DEPARTMENT OF TRANSPORT

RAILWAY ACCIDENT

Report on the Derailment that occurred on 7th September 1981 at Harrow North Junction

ON THE
METROPOLITAN LINE
OF LONDON TRANSPORT RAILWAYS

LONDON: HER MAJESTY'S STATIONERY OFFICE

£3.20 net

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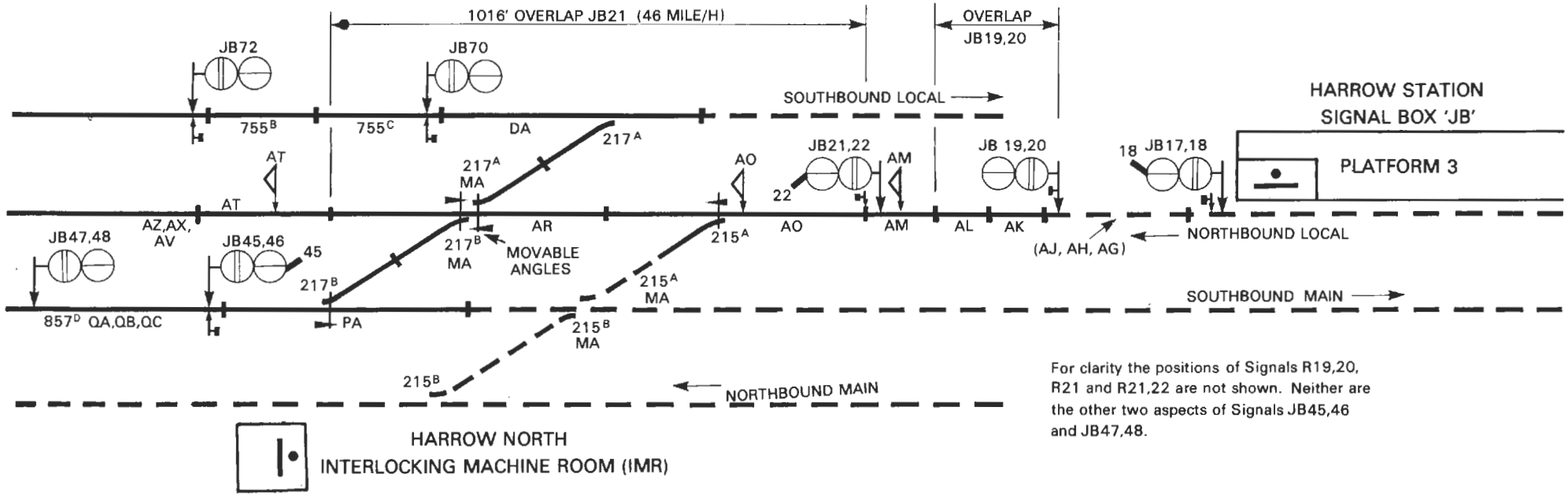
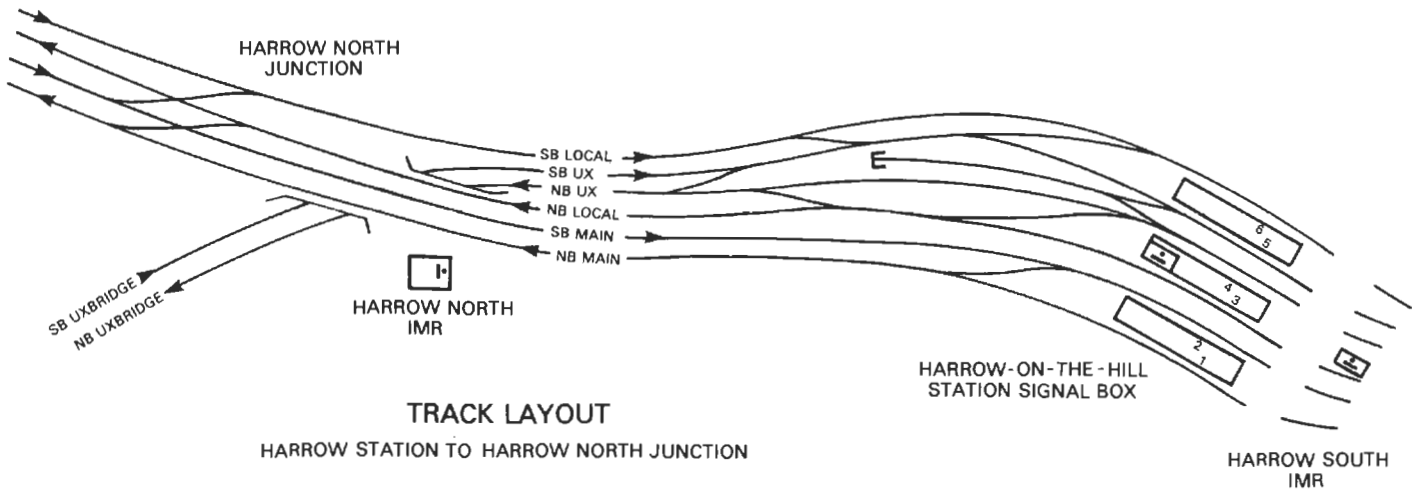
PART SIGNALLING PLAN

