MINISTRY OF TRANSPORT & CIVIL AVIATION

RAILWAY ACCIDENTS

REPORT ON THE COLLISION

which occurred on

7th January 1957

near

WELWYN GARDEN CITY STATION

in the

EASTERN REGION

BRITISH RAILWAYS

LONDON: HER MAJESTY'S STATIONERY OFFICE

1957

FOUR SHILLINGS NET

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Up Main Emergency Detonators exploded at Welwyn Garden City signal box by Train No. 113 on 7th January 1957.

1. Top Side.

2. Under Side.

MINISTRY OF TRANSPORT AND CIVIL AVIATION,
Berkeley Square House,
London, W.1.

21st *June* 1957.

SIR,

I have the honour to report for the information of the Minister of Transport and Civil Aviation, in accordance with the Order dated 8th January 1957, the result of my Inquiry into the collision which occurred at about 7.12 a.m. on Monday, 7th January 1957 near Welwyn Garden City station on the East Coast main line in the Eastern Region, British Railways.

The two trains concerned were the 6.18 a.m. six-coach local train from Baldock to King's Cross, hauled by a powerful tank engine, and the 7.10 p.m. Sunday night express from Aberdeen to King's Cross, formed of eleven bogie vehicles and hauled by a large Pacific type engine. At the time of the accident the weather was misty and cold and the dawn was just breaking.* The local train had stopped at the Up Slow platform, 11 minutes late, and it was then turned on to the Up Main line, on which it was booked to run, ahead of the express, to its next stop at Finsbury Park. In the meantime the signalman had accepted the express from Welwyn North to his Up Main outer home signal at danger, as he was entitled, with the intention of holding it until the local train had cleared the 2½ miles section ahead to Hatfield. The express, however, passed the outer distant signal at caution without reduction of speed, and it continued past the outer and inner home signals at danger. The emergency detonators at the signal box were exploded, but the train ran forward into the section at 60-65 m.p.h. and struck the rear of the local train which had then passed the advanced starting signal and had accelerated to 30-35 m.p.h. The Up Slow, Up Main and Down Main lines were blocked by the collision, and prompt action was taken by the train crews to protect the obstruction from both directions.

The two coaches at the rear of the local train were overturned, and the last coach, a brake second, was wrecked. The engine of the express was also overturned and the leading six coaches were derailed; they were, however, kept in remarkably good line by the central Buckeye couplings and there was very little damage to their all-steel bodies. All of the more serious casualties were in the local train, and I regret to report that a passenger in the last coach was killed. Twenty five passengers were taken to hospital, but only five were detained beyond the first day; the driver of the express train sustained severe shock and was also detained in hospital for a few days but the fireman was uninjured. Eighteen others, including the driver of the local train, were treated at the site for minor injuries or shock.

The site of the accident was in a deep cutting close to the "Twentieth mile" road overbridge, about ½ mile from the station. The guard of the express train lost no time in going back to protect the Up lines and to summon help. On his way back he spoke to the driver of a goods train which was standing in the goods yard on the Up side, and this driver reported the accident to the signalman from a telephone in the yard. The signalman at once asked the District Control at Knebworth for emergency assistance, and in accordance with the local standing arrangements the Controller telephoned to the Police at Hatfield, who called out all the local emergency services at 7.28 a.m.

The first ambulance arrived at the bridge at 7.35 a.m. and it was followed soon afterwards by other ambulances, local doctors and several Fire Service detachments. The police were also present in strength and valuable assistance in the rescue and relief work was given by local residents. By the combined efforts of all concerned the injured passengers were given first aid treatment and conveyed to hospital with the minimum of delay. A first aid post was set up in the Welwyn Garden City parcels office and five of the station staff who were qualified in first aid attended to a number of the slightly injured passengers.

The first three coaches of the local train, which were not seriously damaged, were taken forward by their own engine to Hatfield with uninjured passengers at 8.40 a.m., and the last four coaches of the express were drawn back to Welwyn Garden City station with the express train passengers, who then went on to King's Cross by a stopping train from Huntingdon; this train was worked past the obstruction at 9.30 a.m. on the Up Goods line which had not been fouled. The Down Slow line also was clear, but it was necessary to reserve these two lines until well into the night for the working of the breakdown cranes, and only the single line from Hatfield to Luton, which is on the same formation as the main tracks, remained open continuously.

The derailed engine and vehicles were re-railed by 12.18 a.m. on 8th January, and soon after that the site was clear for the completion of the repairs to the considerable damage to the Up Main and Up Slow tracks for which a good deal of preparatory work had already been done. All the five tracks had been reopened to traffic by 7.25 a.m. under speed restriction, after an interruption of approximately 24 hours, and normal running was resumed at 4.0 p.m. on Thursday 10th January. During the interruption of the main route, the principal trains were diverted via the Hertford loop without unduly severe delays, but the local services had to be terminated at Hatfield and Welwyn Garden City stations, which were linked by a shuttle service over the Luton single line.

In all probability the accident would have been prevented by the British Railways system of Automatic Train Control which has been under trial on this route for some years. There are A.T.C. track

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**NOTE*: *Sunrise was at 8.4 a.m.*

magnets at all the Up and Down Main line outer distants between King's Cross and Grantham, but the engine of the express train was not one of the comparatively few which have been fitted with receiving equipment.

By all accounts the visibility between Welwyn North and Welwyn Garden City stations was approximately 200 yards at the time of the accident. The temperature was about 37°F and there was a light wind between South East and South West.

I. Description

Trains

1. *The local train* was hauled by a 2-6-4 type tank engine, No. 67741 of the L.1 Class, belonging to the Hitchin Motive Power Depot; its weight is 89½ tons in working order and it was driven from the left hand side as it was running, chimney first. With two cylinders 20 ins. x 26 ins., and coupled wheels of 5 ft. 2 ins. diameter, the tractive effort at 85% of the boiler pressure of 225 lbs per square inch is 32,080 lbs. and the six bogie corridor coaches, weighing 190 tons, were a comparatively light load. The following are some details of the coaches, in order from front to rear of the train: —

	Description	*Year Built*	*Body*	*Remarks*
1.	Corridor 2nd—13006	1932	Wood	
2.	Corridor Brake 2nd—62769	1938	Wood	Brake compartment at leading end.
3.	Corridor 2nd—24200	1951	Steel	British Railways standard main line
4.	Corridor 2nd—24264	1955	Steel	coaches. Bodies with reinforced ends
5.	Corridor 1st—13119	1955	Steel	and welded to the underframes.
6.	Corridor Brake 2nd—62617	1929	Wood	Brake compartment at leading end.

Central Buckeye couplings and Pullman type gangways were in use between all the coaches, and the leading coach was screw-coupled to the engine. The combined brake power of the engine (steam) and the train (vacuum) was approximately 70% of the total weight of 279½ tons. The total length of the train was 138 yards.

2. The engine of *the express train* was No. 60520 of the A.2/3 Class with 4-6-2 wheel arrangement. It was stabled at the New England (Peterborough) Motive Power Depot and had been attached to the train at Peterborough (North) station. This engine is driven from the left hand side and there are padded bucket seats with steel backs, for the driver and fireman, one on each side of the cab. The total weight in working order with eight-wheeled tender is 162 tons, and the three cylinders, 19 ins. x 26 ins., driving coupled wheels of 6 ft. 2 ins. diameter, give a tractive effort of 40,430 lbs at 85% of the boiler pressure of 250 lbs per square inch. With the large boiler this is one of the most powerful locomotives in the country, and the 11 bogie corridor coaches were no more than a moderate load, especially as the train was easily timed. As has been mentioned, this engine was not fitted with Automatic Train Control receiving equipment.

The total tare weight of the 11 coaches was 359 tons. The leading four and the 6th, 7th and 8th were built in 1951-55 to the British Railways standard designs with all-steel bodies welded to the underframes, and the 5th and 9th and the two vans marshalled 10th and 11th were built in 1948 with steel panelled and timber framed bodies. On this train also, central Buckeye couplings and Pullman type gangways were in use between all the vehicles, and the leading coach was screw coupled to the tender. The steam brake was in operation on the coupled and tender wheels, controlled by the vacuum ejector working the brakes of the train, and the combined brake power was approximately 79% of the total train weight of 521 tons. The total length of the train was 265 yards.

Effects of Collision

3. The approximate point of collision is shown on Fig 3 of the attached plans. Severe damage to the Up Main track began about 12 yards further ahead, as the two last coaches of the local train and the engine of the express were derailed, and the engine came to rest on its left hand side, along the Up Slow track, about 153 yards beyond the point of impact. The leading coach of the express was tilted to the left at about 45°, and the next four coaches were tilted at progressively decreasing angles; the 6th coach was upright with the leading axle only derailed. The Buckeye couplings held the derailed vehicles in nearly perfect line with each other and with the last five vehicles which were still on the rails.

The last two coaches (6th and 5th) of the local train remained coupled together and came to rest on their left hand sides with a gap of 17 yards between them and the engine of the express. The impact broke the steel castings of the coupling heads or their pivot pins between the 5th and 4th coaches and the 4th and 3rd, with the final result that the 4th coach, which was not derailed, was separated from the 5th coach by 146 yards, and there was a distance of 546 yards between it and the front portion of the train, consisting of the engine and the leading three coaches.

4. It appeared that the front buffer beam of the engine had driven its way under the headstock of the last coach of the local train, demolishing the rear bogie and throwing it aside to the right. The engine buffer beam and the front ends of the main frames were severely bent by the impact, and the headstock of the coach had cut back into the lower part of the smoke box, breaking off the double

blast pipe and cracking the middle cylinder casting. Otherwise the damage to the engine and tender was mainly superficial, but the driver had a fortunate escape from serious injury as the left hand side of the cab was partly buried in the ballast. There was no very serious damage to the coaches of this train and it was confined almost entirely to their bogies and undergear.

