the technology of the systems being installed and are capable of giving an adequate level of confidence in the integrity and reliability of those systems.*

258 *It is also recommended that BR identify all safety-related functions in any signalling scheme, including those implemented in non-vital or non-fail-safe parts of the system, and ensure that appropriate standards of integrity are applied at all stages of the pre-commissioning and the system life cycle.*

259 Questioned about responsibilities for safety, Mr Genner said that at the time the Newton project was being implemented no one had overall responsibility. He explained that each and every member of the project team had responsibility for safety within his own department, and that any issues having application to or requiring action from other departments would be raised at the regular project meetings. He described the safety plan which his department prepared for the commissioning and broadcast throughout the project team.

*Comment*

260 This plan was concerned only with safety at work of railway staff. The safe operation of the system that was being installed seems never to have been in question. Both Mr Genner and Mr Nelson emphasised that safety was central to the design, testing and commissioning activities. However, in spite of the existence of a project management team, safety appears to have been dealt with piecemeal by each department. *The identification of hazards such as single lead junctions in relation to signals passed at danger requires a system-wide view of safety. The duties of a project manager should include ensuring that a co-ordinated approach to ensuring the safety of the system to be produced, is taken by all departments.*

261 Mr Wells' investigation showed that the formal handover of the Newton installation from the Works to the Maintenance organisation, demonstrated by the joint signature of a Handover Test Certificate, had not taken place. Yet the signalling maintenance staff under Mr Waugh had in fact been undertaking maintenance and fault clearance at Newton since the commissioning.

262 The reason given for this was the lack of complete maintenance documentation, particularly for the electronic system. Mr Genner said that no one had positively checked whether there was adequate documentation. He believed that there was no formal specification of what maintenance documents should be provided for a signalling installation.

*Comment*

263 While there are no grounds to suppose that maintenance error was associated with the Newton accident, the possibility of a mistake by a maintenance technician is an obvious hazard, especially in complex systems. The BR Signalling Design Handbook, reference BR 13439/90, section L31, specifies some documents to be supplied for maintenance purposes, but does not cover important topics such as SSI and other electronic systems. *It is recommended that the relevant departmental handbooks should clearly and fully specify what documentation should be provided, and a documentation plan should form part of the project which must be certified complete on commissioning.*

264 Mr Nelson emphasised that he had no role in the project prior to commissioning. Mr Worrall subsequently pointed out in a letter that a procedure had already been introduced prior to Newton which defined the way in which the project office would consult and obtain the views of the Maintenance organisation on projects. The procedure was not followed at Newton. It is unsatisfactory that those who are to be responsible for maintaining the safe operation of a system should have no contact with the conception and design of the system. *It is recommended that BR should ensure that maintenance organisations are consulted and kept informed of progress at each stage of the life cycle of a project.*

265 Mr Pinkstone described the work of the Glasgow Signalling Projects Office in which Mr Genner was employed, and stated that he had every confidence in Mr Genner's abilities.

266 He clarified the situation regarding handbooks and standards. Newton had been tested to the standards laid down in the Signalling Works Testing Handbook, which had been produced in the light of Sir Anthony Hidden's recommendations. This book formed part of a set of three, the other volumes dealing with design and installation. The design and installation work at Newton predated the issue of these two latter volumes. However, it was designed to the best practice of the time. There were numerous former Scottish Region instructions which covered large elements that are now covered by the present design and installation handbooks.

267 When asked whether there was any certification to confirm that the installation at Newton had been carried out to acceptable standards, Mr Pinkstone replied that the only documentation applied to the testing process was in the testing handbook. He was not aware of any formal documentation which indicates that the installation work is of a correct standard.

268 Certain installation work, such as pulling wires and cables through ducts, is not amenable to subsequent test and inspection, but if carried out wrongly can result in damage leading to later failure. *It is recommended that in cases where installation standards are relevant to safety a certificate of compliance should be appended to the master test certificate for the scheme.*

269 Mr Pinkstone also explained that steps were taken to ensure that testing and commissioning staff did not work excessive hours.

270 Mr R Parker, Group Technical Standards Project Engineer for the S & T Department, explained that he was requested by Mr Burrage following the publication of Mr Wells' report to oversee the restoration of the Newton system to an acceptable level of performance. In the course of this he carried out an investigation into the human causes behind the situation. A copy of his report had been made available to the HSE.

271 With regard to Mr Wells' conclusion (paragraph 160(c)) that the Panel Multiplexer and SSI equipment were not installed with sufficient regard to minimising the effects of electromagnetic interference, Mr Parker concluded that the installation was correct with regard to the technical information available to the staff at the time.

272 With regard to the termination problems of the multicore cables, Mr Parker concluded that these were a result of the designer's failure to consider the physical arrangements for connecting the contractor's cables to the existing BR circuitry.

*Comment*

273 It is clearly necessary that designers should take account of the physical constraints of the site on installation and maintenance activities. *It is recommended that site visits and consultation with installers and maintainers should form part of the design process to ensure that physical constraints do not lead to undesirable installation practices or subsequent maintenance difficulties.*

274 By interviewing those involved and looking at the results of the cross-checks carried out by Mr Wells' investigation team, Mr Parker confirmed that the pre-commissioning testing had been fully and satisfactorily performed, in spite of the omissions from the final test certificate.

275 He did regard the failure to sign the test certificate as a serious matter, and he was concerned that the certificates had still not been checked or completed when discovered by Mr Wells three months after the commissioning.

276 With hindsight, he considered that the Newton installation should not have been commissioned without the agreement of the maintenance organisation. He considered it to be a defect of the Signal Works Testing handbook that it did not require the formal commitment of the maintenance organisation in advance of commissioning.

*Comment*

277 *There is a need for a robust procedure of count down before a commissioning, involving the designers, testers, project engineer, and the maintainers.*

278 Mr K Burrage, Director of S & T Engineering for the British Railways Board explained that he was responsible for determining and directing signal and telecommunications engineering strategy, policy, principles, standards and development of equipment for safe operation. He explained that although Mr Nelson was responsible to him for the application in Scotland of the Board's national standards, his line management came under the Director of ScotRail. Mr Pinkstone and Mr Genner were responsible to Mr Burrage both for line management control and for the application in the design project engineering, testing and commissioning field of the Board's national standards. However, it was normal for a scheme such as Newton to be developed locally and not be referred to S & T Headquarters at Paddington at all, provided that it was able to conform to the national standards.

279 In a case where a scheme has been delayed for a period of time, as Newton was, Mr Burrage considered that it would be good management practice for there to be a review of the scheme both financially and technically. He thought such a review would have been appropriate to Newton, but as far as he was aware no such review had taken place.

280 Mr Burrage pointed out that it is always difficult when promulgating national standards to be applied everywhere to make them all-embracing for every eventuality. Designers are expected to make good engineering judgements on what is appropriate to their specific site within the realms of their delegated responsibility. To ensure in the exercise of this discretion that standards are not diluted the main safeguards are line management surveillance and the opportunity for independent audit.

281 He did not consider that it was acceptable for testing documentation to be signed off when it was in

fact incomplete. Where it was complete except for minor items, he would expect those minor items to be noted and approved by a senior engineer in the department.

282 He considered that if the standards he had laid down had been properly followed at Newton the installation would not have been commissioned in the state reported by Mr Wells.

283 Mr Burrage had not been aware of the Sheriff's determination in the Bellgrove Fatal Accident Inquiry until one week before the opening of the Newton Inquiry. (See paragraph 312.) *It is recommended that British Rail should ensure that conclusions and recommendations of inquiries, inquests etc should be made available to all who may be concerned, including relevant standards setting departments.*

284 Mr Burrage agreed that a more comprehensive assessment of what is meant by safety and non-safety systems was needed. He said that he already had staff who were co-operating with continental railways so that all the railway administrations in Europe could come to a common understanding about such issues as fail-safe, what is vital, what is not vital, and so on.

#### **Operational considerations**

285 *Mr A Mackie, Movements Manager for ScotRail,* (recalled) gave evidence relating to a number of significant railway operational considerations, much of which is recounted at appropriate places elsewhere in this report.

286 After summarising the changes in traffic patterns which had been one of the factors involved in redesigning the layout of Newton, Mr Mackie briefly explained the principles of the positioning of signals. Signal positions are dictated by the track layout and the needs to protect conflicting movements and provide adequate headway and line capacity for the service demands.

