MINISTRY OF TRANSPORT & CIVIL AVIATION

RAILWAY ACCIDENTS

REPORT ON THE DERAILMENT

which occurred on

4th September 1953

at

BETHNAL GREEN STATION

in the

EASTERN REGION

BRITISH RAILWAYS

LONDON : HER MAJESTY'S STATIONERY OFFICE

1954

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MINISTRY OF TRANSPORT AND CIVIL AVIATION,
Berkeley Square House,
London, W.1.
14*th April*, 1954.

SIR,

I have the honour to report for the information of the Minister of Transport and Civil Aviation, in accordance with the Order dated 7th September 1953, the result of my Inquiry into the derailment which occurred at 2.26 p.m. on Friday 4th September 1953 at Bethnal Green Station in the Eastern Division of the Eastern Region, British Railways.

The 2.21 p.m. express passenger train from Liverpool Street to Ipswich, running under clear signals, was approaching Bethnal Green Station on the Down Main at a speed of about 20 m.p.h. when it became derailed at a crossover leading to the Down Suburban line due to the irregular operation of the facing points. The engine and tender remained on the Down Main but the rear bogie of the first coach and the rest of the train were diverted to the left. The first vehicle was carried forward broadside until it struck the station platform and then was crushed against an anchor structure carrying the wires of the overhead electrical equipment. The second coach and the leading bogie of the third vehicle were also derailed, but the rest of the train remained on the rails.

There were only four passengers in the leading coach and fortunately they escaped without serious injury; no one else was hurt. The emergency arrangements were prompt; ambulances, Fire Brigade and Police arrived at 2.35 p.m., and the casualties were all cleared by 2.45 p.m.

The Up and Down Main and Suburban lines were blocked, but through working was still possible on the Electric lines. The rear part of the train was drawn back to Liverpool Street at 3.15 p.m. and clearance work was put in hand quickly. In the meantime an extensive reorganisation of the transport arrangements was necessary for the evening peak. A special bus service was introduced between Liverpool Street and Hackney Downs, where trains were run to Enfield and Chingford. The electric services were reorganised to run at 10 minute intervals, passengers for Hertford and Cambridge were directed to King's Cross, and Southend passengers to Fenchurch Street. A reduced steam service ran from Liverpool Street. The Suburban lines were cleared for traffic by midnight and the Main lines by 2.50 a.m. on the following morning when normal working was resumed.

The weather was fine and the rails were dry.

I. DESCRIPTION OF SITE

1. Bethnal Green station is just over a mile from Liverpool Street at the junction of the main lines to Cambridge and East Anglia. The general layout is illustrated in Fig. 1 of the accompanying diagram. The six passenger lines run East and West and are in the following order from the North — Down Suburban; Up Suburban; Down Main; Up Main; Down Electric; Up Electric. The Main and Electric lines are equipped for electrical traction on the overhead contact system at 1,500 volts D.C., but the Suburban lines are used for steam services only.

Shortly after leaving Liverpool Street the gradient rises at 1 in 70 for half a mile as far as the centre of Bethnal Green station. The approach to the station and the tracks through it are straight, but there is a sharply curved left-hand junction at the east end where the Suburban and Cambridge lines diverge to the North. The station platforms serve only the two Suburban lines and the Down Main. At the west end there are a series of crossovers, of which only the two between the Main and Electric lines are much used. The others are provided primarily for use in emergency and for diversions of traffic for engineering works and other purposes.

2. All points and signals are electrically operated from Bethnal Green signal box, which is equipped with the Siemens' system of route relay interlocking as described in Section VI.

3. The permanent way in the Main and Suburban lines at the west end of Bethnal Green station is laid with standard 95 lbs bull-headed rails and cast iron chairs on wooden sleepers and crossing timbers in stone and slag ballast.

II. THE TRAIN

4. The train comprised 10 bogie coaches and it was hauled by a 4–6–0 type engine which, with its tender, weighed 123 tons in working order. The total length of the train was 666 feet and its weight was 442½ tons. The steam brake was in operation on the coupled wheels of the engine and the vacuum brake on all wheels of the coaches, giving a brake power of 333 tons, equivalent to 75¼% of the total weight of 565½ tons. The coaches were of timber construction on steel underframes. The weights and wheel spacings of the engine and leading coach are shown by Fig. 3.

III. COURSE OF THE DERAILMENT

5. The train, which was still climbing the 1 in 70 gradient, was only travelling at about 20 m.p.h. when it reached No. 52 facing points just outside Bethnal Green station. Immediately after the accident these points, which had been set for the passage of the train along the Main line, were found lying bolted for the crossover movement to the Surburban line. The position of the vehicles indicated that the engine, tender and leading bogie of the first coach had passed correctly along the Down Main but the rest of the train had been diverted to the left.

6. The track was ⅜ inch wide to gauge in front of the switches but the blades were undamaged and there were no signs of the points having been split nor caught by any projecting object. The first marks of derailment were opposite the nose of the crossing on the check rail, where there were marks of a wheel having passed over it. Thereafter there were marks on the chairs and sleepers as indicated by Fig. 2.

7. It was clear therefore that the points had moved under the train between the bogies of the first coach. As will be seen from Fig. 3, the distance between the rear wheel of the first bogie and the front wheel of the second one is 34 feet 6 inches; hence the time taken to travel this distance at 20 m.p.h. is just over one second. This coincides closely with the time taken for the actual movement of the points, excluding unbolting and rebolting; so it can be assumed that the points became unlocked while the engine tender and leading coach bogie wheels were passing over them, but they were held in position until the rear wheels of the bogie freed the switch blades sufficiently for the points to begin to move. There was just enough time for the points to reverse completely before the next pair of wheels reached them, after which they were rebolted while the second bogie was taking the diverging route.

8. The pull of the engine in front forced the leading right-hand wheel of the second bogie to the right of the nose of the Vee crossing and thus derailed it at this point. The thrust from the rear pushed the leading coach more and more to the left till it was carried forward broadside on to the platform and finally hit the anchor structure, around which it was bent almost double.

The next five vehicles passed safely through the crossover towards the Down Surburban line but the leading bogie of the second coach was pulled off the rails just before it reached the Down platform, and the whole coach finally came to rest with all wheels derailed and the body crushed against the platform wall. The leading bogie of the third coach was also derailed but the rest of the train was undamaged and it stopped with some of the coaches on the crossover and others still on the Down Main, as shown in Fig. 1.

The coupling between the tender and the leading coach became detached when this vehicle hit the platform, and the engine and tender ran forward undamaged for a further 70 yards.

9. No. 53 trailing points in the Down Suburban line were run through and No. 52 point machine, which was fixed in the six foot way between the Up and Down Suburban lines, was destroyed. The signal posts and a disc signal at the end of the Up platform were demolished, and another point machine and a number of signal cables were damaged.

IV. Investigation Procedure

10. Attention was concentrated on ascertaining the cause of the sudden reversal of No. 52 facing points. The integrity of the signal interlocking was established and it was clear that the signalman was in no way to blame. A comprehensive series of tests were made of the electrical and signalling equipment as described in detail in the respective sections of the report. No faults could be found in any of the equipment which might have led to the irregular operation of the points, but during the Inquiry it came to light that linemen were testing the point motor circuits at the time of the accident. Consequently every aspect of these tests was thoroughly probed, and a number of experiments were made to find out whether a false feed could have been applied in the course of this work; these are described in paras. 50 – 52.

V. The Electric Traction Equipment

11. As already mentioned, the Main and Electric lines are equipped for electric traction on the overhead contact system operating at 1,500 volts D.C. The main high tension power supply is A.C. 3-phase current at 33,000 volts, which is distributed to a number of sub-stations through feeder cables carried on concrete posts beside the track. The sub-station serving the Bethnal Green area is alongside the Down Main about 500 yards to the east of the Bethnal Green East Junction and there is a track sectioning cabin outside Liverpool Street Station.

The outgoing 1,500 volt D.C. feeders from the sub-station are insulated with vulcanised india rubber and bitumen, and are carried in separate wooden troughing to the feeding posts. They are protected by high-speed breakers with associated isolating switches, and similar equipment is provided at the track sectioning cabins. These breakers are set to trip at 4,500 amps and to remain 'out'. Capacitors are also provided between the positive feeders and earth in order to dissipate surges caused by lightning.

The overhead line is of compound catenary design and is carried on steel structures spaced about 70 yards apart on the straight but at shorter intervals on curves. The catenary wires are insulated from the structures by diabolo type insulators and the structures themselves are bonded to the rail either directly or else through earthing wires from adjoining structures. Similarly, at overbridges all supporting steel work is linked to the running rail.

All rail joints are bonded, and cross bonds between rails and between tracks have been provided at intervals so as to ensure complete continuity of the traction current return path. At each sub-station automatic earthing contactors connect the running rail return circuit to earth should the voltage between rail and earth rise to 150/160 volts (normally it does not exceed 25 volts).

The switch gear equipment in all sub-stations and track sectioning cabins is remotely controlled from Chadwell Heath.

VI. The Signalling Equipment

General.

12. The signalling at Bethnal Green, which is illustrated by Fig. 4, was brought into use in January 1949 in connection with the Liverpool Street – Shenfield electrification. There is continuous track circuiting on all lines and movements are advised on automatic train describers, working on a coded impulse system with standard telephone type equipment. The signal box is in the angle between the Up Fast Cambridge line and the Down Main, just to the east of the junction, and it is equipped with route relay interlocking with an illuminated panel on which the route selecting switches are mounted.