5. The brake second at the rear of the local train was marshalled with the three passenger compartments at the trailing end. This coach was probably overturned at the same time as the express engine. It was fortunate that the buffer beam of the engine was driven under the underframe and not vice versa, because the immediate shock of the impact was partly absorbed by the demolition of the bogie and crumpling of the rear end of the underframe, with the result that the engine smoke box did not penetrate beyond the rearmost passenger compartment in which the one fatality occurred. Much of the timber bodywork of this coach was shattered, and the roof was partly torn away, but there was not a great deal of internal damage to the other passenger compartments.

The 5th coach next ahead was probably overturned at the same time. Its all-steel body suffered very little structural damage although at the moment of impact its leading headstock had evidently been thrust over the rear headstock of the 4th coach as the Buckeye coupler casting was broken, demolishing the end of its body, which was also of steel, for a length of about 5-6 ft., and pushing over a compartment partition. Otherwise there was not a great deal of damage to the 4th coach, and as has been stated it was not derailed. There was some minor damage by transmitted shock to the underframes of the leading three coaches and some internal fittings were displaced. The engine was undamaged.

6. The regulator of the engine of the express train was found closed, the reverser was in forward gear at 15% cut off and the blower valve was open.The vacuum brake handle was in the full release position; this, however, was of little significance because the main disc valve and the handle would have become loose directly the vacuum was destroyed as the front hose was torn away, and could have been thrown to the full release position as the engine was overturned.

Route and Site

7. There are long stretches of line with four tracks on this main trunk route from the North, and four tracks are continuous for the 8 miles from Hitchin to a summit in the Chiltern Hills at Woolmer Green signal box—see Figs. 1 and 2. From Woolmer Green onwards, the line is double for approximately 2 miles, passing through two tunnels, 1,046 yards and 446 yards long, and then through Welwyn North station. Immediately south of the station the line crosses the steep sided valley of the River Mimram by a tall arched viaduct, 513 yards long.

The four tracks begin again at the south end of the viaduct, with facing and trailing junctions worked electrically from Welwyn North, and their order there from East to West is Up Slow, Up Main, Down Main, Down Goods (in prolongation of the Down Slow line through Welwyn Garden City station). The surrounding country is hilly and the high embankment at the south end of the viaduct changes in a short distance to cutting which flattens out to level ground at Welwyn Garden City station, rather more than a mile from the south end of the viaduct.

With reference to Fig. 4, there are two island platforms at Welwyn Garden City; their "inside" faces serve the Up and Down Slow lines, and their "outside" faces the Hertford and Luton single lines, which leave the main formation towards the east and west respectively a little to the north of the station. The signal box is at the north end of the Down island platform, and there is an extensive goods yard on the east side. The site of the collision was in a fairly deep cutting about 1,000 yards south of the station, and over this distance and through the 2½ mile section to Hatfield there are six tracks on the formation, namely Up Goods, Up Slow, Up Main, Down Main, Down Slow, Luton single line.

8. The route generally is free from sharp curvature, and is straight or very nearly so for approximately two miles through Welwyn North and Welwyn Garden City stations to the site of the collision. There is a falling gradient of 1 in 200 for most of the 5 miles distance from the summit at Woolmer Green past the site of the collision to the valley of the River Lea. Thenceforward there are rising gradients for 5½ miles through Hatfield to another summit at Potters Bar, and for the remaining 13 miles there is a practically continuous fall to King's Cross, mostly at 1 in 200.

Signalling

9. The majority of the signals on this route are oil-lit semaphores, although there are a good many colour light distants and outer distants. Manual block is in force with three-position instruments, linked electrically with the signals and the local track circuiting in accordance with modern block control practice. The signal boxes concerned in this case were:—

	Miles (approx.) from Woolmer Green
Woolmer Green	—
Welwyn North	1½
Welwyn Garden City	3⅛
Hatfield No. 2	5⅝

10. *Woolmer Green box* controls the facing and trailing junctions between the double and quadruple lines. The Up outer distant is a colour light.

Welwyn North box is at the south end of the station on the Down side. The colour light Up outer distant (Y/Y and G) is situated on a right handed curve at the north side of the two tunnels, and there are directing inner distants in the 279 yard gap between the tunnels. There is a single Up home at the north end of the station, which is followed by the directing starting signals for the facing junction Up line to Up Main and Up Slow at the south end of the viaduct and 868 yards from the box. These starting signals, together with the Up Main outer distant and Up Slow distant for Welwyn Garden City slotted with them on the same bracketted posts, are illustrated by Fig. 5.

11. Fig. 4 shows the signalling and track layout at *Welwyn Garden City*. The signal box is a brick structure with a frame of 81 working levers, and the two detonator placers on the Up and Down Main lines are worked by pull-up stirrups. The signalman has his back to all lines except the Luton line as he stands at the frame, and in clear weather there is an uninterrupted view from the end windows along the straight lines to the north (underneath the steel girder overbridge) and to the south. There is also a good view across the lines through the two windows on the east side of the box. The signalman has the assistance of a booking lad on the 6.0 a.m. to 2.0 p.m. and 2.0 p.m. to 10.0 p.m. turns of duty.

12. The signals and points primarily concerned were (see also Fig. 5): —

	From Outer distant
"Auto" Up Main outer distant on same post as Welwyn North Up Main starter No. 16. Repeated in Welwyn Garden City box.	—
Up Main outer home No. 34 with co-acting arms on account of the overbridge 242 yards in rear. Repeated in Welwyn Garden City box.	1280 yards
Up Main inner home No. 33. ... ... *Up Main inner distant No.* 31.	1729 ,,
(Signal box	1886 ,,)
Fouling point of *crossover No.* 37, *Up Slow to Up Main*, at south end of platform	2147 ,,
Up Main starter No. 32 Repeated in Welwyn Garden City box	2772 ,,

As the inner distant No. 31 is located beyond the outer home No. 34, I should explain that it was installed in September 1956 to repeat the indication of the starting signal No. 32, 1,043 yards ahead, and so minimise the check to a train if the section ahead is cleared after the train has passed the outer distant.

13. The Up Main outer distant has no lever, and its motor-worked arm, which is "slotted" electrically with the Welwyn North starter No. 16 on the same post, is cleared electrically when the arms of Nos. 31, 32 and 34 signals have moved to clear *and* No. 31 lever has been reversed, so ensuring by the interlocking that Nos. 32 and 33 levers have been reversed. As it was suggested that the outer distant signal had shown a false clear indication on more than one occasion, I refer in paragraphs 55-64 to the arrangement of the controlling circuits, and to the tests which were carried out.

14. With the outer home No. 34, 449 yards from the inner home No. 33, the signalman is permitted by the Block Telegraph Regulations to accept a train from Welwyn North to the outer home at danger with the crossover No. 37 reversed for a movement from Up Slow to Up Main. No. 34 lever, as well as No. 33, is locked normal by No. 37 reversed.

15. The lever of the Up Main starting signal No. 32 is released, for one pull only, by "Line Clear" on the block from Hatfield No. 2, and there is a special control which ensures that once "Line Clear" has been given to Welwyn Garden City a second "Line Clear" cannot be given until the train has passed through the section and has occupied and cleared the home signal berth track circuit. In the event of the cancellation of a train which has been accepted, a second acceptance requires the operation of a hand screw release (one minute) at Hatfield No. 2 box. This control was devised after a serious accident at Welwyn Garden City in 1935 which was caused by irregular block working, and it was introduced between Welwyn Garden City and Hatfield in both directions and on the Up lines between Welwyn Garden City and Welwyn North. It is now in fairly extensive use throughout the country and has come to be known as the "Welwyn" control.

There is sequential locking between the successive stop signals, which ensures that the signals are properly restored to danger behind every train. In addition controls on the block prevent the acceptance of a train on the Up Main line unless the arm of the outer home No. 34 is properly at danger and the arms of the inner distant No. 31 and of the Up Main and Up Slow auto distants are properly at caution: the lever of the inner home No. 33 must also be normal in the frame. In other words, the acceptance of a train from Welwyn North proves that all the relevant home and distant signals at Welwyn Garden City are in the "on" position.

The extensive track circuiting at Welwyn Garden City is indicated by an illuminated diagram, and the relevant track circuit functions are shown by Fig. 4. It will be noted that the outer home No. 34 is free of track circuit control and that track circuit CA commences 206 yards in rear of the outer home and continues past it to the inner home No. 33. Under the "Welwyn" control, the occupation and clearance of track circuit CA serves to free the Up Main block for a second acceptance from Welwyn North.

16. The working of the emergency detonator placers is described in paragraph 65. The two detonators were exploded, but as no notice was taken of them by the enginemen of the express some tests were undertaken and they have been described in paragraphs 66-69.

17. I viewed the signals after dark from the driver's (left hand) side of the footplate of an engine of the A2/3 Class. Brigadier C. A. Langley, Inspecting Officer of Railways, was on the fireman's side of the footplate and we were accompanied by the Motive Power Superintendent of the Eastern Region, Mr. E. D. Trask.

We travelled on the engine in this way from Hitchin to Finsbury Park, and a speed of 60-65 m.p.h. was maintained through Knebworth and Welwyn North stations and onward past the site of the accident to Hatfield. Unfortunately, the weather during this run was very clear, so that the conditions at the time of the accident were not reproduced, but I had the impression that all of the Up Main signals were well sited, and the "pattern" of the Welwyn North Up starters at the south end of the viaduct, together with the Welwyn Garden City Up distants, was unmistakable. The oil lights of these signals were very good, and the upper and lower co-acting arms of Welwyn Garden City outer home No. 34 were well sited for far off and close view above and through the bridge respectively; the green lights of the outer home, however, did not stand out very well against the background of the rather brighter lights of the inner home gantry, on which two green lights (Nos. 31 and 33 signals) were displayed.