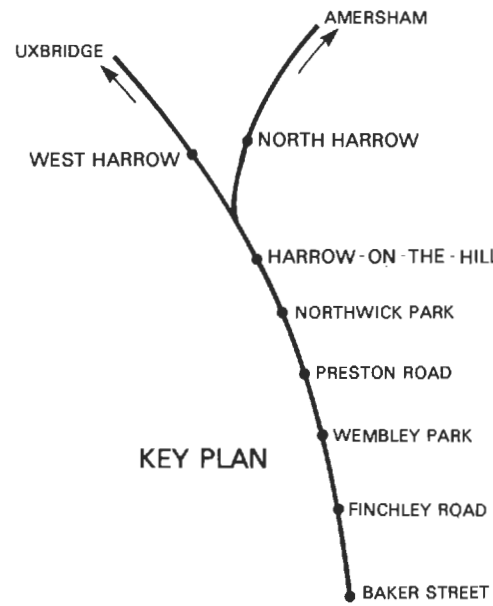


For clarity the positions of Signals R19,20, R21 and R21,22 are not shown. Neither are the other two aspects of Signals JB45,46 and JB47,48.



TRACK LAYOUT

HARROW STATION TO HARROW NORTH JUNCTION



KEY PLAN

RAILWAY INSPECTORATE
DEPARTMENT OF TRANSPORT
2 MARSHAM STREET
LONDON SW1P 3EB

19th April 1985.

SIR,

I have the honour to report, for the information of the Secretary of State in accordance with the Direction dated 15th September 1981, the result of my Inquiry into the derailment of a passenger train which occurred at about 20.57 on 7th September 1981 at Harrow North Junction on the Metropolitan Line of London Transport Railways.

The 8-car train, which was the 20.35 Baker Street to Watford, was travelling under clear signals on the Northbound Local line towards North Harrow Station and had reached Harrow North Junction when its leading bogie was derailed on No. 217 Movable Angles (switch diamonds) which form part of the crossover between the Southbound Main and Local lines where this crosses the Northbound Local line. The remainder of the train took the route onto the Southbound Main line. The train came to rest clear of the crossover with the leading car straddling the Southbound Main and Northbound Local lines. Fortunately all the cars remained upright and there were no injuries to the 47 passengers and train crew.

The traction current on the Southbound Main and Northbound Local lines was discharged on overload at 20.57; following the arrival of the emergency services at 21.10 the traction current on the other two lines was discharged at 21.15 to enable the passengers to be detrained in safety. This was completed by 21.57. The passengers from two other trains, which had been stopped by the discharge of current, were also detrained. A British Railways parcels train was detained on the Southbound Main line. All services between Harrow-on-the-Hill and Northwood were suspended for the rest of the evening and a substitute bus and coach service provided. A restricted through service was operated the following day, Tuesday, and normal working restored on Wednesday 9th September 1981.

DESCRIPTION

The Site

1. The Metropolitan line from Baker Street to Watford at Harrow-on-the-Hill Station runs approximately East to West and the six tracks through the station, reading from North to South, are called Southbound Local (SB Local), Southbound Uxbridge, Northbound Uxbridge, Northbound Local (NB Local), Southbound Main (SB Main) and Northbound Main (NB Main). All are electrified on the 650V DC 4th rail system. Some 750 m towards Watford from Harrow Station the Uxbridge lines diverge to the left and dive under the NB Local and SB and NB Main lines. The double crossover at Harrow North Junction lies 200 m past the bridge over the Uxbridge lines and has facing connections on the SB Main and NB Local lines; the crossovers over the intervening lines are formed by switched diamonds known as Movable Angles (MA). The Northbound crossover is numbered 215 and the Southbound 217. Harrow North Interlocking Machine Room (IMR) is located on the Harrow Station side of the bridge. The track layout is shown on the diagram on the facing page.