Route relay system.

13. With this system the normal interlocking between levers on a power frame is transferred to relays, one of which is provided for every purpose for which a lever would otherwise be required. Each relay has normal and reverse contacts corresponding to those of a lever and it is interlocked electrically with other relays as required. The turning of a route switch on the panel energises the appropriate relay and this initiates changes in the position of the other point and signal relays, as in the case of a normal lever frame. In this installation, the switch indications are actually transmitted to the interlocking relays through small key repeat relays. As with all other relay interlocking panels, the route switches are free to be turned at any time but the points will not move and the relevant signal will not clear unless all the conditions are correct as established by the interlocking and control circuits; clearance of the signal also requires the appropriate point detection. The points can also be worked by individual switches with suitable interlocking and controls.

The signals.

14. The running signals, which include a number of automatics, are of the multi-lens type with 12 volt A.C. double filament lamps taking power direct from the main supply through their own individual transformers; ground and subsidiary signals are of the two-position banner type operated through isolating transformers from the 110 volt A.C. supply. Some of the running signals are mounted on independent gantries, some are on the overhead structures and others are carried on independent posts.

15. Approach locking of the running signals by track circuit occupation holds the route until the train has cleared the junctions ahead, and in the case of through routes this locking is extended back to the first warning signal in rear. Time releases are provided to cover re-routing of train movements.

Relevant signals and point machines.

16. A brief description is given below of the signals and point machines to which reference is made in this report:—

Down signals	*Description*
2A	Down Suburban Home.
2B	Down Suburban to Down Main Home.
8A	Down Main to Down Suburban Home.
8B	Down Main Home.
8C	Down Main to Down Electric Home.
10A	Down Main to Down Fast Cambridge Inner Home.
10B	Down Main Inner Home.
12	Down Main Starter.

Nos. 10A and 10B are provided with banner repeaters at the London end of the station.

Up signals	*Description*
3A	Up Fast Cambridge to Up Electric.
3B	Up Fast Cambridge to Up Main.
3C	Up Fast Cambridge to Up Suburban.
5A	Up Suburban to Up Main Starter.
5B	Up Suburban Starter.
11A	Up Main Starter.
11B	Up Main to Up Suburban Starter.
35D	Auxiliary signal for back shunting movements from Down Electric to Down Main via crossover 56.

Points	*Description*
50	Up Main to Up Suburban crossover.
51	Down Suburban to Down Main crossover.
52	Facing points of Down Main to Down Suburban crossover and facing points of Up Suburban to Up Main crossover.
53	Trailing points of Down Main to Down Suburban crossover.
54	Trailing points of Up Suburban to Up Main crossover.
56	Down Main to Down Electric crossover.
60	Trailing points Up Cambridge Fast to Up Main.
61	Facing points Up Cambridge Fast to Up Suburban, and facing points Down Main to Down Cambridge Fast.

The relay room.

17. The relay room is on the ground floor of the signal box with the battery room adjoining it at the west (London) end, and the workshop, linemen's room and store at the other end; the general layout is shown by Fig. 5. It houses the following types of relay:—

The interlocking (L.R.) relays, working on 24 volts D.C. which are energised by the key repeat (P.R.) relays through the operation of the panel switches.

The control (W.R.) relays, which also work on 24 volts D.C. and control the feed to the point machines.

The detection (W.K.R.) and the track circuit (T.R.) relays, all of which are of the 110 volts A.C. type.

These relays are mounted on racks running along three sides of the room; down the centre is a panel 6 feet 9 inches high carrying the fuse and terminal boards as well as other instruments. A short rack for the P.R. relays is fixed alongside the panel and next to it are cabinets containing the train describer equipment. Thus the relay room is virtually divided into two aisles running East and West with connections at each end. There is a table in the centre of the south aisle for the use of the lineman and a book of wiring diagrams is kept there.

The power supply.

18. The power for the signalling is obtained from the local supply mains at 400 volts 3-phase 50 cycles and it comes in at Bishopsgate sub-station where transformers change it to 2-phase at 600 volts. One phase supplies the Liverpool Street and the other the Bethnal Green signalling. Two 600 volt feeders are taken from the Bishopsgate sub-station to Bethnal Green, one for feeding the Up side and the other for feeding the Down side location cases. Both feeders enter the Bethnal Green box where the supply is stepped down by transformers in the relay room to supply single-phase alternating current at 110 volts to the track circuits, detection relays and the main subsidiary signals, and 12 volts A.C. to the indicating lamps on the control panel. Transformer-rectifier sets provide direct current at 24 volts for the relay interlocking system and at 110/115 volts for charging the secondary battery, which in turn produces the power for operation of the point motor machines. Transformers at the location cases also step down the 600 volt supply to 110 volts A.C. for the track circuits, point detection circuits, etc. in the immediate vicinity.

19. The main power supply switch gear, transformers and rectifiers are at the west end of the relay room, and the leads from the 110 volt D.C. battery in the room next door are taken to bus bars on the same wall. From here the 110 volt D.C. positive leads are taken to the appropriate fuses on the fuse board, but the negative returns are through another distributory bus bar on the wall behind the point control relays on rack D. Glass panels, held in position by butterfly nuts, protect those relays and the bus bar.

Similarly the 24 volt D.C. positive feeds are taken through fuses to the interlocking, control and P.R. relays, and to the panel switches; the negative return circuits are through bus bars conveniently spaced around the walls of the relay room. The 110 volt and 12 volt A.C. supplies are also fed through bus bars.

The cables are carried in ducts underneath the floor and are led from there to the respective bus bars, fuse and terminal boards.

The terminal links.

20. The incoming 110 volt D.C. and other circuits are mounted on porcelain blocks arranged in groups on the terminal panel, a section of which is shown by Fig. 6. Each group, or board, accommodates all the circuit connections of one or more multicore cables, e.g. No. 19 board has 41 and No. 20 board 43 sets of terminals. Each pair of terminals is connected together by a pressed steel link which has a slot at one end and a U opening at the other so that it can be drawn back to break the circuit for testing and other purposes. An illustration of the top seven terminals of multicore cable (BG–B2)B on No. 19 board, to which reference is made later in the report, is given in Fig. 8.

No. 52 points control relay.

21. No. 52 points control relay and its circuits is illustrated by Fig. 7. Three sources of power are linked to the instrument, namely:—

(*a*) The 110 volt A.C. supply which energises the point detection relay (W.K.R.) circuits.

(*b*) The 110 volt D.C. supply which provides power to work the point machine through the operating contacts.

(*c*) The 24 volt D.C. circuits which energise the point control relay coils through the various interlocking and track circuit relays.

The 110 volt A.C. supply (BX.110) comes from a nearby location case to the point detector terminals on the point machine and thence via links on the terminal board in the relay room to contacts on the point detection and point control relays. The return circuit is from the point control relay via another link on the terminal board to the point detector terminals.

The positive lead (B.110) from the 110 volt D.C. bus bar is taken through the appropriate fuse on the fuse board to the point operating contacts on the point control relay whence two circuits, namely normal operating (N.W.M.) and reverse operating (R.W.M.) lead to the point machine after passing through links on the terminal board. Subsidiary circuits from these links are taken to the snubbing contacts on the control relay so as to provide regenerative braking for the point machine at the end of each stroke. These circuits also give a certain measure of cross protection in the case of a false feed being applied directly to the machine. The return negative circuit runs from the point machine to the negative link on the terminal board and thence to the negative distributory bus bar. There is a corresponding negative circuit from the snubbing contacts to the same bus bar.

The 24 volt D.C. supply is taken through the various controlling relays to the point lock relay and thence to the normal and reverse terminals at the bottom of the point control relay. The negative return is led direct from this relay to the 24 volt D.C. negative bus bar.

The diagram shows the relay latched in the normal position. There are two sets of butterfly type contacts, normal on the left and reverse on the right, and each set is mounted on a slide bar which moves under the influence of an armature behind it. In the normal position the six left-hand butterfly contacts are touching their respective terminals, as shown, so that the normal operating circuits are closed and the reverse operating circuits are open, with the points lying in the normal position.

In order to reverse the points, the appropriate switch on the panel is turned to the correct route, namely B.G.8 to route A, or B.G.5 to route A, or No. 52 individual point switch to R. Provided all conditions are correctly established by the other interlocking and control circuits, the reverse operating coil of No. 52 lock relay will then be energised and this in turn will supply current (24 volt D.C.) to the right hand operating coil of the control relay. As soon as this coil is energised the armature will lift the right-hand slide so that the reverse operating contacts are made and 110 volt D.C. current passes through the reverse operating circuit to the point machine; at the same time the left-hand slide will be unlatched and will drop so that the normal contacts are broken.

No. 52 point machine.

22. As will be seen from the signalling diagram Fig. 4, No. 52 point machine not only operates the facing points of the Down Main to Down Suburban crossover but also the facing points of the Up Suburban to Up Main crossover. The actual machine, which is of the combined type incorporating the facing point lock and detector, is located opposite the Up Suburban facing points in the six foot way between the Up and Down Suburban lines. The Down Main points are worked by rodding which also operates the facing point lock and detector at this end of the layout.