By arrangement, the detonators at Welwyn Garden City box were put on the line before the engine reached them, and both were exploded under the right hand leading bogie wheel. From the driver's side I heard the sound of what seemed to be a single explosion, but it was by no means startling or even what I should have called loud above the ordinary noise of the engine running down hill under light steam at 60-65 m.p.h. Brigadier Langley described the sound from his position in the fireman's seat on the right hand side as not particularly loud, and he caught a glimpse of the flash of the explosion.

Table of Distances

18. The following is a summary of the relevant distances with reference to the point of collision: —

	Miles	Yards	
Peterborough (North) station		56 miles	North
Hitchin station		11¼	,, ,,
Woolmer Green signal box, working quadruple-double line junction	3	1,292	,,
Welwyn North			
Colour light Up outer distant (North of the tunnels)	3	846	,,
Directing Up inner distants (in the gap between the tunnels)	2	1,276	,,
Up home	2	507	,,
Signal box	2	324	,,
North end of viaduct	1	1,758	,,
South end of viaduct	1	1,245	,,
Directing Up starters to Up Main and Up Slow			
Welwyn Garden City	1	1,216	,,
Auto Up Main outer and Up Slow distants			
double-quadruple line junction (worked electrically from Welwyn North)	1	1,145	,,
Up Main outer home No. 34		1,696	,,
Up Main inner home No. 33 / Up Main inner distant No. 31		1,247	,,
Signal box		1,090	,,
Fouling point of crossover No. 37, Up Slow to Up Main		829	,,
Up Main starter No. 32		204	,,
Point of collision		———	
Hatfield No. 2 signal box	1	1,577	South
Finsbury Park station	17½	—	,,
King's Cross station	20	—	,,

II. Summary of Events

19. The local train, No. 1565 in the working timetable, was booked to leave Baldock on the Cambridge line at 6.18 a.m. and then to stop at Letchworth, Hitchin and all the main line stations to Welwyn Garden City inclusive where its time was 7.0 a.m. Thenceforward it was booked to run the

17¾ miles to the next stop at Finsbury Park in 24 minutes, representing an average speed of nearly 44 m.p.h. This train had left Baldock on time, but it was delayed by signals at Hitchin and at Knebworth and was 11 minutes late at Welwyn Garden City.

The express train from Aberdeen, No. 113, was due to leave Peterborough (North) station at 6.2 a.m. and to run to King's Cross without stopping, arriving there at 7.40 a.m. The passing time at Hitchin was 6.48 a.m., representing an average speed of 58.1 m.p.h. for the 46 miles from Peterborough; for the remaining 32 miles to King's Cross, mostly downhill, the very easy time of 52* minutes was allowed, representing an average speed of 36.9 m.p.h. Engine No. 60520 had been attached to the train at Peterborough. The top link driver who had been booked for this turn was late on duty, and his place had been taken by another man. The train left Peterborough 7 minutes late and passed Hitchin at 6.59 a.m., 11 minutes late, having been slowed by a permanent way speed restriction at Sandy. Some time was then regained and the train was approximately 6 minutes late when it passed Welwyn North.

In addition to these two trains which were involved in the collision, consideration has to be given to another Up express, No. 111, which overtook the local train No. 1565 at Knebworth, and preceded it on the double line section beyond Woolmer Green. Train No. 111 was due to pass Hatfield at 6.34 a.m., and it was approximately 35 minutes late at Welwyn North.

20. The more important block signal times which were recorded for these three trains in the registers at Welwyn North, Welwyn Garden City, and Hatfield No. 2 signal boxes are given in the table below. There did not appear to have been any significant variations between the three clocks, and the times are fairly consistent when it is considered that they are entered to the nearest minute. There were no corrections or erasures in the registers: —

	Accepted from rear	TES received	Accepted in advance	TES forwarded	TOS received	Remarks
Welwyn North						
Train No. 111	6.56	6.58	6.58	7.1	7.6	
,, ,, 1565	7.1	7.3	7.5	7.5	7.9	
,, ,, 113	7.6	7.8	7.7	7.9	7.16	
Welwyn Garden City						
Train No. 111	6.59	7.1	7.2	7.6	7.10	35 m. late
,, ,, 1565	7.4	7.5	7.10	7.11	—	11 m. late
,, ,, 113	7.6	7.10	—	—	—	6 m. late
Hatfield No. 2						
Train No. 111	7.2	7.7	7.2	7.10	7.10	4-5-5
,, ,, 1565	7.10	7.11	7.10	—	—	recd. for
,, ,, 113	—	—	—	—	—	Train No. 113 at 7.12 a.m.

NOTE.—Times underlined refer to the Up Slow line section from Welwyn North to Welwyn Garden City. All other times refer to the Up Main.

21. The weather conditions during the early morning on this route south of Peterborough were not affecting the running of traffic, and the District Control at Knebworth had had no reports that any of the signalmen had called for the fogmen. Train No. 111 was running late for other reasons, and it had caused some delay to the local train from Baldock, No. 1565, which had arrived at Knebworth 7 minutes late: it was held there for Train No. 111 to pass ahead of it on to the double line section at Woolmer Green and it left again at 6.59 a.m., 11 minutes late. In the meantime Train No. 111 had been checked by the Welwyn North outer and inner distants and by the Welwyn Garden City outer distant on account of another Up express (No. 101) close ahead, and when Train No. 1565 was ready to leave Welwyn North station at 7.5 a.m. (still 11 minutes late) Train No. 111 had not yet cleared the section on the Up Main line to Welwyn Garden City.

In consequence the signalman at Welwyn North offered Train No. 1565 forward to Welwyn Garden City on the Up Slow line, and it was accepted at once (7.4-7.5 a.m.) About a minute later the signalman at Welwyn Garden City was offered and accepted the express No. 113 on the Up Main line, and he decided to hold it there and allow Train No. 1565 to precede it to Finsbury Park on the Up Main line, in order to maintain the booked train sequence. The Regional Officers considered that the signalman acted correctly in so doing, because it is a general rule that delays to the morning business services should be minimised if necessary at the expense of delays to the night expresses, and moreover the express still had plenty of recovery time in hand, whereas none was allowed for the local train.

**NOTE.—This 52 minutes includes 15 minutes "recovery time," which means that, with unchecked running, the engine should be capable of making a punctual arrival at King's Cross if the train is not more than 15 minutes late on passing Hitchin.*

22. The Welwyn Garden City signalman therefore obtained an acceptance from Hatfield No. 2 for Train No. 1565 on the Up Main line directly he received "Train Out of Section" for Train No. 111 at 7.10 a.m. By this time Train No. 1565 had arrived at the Up Slow platform, and the signalman, on receiving acceptance for it from Hatfield No. 2, reversed and bolted crossover No. 37 Up Slow to Up Main, and cleared No. 39 signal and then the Up Main advanced starter No. 32. Train No. 1565 started at once, and accelerated rapidly as the driver was anxious to regain some of the lost time.

23. At about the same time as Train No. 1565 was starting "Train Entering Section" was received from Welwyn North for the express train No. 113, and the signalman stated that, in accordance with his usual custom when he received "Train Entering Section" for a train on the Up Main with the crossover No. 37 reversed, he pulled up the Up Main detonator placer stirrup. When Train No. 113 occupied the berth track circuit CA more quickly than it should have done with the outer distant at caution, the signalman realised that the train might not be stopping and his first concern was to restore crossover No. 37 to normal, and he did so directly Train No. 1565 cleared track circuit BD and so enabled him to withdraw the bolt No. 38. The detonators at the signal box were exploded by Train No. 113 and a red lamp was displayed at the window by the telegraph lad as the train went by, but it continued through the station into the section at a speed which has been estimated at 60-65 m.p.h., and struck the rear of the Train No. 1565 which had then travelled about 840 yards from the platform. Subsequent tests with the same engine and driver and a similar load, indicated that the Train No. 1565 had then reached a speed of 30-35 m.p.h.

The signalman did not put the advanced starter No. 32 to danger in a last minute attempt to stop the express because he saw that track circuit CD in rear of it was occupied during the whole of this critical period either by Train No. 1565 or by Train No. 113 or by both. He did not therefore know how far Train No. 1565 had gone on its way and he was particularly anxious not to reverse the signal in front of this train and so make matters worse.

24. Thorough tests which were carried out by the Signal Engineering Department on the morning of the accident disclosed no fault which might have resulted in a false clear indication of the Welwyn Garden City Up Main outer distant signal with the outer home and inner home signals at danger.

On 8th March the same Up express train, No. 113, overran the Up outer and inner homes at danger in daylight, and stopped in the station after the engine had exploded a detonator at the signal box. The driver stated that the outer distant signal arm had been in the clear position when he passed it, and in consequence even more stringent tests and examinations of all the relevant circuits and their associated equipment were made by the Signal Engineering Department, and they are described later in paragraphs 55-64. Again no fault was found which could have accounted for a false clear indication of the distant signal.

III. Evidence

The collision on 7th January 1957.

25. Relief Signalman J. R. Dolby, who is 64 years of age, had taken duty at Welwyn North signal box at 5.0 a.m. He has been a relief signalman for 9 years during which time he has been passed to work in nearly 30 signal boxes, mostly on the main line and including Welwyn Garden City. He has worked at Welwyn North and Welwyn Garden City boxes on and off for the whole of the 9 years.