The Signalling

2. The Local and Uxbridge lines have standard LT 2-aspect colour-light signalling controlled by route-setting levers in the Harrow-on-the-Hill Station Signal Box (prefix JB) whereas the signals on the Main lines are a mixture of 3 and 4-aspect colour-lights. All lines are fully track-circuited. The signalling at the station is controlled directly from the signal box but there are remote IMRs at Harrow South and North Junctions. On the Northbound Local line the starting signal from platform No. 3 at Harrow-on-the-Hill Station is JB17/18 and the signal protecting Harrow North Junction is JB21/22. Both signals have junction indicators. Even numbered northbound signals refer to routes over diverging junctions in advance. The intervening signals are numbered R19/20, JB19/20 & R21 (a combined stop and repeater signal) and R21/22. On the SB Main the signal protecting the junction is JB45/46 and the signal in rear of it is JB47/48. Both are 4-aspect signals. Nos. 45 and 47 refer to the diverging route; the former has a junction indicator. All stop signals have train-stops associated with them and all facing connections and movable angles have ground track locks. An extract of the signalling diagram showing the signals, turnouts and track circuits is on the facing page.

3. Westinghouse electro-pneumatic miniature-lever locking frames are installed in the signal box and IMRs; the remote locking frame in the IMR being style 'N2'. Each miniature lever in the 'N2' frame works between notched quadrant plates and at its pivot carries a bevel pinion which drives the vertical locking shaft. The locking shafts are held on bearings attached to the front leg of the frame and carry locking tills on their upper parts. An air motor is fitted to the bottom part of each shaft. Each air motor has two independent

cylinders, one to provide the normal to reverse movement and the other the reverse to normal movement. Each cylinder is controlled by a separate electro-pneumatic valve. Also attached to each miniature lever is a horizontal locking slide bar which has at its other extremity a bevel-drive mechanism for driving a second vertical shaft which carries the electrical contacts and which is secured in bearings attached to the back leg of the frame. The front and back legs are connected by a horizontal $\frac{1}{4}$ in thick 'magnet' plate below which can be mounted two AC coil indication or lock magnets per lever. A cruciform turret which locates the lever locking slide and the locking catch is cast on the upper surface of the magnet plate above each magnet and the latch is connected to the magnet by a springloaded brass stem. This stem is located at its lower end by an adjusting diabolo nut which rests in a fork at the non-pivoted end of the armature and this nut is secured in position by a tabbed copper lock plate and a lock nut. An outline drawing of the frame and a drawing of the details of the electric lever lock are at the back of this report.

4. In the signal box the route-setting levers are normal in the mid-stroke position and are reversed by being pushed fully forward or pulled fully back. The push stroke calls one route over a set or sets of points and the pull stroke the other route. When the route which is called is set and proved clear the signal associated with the lever clears and the appropriate indicator on the frame lights up. (It should also be noted that on the type of mimic signal diagram installed at Harrow-on-the-Hill, signals and track-circuits are shown unlit when at Danger or unoccupied but become lit when a signal is cleared or a track-circuit is occupied.) The movement of a signal route-setting lever to the push (H) or pull (L) position energises the appropriate route-setting relay in either the signal box or the IMR. Although there is mechanical interlocking between route-setting levers in the signal box it is not regarded as part of the safety system but rather as a reminder to the signalman against attempting to call conflicting routes. The energisation of a route-setting relay provides a feed to one of the electro-pneumatic (e.p.) valves of the individual air-motors which drive the shafts controlling the specific point or signal function. However, to prevent undue strain on the mechanical interlocking between point and signal shafts (the safety interlocking) which would arise if conflicting routes are pre-selected, the electrical feed to the e.p. valve is taken via interlocking relays. Once a signal has cleared an electric lock is applied to the horizontal locking slide-bar of that signal lever which prevents the lever being replaced, and therefore the mechanical interlocking being released, until an approaching train has traversed the route and is beyond all the points and crossings in the route.

5. Illustrating this in terms of the levers involved in the circumstances of this accident, if No. 21 route-setting lever in the signal box is returned to the mid-position once a train has occupied one of the approach-locking track-circuits, a conflicting route-setting lever can be used but the lever for signal JB21 in the IMR is held reverse by the electric locking until a train has occupied and cleared all the track-circuits between AK and AR and has operated the normally de-energised rail circuit ΔAT. Lever Nos. 215 and 217 in Harrow North IMR are locked normal by Lever No. 21 reversed. The feed to the reverse cylinder of the air motor driving the shaft of No. 217 includes a contact on the shaft of No. 21 requiring that lever to be normal. The route-setting lever for Signal JB45 calls Points No. 217 reverse. In addition to the signals being approach locked by the occupation of track circuits, Points No. 215 are ground track-locked by AOT occupied and No. 217 by ART occupied.