Power for the machine is carried in a multicore cable from the terminal panel in the relay room to a location case on the Down side at the end of the platform and thence through another cable to the machine. The operating sequence is:—

(*a*) The lock bar moves half travel to unlock the points.

(*b*) The point throw bar moves full travel to throw the points.

(*c*) The lock bar completes its travel in the same direction to lock the points.

Each sequence takes approximately one second. After each complete operation the mechanism is brought to rest without shock by making the motor regenerative through the snubbing circuit. Two pole changer coils, one for normal and the other for reverse operation, are fitted so as to reverse the motor circuits when necessary.

The power needed to operate two pairs of points from one machine is approximately 4 amperes at 100 volts.

Interlocking and control of No. 52 points.

23. These points are set and locked by the operation of one of the following route switches:—

Normal position — 5B, 11B, 35D, 2B, 8B and 8C,

Reverse position — 5A, 8A.

The points can only be reversed by the individual point switch when Nos. 50, 51 and 56 points are normal, route switches 5, 8 and 11 are turned to neutral and either route switch 3 is neutral or No. 60 points are reversed.

The points are locked either normal or reversed by the occupation of track circuits M7, M9, S28 and S30 (S22A, S24 and S26 subject to a time release). BG.8 signal is approach locked by track circuits M5, M3, M1 and HW and backlocked by M7. Hence, once B.G.8 has been cleared, No. 52 points are locked through the track circuit relays as soon as HW track circuit is occupied and they cannot be released so far as the Down Main is concerned until track circuit M9 has been occupied and cleared, even though B.G.8 has been restored to normal (a two-minute time release is provided to cover re-routing).

The B.G.8B aspect (*i.e.* Down Main through signal) detects No. 52 points in the normal position and conversely the signal returns to Danger whenever this detection is broken down.

VII. Evidence About the Running and Condition of the Express and Other Trains

Train crew.

24. The evidence of the train crew showed that the express left Liverpool Street about one minute late and travelled normally along the Down Main as far as the London end of Bethnal Green station.

Driver H. A. Gallington said he was running under clear signals at about 20 to 25 m.p.h. when he felt a heavy pull on the engine just as it reached the station platform. He looked out from the left hand side of the cab and saw the leading coach hit the overhead structure. The tender coupling parted at this moment and the brakes were applied automatically, so that the engine stopped a short way down the platform.

Gallington stated that Bethnal Green No. 8 signal was showing a green light as he approached, and both B.G.10 banner repeater and colour light were 'off' for the Main line. He did not notice the aspects of the signals on the Down Suburban line.

25. Fireman G. J. Humphrey also saw B.G.8 colour light showing green and B.G.10 banner repeater 'off' for the Main line, and he confirmed his driver's description of the accident. As soon as the engine stopped, Humphrey jumped on to the platform, ran to B.G.10 signal and telephoned the signalman telling him to stop all traffic and to send for the breakdown equipment and ambulances.

26. Guard A. R. Church, who was in charge and was travelling in the ninth coach, saw all the signals up to and including Bethnal Green No. 8 showing clear aspects, after which he turned back from the van window and began sorting letters, parcels, etc. While he was doing this the train stopped very suddenly and on looking out of the window again he realised there had been an accident. He went forward to find out what had happened and was informed by the Station Foreman that all arrangements had been made to stop traffic.

Guard F. C. Armstrong, who was acting as assistant, then went back to protect the rear of the train, and later he piloted an engine on to it, while Guard Church remained with the undamaged coaches and returned with them in due course to Liverpool Street.

Signalman.

27. Signalman A. G. Reynolds, who was on duty in Bethnal Green signal box, could throw no light on the cause of the derailment. He described the movements which he had dealt with just before the accident and said that on the Down Suburban a series of trains had passed through the station, the last of which was the 2.18 p.m. to Chingford. After this the 2.24 p.m. Liverpool Street to Yarmouth train had been described but it had not arrived before the accident. Nos. 51, 53 and 55 points remained normal for all these movements and the switch of signal B.G.2, which is semi-automatic, was left set for the through route, (position A, *see* para. 16).

On the Down Main the 1.50 p.m. Liverpool Street to Southend had passed at 1.54 p.m., after which Reynolds set the Down Main to Fast junction (No. 61 points) at the country end for the Cambridge parcels train, which cleared the station at 2.0 p.m. The next movement on the Down Main was to be the Ipswich express which was involved in the accident, but before it arrived the 1.58 p.m. from Chingford was described on the Up Fast instrument. Reynolds set the road for this train to enter the Up Suburban platform by turning signal switch B.G.3 to the 'C' position, and this action automatically restored the Down Main to Fast junction to normal. Signal B.G.5B, which is another semi-automatic, was already off, and the Chingford train departed on the Up Suburban at 2.23 p.m.

At about the same time, the Ipswich train was described on the Down Main instrument, the indication appearing opposite the B.G.8 signal position. Reynolds immediately cleared signal switches B.G.10B and B.G.12 for the express and thus gave it a clear run through the station, since B.G.8B, which is also semi-automatic, had been left in the 'off' position after the passage of the previous train on the Down Main.

Reynolds did not see the train approaching and the first indication of trouble which he received was the ringing of the describer bell and the appearance of the letters N.D. (not described) on the Up Suburban instrument. He stopped the bell by pressing the switch and then he saw that track circuits S.28, S.26, S.45 and S.43 on the Suburban lines were occupied as well as M.7, M.9 and M.11 on the Down Main, and he also noticed that the detection of Nos. 52, 53 and 55 points was lost. He looked down the platform towards London and on seeing a cloud of dust he realised there had been an accident. He immediately sent the "Obstruction Danger" signal to Liverpool Street, Mile End and Hackney Downs, and restored all signal switches to the neutral positions. No sooner had he done this than the fireman of the train engine rang up from B.G.10 signal and told him what had happened.

Reynolds asked the timekeeper to call the lineman, who came up a minute or so later. He asked what had happened and then checked the position of the switches before returning to the relay room.

Condition of trains.

28. No defects were found on the engine and coaches of the derailed train which could have affected the working of No. 52 points in any way.

The stock of the 1.58 p.m. train from Chingford, which was the last to pass along the Up Suburban line, was thoroughly examined to see whether there was anything missing or out of place which could have damaged No. 52 point machine. Nothing was found amiss, nor was there anything wrong with any of the other local trains which had passed over that line. The repair cards of the engines on the Surburban lines during the previous 24 hours were also checked and no defect was found which could have any bearing on the possible damage to the point machine.

VIII. Evidence About the Condition of the Permanent Way and the Signalling Equipment

The Permanent Way.

29. Permanent Way Inspector W. M. Reid arrived at the scene shortly after the accident and found No. 52 points lying reversed, with the track damaged, as described in Section III.

Ganger A. W. Hill, who was in charge of the Bethnal Green gang responsible for the Up and Down Main and Electric lines, said that on the day of the accident he and his men were working at the East London Junction between Bethnal Green and Liverpool Street but on the previous afternoon he had been opening two beds of ballast in the Down Main at No. 52 facing points in preparation for relaying two stock rails in the crossing on the Saturday night. The ballast was loose and his men only required shovels in order to open it out between the sleepers. He gauged the points to see what adjustment would be required when the stock rails were put in, and as far as he could recollect they were about $\frac{3}{8}$ inch slack to gauge. The points fitted perfectly, both in the normal and reverse positions. He did not inspect them again until after the accident.

Condition of the signalling equipment.

30. Mr. F. J. Beirne, Area Signal and Telecommunications Assistant, arrived on the scene at approximately 3.0 p.m. He first inspected No. 52 facing points in the Down Main and found them lying locked in the reverse position as already described. The point machine had been smashed but after careful examination he observed that it was in the full reverse position and that the lock had been thrown. No. 53 trailing points in the Down Suburban line had been run through in the normal position.

Mr. Beirne then went to the signal box, where he saw that all signal switches and all the individual point switches were in the neutral positions. The lights in Nos. 52, 53 and 55 point indicators on the panel were out and the track circuits at the scene of derailment were showing "occupied" as already described by Signalman Reynolds. The Ipswich train code letters EP/CO were showing in the B.G.10 column of the Down Main describer and the white circle was also illuminated, indicating that the description had been transmitted forward to Mile End. This does not occur until track circuits M.7 and M.9 have been occupied with No. 52 points set normal, and all the signals are 'off' for the main line (viz. B.Gs 8, 10 and 12).

Mr. Beirne then went into the relay room and inspected the controls for No. 52 points. No. 52 point control relay, No. 52 point and No. 8 signal interlocking relays were all normal, and Nos. 52 and 53 point indicator relays were de-energised. All the glass panels protecting the point control relays were in position with the wing nuts properly screwed on.

Working of No. 52 crossover.

31. In describing the working of the panel, Signalman Reynolds explained that the four crossovers between the Up and Down Main and Suburban lines at the London end of the station were seldom used, as no trains were booked to run over them. They were primarily for use in emergency and for special working, and he did not recollect having touched No. 52 points during the week before the accident. The switches of the three running signals at this end of the station, namely B.G.2, B.G.5 and B.G.8 were normally left set for their respective through routes; they were only turned to the neutral position when one of the crossovers was to be used. Although it was possible to pre-select a route, this was never done, and in any case Reynolds had no occasion to use No. 52 crossover on the day of the accident, nor was he moving any other points at the time of the derailment.