Dolby described the weather as misty. The visibility was not varying much and about the time of the accident, when "it was neither daylight nor dark," he could just see the beginning of the parapet wall of the viaduct 310 yards south of the box. In the other direction his fog object (the Down starting signal 183 yards from the box) was clearly visible and at no time since he had taken duty had he even thought of sending for the fogman for the post at his Down Main inner distant signal. He added that the local train No. 1565 cleared the Up Slow line section to Welwyn Garden City in its normal time of 4 minutes, which he thought proved that the weather was not such as to require the fogman to be out.

The course of the block signalling at Welwyn North and Welwyn Garden City for the three Up trains, namely the express No. 111, the local train No. 1565 and the express No. 113 has already been described in paragraphs 20-23. Signalman Dolby thought that Train No. 111 had passed him at the ordinary express speed of about 60 m.p.h. and that Train No. 113, for which he had been able to clear all his signals, including the inner and outer distants, had been travelling rather faster, but he had felt no apprehension that it was going too fast for the proper observation of signals under the prevailing conditions.

He went on to say that he would have expected the signalman at Welwyn Garden City to have turned the local train No. 1565 out on to the Main line at the expense of a check to the express No. 113 if necessary.

The first notification which he received that anything was wrong was a message at 7.14 a.m. from Signalman Betteridge at Welwyn Garden City to the effect that Train No. 113 had run by all his signals, and a little later he received another message that Train No. 113 had run into the rear of Train No. 1565.

26. Signalman J. Betteridge, who is 56 years of age, has worked regularly in Welwyn Garden City box for 10 years and before that he had worked for 12 years at Welwyn North. He had taken duty at 6.0 a.m. on the morning of the accident and he too spoke of the weather as misty, with the visibility extending to about 200 yards; he had been able to see his fog object all the time, and it had not entered his mind to send for the fogmen.

Train No. 1565 was in the section from Welwyn North on the Up Slow line when Betteridge accepted Train No. 113 on the Up Main at 7.6 a.m. A minute or two later, as Train No. 1565 was running in to the station, he was advised that Train No. 113 had passed Hitchin at 7.2 a.m., and he then decided to hold it and let No. 1565 go forward ahead of it in its booked path on the Up Main line. He therefore kept the Up Main inner and outer home signals against Train No. 113, and obtained an acceptance from Hatfield No. 2 at 7.10 a.m. for Train No. 1565 on the Up Main line, directly he had received "Train Out of Section" for Train No. 111; he then reversed crossover No. 37 and bolted it and cleared signals Nos. 39 and 32 in that order. Betteridge thought that he had received "Train Entering Section" for Train No. 113 (recorded as 7.10 a.m.) just as Train No. 1565 was moving out of the station; the time of his "Train Entering Section" signal for the latter to Hatfield No. 2 was recorded in both boxes as 7.11 a.m.

Signalman Betteridge then began to watch the progress of the two trains on track circuits CA and BD-CD. He noticed that track circuit CA became occupied by Train No. 113 rather sooner than he would have expected with the distant signal at caution and the homes at danger, and he said that his first concern was to restore crossover No. 37 to normal and he did so directly Train No. 1565 had cleared track circuit BD. He said that he had pulled up his detonator placer stirrup for the Up Main line directly he received "Train Entering Section" for Train No. 113, and that he always took this additional precaution when he was stopping a fast train after dark at the outer home signal with crossover No. 37 reversed, although it was not required by the Rules. When I visited Welwyn Garden City box a few days after my Inquiry, Signalman Dolby was on duty there, and he told me that he also was in the habit of taking this precaution.

Although Betteridge had sensed that Train No. 113 had entered the section faster than was usual with the outer distant at caution, he was nevertheless surprised when the train came through the bridge by the inner homes at speed and exploded the detonators. He thought that it was going at about 60 m.p.h., if not more, but he could not say if the engine was under steam. He rushed for his hand lamp but the telegraph lad, M. Winter, got hold of it before him, slid back the window and showed the red light towards the train just after the engine had passed the box. He then sent the "Train Running Away on Right Line" signal to Hatfield No. 2 box (which signals the Up lines only) and "Obstruction Danger" to Hatfield No. 3 (which signals the Down lines) in anticipation of a collision. The time of these signals was recorded as 7.12 a.m.

Betteridge then concentrated his attention on track circuit CA in the hope that it would clear and show him that he could throw signal No. 32 to danger in a last attempt to stop Train No. 113 without the risk of stopping No. 1565 in its path, but the track circuit remained occupied (firstly by Train No. 1565, then by both trains, and then by Train No. 113), and Betteridge said that in these circumstances he did not dare to reverse the signal.

As no notice was taken of the detonators by the enginemen of Train No. 113, it was suggested to Signalman Betteridge that on this occasion he might have worked his detonator placer as an emergency measure just as the train was passing the box, and that the detonators might have gone off under a wheel behind the engine, but he maintained very strongly that he had put them on the line directly he received "Train Entering Section". He was sure from the repeater that the arm of the outer distant signal had returned to caution after the passage of Train No. 111, and he added that otherwise he would have been unable to accept Train No. 113.. He had also noted that the repeaters of the outer home No. 34 and of the outer distant were showing "on" immediately after the accident.

Signalman Betteridge had not known or heard of any previous instance when a caution indication of the Up Main outer distant had been disregarded, nor of any instance of the home signals having been passed at danger either before or after the inner distant No. 31, which he described as an "accelerating signal", had been installed in September 1956; nor had any of his colleagues ever spoken of a false clear indication at the outer distant signal. He said, however, that drivers had asked him from time to time what was the purpose of signal No. 31.

27. Telegraph Lad M. Winter is 19 years of age and he has served in Welwyn Garden City box for nearly 4 years. He described the weather as hazy but not foggy. He confirmed that "Train Entering Section" (7.10 a.m.) was received for Train No. 113 just as No. 1565 was moving out on the Up Main line through crossover No. 37, and when track circuit CA became occupied a short time after that, he also had felt that Train No. 113 was coming along too fast. He was quite sure that Signalman Betteridge had pulled up the Up Main detonator stirrup just before track circuit CA was occupied, and he added "we normally do this if we are running a local out under the conditions which then existed."

As the engine came through the bridge he rushed to the window with the hand lamp. He said that by the time he "got a red light out" the engine had passed the box, but he continued to hold the lamp out until the whole of the train had gone by.

28. Signalman R. Turner, who was on duty at Hatfield No. 2 box, said that he received the "Train Running Away on Right Line" signal (4-5-5) a minute after he had received "Train Entering

Section" for Train No. 1565, and immediately after that Betteridge had told him on the telephone that "the express was overtaking." It was clear from Turner's train register that his acceptance at 7.10 a.m. on the Up Main line had been given for Train No. 1565 by the 3-1 "local train" bell signal.

29. Mr. H. Parker, who has been stationmaster at Welwyn Garden City for 5 years, said that he was called by one of the porters at 7.25 a.m. He arrived at the station at about 7.40 a.m. and went straight to the signal box, where Signalman Betteridge told him of the collision. He looked at the train register to check which trains were involved, but he did not question Betteridge further because he was anxious to get to the site. He arrived there on foot at about 8.0 a.m. in daylight, and found that the rescue and first aid work was going smoothly with plenty of staff.

With regard to the visibility, Mr. Parker said that when the porter called him at 7.25 a.m., he could see the lights of the Shredded Wheat factory about 250 yards away on the opposite side of the railway to his house.

Mr. Parker spoke of Betteridge as a competent signalman, and he had never known him to be concerned in any irregularity. He added that he was also very well satisfied with the work of the signal lampman from Hatfield whose duty it was to attend to the long burning signal lamps at Welwyn Garden City.

30. Station Foreman J. E. Ballard, who was on duty on No. 2 (Up Slow) platform when Train No. 113 went by, described the weather as hazy or misty and not foggy, and he thought that he could see for about 300 yards. He would not have called it a bad morning for train working. He heard the detonators explode and saw their flash, but he could not say for certain whether they went off under the leading wheels of the engine.

31. Besides the crews of Trains Nos. 1565 and 113 which were directly concerned in the accident, I interviewed Driver J. Gray and Fireman F. Halls, both of King's Cross Motive Power Depot, who had worked Train No. 111 southward from Peterborough. The engine was fitted with Automatic Train Control receiving equipment.

Driver Gray said that he had had a fair run to Welwyn North, with visibility poor in some places and good in others. He had been checked by the Welwyn North inner and outer distants at caution but the starting signal had been clear with the Welwyn Garden City outer distant arm below it at caution. He had first seen these signals when he was about half way across the viaduct (250 yards), and he had received the A.T.C. warning horn. Continuing forward at moderate speed he saw the outer home signal in the clear position just as he had got through the overbridge (242 yards in rear of the signal). A little further on the A.T.C. bell in the cab had rung to indicate that the inner distant 200 yards ahead was clear and he then opened the regulator. He thought that he passed through Welwyn Garden City station at less than 40 m.p.h.

Gray said that there seemed to be some "fog or haze" at the viaduct, which became rather thicker as he approached Welwyn Garden City, but the weather became much clearer beyond the station. He considered that as a rule the oil lights of the semaphore signals at Welwyn North and Welwyn Garden City were good.

Fireman Halls spoke of a "moving fog" in the neighbourhood of the viaduct, "sometimes clearer than others." He was looking out for signals as the train crossed it quite slowly, and he thought that he had seen the Welwyn North starter "off" and the Welwyn Garden City outer distant "on" at a range of 75-100 yards. He had seen the clear outer home at about the same distance, and he had then heard the A.T.C. "clear" bell for the inner distant.