Course of the Accident

6. Train T40, formed of a standard 8-car set of 'A60' stock with Car No. 5034 leading, departed from No. 3 Platform at Harrow-on-the-Hill on time at 20.55. The train travelled on the Northbound Local line observing the restriction of speed to 30 mile/h, which extends from 70 m in rear of Signal JB19/20 until it rises to 60 mile/h 152.4 m in advance of No. 217 Movable Angles, and passed Signals JB19 and JB21 at Green. As the train was passing over No. 217 Movable Angles the leading bogie of the leading car was derailed. The rear bogie of the leading car and the remainder of the train took a diverging route to the left through the angles onto the Southbound Main line. The train came to rest clear of the crossover with the leading car almost straddling the Northbound Local and Southbound Main lines. All the cars remained upright. The traction current on the Northbound Local and Southbound Main lines was discharged on overload at 20.57. Subsequent examination of the train showed that the trip-cock had been actuated but the cab controls were in their correct positions.

Damage to Train and Permanent Way

7. Some 150 m of the permanent way was damaged. The damage to the plain line consisted mainly of displaced and buckled current rails and distorted track alignment. Of the point and crossing work No. 217 Movable Angles and No. 217B Points had bent rails and bent and broken fittings. Only the leading car was damaged and this suffered damage mainly to the floor-plate, the bogies and the underfloor equipment but the body by the 'N' door was also slightly damaged. Cables were damaged where they ran in armouring or trunking below the solebars and those between the cars were also stretched. The emergency lighting circuits in the two leading cars became earthed because of the accident damage and as a result there was no lighting whatsoever in those cars.

Evidence

As to the running of the train and the course of the accident

8. The driver of the train was *Motorman J. Hodges*. He said that he had taken over Train T40 at Wembley Park South at 20.12, driven it to Baker Street and departed from there at the booked time of 20.35½ bound for Watford. The starting signal was at Danger at Harrow-on-the-Hill when the train arrived about 1½ minutes early but the signal was cleared on time at 20.55. After he had received the 'Train Ready to Start' signal from the guard he started the train, keeping the speed down because of the 30 mile/h speed restriction which began some 270 m ahead, until he saw Signal JB21 at Green. He then increased speed to between 25 and 30 mile/h. As the train passed the signal he shut off power and coasted but when the leading cab reached No. 217 Movable Angles the train lurched and he was thrown off his seat. The driver's safety device operated and automatically applied the brakes. Hodges said that he picked himself up but was again thrown to the floor. After picking himself up again he saw that the cab was heading for the post carrying Signal JB45/46 so he threw himself to the floor. When the train stopped he got up and cut out the motor generators. He then went to the signal-post telephone to tell the signalman at Harrow-on-the-Hill what had happened and to ask him to put all the signals in the area back to Danger and to discharge the traction current. Hodges confirmed that up until the time of the accident there had been nothing whatsoever wrong with the train but after it had occurred he said that the first two cars were in complete darkness. After he had finished speaking to the signalman on the telephone he climbed back into the train and met his guard who had walked through the train to see that the passengers were alright. Because he wanted to ensure the traction current was discharged he got down from the train and again spoke to the signalman. He noticed that by this time the emergency services had arrived and he advised them to remain clear of the tracks in case some of them were still live; he had already used his short-circuiting device on the track ahead of his train. He remained by the train until all the passengers had been detrained and senior London Transport Officers had arrived.

9. *Guard M. E. Martin* was the guard of Train T40. He had the same turn of duty as Motorman Hodges and confirmed the latter's story up until the time of the derailment. The first sign of something amiss was th rear car swaying and the main lights going out. The emergency light remained lit and by its light he saw that the brake-pipe gauge showed a loss of air pressure. He opened the guard's door, noticed the angle of the train, and after shutting the door and checking that the tail lights were showing, walked through to the front of the train. He said there were no lights on at all in the leading three cars. When he spoke to the three passengers in the leading car they told him that the motorman had already been in and enquired about them. He then moved them back to the rear of the train. When he reached the rear cab he applied the handbrake, put his headlamp to show red through the rear window and went forward again to see Motorman Hodges. He saw that Hodges was alright and was using the telephone and therefore he returned to the rear cab and waited for the emergency services to arrive. The police and firemen soon began climbing over the fence on the southern side of the railway. He shouted to warn them in case the traction current was still on because, although the current rails were plainly visible, it was quite dark and not easy to step over them. The police wanted to detrain the passengers immediately but Martin said that they would be safer in the train until proper arrangements had been made for them to complete their journey.