Enquiries made of all the signalmen employed at Bethnal Green established that No. 52 points were last used on 31st August, four days before the accident, for the movement of a light engine from the Up Suburban to the Up Main.

IX. Evidence of the Signals and Telecommunications Staff

32. Lineman G. Eastwood and Assistant Lineman R. Turner were both in or near the Bethnal Green relay room at the time of the accident and Flagman G. A. Lewin was the lookout man on duty. Eastwood, who had been appointed assistant lineman in 1923 and lineman in 1939, had been working at Bethnal Green since October 1948. Turner, who was appointed assistant lineman in 1947, had been at Bethnal Green since June 1949.

Lineman Eastwood.

33. Eastwood said that he arrived at 1.50 p.m. and went straight to the mess room, where he was met by Turner who appeared rather concerned and told him that on testing the 110 volt D.C. circuit he had found an earth on the negative side, with the volt meter showing 100 volts and the test lamp fully alight. Both men returned at once to the relay room (*see* Fig. 5) where the instruments were connected to one of the fuse bars with the earthing wire on the metal frame. Eastwood decided to check the test with his own lamp and returned to the mess room to get it. He substituted his lamp for Turner's and obtained the same result.

His next action was to move the instruments to the power supply panel at the west end of the box, where he normally made these tests on the D.C. bus bars. Again he got the same result so he left the volt meter and lamp connected to the positive bus bar and began searching for the fault on the negative side. He disconnected in turn the two terminals carrying the connections from the main negative bus bar to the distributing bars on the wall behind rack D, and he followed this up by withdrawing eight fuses from the D.C. fuse panel. Turner was with him throughout this part of the test and each time Eastwood removed a terminal wire or fuse he asked Turner "How is it now?" Their efforts, however, were fruitless and the test lamp continued to burn brightly. About this time Lewin came into the relay room and told them their tea was ready, so Eastwood and Turner returned to the mess room.

The two men discussed the problem while drinking their tea and Turner told Eastwood that he thought the fault might be on No. 10 signal since he had been working on it during the morning and he might have trapped a wire in the case. They returned to the relay room together and went to the table in the south aisle to examine the wiring diagrams before making any further tests. Eastwood said he very soon remembered that there was no 110 volt D.C. on the signal circuit and he was about to look through the book of point motor wiring diagrams when Communications Lineman K. Peacock came in and asked about the trouble. Eastwood explained the difficulty and Peacock replied that it was not in his line. They held a short conversation together and then Lewin came in again and told Peacock that his tea was ready. Peacock left the relay room with Lewin, and, according to Eastwood, Turner followed him and did not come back again until after the accident.

34. Continuing his evidence, Eastwood said that after Turner left him he began thinking out a plan for tracing the fault. The various point operating links were located on the panel according to the position of the multicore cables and thus they were not in strict consecutive number order; some were on No. 6 board, others on Nos. 19 and 20 boards, and so on. After spending some minutes tracing the circuits, he decided to check the actual position of the links on the panel, so he walked round to the north aisle and began at No. 20 board where the terminals of No. 50 points – the first in the book – were located. (*See* Fig. 6.)

These links were at the top of the board and he had to stretch upwards in order to turn round the labels so that he could check them. He had a lighted wander lamp with a metal guard over it tucked under his left arm and he shone its light on the labels in order to read them more easily. He said that although he did not recollect having seen any flash or felt any shock, something made him drop the lamp at this moment, an experience he had never had before.

He did not appreciate the significance of this act until some days after the accident, when he realised that the wire guard of the lamp must have been very close to the No. 52 point operating terminals on No. 19 board whilst he was stretching up to reach the labels on No. 20 board. Consequently he did not give this evidence at the initial railway inquiry and it only came to light after the testing of the signalling equipment had been completed.

Eastwood said that he did not attempt to draw any of the terminal links for testing purposes as he had not yet made up his mind what to do. He added that this was the first time he had had to deal with such a fault and he thought of trying to "sort out the job to a certain extent before advising the Chief Lineman or his Inspector". He said he spent several minutes looking at the terminals on the No. 20 board but he did not check any others. After that he went back to the diagrams and began turning these over again with the intention of making out a list giving the positions of all the point operating terminals.

He thought he had been working on his own in the relay room for some 10 to 15 minutes, and he said he was still at the diagram table when Peacock returned and called his attention to the ringing of telephone bells. Eastwood immediately went up to the cabin via the steps at the London end of the building to find out what was the matter. As he was walking up them he saw a large cloud of dust and smoke and the outline of an engine and some coaches on the Down Main and Suburban lines at the far end of the platform. He realised that there was something wrong and on reaching the cabin he noticed at once that B.G.8 signal switch was in the neutral position. The signalman remarked that he had just put it back, but they did not waste time discussing the trouble and Eastwood ran down to the relay room to telephone to his Inspector. He then checked the positions of the relays and noticed that the No. 52 interlocking and point control relays were normal and the detection relays for Nos. 52 and 53 points were both in the de-energised position. He then went out to the scene of the accident and immediately examined No. 52 points.

35. On further examination Eastwood admitted that he met Turner again in the south aisle of the relay room on his return from examining No. 20 board. He told him that they would have to take off the covers protecting the relays in rack D in order to look for the fault on the negative distributory bus bar. He asked Turner to remove the centre cover but before he had time to do this Peacock came back and Eastwood went up to the cabin as already described. Eastwood added that on his return to the relay room Turner had or was in the process of taking off the centre cover so he told him to put it back at once.

36. Finally, Eastwood agreed that in order to trace a fault on the negative side of the 110 D.C. circuit he would draw the negative links on the terminal board and also disconnect the terminals on the bus bar behind rack D. He had actually traced a minor fault on 17th August (*see* para. 43).

Assistant Lineman Turner.

37. Assistant Lineman Turner had difficulty in remembering what he was doing during the critical period in the relay room just before the accident. He said he had been on the early shift from 6.0 a.m. and he had been told by Lineman Poole to test the 110 D.C. circuit. He did this at the end of the morning shift with the results already described by Lineman Eastwood. Turner confirmed Eastwood's story up to the time they went to have their tea but afterwards his evidence was not at all clear. First of all he stated that he came back with Eastwood and watched him checking the diagrams at the table, and he stayed with him until they heard the bells ringing (as a result of the accident).

38. On further examination he changed this story and said that he and Eastwood began testing again near the power panel when they returned from the mess room after having their tea. Turner explained that he concentrated on watching the volt meter and could not see what Eastwood was actually doing, nor did he hear him drop the wander lamp. Every now and then Eastwood called out "How's that ?" and two or three times he walked past him, presumably on his way to the diagram table. This testing went on for five to ten minutes without success.

Turner then left the room to go to the lavatory but he returned when he heard the bells ringing. He met Eastwood, who told him that they would have to take off the covers protecting the point operating relays so as to get at the negative bus bar. Turner however denied that he touched these covers before Eastwood returned from the cabin.

When confronted with Eastwood at the end of the Inquiry, Turner retracted this statement and said that the testing to which he had referred had occurred before they had had their tea and not afterwards.

39. Turner demonstrated on a model how he would test for a negative fault. He explained how he would draw back the N110 links in turn, ask his assistant (if he had one) "How was that ?" and then slip them back again. During this demonstration Turner let the link slip so that it touched the one directly below it.

He also said that very occasionally he had found the link terminal nuts were loose and the last time he could remember was some 6 or 8 months ago at Mile End but on a different set of equipment.

Flagman Lewin.

40. Flagman G. A. Lewin said that he remembered Lineman Eastwood coming into the mess room when he arrived on duty just before 2.0 p.m. and he overheard Turner telling him about the earth on the D.C. circuit. The two men went into the relay room together and were followed shortly afterwards by Lewin who stood for a moment or so near the train describer cabinet watching them working at the power panel at the far end of the room. He then told them their tea was ready and they came back to the mess room about five minutes later.

Lewin said they did not stay long, and when they returned to the relay room he again followed them and watched them at work. They appeared to be carrying out some more tests on the terminal boards and Eastwood made several journeys to the table where the diagrams were. After a few minutes Lewin went back into the mess room and made some tea for Lineman Peacock. On returning to the relay room a short time later he noticed that Lineman Eastwood was missing but Turner was standing near the terminal boards. Lewin then got his flags and went out to look for Eastwood whom he met coming down the stairs from the signal box, after which they proceeded together to the scene of the accident.

On cross-examination, Lewin became vague as to the actual actions taken by Eastwood and Turner. He could not describe the tests that were carried out nor did he appear to have been in the relay room for more than a minute or so on each occasion.

Lineman Peacock.

41. Lineman K. D. Peacock, who is the Communications Lineman in charge of the train describer equipment, said that he arrived at Bethnal Green at about 2.0 p.m. and walked through the relay room to the mess room. Lineman Eastwood was at the table half way down the south side looking at some diagrams. He asked him if he had any trouble, and on being told there was an earth on the 110 D.C. circuit, he replied "That's not in my line". After a short conversation Peacock went into the mess room to have a cup of tea which Lewin had prepared for him. Peacock was quite sure that Turner was not with Eastwood when they were talking together but he believed Turner came into the mess room whilst he was having his tea. Peacock said that about 20 minutes later he heard telephone bells ringing and went into the relay room to find out the trouble. He met Eastwood coming towards him and after they commented about the bells Eastwood left the relay room; Peacock did not see him again.