32. The enginemen of Train No. 1565 were Driver F. Thurston and Fireman D. W. Stapleton, both of Hitchin Motive Power Depot, and both were thoroughly experienced in the working of outer suburban trains to and from King's Cross. Driver Thurston said that the morning was not really a bad one for train working; he described it as dark and misty, and he did not think that the mist had become thicker at Welwyn North and over the viaduct. After starting from Welwyn North Station he had found no difficulty in picking out the Welwyn North starters and Welwyn Garden City distants as he was getting towards half way across the viaduct, at a range of 250-300 yards, and he added that he might have seen these signals earlier if he had not been concerned with controlling some slipping of the engine wheels as it came on to the viaduct. He had checked the speed for the turn out to the Up Slow line and he said that he remembered very well that both the distants were showing yellow lights "with a green one on top for the Slow."

He could not see the Up Slow outer home (which has one arm only) until he got through bridge No. 68, and he did not see the inner home until he was close to it because of smoke and steam which was drifting across from east to west from an engine which was standing on the Hertford line just north of bridge No. 67A. He thought that if this engine had not been there he might have seen the inner home soon after he passed the outer home (it was established that an engine which was shunting the yard from the north end was in fact standing in this position at the time). Driver Thurston considered that the Welwyn Garden City signal lamps were in good order.

He went on to say that the signal No. 39, Slow to Main at the far end of the platform, was cleared very soon after he stopped, and he started away a few seconds later on receiving the guard's hand signal. He saw the green light of the starter No. 32 directly he got out on to the Main line (about 575 yards); he judged that he would get a good run to Finsbury Park, and decided to make up a little time, so he opened the regulator fully. He said that the engine was "doing well" as it passed the starting signal and that the speed had then reached 30 m.p.h. if not more.

The regulator was still open when the collision occurred and Driver Thurston described its effect as "a push forward and a draw back." He was knocked off his wooden seat on to the floor and when he got up he shut the regulator and put the brake on but he found that there was "no tension" on the brake handle and that the vacuum and steam brakes had already gone on. He walked back to meet the guard, who told him what had happened and he then concerned himself with the protection of the Down lines from Hatfield.

Fireman Stapleton generally confirmed Driver Thurston's account. He also described the conditions as dark and misty "but not more than that." As the train approached the viaduct he had finished firing for the time being and was looking out on the right hand side. He "believed" that he had seen the Welwyn Garden City outer distants from the north end of the viaduct (about 500 yards) and he recollected that they were showing "green for Slow road, red for Main and two yellows underneath," and that the lights were good. He had not seen the green light of the outer home until the engine had got through bridge No. 68, and he never saw the inner home on account of the smoke and steam from the standing engine.

33. The guard of Train No. 1565, E. F. Blott, was travelling in the brake compartment at the leading end of the last vehicle. He said that the visibility at Welwyn North was not too bad but that he could not see the signals ahead at the far end of the viaduct. He was not looking out for signals as the train went on to Welwyn Garden City.

As the train left the platform he was not sure that one of the door handles was properly turned, so he went forward along the corridor and he was at the front end of the 4th coach when the collision took place instead of in the brake compartment of the rearmost coach which was so severely damaged. As has been mentioned, the 4th coach became separated from the front and rear of the train. Guard Blott first went back and ascertained that the Down Main line was fouled and he returned at once to tell Driver Thurston who sent Fireman Stapleton forward with detonators. After learning from the guard of Train No. 113 that protection from the rear had been arranged, Blott helped with the rescue work and eventually worked the front portion of the train to Hatfield.

34. As has been stated Engine No. 60520 was attached to Train No. 113 at Peterborough, and it was in charge of Driver C. A. Knapp and Fireman G. Tyers, both of New England (Peterborough) Motive Power Depot. Driver Knapp had signed on at 5.19 a.m. to work a freight turn of duty, but the No. 1 Link driver who had been booked to work Train No. 113 was late, and Knapp was told to take his place. Tyers was the booked fireman for Train No. 113.

Driver Knapp is 59 years of age and has had 38 years' service with the railway. He has worked continuously at New England for nearly 29 years, as a fireman for the first 14 years, as a passed fireman for 2½ years and for the last 12 years as a driver. He has long experience of driving on the main line between Peterborough and Hitchin, mostly with freight trains. He learned the road as a driver between Hitchin and London in March and April 1956, and then "signed for" this section of line on the route card. He stated that at one time he had acquired a very good knowledge of the road between Hitchin and London as a fireman.

His first trip as a driver from Peterborough for the whole of the way to London was on 21st June 1956, and by the end of the year he had worked 4 express and 2 stopping passenger trains to London, 6 fully or partially fitted freight trains and 8 loose-coupled freight trains, or 20 trains in all in the 27 weeks; four of these trains had passed Welwyn North and Welwyn Garden City after dark. The last occasion before the accident on which he had driven an express passenger train to London was on 16th December 1956, passing Welwyn after dark, and on 27th December he had acted as conductor to some Doncaster men with a partially fitted freight train. From his answers to questions about the form and location of the Up signals at Woolmer Green, Welwyn North and Welwyn Garden City, it seemed that he had a good working knowledge of the route, and he gave a clear description, without any prompting, of the Welwyn Garden City distant signals. He said that they were beneath the Welwyn North starters, "not a long way from the south end of the viaduct" and "in front of the turn-in point," and he added that they were not difficult signals to locate. He did not seem to be so certain in his recollection of the two co-acting arms of the outer home signal.

35. Owing to the severe shock which Driver Knapp had received, he was not fit for me to interview him until 29th January, three weeks after the accident. His recollection of his previous turn of duty was uncertain (he had actually booked off at Peterborough at 8.15 a.m. on Sunday 6th January), but he was sure that he was well rested when he booked on at 5.19 a.m. on the Monday morning, having slept during the late Sunday morning and early afternoon, and again for a few hours during the night. In describing his journey, he said that he was familiar with engines of the A2/3 class and that No. 60520 was in good condition, and also that fireman Tyers had "given him plenty of steam." He thought that he had started from Peterborough "practically on time" (in actual fact the start was about 7 minutes late), and had had a normal journey, observing a speed restriction at Sandy on account

of permanent way relaying. He said that the night was misty and hazy but that he had had no real difficulty in observing the signals until he reached the Welwyn viaduct and ran into a belt of fog.

All the Welwyn North signals, including the outer distant had been clear for his train, and he stated that he saw the green lights but not the arms of the Welwyn North Up Main starter and of the Welwyn Garden City Up Main outer distant. He was then satisfied that he had a clear run through Welwyn Garden City station. He missed the outer home and was still looking out for signals when he saw the inner home gantry blotted out by smoke and steam. He said that smoke and steam came in through the window of the cab and after it had cleared the next thing he saw was the red tail light of Train No. 1565 ahead of him, but he was "not worried" for a few moments because he had thought that it was the tail lamp of a freight train "or something" on the adjacent Slow road. He was not sure whether he had got his brake on when the collision occurred. He said that he had not seen the Welwyn Garden City starter (No. 32), nor had he seen the signal box (which was on the side away from him), nor the lights of the station, nor had he heard any detonators. He was sure, however, that he had not lost his location. He thought that his speed through Welwyn North and Welwyn Garden City had been about 60 m.p.h. He had shut the regulator after he passed the Welwyn Garden City outer distant, having plenty of time in hand, and he said that he had opened the blower valve as he was passing through the tunnel just before he reached Welwyn North station; he could not however remember whether the boiler had begun to blow off steam after the regulator had been shut.

Driver Knapp realised that it was his business to see the stop signals at Welwyn Garden City, but he said that he went on because the clear indication of the outer distant had given him permission to go through to Hatfield. On being pressed on this point he said that he did not think it had been right to go on without seeing the other signals, and he added "but that is how it happens", and he referred to a case some years ago in which he had got into trouble with a signalman for stopping his train when the distant signal had been clear. When he told me that he had found it difficult to see the Welwyn Garden City outer distant, I asked him "And you thought you had got the two greens?" and he replied "I am satisfied on that. I do not think I should have gone through that particular section if I knew the signal was against me. I am not a reckless driver". On being further questioned about his view of the outer distant he said that he had seen the lights of this group of signals at the distance of an engine length or perhaps more. He had not reduced the speed to find the signal, and it had come on him suddenly in the mist which had become worse over the viaduct. He said that even with the signal coming up to him out of the mist at an engine length or so away he had not found it difficult to be certain that the distant arm was showing a green light.

Driver Knapp recollected that he had heard the sound of his engine passing under two bridges beyond the Welwyn Garden City outer distant signal, and he agreed that the first bridge was a good landmark to locate the outer home signal. He said that he had been looking out for signals at this time, but he could not explain why he had not seen the outer home. When he was told that he had passed signals at danger he said that "it was news to him", and the fact that he had not seen any of the stop signals at Welwyn Garden City did not seem to have caused him much concern, notwithstanding that he had only been able to see the outer distant at short range.

He said that Fireman Tyers had not told him of any signal indications, with the exception of the green light of the Welwyn North outer distant, which the fireman was able to see before himself on the inside of the right handed curve.

36. Fireman G. Tyers had booked on duty at 5.10 a.m. He is 30 years of age and has been a fireman for 11½ years. He has been in the No. 1 link for nine months, but he said that he had been firing with passenger trains to King's Cross for the last 7 years. He knew Driver Knapp well, although he had not fired with him before, and he said that Knapp had seemed to be in his usual good health and spirits on the morning in question, and he had every confidence in him as a driver.

According to Tyers the engine was in "reasonable" condition, with the right hand piston gland blowing slightly, and it was steaming well. He said that the last occasion on which he had fired had probably been when the train was somewhere near Knebworth. He had observed the Welwyn North colour light outer distant signal at Green, but after that he saw no more signals. He caught sight of the tail lamp of Train No. 1565 just before the collision and shouted "Whoa", and he thought that Driver Knapp had applied the brake. Tyers had not heard the sound of any detonators on passing the signal box.