287 As far as possible signals at Newton had been kept in their original positions, but as there had been drastic changes in the track layout there were inevitably changes in the signalling. However, Signal M145 in the new layout was within one metre of its position in the old layout.

288 Mr Mackie described how the proposed location of each new or altered signal is examined by a signal sighting committee, consisting of representatives of the signal development section, the traction inspectorate (to provide the driver's point of view), the signal engineer, and if necessary the civil or electrification engineers as circumstances dictate. The committee recommend whether the location is suitable in terms of visibility for a driver, and as part of the exercise they recommend the

shape and form that the signal requires to take. The ideal signal would be on a straight post to the left of the driver, with the red aspect some 12 feet 6 inches above rail level. However, if the signal were positioned on a curve, it might be that the sighting committee would recommend that it be elevated in height or be placed on an offset bracket to bring the signal head nearer to the ideal desired position.

289 Mr Mackie explained in detail the various procedures involved in the use of the radio system for communication between drivers and signalmen. The setting up procedure at the start of a journey is as follows:

The driver of a train at the start of a journey has to correlate the stock number, which is the number of the vehicle which he is driving, with the number of the train as contained in the train head code. He does that by first setting his cab radio to the correct area code (although in the case of a turn-back train at Newton, it will have been automatically done for him when he came into the Motherwell control area on the in-bound journey). Once the radio is set up to the proper area code the driver inputs by means of a key board the number of the signal at which he is standing. He then presses a set up button, which automatically sends a message containing the input information to the signalling centre. At the signalling centre the radio computer takes the data and obtains from the train describer computer the head code contained in the signal berth where the train is standing. It returns the train head code by radio to the train and the train head code is then displayed in the driving cab.

290 There are two procedures which the signalman can use to call a train in emergency circumstances. If the signalman required the train to stop in an emergency, by means of his key board he would depress the stop button, insert either the four digits of the train head code, or the six digits of the train stock number and then press the enter button. This would cause the display of an alarm on the train radio key board and would cause an audible tone to sound, which the driver would silence by pressing the stop button in the cab. That in turn would cause an acknowledgement display to the signalman on his VDU, but no voice contact is catered for, nor is it necessary by that means. There is a second procedure by which the signalman can send a general call to all trains in his area by voice; the procedure on the keyboard is somewhat quicker, but it takes a little longer for the message to be received.

291 A signalman initiates a general call by pressing one button. The system then allows him to compose a speech message which can be no longer than 15 seconds and that is transmitted to one group of aials

while he is composing it. It is then re-transmitted automatically to the aerals in Group 2 and then Group 3 in succession, so it may result in a 15-second delay, or indeed a 30-second delay in the message being received. Mr Mackie's understanding was that the general call facility is not intended for emergency use, but is simply an advisory system. Aerals in Newton, he understood, are in Group 2, so there would have been at least a 15-second delay in transmission of a stop message of this means to the trains.

292 At the time of the accident the only trains on which the radio system described above was operational were those which were driver-only operated. The radio equipment had been installed on other trains but it was being used only for test purposes and there was no requirement for communications to be conducted by that means. Thus, on Driver McEwan's train the radio system was fully operational, while on Driver Scott's train the equipment was present for test purposes, although the radio system records show that Driver Scott had in fact entered his radio into the system so that it could have been used.

293 Mr Mackie explained the instructions to the signalman setting out the actions to be taken in the event of a train running away. These are contained in the special instructions for the original box, and have to be followed by the signalman in addition to the train signalling regulations and the rule book. Mr Mackie likened the train signalling regulations and the rule book to the general rules of the game, with the special instructions setting out how the game is played in accordance with these rules at a particular signal-box. In the case of Motherwell the relevant instruction, item 6.11 of the special instructions, "Train divided or train or vehicle running away", refers to placing signals at danger and clearing the line ahead or diverting the runaway into a clear line. There is no mention of the use of radio for warning drivers of the emergency.

294 Mr Mackie said that signalmen and drivers were trained in the use of radio. The training sessions did not include joint training of signalmen and drivers talking to one another over the radio. In the training exercises for signalmen the role of the driver was taken by the instructor, and the converse applied in training exercises for drivers.

295 The use of the radio is discussed further in the section dealing with 'Secondary Devices' (paragraphs 351 to 370).

### **The redevelopment of Newton Junction**

296 *Mr Chris Leah*, responsible as *Provincial Manager for ScotRail* in 1986 for the 'bottom line' management of the Provincial Business in Scotland, told the Inquiry how the ideas for the redevelopment of Newton Junction

originated in the early eighties with the need to renew the junctions. Newton was a complex layout. From 1982, the Board's aim being to manage the business in a cost-effective way, the policy was to take out surplus infrastructure wherever necessary and practical to do so. Newton's layout provided facilities for traffic that no longer existed and there was an opportunity to relay the junction in a way that was cost effective for maintenance and which rationalised the infrastructure to their current traffic levels.

297 Mr Leah said that the proposal was assessed against criteria which were to reduce costs to an extent that justified the change of layout, to rationalise and take advantage of that particular opportunity to improve the running of the West Coast Main Line, and to cater for the future traffic on local services, run by and paid for by Strathclyde PTE. He explained how the investment was considered and agreed, the Provincial Business in Scotland taking the lead in settling the specification, involving the InterCity Business and taking inputs from the technical functions bearing in mind all the principles of signalling, of train working and of timetabling. The scheme was developed through discussion in an interactive manner, finally being approved by the Board's Railway Investment Panel.

298 Mr Leah described the long process of authorisation which went on between 1986 and 1989 for Newton as a corporate process, involving the Project Manager and all the Businesses concerned and the people who would have to operate the system, particularly the Regional Operations Manager. These, he said, would "sign off" only for something which could be worked and was robust in a "safety context", safety being "non-negotiable to the Business". No one person had the role of overseeing the safety interest but the corporate process of decision making and the principles inculcated in signalling and civil engineering took safety fully into account; if the people speaking on behalf of technical standards felt a layout was unsafe, it would not proceed in that form.

299 The development of proposals for Newton had changed in 1986 when new business structures came into being. InterCity were looking for a reduced journey time on the West Cost Mainline between London and Glasgow and asked for the line speed through Newton to be increased to 90 mile/h. That required some changes to the original 1985 layout. Discussions took place involving the funders of the scheme Strathclyde PTE and InterCity, the Project Manager, Civil Engineering, S&T and the Regional Operations Manager as to the best layout which could meet the demands of the Provincial Business and InterCity's need for 90 mile/h.

300 The idea of the single-lead then emerged, said Mr Leah, as a result of the clearance difficulties in achieving 90 mile/h and a double junction towards Kirkhill.

301 Asked whether there was a system, or if anyone was responsible within the system, for advising the group of people involved in the corporate process of discussing and agreeing the scheme on risk assessment Mr Leah replied that there was not, to his knowledge; asked whether the group had called for a safety case including a *risk assessment* for the new layout as it developed, he said that he had not called for a risk assessment himself as he expected the professionals to "get the safety right", it being an overriding factor from the Business's viewpoint that as "safety is inherent in the railway system it is a unique selling point for the railway business". The last thing he would wish to do would be to prejudice safety under any circumstances.

302 The decision to go ahead with the scheme was finally taken, he thought, around July/August 1990, when the scheme was approved by the Provincial Investment Panel and the Railway Investment Panel. The accident at Bellgrove had occurred and there had been a moratorium on schemes until July 1990, when the Department of Transport's Railway Inspectorate decided to allow it to go ahead.

303 Safety on the railway is the responsibility of the operator. Proposals for the major resignalling and realignment of the railway require the approval of the Secretary of State for Transport. The Secretary of State's powers are delegated to the Chief Inspecting Officer of Railways and the proposal for the works at Newton were submitted to the Railway Inspectorate for approval on 2 October 1989. The normal procedure is to give 'provisional approval', if the proposal is designed to appropriate standards, to enable the work to be constructed and brought into use prior to the inspection of the completed works. British Railways are responsible for the proper design and installation of the works to the agreed standards and these procedures allow the replacement of the railway infrastructure while maintaining public services.