10. On duty in Harrow-on-the-Hill Signal Box was *Regulator A. Dack* whose turn of duty was from 14.00 to 22.00. He described how he set the route for Train T40 by pushing the levers for Signals JB19 and JB21 which cleared and as the train was running to time he cleared Signal JB17, the No. 3 platform starting signal. He returned Lever Nos. 19 and 21 to the mid-position, as was his custom, when the signals had returned to Danger and when the train had occupied track circuit AO. This left the levers ready for pre-selecting the route for the next train. He then looked at his diagram to check that Train T6 was showing on the Southbound Main Line in rear of Signal JB47/48 and set the route for this train by pushing Lever Nos. 47 and 45, the latter operating the junction signal for the crossover from the Southbound Main to the Southbound Local via Points and Movable Angles Nos. 217. Dack said he turned aside to speak to the lineman, Automatic Equipment Technician (AET) Thorpe, but noticed a shadow, glanced at the diagram, and was convinced that he saw Signal JB47 off; that is that the indication was lit. At that moment he heard a bang. As far as he was concerned Train T40 had passed over the route and was occupying track circuit AO but as he was looking at the indications for Train T6 he had not noticed if T40 had also occupied track circuit AR.

11. Dack said that, after hearing the bang, the traction current indication light went out and the audible alarm started. At first he thought that it was Train T6 that was derailed. He notified the Controller immediately that there was an obstruction to the line but shortly afterwards Motorman Hodges telephoned him to request that the traction current should be discharged and all signals set to Danger to protect his train. Dack told Hodges that he had already done this, that a lineman was on his way to the junction, and that he would allow nothing to move until it was safe to do so. He said that under these circumstances it was normal practice for the emergency services to be called by the line controller.

As to the Condition of the Signalling Equipment

12. Regulator Dack said that he was aware that Lever Number 21 was a 'sticky' lever. By that he meant that the lever in the IMR did not always respond when he set the route on the frame in the signal box. He said that no formal record of such occurrences were kept by the regulators but as faults arose they were reported to the Automatic Equipment Technician (AET) on duty in an adjoining part of the cabin. However the AETs did maintain a record. Dack said that the normal practice with a sticky lever was to 'restroke' it and it then usually responded. It had happened two or three times since he first reported the fault.

13. The AET in the regulating room at the time of the accident was *Automatic Equipment Technician F. Thorpe*. He described his duties and explained that during the hours in which trains were running the opportunity for undertaking anything other than emergency work was limited. He was aware from his log that there had been trouble in the past with Lever No. 21 but that it had not failed that evening, in spite of the fact that attention to the lever had first been given two days earlier and this had not been reported as being complete. He was in the regulating room when he heard the circuit breakers in the substation some 150 m south-west of the signal box operate. He looked at the diagram and saw that the indicator showed that the traction current had been discharged. He also noticed that AR and PA track circuits were showing occupied and that the A end of Points No. 217 was showing reverse but this indication flickered and then went out. He looked to see which routes the Regulator had set and saw Lever Nos. 45 and 47 were in the push position. He did not notice the positions of Levers Nos. 19 and 21. After reporting to the central report centre at Acton he subsequently went to Harrow North IMR and noted the positions of the levers there. He found that Lever Nos. 45 and 47 were in the reverse position as was 217; the remainder were normal. He agreed that this showed that both Lever Nos. 19 and 21 had gone normal in response to Regulator Dack calling the route for numbers 45 and 47. He confirmed that Points No. 215 were normal and were held so by Train T40 occupying track circuit AO. He tried Lever Nos. 19 and 21 and both were mechanically locked in the normal position.

14. The person who had attended to the 'sticking' Lever Number 21 on 5th September, two days earlier, was *Locking Fitter M. Dight*. After obtaining permission from the regulator on duty he turned the air off the frame in Harrow North IMR and tried Lever No. 21 by hand. He decided it was sticking between the D and E positions; that is between the reverse indication position and the position where electrical contact is just not broken before the lever reaches the full reverse position. He checked to see that there was no improper interference in the locking dogs. His assistant then tried the lever as he watched the slide. He decided that there was evidence of this rubbing in the guides so he polished it with some fine emery cloth. After testing the lever again he thought that the polishing was having some beneficial effect. He therefore polished it a little more, cleaned it up, and restored the air to the frame to test the lever on power. He did this himself at Harrow North and then asked the AET on duty at Harrow-on-the-Hill to try the remote lever there. Both tests proved satisfactory. He had not checked any of the clearances between the slide and the guide or elsewhere because the polishing of the slide, a normal practice, seemed to cure the problem. He had observed the electric locks operating while his assistant was working the frame but did not look at the locks themselves as he had never known of a defective lock causing a 'sticky' lever. He had with him the maintenance schedules and agreed that if he had thought that the lock was incorrectly set he could have changed it. He had not gone down into the pit between the front and back legs of the frame.

As to the Signalling Layout, Equipment Design and Technical Tests

16. *Mr N. S. Hurford* was the Signal Engineer (Design) of London Transport and he described in detail the technical layout of the equipment at Harrow-on-the-Hill and Harrow North. He also described the track layout and the functions of the various items of signalling equipment on and about the track. He explained that the electric lock whose failure had ultimately led to the derailment was a common one on London Transport as it formed part of their basic standard design of interlocking frame. He estimated that there were between 5,000 and 6,000 on LT alone; British Railways also used them but not so commonly.