He thought that he must have sat down in his seat and begun to look for signals when the engine was near the south end of the viaduct, having finished sweeping up the footplate and slacking down the coal as the engine came out of the Welwyn North tunnels. He said that ordinarily there was no difficulty in seeing all the Welwyn Garden City signals from the fireman's side of the footplate, but that the weather was quite thick on the morning in question and he had not been able to see them; he added that what smoke and steam there was was "passing down the boiler" on his side.

Fireman Tyers had noticed that the regulator was shut as the engine passed through Welwyn Garden City station, as was usual with Up express trains in view of the 60 m.p.h. speed limit at Hatfield, but so far as he could recollect steam was not blowing off from the safety valves. He had tried to observe the signals but he said that the weather had been "pretty thick" around the Welwyn Garden City outer distant, and he just could not see it; he also said that he had been unable to see the Welwyn

Garden City starter No. 32 although he had looked for it. He had not been disturbed at not having seen any of the Welwyn Garden City signals himself, because he had every confidence in Driver Knapp; he had seen him in his ordinary position in his seat looking out of the cab side window, and he assumed that he was observing the signals and interpreting them correctly.

37. Guard G. S. Robertson of Edinburgh was travelling in the brake van which was the 10th or last vehicle but one of Train No. 113. He said that the journey was a normal one with no signal checks south of Hitchin, and he described the weather as "a sort of patchy fog". He was seated in his seat, and he did not look out for any of the signals after passing Hitchin because the train was running normally, and he did not hear any detonators at Welwyn Garden City. He did not think, however, that he would have heard a detonator exploded by the engine with the windows of his van closed.

Up Main signals at Welwyn Garden City again passed at danger on 8th March 1957.

38. As has been mentioned in paragraph 24, the train concerned was again No. 113, the 7.10 p.m. Up Express from Aberdeen to King's Cross, and it was formed of 10 bogie vehicles. The engine was No. 60514, again of the A2/3 class, (see paragraph 2) and it had been attached to the train at Peterborough; this engine, like No. 60520, is not fitted with automatic train control receiving equipment. The combined brake power of the engine and train was approximately 79% of the total weight of 520 tons.

Train No. 113 was running approximately 31 minutes late when it passed Welwyn North at 7.34 a.m. in broad daylight, and it was undisputed that the visibility in the early morning haze was not less than 500 yards. According to the statement of the New England driver, the Welwyn Garden City Up Main outer distant was clear, but he saw the inner home at danger just after he had passed the outer home, braked hard and stopped the train between the station platforms. He had not seen the outer home.

39. On account of No. 1593 passenger train running close ahead Train No. 113 had been checked by signals at Langley and Knebworth, and again by a Y/Y aspect at the Welwyn North outer distant, but the train was accepted from Welwyn Garden City in time for it to receive a clear Up Main inner distant between the tunnels. Relief Signalman J. P. Harris who was on duty at Welwyn North noticed that the train came out of the tunnel slower than usual after the check at the outer distant, but that it was regaining speed as it passed the box. Owing to the haze, Harris was unable to see his Up Starting signals and the Welwyn Garden City Up distants at the south end of the viaduct.

40. Relief Signalman J. R. Dolby (who was at Welwyn North at the time of the accident on 7th January—see paragraph 25) was on duty at Welwyn Garden City. He stated that he accepted Train No. 113 at 7.33 a.m. directly he had sent "Train Out of Section" for No. 1593 (for which all his Up Main signals had been clear, including the outer distant). He received "Train Entering Section" at 7.34 a.m., and kept his Up Main inner and outer homes at danger, intending to let Train No. 113 wait at the outer home, so that he could cross the empty stock of a terminating train from the Down to the Up side through crossover No. 29 while Train No. 1593 was clearing the section ahead.

Dolby thought that he had begun the crossing movement at about the same time as he received "Train Entering Section" for Train No. 113 (7.34 a.m.), and he said that he had completed the movement, but had not quite completed the restoration of the route when he saw that the train was passing the outer home signal at danger. He therefore worked the Up Main emergency detonator placer and restored No. 27 points to normal just as the train was approaching the inner home. He saw that it was under control as the engine passed the box at 20-30 m.p.h. and exploded the detonators. The train actually stopped with the engine 290 yards beyond the inner home and 739 yards beyond the outer home.

The fireman then came to the box. Dolby told him that he had run past the home signals, on which the fireman had replied that the distant had been off and the home signals on. According to Dolby the fireman had said "We have not forgotten Driver Knapp" or words to that effect, and he had answered "We have not forgotten either". By that time "Line Clear" had been received for Train No. 113 from Hatfield No. 2, so Dolby told the fireman that "he was right away" and the train re-started as soon as he had rejoined the engine.

Dolby was satisfied that the Up Main outer distant signal had been properly at caution with the stop signals at danger when Train No. 113 approached and passed them, and he pointed out that if the arm of the outer distant had not returned properly to caution behind Train No. 1593 he would have been unable to put his block instrument to "Line Clear" to release the Welwyn North starter. At about the same time as the fireman had arrived in the box he had verified that all the Up Main signal repeaters (Nos. 32, 34 and the auto outer distant) were showing "on", and this was confirmed by the Telegraph Lad, M. Winter. Dolby also said that he must have satisfied himself, as usual, that the repeaters had gone to "on" when he put back the signal levers after the passage of Train No. 1593 at about 7.32 a.m.

As Signalman Dolby had worked in the district for a long time, including a number of years as regular man at Welwyn Garden City, I asked him whether he had ever heard of a case of malicious or mischievous interference with the Welwyn Garden City Up Main outer distant. His reply was "No, Sir, I have not heard of anything. I have every confidence with that signal and I always have had".

41. The enginemen of Train No. 113 on 8th March were Driver H. R. Fowler and Fireman D. Kingswood of New England Motive Power Depot. They are in the No. 1 Link, which covers the express passenger work, and Driver Fowler has long experience of the main line between Peterborough and King's Cross. He was medically examined and his sight was tested on his reaching 60 years of age in February 1957, and he was then passed fit for normal duties.

Driver Fowler said that, although the weather was damp and hazy, with smoke and steam inclined to hang about, he had no trouble in observing signals throughout the journey. He also said that Engine No. 60514 was in good order and was steaming well. After a 24 minutes late start from Peterborough, he received the first signal check at Biggleswade and he recollected the checks at Langley and Knebworth and by the Welwyn North outer distant. He found the Welwyn North Up Main inner distant "off", on which he opened the regulator again, and he stated that as he was coming on to the viaduct he saw that the Welwyn North Up Main starter and the Welwyn Garden City Up Main outer distant underneath it were both "off". As he approached these signals the fireman had asked him if "we were all right", and after looking at the signal again he had replied "We are right away".

He did not see the Welwyn Garden City outer home on account, he said, of steam and smoke from the engine of a coal train (No. 1063) which was standing at the Up Slow outer home, but after he had passed the outer home he saw the inner home at danger, on which he shut off steam and applied the brake fully. He thought that his speed at that moment was about 60 m.p.h. and he said that the brake had acted well, reducing the speed to about 30 m.p.h. as he passed the inner home. When the train stopped in the station he told Fireman Kingswood to go to the box and find out what was wrong, but he did not give him any message; he thought that the signalman might have thrown back the home signals on account of some emergency.

On being asked to explain why he had not seen one or other of the two co-acting arms of the outer home, Driver Fowler said that the top arm had been obscured by the haze as he approached overbridge No. 68 and that, when he got through the bridge, the lower arm was obscured by smoke and steam from the engine of the coal train. He could not say whether the top as well as the lower arm had been obscured by this smoke and steam, nor why he did not look for the top arm after getting through the bridge. He was not, however, concerned at not having seen the outer home, because he was so sure that the outer distant had been clear, and as evidence of his close watch for the signals, he said that, having been checked several times after passing Hitchin, he was on the look-out for another check.

42. Fireman Kingswood confirmed that the weather was hazy, but that there had been no difficulty in observing the signals. He also confirmed that the Welwyn North outer distant had shown two Yellows and that Driver Fowler had "opened up" the engine again when he saw that the inner distant between the tunnels was "off". He said that the engine was working lightly with a short cut off and that the exhaust steam drifting down on his side had prevented him from seeing the Welwyn Garden City outer distant, so he asked Driver Fowler what the signal was showing when he was about 100 yards from it. He received the reply "all right" or "right away" and he noticed that Fowler then had another look at the signal. Kingswood then did some light firing and the next thing he remembered was the brake going on as the engine approached the Welwyn Garden City inner home signal; at the same time Driver Fowler had said, much to his surprise, "They are on here". He then saw himself that the inner home was at danger.

Kingswood thought that the brakes were applied when the engine was about 100 yards north of the inner home signals and that the speed of the train was then about 60 m.p.h., though he admitted the possibility that the speed had been rather lower, perhaps 50 m.p.h. He said that the train stopped very quickly and he heard the detonators go off. After the train had stopped, Driver Fowler told him that he had not seen the outer home on account of smoke and steam hanging about, but he had not noticed this himself as he had been firing at the time.

Kingswood was then sent by Driver Fowler to the signal box. He said that when he got there the signalman (Dolby) told him that the train had overrun the outer and inner home signals, on which he had replied that the driver had assured him that the distant signal was "off". When I questioned him about this conversation, Fireman Kingswood said that he had the impression that Signalman Dolby had been sceptical when he (Kingswood) had referred to Driver Knapp's similar experience on 7th January.