304 As the proposals for Newton met the design principles for single-lead junctions and as the Chief Inspecting Officer had by then concluded in his report of the Inquiry into the accident at Bellgrove that single-lead junctions could be acceptable, Major C B Holden, on behalf of the Chief Inspecting Officer, conveyed provisional approval, subject to the work being inspected in due course, in a letter dated 25 July 1990. As was usual the provisional approval allowed the realigned works to be brought into use before the inspection. The junction was commissioned in two stages on 9 and 23 June 1991 and the inspection had not taken place before the accident occurred on 21 July 1991. It was the intention to inspect the whole of the signalling works, of which Newton was a part, together.

*Comment*

305 It is clear that the corporate decision process described by Mr Leah relied in good faith on the traditional belief that safety is inherent in the railway system, being inculcated in the principles of operation, signalling and civil engineering that have developed over many years. However, Sir Anthony Hidden made a number of recommendations in his report\* of the accident at Clapham on 12 December 1988 which, had they been taken properly into account in connection with the Newton scheme during the 'moratorium', might have caused a rethink. In particular, had recommendations 48 and 50 been followed in the appraisal of the Newton scheme they might have occasioned an inter-disciplinary view of safety to be taken identifying the risks resulting from the conjunction of single-lead junctions, a solution to a civil engineering problem, with signals passed at danger, an operating problem. Nor were the lessons of the Bellgrove accident, which resulted in an Inquiry and report under the Regulation of Railways Act 1871 by the Department of Transport's Railway Inspectorate and a Fatal Accident Inquiry and Determination by the Sheriff, sufficiently taken into account in the final stages of the development.

**Introduction of new layouts**

306 *Mr J Carrigan*, a train driver at Glasgow Central and local representative for ASLEF, gave evidence of the concern felt among drivers at the way in which they had been introduced to the new tracks and signalling layout at Newton. Each driver had been given a notice of the alterations in the form of a track and signalling plan of the Newton area. Many felt that this was too complex to understand readily and would have preferred to have had a period of route learning, as is required for all drivers before being authorised to take trains over a route they have not previously worked, or to have been accompanied by a traction inspector on their first journeys through Newton, or at least to have had a traction inspector explain the diagrams to the drivers to ensure that they understood the layout.

307 BR undertook through their Counsel to the Inquiry that for similar projects in the future steps will be taken when the notices are handed out by the traction inspectors to make certain that the drivers understand what the information is that they are being given.

308 Mr Carrigan was also concerned that the feedback received by drivers who reported signalling irregularities was sometimes incomprehensible or non-existent. BR stated through their Counsel that they accepted that it was important that steps be taken to make drivers clear as to what is being reported back to them, and that steps had been instituted to deal with that. The Inquiry welcomed this: see also paragraph 347.

\* Reference: Report of the Inquiry into the Collision at Clapham Junction on 12 December 1988.

**DISCUSSION**

**Single-lead junctions and risk assessment**

309 Such a collision as occurred on 21 July could obviously not have happened, had the parallel tracked layout that previously existed at Newton not been altered to include the single track on which the trains collided.

310 Understandably, there has been mounting concern over the risk of trains colliding on single-lead junctions since the collisions at Bellgrove Junction (1989), Hyde (1990) and Newton. At the time of the Newton accident the Inspector's report of the Inquiry into the Hyde accident, which involved a signal passed at danger at the platform end and a single-lead junction, had not been published. The report of the Inquiry into the similar accident at Bellgrove Junction was however published in May 1990.

311 *Mr R J Seymour, Chief Inspecting Officer of Railways, was appointed by the Secretary of State to hold an Inquiry into the Bellgrove accident. Before reaching his conclusions, Mr Seymour took account of the report of the Fatal Accident Inquiry into the Bellgrove accident, held by Sheriff Mackay at Glasgow between 10 and 25 July 1989.*

312 This is of interest in relation to Newton. Sheriff Mackay determined that:

"had British Rail taken the reasonable precaution of designing the railway system to avoid the conjunction of:

(i) a geographical single-lead junction between double lines being sited only 116 yards from and following upon a station signal;

(ii) the absence of any secondary safety device with the object of securing that a train which passed that signal at danger was stopped or diverted prior to entering the adjacent single-lead junction;

(iii) the absence of a system designed to hold trains waiting for that signal at a preceding signal while conflicting traffic cleared the junction; and

(iv) the timing of two trains to arrive at such a station within a minute of each other;

the accident might have been avoided. I regard the operation of this junction in this position as contributing a defect in the system of working."

313 In considering whether single-lead junctions were unacceptable on safety grounds, Mr Seymour accepted four propositions put to his Inquiry by Mr Warburton, then

BRB's Director of Operations. These propositions\* were:

(i) "that single-lead junctions are now widely used throughout the railway system; they are easier (and cheaper) to maintain, they allow higher train speeds over junctions, and they are less prone to dangerous deterioration than the traditional double lead junction:

(ii) that the overall safety record of single-lead junctions is no different from that of double or parallel junctions; for example, that at Colwich in 1986 occurred at a type 1 (double) junction.

(iii) that the single-lead junction is no different in principle from countless other situations where trains run in both directions over a single track under the control of the signalling system: for example at the platforms of terminal stations, on single track branch lines and on bi-directional sections of main lines;

(iv) that the safety of any railway, whatever the layout, must depend on the basic principle that drivers stop their trains at danger signals".

314 The Bellgrove report goes on to say that it is a matter of historical record that BR has been pursuing the policy of converting double-lead junctions to single for many years, with the general approval of the Railway Inspectorate on the government's behalf; the Inspectorate being the Secretary of State's adviser in this matter, as it is he who formally approves proposals for 'new works' on passenger lines by the railways. The Bellgrove report concluded (paragraph 129) that single-lead junctions are acceptable in principle on safety grounds; and "that the limited benefits of a parallel junction did not justify realignment of Bellgrove Junction in that form" (paragraph 131). The report recommended that the track layout at Bellgrove should be reviewed. BR subsequently carried out a review but decided that no changes were needed; in particular, that the provision of trap points would not be in accordance with the Board's Signalling Principles since acceptable overlaps were available.

315 The Annual Report of the Transport Users Consultative Committee for Scotland 1990-91, published on 3 October 1991, called however for a moratorium by BR on the installation of single-lead junctions when renewing track layouts at stations.

316 The report commented at paragraph 62: "One fact that cannot be escaped however is that the single-lead junctions installed immediately past the ends of

\* Source: Report of the Inquiry into the Collision at Bellgrove Junction on 6 March 1989.

platforms do not give the same margin of safety in the event of a driver passing a red signal, as they do not provide an overrun facility. Particularly where a driver is concentrating on waiting for the conductor's clearance to leave the station, there is a possibility of his forgetting that the signal was at danger. Under normal circumstances, this would not create a danger, but it does when entering a single-lead junction. The Committee therefore urges the British Railways Board to reconsider the policy of introducing single-lead junctions, unless or until a form of automatic train protection is installed."

317 After the Newton accident HM Railway Inspectorate, now part of the Health and Safety Executive (HSE),\* introduced a moratorium on further introduction of single-lead junctions, pending any recommendations flowing from the Newton Inquiry.

318 Although single line working is as old as the railways, the introduction of single-lead junctions has been a comparatively modern development. The possibility of conflicting movements of trains on single lines was always recognised as a risk to be controlled and as technology advanced so the control methods changed. Over the last 40 or so years the methods have involved signalmen and drivers in the exchange of a token locked into machines at either end of the line, with the driver of the train entering the line carrying a form of authority (essentially acting as the single key available to allow entry to the system). This was followed by the introduction of track circuit block, where the presence of trains is detected electrically and automatically prevents the clearance of a signal into an occupied section, and then by the Tokenless Block method, which removed from the driver the need to carry a token (or the 'key' referred to above).

319 Bidirectional operation of lines protected only by signals, eg at terminal stations, has however always been a feature of railway operation, mainly for short sections of line entirely within the area of control of one signal-box. For many years railway signalling technology has enabled the interlocking of all signals and train movements so that it is impossible for conflicting movements to be signalled.

320 BR's attitude towards development of single-lead junctions can perhaps be understood in terms of its having been conditioned by the belief that any layout can be signalled in compliance with BR's signalling principles. These however depend ultimately on drivers always observing red signals. Until the Newton accident, following those at Bellgrove and Hyde, prompted a rethink, effective risk assessment

\* HM Railway Inspectorate joined the Health and Safety Executive in December 1990, after the Secretary of State for Transport decided and the Health and Safety Commission agreed that such a move was likely to bring regulatory benefits.

techniques had not been applied to the use of single-leads.