Lineman Poole.

42. Lineman G. W. Poole said he had been working at Bethnal Green since 1950 and on the day of the accident he was on the early shift which ended at 2.0 p.m. He did not have time to make the daily voltage tests for earth so he told Turner to do this and report to Lineman Eastwood.

Poole demonstrated on the model how he would draw the links on the terminal board in order to trace a fault on the 110 volt D.C. circuit. He explained that when he first did this he occasionally had difficulty owing to the edge of the link catching on the under nut of the terminal, but he overcame this by holding the link in the middle. During this demonstration Poole also allowed a link to slip and make contact with the one below.

Extract from Linemen's log book.

43. Amongst other work, Lineman Eastwood was responsible for the maintenance of No. 52 points and detectors, Nos. 50–59 point control relays and the terminal and fuse panels. The following extracts from the Linemen's log book give Eastwood's notes on some of the work he did on these parts of equipment during the three weeks preceding the accident:—

Date	*Shift*	*Details of work*
August 17th	6 a.m. – 6 p.m.	Check on voltage readings. 3 volts to earth showing on B.110. Tests on circuit to trace this. *Testing on N.110 for earth cleared by disconnection on bus bars in W.R. cabinet at 61–62 points, earth still on.*
August 18th	6.0 a.m. to 6 p.m.	Check on voltage readings B.110, 1.8 volts to 0.3 volts varying to earth. Checking circuits for same.
August 19th	6 a.m. to 6.0 p.m.	Check and record of voltage readings. 110 B 0.8 volts to earth.
August 24th	10 p.m. to 6.0 a.m.	Cleaning relay shelves, checking labels, terminal panels etc.
August 25th	6.0 p.m. to 6.0 a.m.	Cleaning relays shelves etc. Labels examination.
August 26th	6.0 p.m. to 6.0 a.m.	Cleaning relay room, power panel etc.
September 2nd	10.0 p.m. to 6.0 a.m.	Examining W.R's. for cleaning etc.
September 3rd	2.0 p.m. to 10.0 p.m.	Examining point machine spur wheels.

(*Note.*—W.R. stands for point control relay.)

X. The Testing of the Signalling Equipment

No. 52 point machine.

44. A comprehensive series of tests were made to ascertain whether any false feed could have been applied to No. 52 point machine through any part of the signalling equipment. The three operating wires of the 110 volt circuit to the point machine, namely normal, reverse and negative, were tested between the signal cabin and the location box at the west end of the station platform and between the location box and the point terminals. In every case the resistance to earth and between each wire was at least 50 megohms. The resistance of all the other wires in the 28 core cable between the location box and the signal cabin were similarly checked and the lowest reading recorded was again 50 megohms.

The point machine was carefully examined but nothing could be found in it which might have caused a short circuit, though the resistance of the normal pole changer coil had dropped to zero due to a piece of the broken cast iron casing having pierced the coil. When this was removed a resistance of 10 megohms was obtained between the coil and the case, which was the same as the resistance of the reverse coil. The internal leads in the machine had been pulled away from the terminal strip when the box was smashed but the insulation of the leads themselves was excellent. The field coil and armature were also checked and in all cases the resistance to the case recorded infinity readings.

The lock and detector rod insulations of No. 52 points were tested with a 1,000 volt megger and the minimum resistance recorded was 0·5 megohms on the drive rod from the machine to the points, thus there was a small electrical leakage from the machine casing to the return traction current path, but, as indicated above, the motor was properly insulated from the casing.

Internal wiring circuits.

45. All wires in the signal cabin which could possibly affect or have contacted any of the No. 52 point control or operating circuits were tested, both for resistance and for continuity, and no faults were found. The various operating and control circuits for No. 52 points and No. 8 signal were then set up and tested individually for insulation and continuity with similar results. There was no leakage between the 110 D.C. circuits which operate the points and the 24 volt D.C. supply which operates the relays.

Relevant relays.

46. All the relevant relays in the circuit were examined to see if there were any metallic objects or loose wires which might cut out controls or give false operation, but everything was found to be in good order. The detachable tops of No. 52 interlocking relay and the appropriate P.R. relays were taken off to see whether there was anything between the contacts, but they were all clear. The plugs on the ends of the leads used for testing the relays were examined for signs of burning which might occur if there had been a short circuit. None was found but in any case these leads are so laid out that it is virtually impossible to make a short circuit in the course of the normal testing of the 24 volt D.C. or 110 volt A.C. relay systems.

Track circuits.

47. All the relevant track circuits operated correctly when the rails were cross connected through a 0.5 ohm resistance.

Earth leakage tests on No. 73 point machine.

48. Steps were taken to trace the negative fault on the 110 volt D.C. system which Lineman Eastwood had been looking for. The terminals on the negative bus bar were disconnected one by one and the fault was finally traced to No. 73 points where the negative lead to the normal pole changer coil had been trapped between the terminal block and the casing, giving intermittent earthing.

The possibility of a leakage from one motor affecting another was investigated by putting back the earth on No. 73 pole changer coil, applying a false earth at various points on the adjoining No. 71 points motor and then operating No. 73 motor; but in no case did No. 71 motor begin to move.

Other point machines.

49. The insulation of every point machine operated from Bethnal Green cabin was thoroughly tested, including cables, motor pole changer coils and rod insulations. The result of these tests showed that the insulation was generally very satisfactory though there were minor leakages on the point machine pole changer coils in one or two places. None of them could have had any effect on the point operation, because the resistance of the insulation was still so great that only a negligible current could have passed through earth to another point machine.

No. 19 terminal board.

50. Two days after the completion of these tests, Lineman Eastwood made his statement about dropping a wander lamp while examining No. 20 terminal board (para. 34). A practical demonstration confirmed that in these circumstances the light would have been very close to the top links of BG-B2/B multicore cable on No. 19 board (*see* Figs. 6 and 8) and, consequently, experiments were made in my presence to see what would be the effect of touching them. Tests were made with the following results:—

Cage touched link Nos:	*Effect*
1 and 2.	Arcing, bright flash and burns on the terminals. No. 52 motor fuse was blown. This experiment was repeated with exactly the same results.
1, 2, 3 and 4.	Severe arcing, bright flashes, the wire cage of the lamp was burnt through and No. 52 motor fuse was again blown.
1 and 3.	Similar results.
2 and 3.	No results.
3 and 4.	Flashes and burns. No. 53 motor fuse was blown.
1, 2, 3, 6 and 7.	Flashes and burns. No. 54 motor and the group fuses were blown.
2, 3, 4 and 5.	Flashes and burns. No. 53 motor and the group fuses were blown.

Each time the contacts were made the snubbing connections provided a short circuit back to the negative bus bar.

In no case did No. 52 point machine move and the maximum voltage recorded there was only 5 volts. In any case the arcing was so severe that Eastwood would undoubtedly have noticed it if the lamp had in fact touched any of the appropriate links, provided all the terminals had been properly connected.

51. Although it appeared that a false feed by this means could be ruled out, examination of the wiring diagrams indicated that a current could be applied to No. 52 points by withdrawing No. 3 link and allowing it to slip on to No. 4 link directly below it, as shown by Fig. 8. Also, if the right-hand terminal of No. 3 link was so loosened that the link no longer made contact with the terminal (*see* Fig. 9) a current could then be applied to the point motor by connecting the left-hand terminal of this link to No. 4 by means of the wire guard of the wander lamp.

Further experiments were made in my presence to test these theories and in each case the point machine was operated when No. 3 link touched No. 4; there was no arcing nor burning on either link. Similar results were obtained by touching Nos. 3 and 4 links with the wire guard but only when the right-hand nut of No. 3 link was loosened and the link itself was set so that it was quite clear of the central stud and of both the top and bottom nuts.

In each case the negative return from No. 52 points motor was broken at the link and this cable was connected to the live positive NWM circuit of No. 53 points control relay, which was in the normal position. Thus a positive feed was applied to No. 52 points motor via cable N.110, the return path to negative being in the reverse direction through the reverse operating snubbing contacts as illustrated by the arrows on Fig. 7.

No. 52 point control relay.

52. The possibility of getting a false feed by cross-connecting the terminals on the point control relay was also investigated, especially as Eastwood had said that he had intended to take off the covers protecting these relays in order to look for the fault on the negative distributory bus bar. With the relay latched in

the normal position as illustrated by Fig. 7, the reverse operating wire could not be fully energised by connecting its terminal, No. 24, to any of the live positive terminals, namely Nos. 5, 6, 11, 12 and 17, because the snubbing connection provided a short circuit to the negative bus bar through the reverse operating link on the terminal board and terminals 4, 3 and 9 on the relay.

On the other hand, the relay could have been unlatched merely by touching the left-hand catch bar so that it released the left-hand slide bar and allowed it to drop and break all the butterfly contacts, both normal and reverse. In this condition a false feed could be applied by connecting terminals 17 and 24 together – for example with the wire guard of a wander lamp – because the cross protection accorded by the snubbing circuit was now broken.

XI. Testing of the Electric Traction Equipment

53. Exhaustive tests were made to establish whether a leakage from the traction system could have caused the operation of No. 52 points. The equipment was checked on the night of the accident and it was found to be working normally. Two days later, on Sunday, 5th September, a detailed examination was made.