43. The guard of Train No. 113, W. K. Henderson of Edinburgh, who has worked regularly on the East Coast route for 11 years, was travelling in the brake compartment in the 10th vehicle. He said that the train had been subject to constant signal checks south of Hitchin and that it was not travelling very fast through Welwyn North, although there had been some acceleration after that. He thought that the speed was about 40 m.p.h. when the brake went on at Welwyn Garden City, and that his van was about 100 yards north of Welwyn Garden City signal box at that moment. He said that this brake application did not seem to be a full one and that the vacuum on his gauge had not fallen below 10 inches. In fact he thought that the train was making a normal stop, just as he would have expected after so many checks; he was, however, surprised when he looked out and saw the position of the train.

Guard Henderson added that he had been watching his vacuum gauge fairly continuously since the train began to receive signal checks. In summarising his evidence he stated that the train was brought to a stand in a relatively short distance without the necessity for a full brake application.

44. No complaints of irregular working of the Welwyn Garden City Up Main outer distant had been received from any other driver that morning. The following was the sequence of Up trains which passed Welwyn North between 7.0 a.m. and 8.0 a.m.:—

	Time at Welwyn N.	Welwyn Garden City Up Main Outer distant	Remarks
1063 Coal	7.12	ON	Stopped at W.G.C. Up Slow outer home 7.22 to 8.0
1603 Passenger	7.20	ON	Stopped at W.G.C. Up Main outer home 7.24
1593 Passenger	7.29	OFF	Clear run through W.G.C.
113 Express	7.34	Stated by Driver Fowler to be OFF	Outer and inner homes passed at danger
1605 Passenger	7.48	ON	To Slow line at W.G.C.
1625 Empty coaches ...	7.51	ON	To Slow line at W.G.C.
275 Vacuum fitted freight	7.59	ON	Stopped at W.N. starters and at W.G.C. Up Main outer home

The drivers of Trains Nos. 1593 and 275, A. J. Cook (Hitchin) and F. W. Briggs (New England) stated that they had never experienced trouble of any kind with the Welwyn Garden City Up Main outer distant signal, and Driver Cook, who passed the Up Main outer home five minutes before Train No. 113, did not notice any smoke and steam from the engine of the standing coal train (No. 1063). Driver A. T. K. Crisp (New England) who was driving this train stated that while he was standing at the Welwyn Garden City Up Slow home there might have been a little steam from the open cylinder cocks and from the injector overflow pipe.

45. Driver Fowler also stated that he had never experienced any trouble with the Welwyn Garden City Up Main outer distant until the morning of 8th March 1957, and he considered that this group of signals was a good one to see. He had, however, heard complaints that drivers had been finding the Main line outer distant clear and had then been diverted into the Slow line at Welwyn Garden City station. He said that one of these men had been Driver Crisp (see above), and that another New England driver, J. W. Lupton, had had this experience with a coal train three times in one week in November 1956. Lupton had also told him of a Hitchin driver, W. Squires, who had received a false clear indication at this distant signal about a fortnight after the collision, and of a New England goods guard, J. Houghton, who had seen the Up Main outer distant clear and the outer home at danger at one and the same time. Driver Fowler had also heard that two King's Cross drivers had experienced false clear indications at this distant signal, and it was eventually traced that he could only have been referring to Driver E. Denley and Driver G. Rolt.

46. Driver Crisp, in a subsequent statement to the Regional Officers, disclaimed any knowledge of an irregularity at the Welwyn Garden City Up Main outer distant. Driver Squires reported, as he should have done, that on 25th January 1957 the arm of quite another signal, namely the Welwyn North Up Main inner distant, which is manually worked by wire, was out of the horizontal position with the Welwyn North signals ahead at danger. This was investigated, and it was found that the doubtful indication of the signal had probably been due to an overtight wire, as sometimes happens in cold weather.

Driver Denley did in fact receive a false clear indication at the Welwyn Garden City Up Main outer distant signal on 14th March 1956. In a long spell of dry weather, a lineside fire had set alight two of the cables at the signal location; their insulation was burnt away with the result that a wrongful contact was made between two wires which cleared the outer distant signal with the outer home "on". The cables were immediately renewed.

On 18th February 1957 Driver Denley reported a fault at another signal, again as he should have done; this was the Welwyn North Down Main colour light outer distant (at Welwyn Garden City), and it was showing two Yellows when it should have been showing Green. This is a fairly common type of "safety side" signal failure, and it was quickly put right.

Of the six men whom Driver Fowler mentioned as having had similar experiences to his own at Welwyn Garden City, there remain Driver Lupton and Guard Houghton of New England, and Driver Rolt of King's Cross, all of whom I interviewed.

47. During the week Monday 12th November 1956 to Saturday 17th November inclusive, Driver J. W. Lupton and Fireman A. W. Daynes worked Up coal train No. 1063 from New England Yard to Hatfield (except on the Friday when another pair of men were in charge). The train was due to arrive at Hatfield at 7.5 a.m., and it passed the Welwyn Garden City Up distants in daylight and clear weather on each day of the week.

Driver Lupton stated that on three occasions during the week he had seen the Up Main outer distant signal at the south end of the viaduct in the clear position and had then been turned from Up Main to Up Slow at Welwyn Garden City station. He also said that on one of the days, he thought the Thursday or Saturday, he had stopped at the Welwyn Garden City signal box on his return journey during the morning with the engine running light on the Down Slow line, in order to ask what was wrong with the outer distant. He said that the signalman had told him to get on forward (on to the Down Goods line) as he was delaying a passenger train by stopping on the Down Slow, so he went out of the box and did not return.

It was established from the signal box train registers and the guards' journals that the only occasion on which the train went from Main to Slow at the station was on Wednesday 14th November. On the Monday, Thursday, Friday and Saturday, the train was turned from Main to Slow at the south end of the viaduct and on the Tuesday it went through on the Main line to Hatfield, with all the Welwyn Garden City signals "off", including the outer distant.

Although Driver Lupton said that he would not question the routing of his train recorded for each day by the train registers and the guards' journals, he persisted that the Welwyn Garden City Up Main outer distant had been wrongly "off" for his train three times during that week, and he was sure that he had not been mistaken. On one occasion he had looked back as he approached the outer home at danger and he had seen that the distant had been replaced, and in a statement to the District Officer he referred to his view of the two red lights of the outer home: at my Inquiry, however, he said that he saw the two co-acting arms at danger in daylight. Fireman Daynes remembered two occasions on which he himself had seen the outer distant "off" with the outer home "on". Driver Lupton also said that the Up Main outer distant had never been wrongly "off" on the days when he was turned to the Slow line at the south end of the viaduct, and he was certain that he had not been confusing the Welwyn Garden City outer distant with the Welwyn North inner distant between the tunnels.

When it was again pointed out to Lupton that it was only on the Wednesday that he had run on the Up Main line to the outer home at danger, he said that it must have been on that occasion that the outer distant had been clear. He was perfectly sure that he had made no mistake, and that he had mentioned to Fireman Daynes "Look we are going on the Main line". He still insisted that he had noticed signalling irregularities at Welwyn Garden City on two other occasions during the week, but when he was pressed on this point he could not say what was their nature. Driver Lupton gave no satisfactory explanation why he had made no report to the District Motive Power Superintendent at Peterborough of any of these signalling irregularities until 15th March 1957, i.e. after Driver Fowler had passed the inner and outer homes at danger on March 8th.

48. Each one of the three London goods guards who had covered the working of Train No. 1063 during the week in question said that he would normally look for the Welwyn Garden City Up outer distants as a guide to the working of the van brake with a loose coupled train on the changing gradients. None of them had noticed or heard of any signalling irregularity during the week.

49. Relief Signalman Dolby recollected after some prompting that on one morning during the autumn when he was on duty at Welwyn Garden City the driver of a light engine returning from Hatfield had stopped the engine in the platform on the Down Slow and had come to the box with some complaint about the Up Main outer distant signal. He had told this driver to move forward out of the way on to the Down Goods line to avoid delaying a passenger train. He said that he had not asked the driver to move on because he did not want to listen to his complaint, and he had expected him to move his engine forward clear of the points and then come back to the box, but the driver had gone right away on the Down Goods to Welwyn North. It appeared from the train register that this incident could only have occurred on Wednesday 14th November, the day on which Driver Lupton travelled on the Up Main line to Welwyn Garden City, and was diverted there to the Up Slow.

Dolby again expressed his confidence in the Up Main outer distant signal, and in answer to a question he denied that he had changed his mind on the Wednesday morning about the routing of the train to Hatfield, and that in consequence he had thrown the stop signals to danger after Driver Lupton had passed the outer distant at clear. This would have required a cancellation of "Line Clear" on the Up Main and the operation of the screw release of the block control in Hatfield No. 2 box. There was no record in the train registers that any such cancellation had taken place, and the Regional Officers were satisfied from a close examination of the registers that the normal sequence of block working had been maintained during the week.

50. At his interview with the District Motive Power Superintendent Driver Lupton had said Guard Houghton would support him. Guard J. Houghton, New England, described his experience in daylight with an Up coal train on the afternoon of Saturday 26th January 1957. He stated that after a check at the Welwyn North colour light outer distant his van had reached the north end of the viaduct when he saw the Welwyn North Up Main starter and the Welwyn Garden City Up Main outer distant underneath it in the clear position, and at the same time he saw the outer home "on" (the latter at a range of about 1,800 yards). He described how the distant arm "made a sort of flicker" and dropped to the "on" position when his van was about 6 yards beyond it, and when he was asked what had happened to the stop arm above it, he said that he had not noticed because he had been so fascinated in watching the behaviour of the distant arm.