321 The collision at Newton re-awoke the public concern over the use of single-lead junctions which had arisen following the accident at Bellgrove in 1989, and which was accurately reflected in the Annual Report of the Transport User Consultative Committee for Scotland, already mentioned at paragraphs 315 to 316.

322 In order to assess the objective basis for this concern three risk analysis studies were made independently of one another.

323 HM Railway Inspectorate requested the HSE *Major Hazards Assessment Group* to perform an analysis of the relative risks of double and single-lead junction configurations.

324 British Rail commissioned *SRD* of Warrington to carry out risk assessments of the Newton layout as it was at the time of the accident and as it is proposed to be revised in future.

325 *Dr I Murphy*, Lecturer in Mathematics at Glasgow University, who attended the Inquiry as a member of the public, submitted a paper to the Inspector setting out his assessment of the probability of collision at single-lead junctions.

326 Each of these analyses was based on a consideration of the topology of junction layouts from which the number of logically possible conflicting movements can be deduced. Although the three studies differ somewhat in their scope, they all agree that single-lead junctions have a greater propensity than double-lead junctions for head-on collision to occur in the event of a train passing a signal at danger. Given the probabilities of signals being passed at danger, described by Mr White later in this report, the risk of head-on collision would be typically 5-10 times greater if the signal were protecting a single-lead junction than if it protected a double-lead junction.

327 It is not easy to proceed from this basic assessment of the relative propensity for collision to occur to calculation of actual risk. There are many variables involved, such as real, as opposed to timetabled, traffic patterns, and some factors, such as the probability of a driver taking action to recover the situation after the passing of a signal at danger has occurred, that can only be conjectural.

328 While the figures calculated tend to support the perception of single-lead junctions as being high risk locations in railway terms, they are hard to reconcile with the fact that many railway layouts which are topologically equivalent to single-lead junctions, such as terminal platforms, bidirectional lines, etc, do not exhibit

the rate of collision that the risk assessment would seem to predict.

329 *Mr T Worrall, Director of Operations, British Railways Board*, told the Inquiry that after the Newton accident BR had held a review of junction configuration types, following which they identified ten locations incorporating single-lead junctions where they considered that immediate action was required to reduce risk. Collisions had already occurred at three of these locations, including Newton. A common feature of each of these junctions was that each was associated with a starting signal on a platform in an intensively worked suburban area.

330 *The perception of increased risk at single-lead junctions is thus supported by analysis and experience.* Further study is required, however, to decide whether these conclusions can be extended to any other track configurations whose topology is similar to that of a single-lead junction.

331 *It is therefore strongly recommended that BRB develop and adopt a system of risk analysis combining engineering and operating factors to be applied to proposed schemes involving single-track working; that their approach be developed in consultation with the Health and Safety Executive, which has considerable relevant experience of these techniques in relation to industrial risks; and that HM Railway Inspectorate should demand evidence of risk assessments having been carried out before schemes are approved by the Secretary of State for Transport.*

#### Signals passed at danger

332 A number of witnesses referred to the problem of signals passed at danger (SPAD). Mr Mackie stated that there was currently a disturbing rising trend in such incidents in ScotRail. Mr Burns confirmed that signals passed at danger could occur with highly responsible drivers dedicated to safety, and that such incidents were not a peculiarity of people unsuitable to be drivers.

333 *Mr John White, Project Manager SPAD* working for the Director of Operations, told the Inquiry about his work since the publication some two years ago of a report into the problem of drivers passing signals at danger. The Report,\* by the Royal Holloway and Bedford New College, and known as the Gilchrist Report after its author, was of a three-year study commissioned by BRB and undertaken between October 1986 and October 1989. The need for the study had been recognised in the mid 1980s, when it was realised that the number of signals passed at danger (SPAD) was increasing and that the reasons were not understood.

\* Reference: Technical Memorandum: An Investigation into the Causation of Signals Passed at Danger by A O Gilchrist, published by British Rail Research, Derby.

334 Mr White described the trend in recent years against the report's analysis of four main categories of SPAD: disregard (30%); miscommunication (6%); misjudgement (50%); and misreading (24%). SPADs are further defined as: a running signal SPAD; a shunting SPAD; and a starting against a signal SPAD. *Disregard of a signal* would be when a driver literally does not see the signal or does not register what it is displaying and goes, believing the road is his. A misread tended to arise when more than one signal is in the driver's view and he reads the wrong one.

335 Asked what could happen to cause SPAD when *starting against a signal from a platform*, he described how drivers were critical of the use of the bell whereby a guard with a passenger train would give two beats on the bell as the ready-to-start signal without having checked the signal at the end of the platform; if the driver then failed to check he could set off against a red signal. Mr White went on to say that there were probably two or three times as many SPADs involving starting away from signals not at a platform as platform starting signals, and that those involved at platforms are not always passenger trains.

336 Mr White had no information specific to DOO trains but from his experience of his work over the last two years did not regard the driver of a DOO train as more or less vulnerable to SPAD than a driver with a guard.

337 Asked about distractions for drivers at stations, Mr White said that these could arise from passengers and particularly affected driver-only operations, as the driver would be the only person a passenger could approach.

338 Mr White described how the study and his subsequent work, concentrating on human factors, was leading to actions by BR management relating to recruitment and training, the way that people were managed, and job status. The system of medical examinations for drivers had been revised to ensure that they were regularly monitored medically, and medical examinations had been instituted following each SPAD incident, so as to build up knowledge of drivers who could become involved in SPADs. Medical and psychological examinations of 200 drivers in France involved in "grave error" had shown that 30% required retraining or rehabilitation before they returned to driving and just over 1% had to cease driving, having in effect a "hidden pathogen".

339 Other actions taken by BR, said Mr White, included a pilot scheme in three areas to improve welfare facilities; an attempt to improve the methods of supervision for drivers throughout BR; a "more enlightened approach" to formal discipline, in an attempt to dismantle the "blame culture" and encourage drivers to be open with management; and, as part of BR's Organising for Quality initiative, the recent introduction

of the principle of the specialist driver manager, which would be developed over the next year or two.

340 Mr White also referred to the publishing of 'Up Front', a publication for drivers, communicating what was being done about SPADs; to the introduction of a system to involve drivers in the design of cabs on all new locomotives; and to an improvement in the way that management monitored route learning by drivers.

341 For the future, attention was being given to the age of recruits, BR having always tended to recruit young; to psychological or psychometric testing; to consideration of the possible value to BR of a Department of Applied Psychology; to developing an improved system for driver training, stimulated by the investigation of the accident at Hyde, and drawing upon the experience of continental railways; to considering ways in which job status and conditions of work for drivers could be improved, looking at shift patterns and problems of boredom and monotony and, related to fatigue and driver performance generally, drivers' travelling time to and from work which, in some locations, is quite significant.

342 Other areas under examination by Mr White included the organisation relating to drivers, with the aim of building a better supervisory structure on the driver manager concept and diminishing the blame culture to which he had earlier referred, with improved communications particularly on safety issues being developed under the wider BR safety programme.

343 Finally, Mr White explained how his work, having concentrated on trying to understand the causes of SPAD and trying to prevent them, was now also beginning to look at the effect of SPAD, with the aim of minimising their consequences.

*Comment*

344 The BR work in the field of SPAD since the Gilchrist Report is commendable. It recognises that the problem exists, is serious, and is likely to persist until the introduction of more advanced technology reduces the effect of human error. Earlier in this report reference has been made to the principle inherent in BR's approach to safety that drivers observe signals. This approach is clearly right, as far as it goes. But the fact remains that several hundred SPAD occur each year and that some of these are extremely critical events in terms of safety and their potentially disastrous consequences.

345 A SPAD at a platform starting signal which takes a train onto a single-lead junction into possible conflict with an approaching train has just such a potential for disaster.

346 That BR has now recognised through their studies that the *effect* of SPAD requires examination as well as their causes in an attempt to reduce the risk to drivers and

the travelling public from SPAD is greatly to be welcomed.