17. Mr Hurford also explained that, historically, the design of double junctions of the kind at Harrow North had never included the direct locking of a set of movable angles by the occupation of the track circuits other than that over them; in this case track circuit AO was not included in the lock of No. 217 Movable Angles. This was because route holding was achieved by not releasing the appropriate route-setting lever from its mid-stroke position until such time as a train had been proved clear of the route. He agreed that he would re-examine the position in the light of this accident but pointed out that the principle involved signalling layouts other than the few double junctions.

18. *Mr M.I. Bletcher, Signalling Maintenance Engineer* said that the last full overhaul on the frame at Harrow North had been carried out in August 1978. Routine checking of the whole frame is carried out nominally annually but, depending on other calls on the fitter's time, takes place every 12 to 18 months. At the time of the incident this routine check was in progress at Harrow North but, because only four shifts of maintenance had been completed, the stage of checking the clearances on the electric locks had not been

reached. He said the reason for the latch not holding No. 21 lever slide was that the effective length of the stem had been increased, thus lifting the latch when the lock was de-energised, because the diabolo nut had worked its way down the threaded portion of the stem. The position of the diabolo nut was set to give the correct clearances to the latch and then secured in this position by a copper lock plate and lock nut. However, after the accident, the lock plate and lock nut were found complete in the pit below the frame. Their absence had allowed the diabolo nut to become unscrewed down the threaded portion of the stem because of the vibration on the frame during lever movements and because the concentric push-off spring exerts a continuous downward force on the nut. Both the tabs of the copper lock plate were complete, showed signs of having been correctly bent and should have prevented the lock nut from turning. No satisfactory explanation of the lock plate failure could be found. All the other similar locks on LT had been examined and no repetition of the fault discovered. He had advised the manufacturers of the incident and understood that British Railways had also checked their locks, again without finding a similar fault. He concluded that the failure was an entirely random one. He commented that Locking Fitter Dight had carried out quite correctly the normal fault finding and correction process and he could not blame him for failing to spot such an obscure failure, which probably would have defeated many more experienced signal engineers.

19. During the night of 7th and 8th October 1981 various tests on the signalling equipment at Harrow-on-the-Hill and at Harrow North were made in my presence by Mr Bletcher. The object of these tests was to confirm the validity of the route-holding locking for route-selection Lever Nos. 21/22 and 45/46. In the first test the route along the Northbound Local was set and the movement of a train over the route simulated. The levers in the IMR only completed their full strokes after the appropriate track circuits had been occupied and, in the case of Lever No. 21, when the rear of the train was proved to be clear of track circuit AR. The second test was designed to see if the aspect of Signal JB47/48 could clear under the conditions which occurred on the night of the accident as had been supposed by Regulator Dack. In this test the presence of a train occupying the berth track circuits for Signal JB47/48 was simulated and the route set for a northbound train as in the previous test. The route selection levers in the signal cabin were replaced when the "train" was occupying the track circuits in advance and rear of Signal JB21/22. The electric lock on Lever No. 21 in the IMR was artificially disengaged and the lever fully restored by hand. Route-selection levers for routes 45 and 47 were operated and track circuit AM cleared. At this stage AOT was energised and Lever Nos. 19 and 215 were normal and 217 reversed. The aspects of Signals JB45 and JB47 did not clear. Subsequently track circuits AR and PA were occupied as had occurred during the incident but it was not until these two track-circuits had been cleared and both AT and ΔAT occupied did the signal aspects clear. In the third test the conditions were as for the second except that the route selection was not restored until a little later, that is when AMT had cleared; the results were as in the second test. Regulator Dack must therefore have been mistaken. Checks were also made on the track locking of Points Nos. 215 and 217 and all was in order. The tests therefore showed conclusively that the sole reason for No. 217 Movable Angles becoming reversed on the approach of Train T40 was because Lever No. 21 in the IMR was not held at mid-stroke but allowed to move to the fully normal position. The remainder of the signalling functioned correctly.

Conclusion And Remarks

20. The derailment of Train T40 occurred because the train was diverted from its proper course by the improper reversal of No. 217 Movable Angles. These had reversed because the mechanical failure of an electric lock in route-locking circuits allowed the route set for the train to be destroyed and a conflicting route to be set in response to the quite legitimate operation of route-selection levers in Harrow-on-the-Hill Signal Box. The movement of the whole of Points and Movable Angles Nos. 217 would have been prevented if they had been directly track-locked by the occupation of all track circuits in the overlap of the protecting Signal JB21 instead of just the track circuits in which they lay.