The insulation of the transformer, which was on load at the time of the accident, gave a resistance of 9 megohms between the secondary winding neutral point and earth. The automatic earthing contactor operated at 155/160 volts and indicated back correctly to the control room. The capacitors gave a resistance of 2·5 megohms to earth. When the difference in potential between the neutral (running rail) and earth was checked, the maximum readings were 25 volts at Bethnal Green sub-station and 12 volts at Liverpool Street track sectioning cabin; they were the same as those taken directly after the accident, and in each case the earth was positive and the running rail was negative.

The insulation resistance to earth of each section of the overhead equipment was then checked. The lowest was 50,000 ohms on No. 5 section on the Down Main from Liverpool Street track sectioning cabin to Bethnal Green sub-station; the highest was 300,000 ohms on the Up Electric line between the same two points. None of the insulators was cleaned before testing and as there were some 120 on section No. 5 the insulation at any one point must have been in the neighbourhood of 6 million ohms. Thus the leakage from the 1,500 volt D.C. line over each insulator was a very small fraction of an ampere. (0·00025) All the 1,500 volt feeders were tested and insulation varied from 30 megohms to infinity.

54. A further series of tests were carried out on the next day to check the voltage between the sub-station neutral (running rail) and earth (sub-station main earth) at various loads. The maximum reading was 25 volts with a load on the sub-station of 2,400 amps. The voltage drop was also recorded in the running rail return system between No. 52 points and the sub-station at various loads and it averaged 0·27 volts per 100 amps. From this it can be assumed that if the point motor equipment had been connected directly between the running rail at No. 52 points and the running rail at the sub-station, a traction current of 37,000 amps would have been needed to produce the 100 volts necessary to work the points machine. It will be appreciated that in order to pick up a leakage current of this magnitude the motor equipment would have had to have been connected so as to form a shunt path between two points of the return circuit, and in these circumstances the voltage available is dependent on the distance between the two connections. Thus if the second connection had been through one of the point motors (*e.g.* No. 73 on which the negative fault was eventually found), instead of at the sub-station, the voltage difference would have been negligible.

The production of a traction current of 37,000 amps is greater than the total possible output of the sub-station rectifiers and in any case the circuit breakers would have come out long before this figure was reached as their overload capacity is 4,500 amps, giving a maximum per section of 9,000 amperes. At the time of the accident there was only one train moving and the maximum amount of current could therefore not have been more than 1,200 amperes.

XII. Review of the Evidence and Tests

Cause of the derailment.

55. As already stated in Section III, a study of the course of the derailment makes it clear that the engine, tender and leading bogie of the first coach passed correctly over No. 52 points while they were lying in the normal position for the Down Main, after which they reversed suddenly so that the second bogie of this coach and the rest of the train were diverted to the left.

Although the points were somewhat wide to gauge and the stock rails were due for replacement, there was nothing in their condition which contributed to the derailment. It can therefore be concluded that the points were reversed due to the irregular operation of the points machine.

Signals and track circuits.

56. There is no doubt that the express was correctly signalled along the Down Main with signals B.G.8B, 10B and 12 showing clear aspects. This was proved, not only by the evidence of the train crew and signalman, but also by the transmission of the code letters to the train describer in the box ahead. In these circumstances, No. 52 points should have been locked normal when route switch 8B was operated, and they should have been held in this position from the moment the train occupied track circuit H.W., 755 yards in rear of the points, till it cleared track circuit M.9, 67 yards ahead of them. Thus any movement of the points should have been prevented even if another route had been pre-selected as the train was approaching. There was no suggestion that this had been done, and the signalman was in no way to blame.

Internal and external signalling circuits and the condition of the relevant relays.

57. The tests showed that the internal and external wiring was in excellent condition and that insulation of all cables was satisfactory. No fault could be found with the interlocking and track circuit controls. All circuits in any way affecting No. 52 points were checked and the points could only be worked when conditions for their safe operation were set up correctly.

The platelayers' work on No. 52 points on the previous day had in no way affected the signalling circuits.

The interlocking and control relays were also found latched in their normal position directly after the accident so it can be concluded that a false feed to the points must have been applied at some point which would have cut out all the interlocking and track circuit controls.

Possible causes of the irregular operation of No. 52 points.

58. Four possibilities presented themselves:—

(*a*) A leakage from the overhead traction equipment.

(*b*) Breakage of the point machine casing, causing cross-connections in the machine itself.

(*c*) A leakage from another point machine or some other source of D.C. power.

(*d*) A false feed to the points machine through cross-connections in the 110 volt D.C. circuits.

The overhead traction equipment.

59. The tests of this equipment proved conclusively that no leakage from this source could have affected the point motor. The insulation of the 1,500 volt overhead wires and feeder cables was excellent, and the current loss to earth from this source was negligible; it only amounted to a $\frac{1}{4}$ thousandth of an ampere compared with four amperes needed to work the points.

Leakage from the traction return circuit can also be discounted, because even if the point machine had been connected so as to form a shunt path between two points on this circuit, the power needed to produce 100 volts through the point motor under the most favourable conditions was far greater than the total capacity of the sub-station and over four times greater than the overload capacity of the section circuit breakers.

Breakage of the point machine.

60. If a broken piece of the cast iron cover of the machine had dropped on to Nos. 2 and 3 terminals (*see* Fig. 7), some current from the normal operating wire, which was alive, might have passed to the reverse operating terminal, thereby energising the motor, though the subsidiary circuit to the snubbing contact would probably have provided a more direct negative return and might in consequence have blown a fuse. The cover was found smashed after the accident but examination of the trains running on the Surburban lines failed to reveal any missing part which might have dropped on to the machine and broken it before the accident. On the other hand, the rear bogie of the leading coach of the derailed train had ploughed its way through the points machine. There is little doubt therefore that the damage was caused by this means and that the machine was intact when the points began to move. Thus the application of a false feed from this source need not be further considered.

Leakage from another point machine or other source of D.C. power.

61. The lineman's evidence showed that at the time of the accident there was a full 100 volt earth on the negative side of the 110 volt D.C. system which was afterwards traced to No. 73 point machine. A false feed could not, however, have occurred on this occasion. In the first place, false operation of any other machine could not have taken place because the fault was a negative one. Secondly, even if No. 73 motor had been in the opposite position, giving a positive earth, the 500 ohm resistance of the pole changer coil was so high that there would have been insufficient leakage current to have worked another machine. Subsequent tests confirmed that even by deliberately earthing various parts of an adjacent machine no false movement occurred due to either of these conditions. Finally No. 52 points motor was properly insulated from its casing and from all mechanical parts of the machine and it was thereby free of 'earth'.

Leakage from some other source of D.C. power can also be eliminated because the insulation of all the wires in the multicore cables leading to the location terminal board was of a high standard and the connections in the terminal location board were intact.

Cross-connections in the 110 volt D.C. circuit.

62. There are two places in the relay room where cross-connections of the 110 volt D.C. circuit could have produced a false feed to No. 52 points machine, namely at No. 52 points control relay and at No. 19 terminal board. There is no positive evidence that either was touched but it is most significant that two linemen, Eastwood and Turner, were actually looking for a fault on this circuit at the time of the accident, and the only places where they could trace it were on the terminal boards and on the negative bus bar behind the points control relays on rack D. Unfortunately their evidence about their actions during the critical period whilst the express was approaching Bethnal Green was both confusing and conflicting.

Although Eastwood said he intended to search for the fault on the bus bar behind rack D there is no evidence to show that he had started this work by the time the accident occurred. It is therefore very doubtful whether the false feed was applied at the points control relay, especially as it was found properly latched in the normal position.

Eastwood, on the other hand, stated that he was standing by the terminal board just about the time the train was passing through the points and he was holding his lamp very close to the terminals on No. 19 board. This suggested that he might have touched the links with the wire guard and so operated the points. But, as explained in paragraph 51, they could only be worked when the right-hand terminal on No. 3 link was so loosened that it no longer made contact. This could have happened if the nuts had been left loose by the last lineman who had either cleaned or tested them. Eastwood was responsible for looking after this part of the relay room equipment but there was nothing in the log book to show that he or any other lineman had been doing any work on the terminal boards after the 31st August, which was the last day on which the points were operated.

Finally, there is the possibility of a slipped link causing the trouble. The quickest way, although not conclusive, of finding a major negative fault is to draw back the negative links in turn until the fault is located, and in doing this it is easy to let the link slip and touch the one below it, as was demonstrated unintentionally by both Turner and Poole. Eastwood denied emphatically that he had done this and he tried to give the impression that he had spent most of his time examining the diagram book and the terminal link labels in order to formulate a plan for searching for the fault. He is, however, an experienced lineman who has been at Bethnal Green almost since the day the signalling was brought into use. It is therefore difficult to believe that he did not know how to trace a fault, especially as he had found one on Nos. 61 and 62 points a fortnight earlier.

XIII. Conclusion

63. No. 52 points were reversed underneath the first coach of the train by the irregular operation of the points machine. This can only have been caused by a false feed through a cross-connection of the 110 volt D.C. circuits. Lineman Eastwood was working on these circuits at the time and I have no doubt that he made the connection inadvertently either by touching the links with his lamp with No. 3 terminal loosened, or, more probably, by letting No. 3 link slip on to No. 4.