347 It is worth recording here that during the Inquiry Mr Simon Lane, ScotRail's Operations Manager gave *two further helpful undertakings: the first related to the introduction of one or two stage commissioning exercises for new layouts in future. These would reinforce the drivers' professionalism in being able to comprehend the notices provided about new signalling schemes and layouts, and traction inspectors would be available to make sure they were understood. The second promised that improved feedback would be provided to drivers about their reports of signalling irregularities. These undertakings were welcomed by the Inquiry; the latter had been a recommendation of Sir Anthony Hidden after the Clapham accident.*

348 Consideration of the human factors involved in the driver's tasks when starting from a platform suggest a number of questions relevant to the possibility of Driver McEwan's having passed Signal M145 at danger. Unfortunately, not all of these questions can be answered.

349 The questions to which answers have been obtained from the available evidence are as follows:

- (a) Did Driver McEwan receive any external trigger, such as a bell signal from the conductor, to cause him to start the train? This is denied by the evidence of Mr McKinnon and Mrs Hanlon.
- (b) Was Driver McEwan misled by Signal M145 being cleared for a route towards Kirkhill and then replaced to danger in front of him? This possibility may be eliminated by the evidence of Mr Dillon and by the position of No 22 points after the accident.
- (c) Did a blink of the signal aspect at the critical moment suggest that the signal was about to clear? Any interruption of the current to the signal lamp would have been recorded as a fault on the technicians terminal printer. No such fault was recorded. The only exception to this is the brief interruption of signal feeds that occurs when a lineside signal module carried out a periodic self-test. The module for Signal M145 was not due to perform a self test at or near the time of the accident, and subsequent investigation of the module confirmed that the internal timers which govern the test interval were working correctly.

350 The remaining questions cannot now be answered, but they indicate possible human factors which may have led to the signal being passed at danger:

- (a) Did the fact that Signal M145 was usually already showing a proceed aspect when a train came into the platform from the turn-back siding, eg as stated

by Mr McCormack (paragraph 72), habituate Driver McEwan to expect the signal always to be clear? Such 'errors of habit' are recognised by human factors specialists to be a cause of people failing to observe apparently obvious indications.

- (b) At Newton it was Driver McEwan's responsibility to start his train at the correct time. Did the observation of the departure time on his watch provide a mental trigger for him to start equivalent to the guard's bell signal in the classic situation of a SPAD at a platform as described by Mr White (paragraph 335)?
- (c) Did the need to look back along the train to ensure that it was safe to close the doors before starting distract Driver McEwan from observing the signal?
- (d) In the fading light of evening, was Driver McEwan confused by the blue-green after-image that would have been present before his eyes if he had been gazing at a red signal light for a period of time? The retina of the eye retains an after-image after looking away from an object. In the case of a brightly illuminated object which has been viewed continuously this after-image may persist for a long time, and will take on a colour which is the complement of that of the object. Thus, for a red object the after-image will be green or blue-green.

### Secondary devices

351 Mr White also referred to a number of secondary devices and actions proposed by BRB that could be helpful in assisting drivers in these circumstances.

352 *Mr T Worrall*, Director of Operations, amplified some of this information when he gave evidence to the Inquiry. (His evidence concerning *Automatic Train Protection* is recorded separately under that heading at paragraphs 379 to 384).

353 These matters were reviewed by HM Railway Inspectorate after the Inquiry, with conclusions as set out below.

354 As already described, the possibility of signals being passed at danger (SPAD) has to be accepted. Although the frequency is low, the outcome under certain circumstances may be disastrous. Accordingly consideration must be given to equipment or systems which can act to stop a train or alert a driver to a mistake. Whatever method is adopted must not introduce additional hazards or lead to other signals being held unnecessarily at Danger so that they have to be passed under instruction. These are discussed below.

355 *Flank protection*. The overlap track circuits of signals protecting a junction are included in the controls of other signals which protect conflicting routes. Consequently a

SPAD will cause other signals to be replaced to or held at danger and may prevent a collision. The disadvantage of this system is that a single track circuit failure at a complex junction can hold several signals at danger and the railway must then be operated, without the interlocking safeguards, by instruction. A limited application, where routes converge to a single track and opposing routes can be protected in this way, should be adopted.

356 *AWS magnet*. The driver of a train which has arrived at a platform, with the signal at the end of the platform (the platform starting signal) at danger, will have had to cancel an AWS indication. While a reminder of this is displayed in the cab, the benefit of the AWS warning is to a large extent lost. If a second AWS magnet were to be placed in the overlap of the signal and suppressed when the signal showed a proceed aspect then the driver of a train which passed a signal at danger would receive an unexpected second warning which would lead to an emergency brake application if the driver did not react. The disadvantages may be that a failure of the suppression would lead to an unnecessary warning and emergency brake application by the driver who might become confused. The provision of the AWS magnet in the overlap would also complicate the signalling controls for first wheel replacement of the signal to danger.

357 *Driver's reminder device*. This is a device on the control panel which the driver can apply to the brake handle when a train comes to a stand at a platform starting signal displaying a stop aspect. It prevents release of the brake until removed by the driver but depends on the driver's discipline to apply it.

358 *Over-run Indicator*. This is an indicator operated by track circuit occupation and placed in the overlap (in advance) of a platform starting signal (it may be located in the 'four-foot') which displays a steady red aspect when the main aspect is red but which flashes and illuminates the word 'STOP' in red if the main signal is passed at danger.

359 *Detonator placer*. This device operates in a similar fashion except that instead of a subsidiary signal a detonator machine automatically places detonators on the rail ahead of the train which explodes them. It can also be operated manually. The disadvantages until recently have been the presence of explosive material in the open, the danger of flying fragments, the risk of misuse by vandals and the need to produce an explosion audible above ambient noise and at speed. However a machine has now been developed which seems to overcome the first two of these but the audibility of the explosion has yet to be proved.

360 *Trap points/throw-off points*. These are placed (in advance of) in the overlap of the signal to divert a train

passing a signal at danger away from its route and, if space permits, into a sand drag or buffer stop. They are used regularly where freight only lines converge with passenger lines to protect passenger trains from freight trains which have passed a signal at danger possibly in the past because of poor braking ability. The positioning of the points requires great care so that if there is a SPAD they do not derail a passenger train down an embankment, into a bridge abutment or towards another track. The possibility of a high speed SPAD must be considered. Their installation is contrary to the normal principle of installing as few facing points as possible. In certain carefully engineered situations their use should be considered but they may well make matters worse and if the signal has to be passed at danger under instruction they may require manual operation.

361 *The timetable.* The timetable must never be considered to be a safety device. Trains cannot be depended upon to run to timetable with the degree of confidence required for safety. However, it is clear that the risk that passing a signal at danger will result in a collision will be greater if the timetable creates more situations where trains are in a position to make conflicting movements. The timetable is thus an important factor to be taken into account when performing a risk assessment of a railway layout with a view to deciding priorities for the introduction of secondary safety devices.

362 *Double block working.* Enhanced protection within the existing system of line-side signals can be provided by 'double block working' where two successive signals on the approach to the point to be protected are held at danger. Thus it would be necessary for a train to pass two consecutive signals at danger for a hazardous situation to arise.

363 This technique would require little additional signalling equipment and would be relatively inexpensive to apply, although with current shortages in signal engineering staff the timescale for retrospective action might be protracted. The latter problem could largely be overcome by an interim solution of imposing double blocking as a system of work implemented by the signalmen.

364 Double block working inevitably reduces traffic capacity, and would be likely to cause delays at busy junctions.

365 *Radio.* Where trains are equipped with radio, an urgent warning broadcast from the signal-box in the event of a signal being passed at danger might enable a collision to be avoided. Although this facility was available in the case of Newton, the signal-box special instructions relating to emergency procedures made no mention of its use. Not only should the use of radio have been included in the emergency instructions, but

they should also have included guidance as to which of the two possible radio procedures should be used.

*Comment*

366 *BR should ensure that wherever track-to-train radio systems are available, signalman's instructions and training are adequate to ensure their prompt and effective use in emergency.*

367 *BR should also consider technical improvements to the radio system to facilitate the rapid transmission of emergency stop messages. In the system at Motherwell the broadcast speech message had potentially long delays, while the transmission of a data stop command needed to be sent individually to each train. In the latter case, delays would result from the signalman having to dial the identity of each train separately, with a risk of further delay due to misdialling.*

368 It is not reasonable to expect any human operator to be continuously sufficiently attentive to perceive the onset of a hazardous situation and manually issue a warning in the few seconds which might be all the time available, but it is conceivable that an automatic warning triggered by flank protection circuits could be effective.