21. The direct cause of the mechanical failure of the electric lock was the loss of the lock nut which allowed the adjusting nut to alter the setting of the locking latch. Quite when this loss occurred was not established; it may or may not have happened before Locking Fitter Dight attended to the frame two days earlier. The lock nut had been correctly fitted with a copper locking plate (or tab washer) whose tabs showed that at some time after their initial installation they had been properly bent over to prevent the rotation of the lock nut. This is a well-proven method in general engineering use. Inspection of most if not all similar locks in use in this country has not revealed a similar failure. I therefore consider this to be an entirely isolated failure and accordingly have no recommendations to make. I also consider that Locking Fitter Dight cannot be blamed for his failure to notice this defect during his work on the frame. However London Transport decided that the means of preventing the lock nut from turning will be changed from a locking plate to a retaining clip and split pin because, in their view, this will give greater security and be more easily checked to see that it is still correctly fitted.

22. I believe that as a matter of principle track circuit AO should be included in the direct locking arrangements for Points No. 217. However I accept that had this very rare equipment failure not occurred the

locking arrangements would have been adequate. Nevertheless, London Transport agreed to include the track circuit in the locking arrangements and this has been implemented. Accordingly I have no recommendations to make on this account either.

I have the honour to be,

Sir,

Your obedient Servant,

C. B. HOLDEN
Major

The Permanent Under-Secretary of State
Department of Transport

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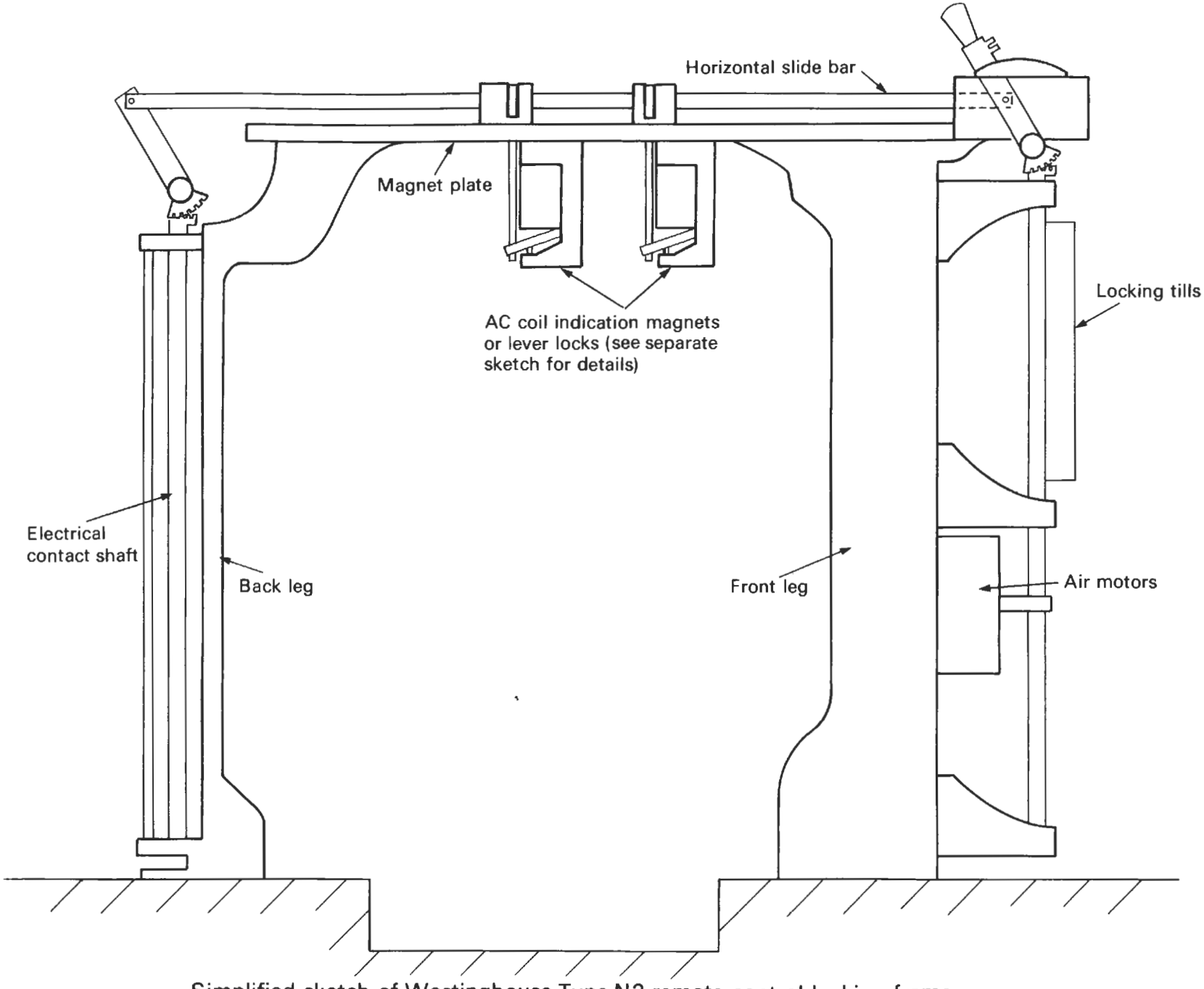
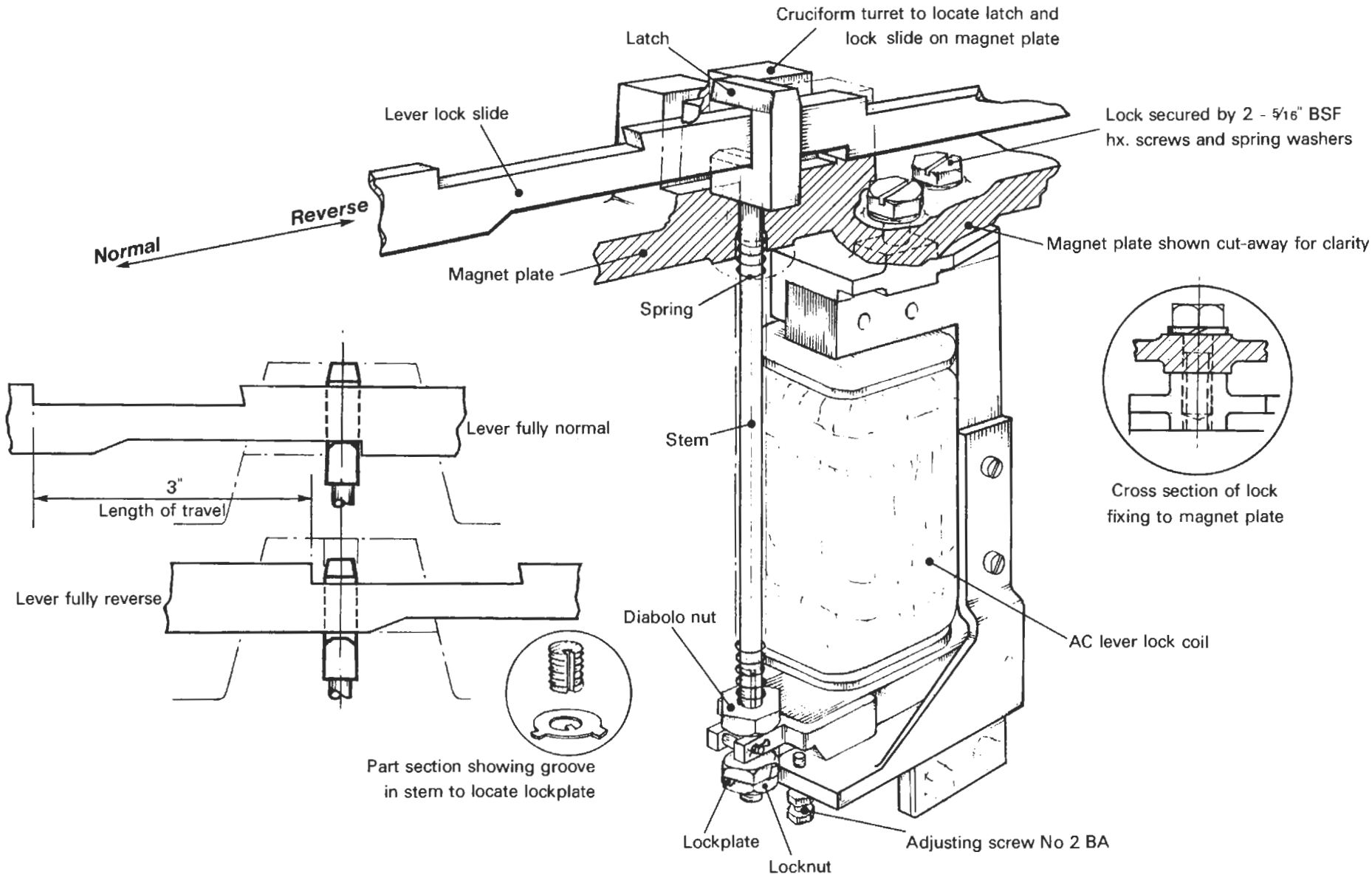


Simplified sketch of Westinghouse Type N2 remote control locking frame

Department of Transport
RPHP3 Drawing Office 85/ 138

Mounting of lever lock on power frame magnet plate

(By courtesy of Director of Signal Engineering, London Regional Transport)



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