XIV. Remarks

64. Although in this case the accident was primarily due to a mistake by a lineman, some of the equipment he was using was not entirely suitable. In the first place, wander lamps with un-insulated wire guards should never be allowed in a relay room where there are, of necessity, large numbers of live terminals which have to be inspected and tested from time to time. All these lamps on the Eastern Region have now been replaced by others with properly insulated guards.

65. The more likely cause of the accident, however, was the slipping of a terminal link during testing, and, as explained earlier, this could easily occur if the lineman was not careful. The type of link in use at Bethnal Green and also at one or two other signal boxes in the Eastern Region is an obsolescent pattern. It is being replaced by a modern link fitted with a tough fibre extension in the shape of a slot which embraces the terminal when the link is shifted to break the circuit, thus ensuring that the link cannot slip and make contact with the adjacent terminals.

66. During the testing of the point machines it was found that the insulation of some of the pole changer coils was not up to standard. This had no particular effect on this occasion but the breakdown of the insulation of point machines is a serious matter and I have been informed that all defective coils are being replaced.

67. Electrical signalling equipment is so designed that defects and mistakes in its operation normally lead to safety side failures, and the most meticulous care is taken to check the integrity of the interlocking and controls before new works are brought into use. This attention to detail, coupled with a high standard of maintenance, has produced an excellent safety record so that accidents due to failure or mis-use of apparatus have been very rare occurrences on British Railways. The circumstances revealed at Bethnal Green have shown that further improvements are needed to guard against carelessness in testing and I recommend that the action taken in this case is extended to other signalling installations where similar equipment is installed..

68. Another derailment due to the irregular operation of electrically worked points occurred at Thirsk on 20th January and this will be the subject of a further report. The cause was quite different, but the coincidence of these two failures on similar types of equipment has led to a thorough investigation of the whole subject of electric points operation to see whether the present safeguards can be further improved. In neither case, however, was the accident in any way attributable to the working of the panel or of any of the route relay interlocking equipment.

I have the honour to be,
Sir,
Your obedient Servant,
C. A. LANGLEY,
Brigadier.

The Secretary,
Ministry of Transport and Civil Aviation.

11930 *Wt.2138/3054* K9 5/54

EASTERN REGION

DERAILMENT AT BETHNAL GREEN ON 4th. SEPTEMBER, 1953.

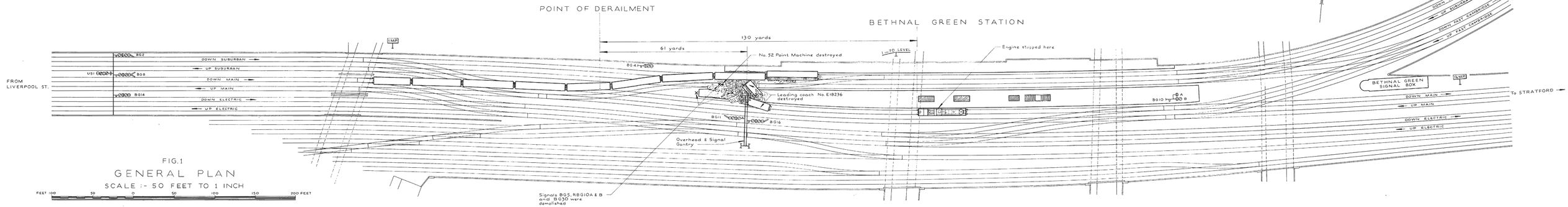


FIG.1

GENERAL PLAN

SCALE :- 50 FEET TO 1 INCH

FEET 100 50 0 50 100 150 200 FEET

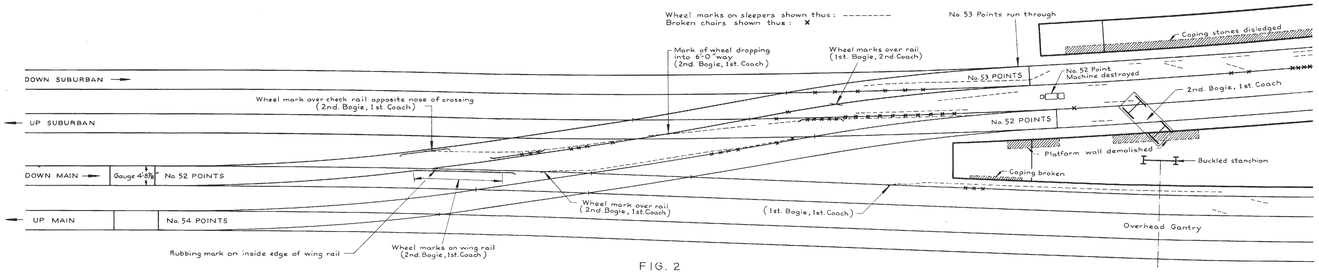


FIG. 2

ENLARGEMENT OF CROSSOVER SHOWING MARKS OF DERAILMENT

SCALE: 1/16" TO 1'-0"

COACH No. E18236 — CORRIDOR COMPOSITE

ENGINE No. 61046 — TYPE B.1.

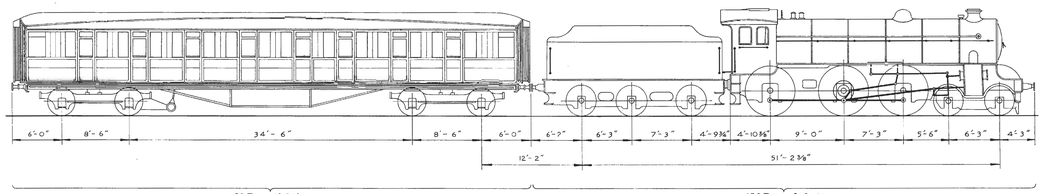


FIG. 3

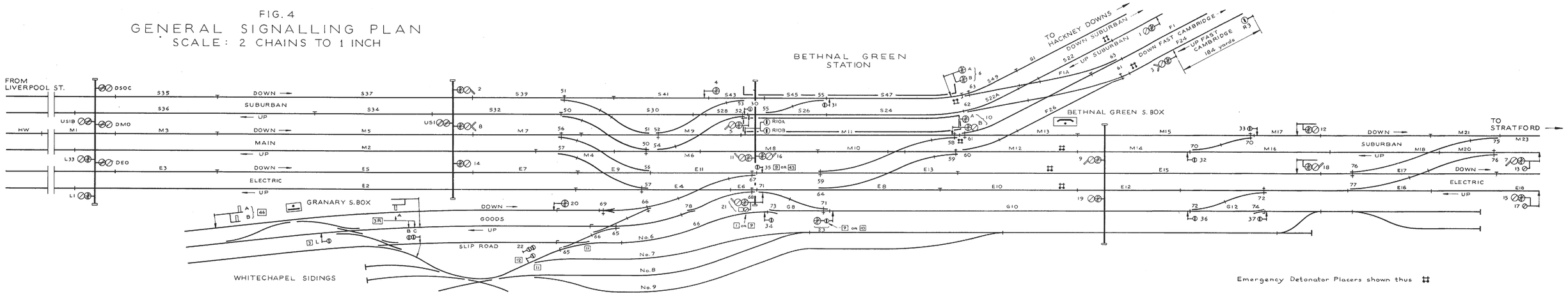
ENGINE AND LEADING COACH OF THE 2·21 P.M. LIVERPOOL ST. TO IPSWICH TRAIN

J.W.W.

FIG. 4

GENERAL SIGNALLING PLAN

SCALE: 2 CHAINS TO 1 INCH



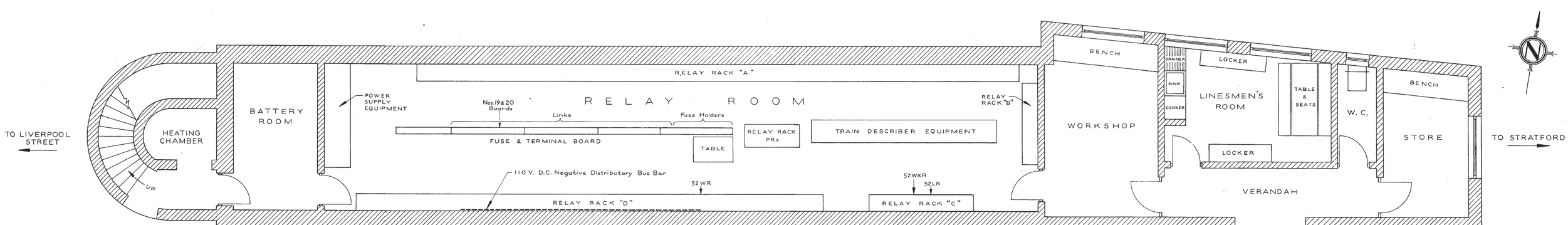


FIG. 5

RELAY ROOM AND LINESMEN'S ACCOMMODATION — BETHNAL GREEN SIGNAL BOX

SCALE: ¼" TO 1'-0"