369 BR is in the process of equipping its entire system with radio, but the automatic alarm feature suggested here does not currently exist.

370 *Train running away alarm.* Initiated in the same way as flank protection, by the occupation of an overlap track circuit with the signal at danger, but instead of placing signals to danger an audible or visual alarm is set off alerting the signalman.

**Data recorders**

371 The presence of a recorder which can monitor key system parameters can be of immense assistance in accident investigation, as is shown by the example of the 'black box' flight recorder used in aircraft. In the case of Newton, while there were no data recorders on the trains, there was a data recorder in the signalling system but, unfortunately, this failed to record any data at the time of the accident due to a technical defect which occurred earlier that day.

372 There are many circumstances in which an on-train data recorder could provide invaluable information. At Newton, however, the more precise information about train speed and position which would have been available from such recorders would not have contributed greatly to establishing the cause of the accident, as the recorders would not have been able to register the state of the signals at the times that the trains passed them. This would be possible only in conjunction with a system such as Automatic Train

Protection (ATP), where signalling data are transmitted to the train and processed on board.

373 The Inquiry heard evidence about data recording. *Mr Worrall* explained BR's commitment to fit data recorders to all new rolling stock and retrospectively to rolling stock which has an appreciable life left. Ten recorders from each of three manufacturers were currently being fitted for evaluation. The recorders will monitor such features as train speed, braking, Automatic Warning System (AWS), door interlock, and so on. They will be used both for accident or incident investigation, and for counselling drivers on their performance.

374 *Mr Newing* described the signalling data logging facilities provided by the Technician's Terminal which forms part of the SSI system. The Technician's Terminal consists of a computer which has a VDU display and keyboard which is the main means of access for the technician, a printer which enables it to print out fault messages, and a data logger which consists of a dual tape deck which records digital data on magnetic tape cartridge. The data recorded consist essentially of every change of state of the data telegrams transmitted between the SSI interlocking and the trackside functional modules, together with a record of commands received from the signalman's control panel. These tapes can be removed from the Technician's Terminal and read and interpreted by a computer system to reconstruct the sequence of events in the signalling system.

375 When the tape in use on the day of the accident was analysed by ScotRail staff, it was found to contain data relating to a previous day. The tape was taken to British Rail Research at Derby, where *Mr Newing* carried out a further analysis. He concluded that data were recorded on the tape starting from midnight on 21 July 1991 until 0822 on that day. At that time there was a failure of the power supply for a short period, which was correctly recorded on the Technician's Terminal print-out. Following the restoration of power there were no further data relating to the day in question on the tape. The remaining data on the tape were discovered to relate to a previous use of the same tape. This was deduced from a step in time which occurred in the tape at the time of the power failure, and by examining known events on that day compared with events on the tape.

376 *Mr Newing* had had little opportunity to examine further the functioning of the Technician's Terminal equipment as it had remained in site at Motherwell and so he was not able to determine the cause of the failure to restart recording after the power interruption. This will be investigated further by BR when the equipment is eventually recovered from Motherwell.

377 *Mr Newing* believed that there was no reason to doubt that the rest of the Technician's Terminal was working correctly at the time of the accident, and he

considered that the information recorded on the fault print-out could be trusted.

*Comment*

378 It is disappointing that the SSI data recording system was not able to contribute to the accident investigation. *It is recommended that BR should continue to provide data recording as a standard feature of all new signalling systems, and that steps are taken to improve the reliability of the data recorder.* A proposed target is that, where a data recorder is fitted, data should be available for analysis on more than 99% of occasions when an investigation is required to be carried out.

**Automatic train protection**

379 *Mr Worrall* gave evidence to the Inquiry about Automatic Train Protection (ATP), a system which supervises the speed of a train and enforces obedience to speed restrictions and signalling.

380 An ATP system consists of track and train subsystems. The main information processing takes place in the train subsystem, which is programmed with the train characteristics, some of which may have to be entered by the driver. The train subsystem also continuously measures the train speed and position.

381 The track subsystem transmits to the train signal aspect information, speed restriction data appropriate to the route over which the train is signalled, track parameters such as gradient, and provides position data at frequent intervals to re-align the train subsystem.

382 BR is currently carrying out trials of an ATP system on the Chiltern and Great Western Lines. Each line has been equipped with an ATP system from a different manufacturer but to a common operational specification. The systems are thus functionally identical but differ in the detailed design of the equipment. The track subsystem in each case is based on the provision of an information beacon transmitting data to the train via a loop aerial mounted in the track. The beacons are installed at each signal and at certain intermediate locations.

383 In his evidence *Mr Worrall* referred to the British Railways Board's publicly expressed commitment to ATP as the means by which BR will protect against the consequences of signals being passed at danger. He explained that the aim of the trials was to formulate a national specification to form the basis of a system to be applied throughout the major part of BR. He said that the trials were due to be completed at the end of 1992, but that the national specification should be available for tenders to be invited in the Autumn of 1992.

384 It was pointed out that Sir Anthony Hidden had recommended in his report on the Clapham accident that ATP should be fully implemented by 1996/97.\* Mr Worrall replied that BR had never committed themselves to this timescale, which they felt was not achievable for financial and logistical reasons, and were instead planning on the basis of a ten year timescale.

*Comment*

385 *There is no doubt that ATP would have prevented this accident. The recommendations of previous Inquiries are strongly endorsed and reinforced by this report.*

**RECOMMENDATIONS**

1 As stated by the Operations Manager of ScotRail on the second day of the Inquiry, the double lines between the platforms at Newton and the Up and Down Kirkhill lines should be reinstated as a Stage 2 development at Newton. (Paragraph 14).

2 The isolation of bare feeders requires further clarification and attention by BR. (Paragraph 114).

3 BR should review the effectiveness of their procedures and ensure that they are strictly followed to secure protection against electrical hazards in emergencies. The procedures should ensure that all electrical hazards in the area of an emergency are identified and isolated, to avoid repetition of the exposure to live bare feeds as occurred at Newton. They should also ensure that positive confirmation of an isolation is obtained before any persons on site are allowed to approach equipment which might otherwise be live. (Paragraph 117).

4 BR should consider reinforcing the oral communication between signalmen and electrical controllers with a system providing a visual indication or printed confirmation of the status of the electric traction supply. (Paragraph 118).

5 Mr Wells' findings give cause for concern about the management of the installation of the signalling at Newton, echoing the concern expressed in the report on the Clapham accident. It is recommended that BR give the closest attention to improving this aspect of the management of safety. (Paragraph 170).

6 Where contingencies arise such that the person in charge of commissioning judges it appropriate to proceed on the basis of incomplete test certificates, he

\* NB: The actual Clapham recommendation (46) was: "After the specific type of ATP system has been selected, ATP should be fully implemented within five years, with a high priority given to densely populated lines".

should record the deficiencies on the master test certificate, and record his reasons for so doing. (Paragraph 255).

7 BR should ensure that its testing techniques and commissioning procedures are appropriate to the technology of the systems being installed and are capable of giving an adequate level of confidence in the integrity and reliability of those systems. (Paragraph 257).

8 BR should identify all safety-related functions in any signalling scheme, including those implemented in non-vital or non-fail-safe parts of the system, and ensure that appropriate standards of integrity are applied at all stages of the pre-commissioning and the system life cycle. (Paragraph 258).

9 The identification of hazards such as single-lead junctions in relation to signals passed at danger requires a system-wide view of safety. The duties of a project manager should include ensuring that a co-ordinated approach to ensuring the safety of the system to be produced, is taken by all departments. (Paragraph 260).

10 The relevant departmental handbooks should clearly specify what documentation should be provided, and a documentation plan should form part of the project which must be certified complete on commissioning. (Paragraph 263).

11 BR should ensure that maintenance organisations are consulted and kept informed of progress at each stage of the life cycle of a project. (Paragraph 264).

12 In cases where installation standards are relevant to safety a certificate of compliance should be appended to the master test certificate for the scheme. (Paragraph 268).

13 Site visits and consultation with installers and maintainers should form part of the design process to ensure that physical constraints do not lead to undesirable installation practices or subsequent maintenance difficulties. (Paragraph 273).

14 There is a need for a robust procedure of count down before a commissioning, involving the designers, testers, project engineer, and the maintainers. (Paragraph 277).

15 BR should ensure that conclusions and recommendations of inquiries, inquests etc should be made available to all who may be concerned, including relevant standards setting departments. (Paragraph 283).

16 BR should develop and adopt a system of risk analysis combining engineering and operating factors to be applied to proposed schemes involving single-track

working; that their approach should be developed in consultation with the Health and Safety Executive, which has considerable relevant experience of these techniques in relation to industrial risks; and HM Railway Inspectorate should demand evidence of risk assessments having been carried out before recommending approval of schemes by the Secretary of State for Transport. (Paragraph 331).

17 Mr Simon Lane gave two further helpful undertakings at the Inquiry: the first related to the introduction of one or two stage commissioning exercises for new layouts in future. These would reinforce the drivers' professionalism in being able to comprehend the notices provided about new signalling schemes and layouts, and traction inspectors would be available to make sure they were understood. The second promised that improved feedback would be provided to drivers about their reports of signalling irregularities. These undertakings were welcomed by the Inquiry; the latter had been a recommendation of Sir Anthony Hidden after the Clapham accident. (Paragraph 347).

18 BR should ensure that wherever track-to-train radio systems are available, signalman's instructions and training are adequate to ensure their prompt and effective use in emergency. (Paragraph 366).

19 BR should also consider technical improvements to the radio system to facilitate the rapid transmission of emergency stop messages. In the system at Motherwell the broadcast speech message had potentially long delays, while the transmission of a data stop command needed to be sent individually to each train. In the latter case, delays would result from the signalman having to dial the identity of each train separately, with a risk of further delay due to misdialling. (Paragraph 367).

20 The SSI data recording system was not able to contribute to the accident investigation. It is recommended that BR should continue to provide data recording as a standard feature of all new signalling systems, and that steps are taken to improve the reliability of the data recorder. (Paragraph 378).

21 ATP would have prevented the accident. The recommendations of previous enquiries are endorsed by this report. (Paragraph 385).



## SPECIAL NOTICE

# PERMANENT WAY AND SIGNALLING ARRANGEMENTS

## NEWTON

## RE-SIGNALLING

(THIS NOTICE NEED NOT BE ACKNOWLEDGED)

June, 1991  
GLASGOW

By order of  
OPERATIONS MANAGER  
ScotRail

## NEWTON RE-SIGNALLING

### OPENING ARRANGEMENTS

The altered permanent way and signalling arrangements shown on the accompanying diagram and described herein will be brought into use in two stages:—

Stage 1—Sunday, 9 June, 1991  
(Hamilton and Kirkhill lines)

Stage 2—Sunday, 23 June, 1991  
(West Coast main lines)

### OVERHEAD LINE EQUIPMENT

Overhead line equipment will be repositioned relative to the altered layout of the permanent way at "Stage 1" and at "Stage 2" of Newton Re-Signalling, and all staff are reminded that ALL lines, including the North and South connecting lines and the Turnback siding, must continue to be regarded as being ALIVE at high voltage (25,000 volts) at all times.

### DESCRIPTION OF SCHEME

#### Stage 1—(Hamilton and Kirkhill lines)—Sunday, 9 June, 1991

The lower half of the enclosed sketch (marked "Stage 1") applies.

The area between Burnside station (exclusive) and Newton West Junction (exclusive) previously controlled by Cathcart signal box will now be controlled by Motherwell signalling centre.

The single connecting line at Newton West Junction between the Down main line and the Up and Down single Kirkhill line will be designated the Up and Down North connecting line. The facing connection Down Kirkhill single line to Down North connecting line will be secured normal out of use pending the commissioning of "Stage 2", and no signal routes will be available over the North connecting line.

The single connecting line at Newton East Junction between the Down main line and the Up Kirkhill line will be designated the Up and Down South connecting line. The facing connection Up Kirkhill to Up South connecting line will be secured normal out of use pending the commissioning of "Stage 2", and no signal routes will be available over the South connecting line.

The Up and Down Kirkhill lines in the Newton station area will both become bi-directional.

The former Down siding will be removed and a new siding will be provided leading from the Up Hamilton line, and designated Turnback siding.

#### Method of Working

The Track Circuit Block regulations will continue to apply throughout the whole area concerned.

#### West Coast main lines

The Up and Down main lines between Cambuslang and Uddingston will be under the Engineer's Absolute Possession from Sunday, 9 June until the commissioning of "Stage 2", and the permanent way and signalling details shown on the enclosed sketch and marked "Stage 2" will not apply at "Stage 1" of this scheme.

#### Stage 2—(West Coast main lines)—Sunday, 23 June, 1991

The upper half of the enclosed sketch (marked "Stage 2") will apply (together with the details shown as "Stage 1" and already brought into use).

The North and South connecting lines will be brought into use, together with the connections Down Kirkhill single line to Down North connecting line, and Up Kirkhill line to Up South connecting line, and signal routes through these connections will become available.

#### Method of Working

The Track Circuit Block regulations will continue to apply throughout the whole area shown on the enclosed sketch.

**SIGNALLING ARRANGEMENTS**

The description of all new signals shown on the accompanying diagram is as follows:—

Signals prefixed by the letter "M" will be controlled from Motherwell signalling centre.

The application of all running signals with the exception of those detailed below is to the next signal capable of displaying a red aspect.

**STAGE 1**

**RUNNING SIGNALS**

Signal	Aspect	Route Indication where provided	Application To or towards
--------	--------	---------------------------------	---------------------------

ROUTES MARKED WITH AN § NOT AVAILABLE UNTIL "STAGE 2".

**UP KIRKHILL**

M142	Main	Position 1 Junction Indicator	M156
	Main	—	M154
	Position Light	'U'	Up Kirkhill
	Position Light	'D'	Down Kirkhill
M147	Main	—	M143
	§ Main	Position 4 Junction Indicator	M137
	§ Position Light	'X'	Up Main LOS
M156	§ Main	Position 1 Junction Indicator	M166
	Main	—	M174
	§ Position Light	'L'	South connecting line
	Position Light	'S'	Turnback siding
	Position Light	'H'	Up Hamilton

**DOWN KIRKHILL**

M145	Main	—	M143
	§ Main	Position 4 Junction Indicator	M137
	§ Position Light	'X'	Up Main LOS
M154	§ Main	Position 1 Junction Indicator	M166
	Main	—	M174
	§ Position Light	'L'	South connecting line
	Position Light	'S'	Turnback siding
	Position Light	'H'	Up Hamilton

**DOWN HAMILTON**

M179	Main	—	M145
	Position Light	—	Down Kirkhill

**POSITION LIGHT SIGNALS**

Signal	Route Indication where provided	From	Application Towards
M144	'U'	Down Kirkhill	Up Kirkhill
	'D'		Down Kirkhill
M161	'D'	Up Hamilton	Down Kirkhill
	'U'		Up Kirkhill
M163	'D'	Turnback siding	Down Kirkhill
	'U'		Up Kirkhill

**STAGE 2  
RUNNING SIGNALS**

Signal	Aspect	Route Indication where provided	Application To or towards
<b>UP MAIN</b>			
M138	Main	—	M148
	Main	Position 4 Junction Indicator	M146
<b>DOWN MAIN</b>			
M139	Main	—	M137
	Position Light	'X'	Up Main LOS
M171	Main	Position 1 Junction Indicator	M165
	Main	—	M159
<b>UP AND DOWN NORTH CONNECTING LINE</b>			
M146	Main	Position 1 Junction Indicator	M156
	Main	—	M154
	Position Light	'U'	Up Kirkhill
	Position Light	'D'	Down Kirkhill
<b>UP AND DOWN SOUTH CONNECTING LINE</b>			
M165	Main	'D'	M145
	Main	'U'	M147
	Position Light	'D'	Down Kirkhill
	Position Light	'U'	Up Kirkhill
M166	Main	Position 1 Junction Indicator	M178

**POSITION LIGHT SIGNALS**

Signal	Route Indication where provided	From	Application Towards
M168	—	Down Main	Up Main
M173	'L'	Up Main	Down South connecting line
	'M'		Down Main

**AWS EQUIPMENT**

AWS track equipment is provided as outlined on the accompanying diagram and is shown immediately on the approach side of the signal to which it applies.