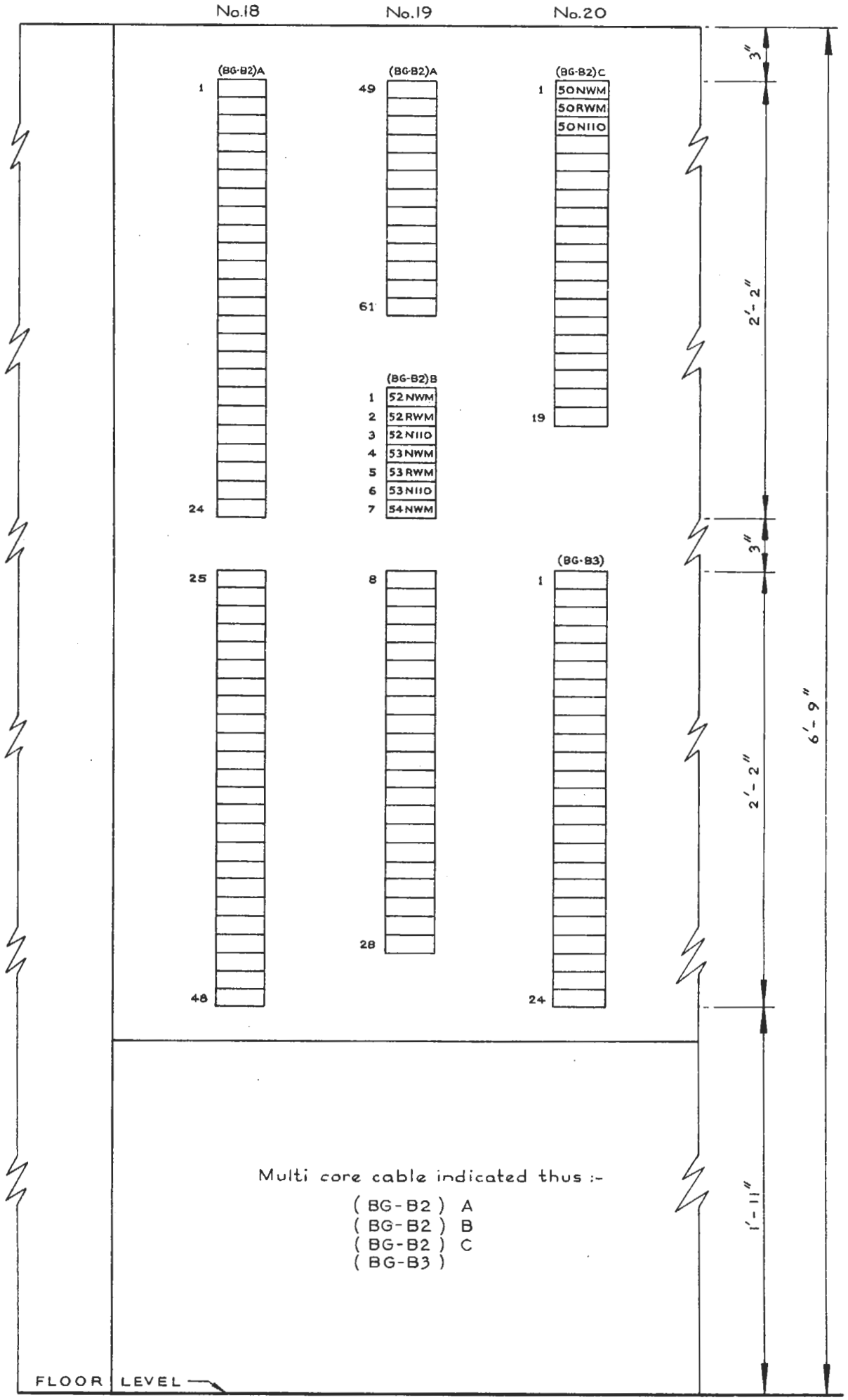


FIG. 6

PART ELEVATION OF TERMINAL BOARD

SCALE: 1½" TO 1'-0"

J.W.W.

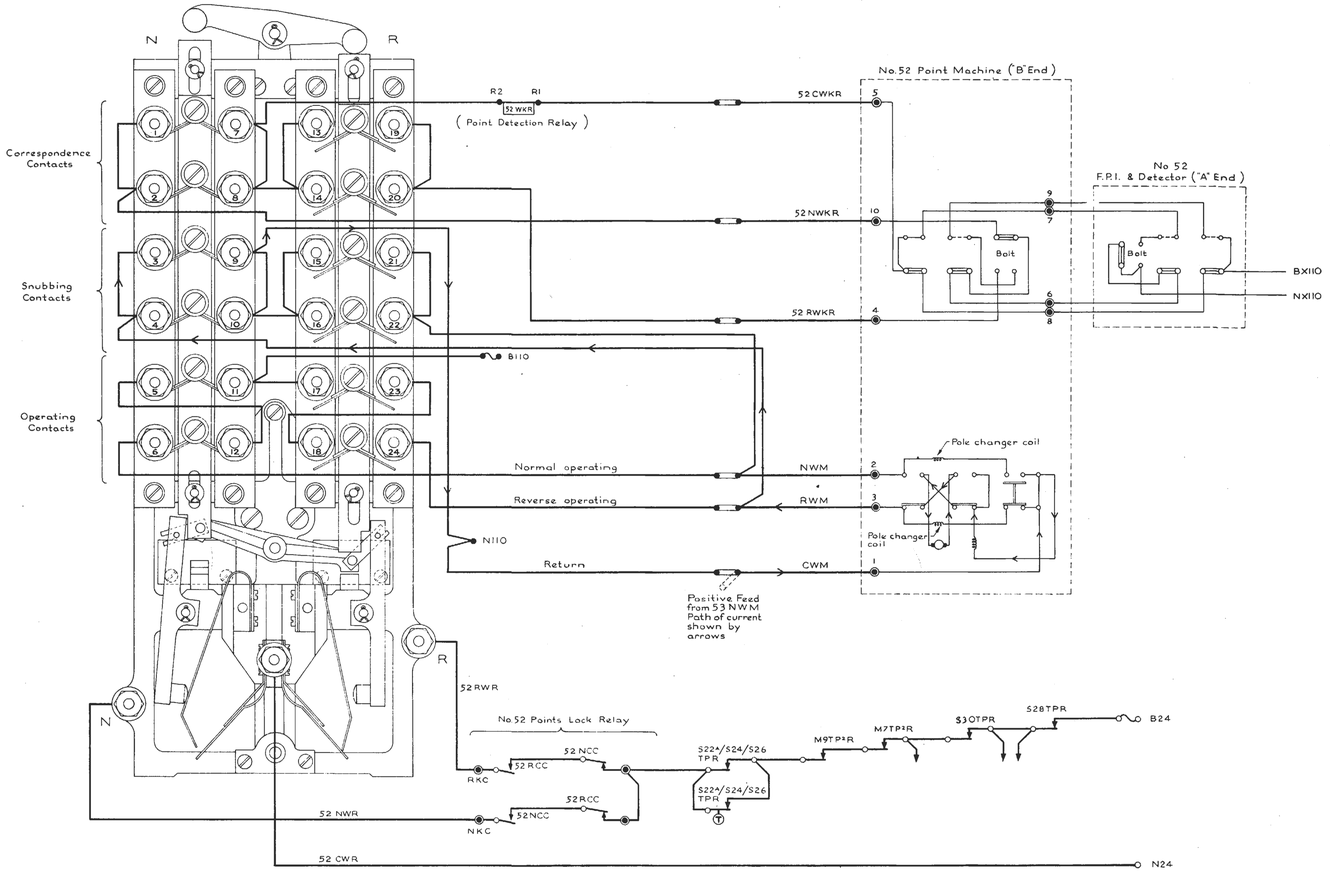


FIG. 7 No. 52 POINTS CONTROL RELAY (SHOWN SET IN THE NORMAL POSITION)

(BG - B2) B

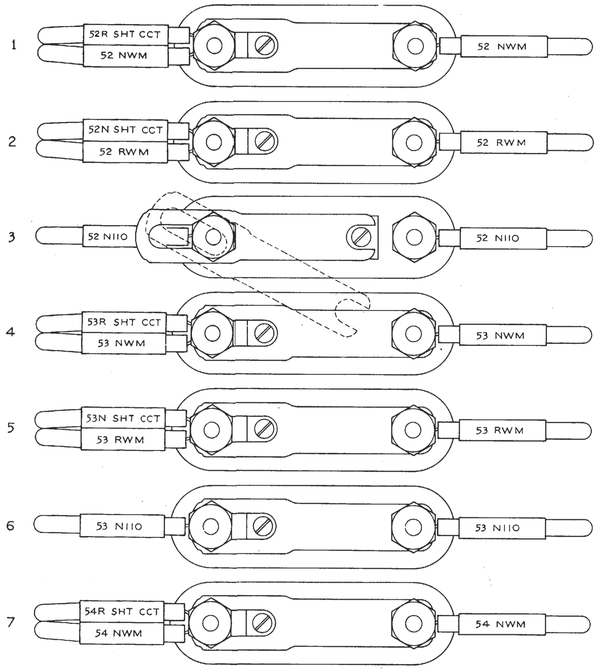


FIG. 8 No. 19 TERMINAL BOARD
(BG-B2) B Multi-Core Cable Links
(SLIPPED LINK SHOWN DOTTED)
SCALE: FULL SIZE

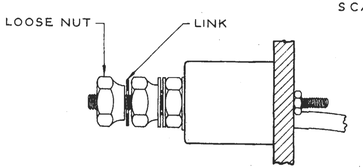


FIG. 9
END VIEW OF LOOSE TERMINAL
SCALE: FULL SIZE

J.W.W.