A single arrowhead associated with the symbol indicates that the equipment is operative only for the direction shown.

A double arrowhead indicates the equipment is operative for both directions.

**TELEPHONES**

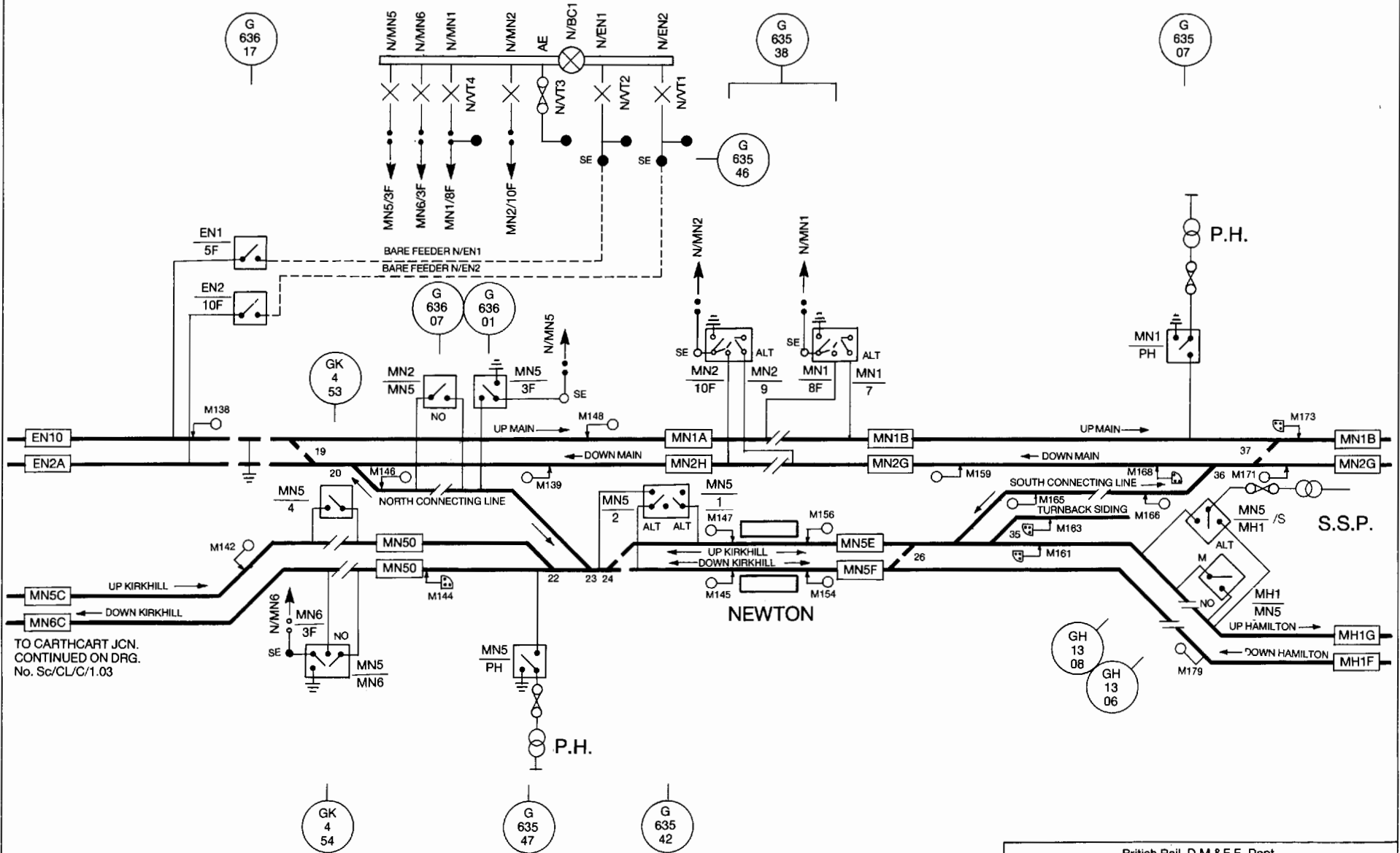
Although not shown on the accompanying diagram, telephones with black and white diagonal striped signs will be provided at all new signals capable of displaying a red aspect except where shown below.

The following signal will not be provided with a telephone:—  
M135 (L.O.S.)

Telephones with St. Andrews Cross signs will be provided in accordance with regional practice.

T020519 0030194 038

# NEWTON T. S. C.



TO CARTHCART JCN.  
CONTINUED ON DRG.  
No. Sc/CL/C/1.03

British Rail. D.M.&E.E. Dept.									
<b>ISOLATION DIAGRAM</b>									
Drq. No. Sc/WCML/C/2.04					Date 23-06-91				
Revision	A	B	D	E					

**Appendix 3** Witnesses to the inquiry

<i>Name</i>	<i>Paragraph number</i>
BENNETT	225
BRADY	143
BURNS	55
BURRAGE	278
CARFRAE	127
CARRIGAN	306
CASELLS	130
CRIBBENS	173
DILLON	76
DORRAN	112
FARRISH	51
GARDINER	58
GENNER	248
GORDON	146
HANLON	48
JAMES	105
LEAH	296
MACKIE	138 & 285
MCCORMACK	69
MCKINNON	31
MCPMAHON	37
MENZIES	147
MUNRO	99
NELSON	264
NEWING	166 & 247
PARKER	270
PINKSTONE	265
SIMPSON	149
SLIVINSKI	42
SWEENEY	56
THOMPSON	102
TREVET	41
WALLACE	109
WAUGH	120
WELLS	160
WHITE	333
WORRALL	329 & 379

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# NEWTON

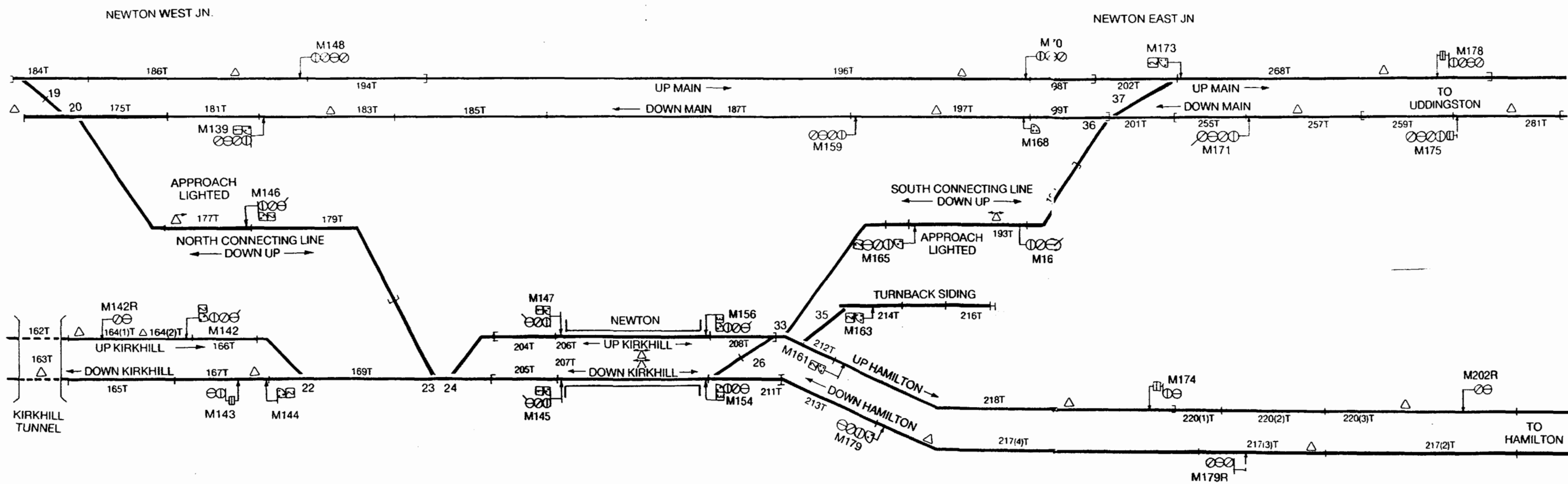


FIGURE 1



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