51. The driver of this train on 26th January 1957 was C. Rose of King's Cross, and he stated that he approached the Welwyn North starters and the Welwyn Garden City distants slowly after a check at the Welwyn North colour light outer distant. He found the Welwyn North Up Main starter "off" and the Welwyn Garden City outer distant arm underneath it "on." The Up Main outer home was cleared as he approached it, as also was the inner home, Main to Slow. Driver Rose stated that he had been driving between Hitchin and King's Cross for the last 6 years and that he had never experienced any trouble or irregularity with the Welwyn Garden City Up outer distant signal.

52. Driver G. Rolt, who is in the top link at King's Cross and has long experience of this route, made the following written report on 25th October 1956 in reference to his experience with an A.T.C. fitted engine hauling an Up continuously braked freight train:—

"Sir, 25/10/56.

I report for your information the irregularity of signalling at Welwyn Garden City on Tuesday 23rd. At about 4 p.m. the outer distant was off and inner distant on. This was all wrong to my idea, and the sooner this distant is dispensed with the better, as in the past the first distant has taken me right through the section. As you are aware this is a new distant and some men are taking it for Hatfield, thinking they get a run right through. I would like you to look into this very carefully as I wouldn't like anything to go wrong.

Train No. 273. Engine No. 60006.

Yours faithfully,

(sgd) Dr. G. Rolt."

At the time, this report was not dealt with by the District Motive Power Superintendent, King's Cross, as a report of a wrong side failure of the Welwyn Garden City Up Main outer distant signal, but as yet another criticism of the new inner distant signal which was installed in September 1956 (paragraph 12), and had not apparently found favour with the majority of drivers. The view had been expressed in various ways that a distant signal arm in this position was misleading, in the manner suggested in Driver Rolt's report, and there was evidently strong preference for a banner repeater. These complaints, which culminated in Driver Rolt's report, were supported by the Motive Power Inspectors (at King's Cross) and were the basis of a written statement by one of them (which received some publicity at my Inquiry) that signalling troubles at Welwyn Garden City were getting too frequent. The Motive Power Superintendent, Mr. E. D. Trask, subsequently pursued the matter in correspondence with the Operating Superintendent, but Driver Rolt was not questioned until after Driver Fowler (paragraphs 41 and 45) had referred on 25th March to complaints of King's Cross drivers about the Up Main outer distant signal. He then stated that his object in making the report had been to draw attention to a new signal which in his opinion served no useful purpose, and that he was still of the same opinion.

53. In describing his experience on 23rd October Driver Rolt said that the weather had been fine and clear, and that he had seen the Welwyn North Up Main starter and the Welwyn Garden City Up Main distant both in the clear position as he passed through Welwyn North station. On being asked what happened next, he replied "Under the old conditions Welwyn Garden City distant being off would take me right away through to the colour light ground distant signals for Hatfield. Under the new conditions we would sight the so-called inner distant in the caution position about 200 yards before we got to it. We were not prepared to find it on, that is why we were not taking particular action."

Driver Rolt went on to say that the outer home and the inner home had been "off," but he had seen the inner distant arm under the inner home at caution at a range of about 200 yards. He had applied the brake "fairly heavily" from a speed of about 50 m.p.h., and he was about to stop short of the Up Main starter No. 32 when this signal was cleared. He could not remember definitely what A.T.C. indications he had received at the outer and inner distants on the day in question, but he said that he had never known the apparatus to give the clear bell signal when it should have given the warning horn. He also said that he had never before had any trouble with the Welwyn Garden City signals. Generally it appeared that Driver Rolt was confused by the layout of the signalling and that this was uppermost in his mind, as he seemed reluctant to suggest that a false clear indication had been shown by the outer distant, or that there had been any irregular working by the signalman.

The fireman, D. Tomkinson, who had been working on this route for 5 years, said that he himself had seen the Welwyn North Up Main starter and the Welwyn Garden City outer distant both in the "off" position. He could not recollect having heard any A.T.C. indications during the journey.

54. Relief Signalman D. Hatton was on duty at Welwyn Garden City when Driver Rolt's train was signalled on 23rd October 1956. He had no recollection of the passage of the train, still less that it had made an emergency stop, but with his train register in front of him he said that it was very probable that the train had in fact been nearly stopped at the Up Main starter No. 32, with the inner distant at caution. The register recorded that the train had not been accepted by Hatfield No. 2 box until 3.45 p.m., 3 minutes after "Train Entering Section" had been received from Welwyn North, and

Signalman Hatton said that the outer distant should not therefore have been clear for the train. He said that he had worked in Welwyn Garden City box perhaps three times a fortnight for the last seven years, and that he had never known of any trouble with the Up Main outer distant signal; the following is an extract from his evidence on that point: —

"Q. You have never had your outer distant showing "off" when it should not have done?

A. No sir.

Q. How have you been able to tell that?

A. You can tell by the indicator.

Q. I see; and do you look at your indicator every time you work your signal?

A. Yes, naturally you would.

Q. And are you satisfied that your outer distant has always gone on when it should have gone on?

A. Quite satisfied."

Signalling Equipment

55. In paragraphs 13 and 15 reference has already been made (a) to the electrical working of the Up Main Outer distant semaphore signal with no independent lever in Welwyn Garden City box, and (b) to the control which prevents the Up Main block being placed to "Line Clear" to free the Welwyn North starter unless the Up Main and Up Slow outer distants are properly at caution and other signals properly at danger. A brief technical description may be of assistance in considering the evidence which follows on the condition of the equipment.

56. With regard to (a), the standard upper quadrant distant arm is connected by wire to the crank of the signal machine which is fixed to the main lattice post, about 5ft. from the ground. The signal machine is of conventional design, and to clear the signal the crank is driven through 90° by means of a train of gears which are enclosed in the watertight cast-iron casing together with the 12 volt D.C. motor, which takes a current of approximately 3 amperes. When the arm reaches the "off" position the current is cut off from the motor, and the crank is held by an electro-magnetic latch. When the current is cut off to restore the signal to normal, the latch is released to allow the arm to fall "on," turning back the motor through the gears. A special coupling and pawl prevent movement of the crank by hand from outside the casing, but it is possible to pull the signal arm "off" by taking hold of the vertical wire which is not difficult to reach from the ground.

Current for the signal machine is furnished by an 8-cell trickle charged secondary battery in a hut at the signal location, and the current is switched on and off on the positive and negative sides by a D.C. neutral line relay in a cupboard close to the battery hut.

57. A current of approximately 4 milli-amperes is required to "pick up" the relay, with a minimum pressure of approximately 4 volts across the operating coil. This current is furnished by a 6-cell secondary battery in the battery room of Welwyn Garden City signal box. With reference to Fig. 6, the circuit from the positive side of the battery is taken to the relay at the distant signal location (1,886 yards in a direct line) through the following contacts in series:—

(i) A contact of a stick relay controlled by track circuit CA. This contact is opened when track circuit CA is occupied.

(ii) The contact of a polarised relay, the operating coil of which is in series with the repeater of the starter No. 32. The contact is made only when No. 32 signal arm is properly "off."

(iii) A contact of the relay which energises the A.T.C. electro-magnet of the inner distant No. 31. The operating coil of this relay is energised only when positive and negative contacts are closed by the reversal of No. 31 lever *and* the contacts of a circuit breaker are closed by the signal arm "off." Lever No. 31 is preceded in the mechanical inter-locking by levers Nos. 32 of the starter and 33 of the inner home.

(iv) The contacts of two circuit breakers in series, one worked by each of the co-acting arms of the outer home No. 34. The circuit is closed only when both the arms are properly "off."

(v) Lastly, through the contacts of a circuit breaker worked by the arm of the Welwyn North Up Main starter No. 16, the contacts of which are closed only when this arm is properly "off." This arrangement takes the place of the more usual mechanical slot between stop and distant arms on the same post.

58. From the battery to (i) above and between (i) and (ii) the connections are by internal signal box wiring.

From (ii) there is a buried cable to a terminal pole close to the signal box and thence to (iii) there are approximately 210 yards of overhead line (150 lbs PBJ), carried on the pole route on the West side of the tracks, and approximately 60 yards of cable.

Between (iii) and (iv) there are approximately 440 yards of pole line and a few yards of cable.

Between (iv) and (v) there are a few yards of insulated wire to reach the pole line again from signal No. 34, then 1,300 yards of pole line, and then a few yards of insulated wire to the distant signal location.

The current is returned from the operating coil of the relay to the negative side of the battery in the signal box by a return wire on the poles which is common to other signalling circuits.

59. Thus, if all is in order, the relay of the Up Main outer distant cannot pick up to clear the signal unless the following conditions are fulfilled: —

Signal levers reversed	31 (preceded by 32, 33)
Arms properly "off"	32, 31, 34
	Welwyn North 16
Track circuit clear	CA

It was not disputed that when the Welwyn Garden City signals were passed at danger on 7th January, levers 34, 33 and 31 were normal in the frame, and that arms 33, 31 and 34 were "on": also that on 8th March levers 32, 33, 34 and 31 were normal, and that arms 32, 33, 34 and 31 were "on".

60. With regard to (h) of paragraph 55, the Up Main block circuits between Welwyn Garden City and Welwyn North are fairly complicated, and it is only necessary to mention that the "Line Clear" releasing circuit to Welwyn North is taken through the contacts of a polarised relay. The operating coil of this relay is in series with the single repeater which serves for the Up Main outer distant and Up Slow distant arms, and the contacts remain open, so disconnecting the "Line Clear" circuit, unless *both* the distant arms are properly at caution to send current of the right polarity into the repeater circuit. This is a very usual arrangement of block "interlinking" to prove that the distant signal arm is properly at caution when a train is accepted.

61. Chief Signal Inspector G. A. Mosby is responsible, under the District Signal Officer, Mr. G. F. Bloomfield, for the maintenance of the signalling equipment in the King's Cross district. He was informed of the accident when he arrived at his office at Finsbury Park at 8.0 a.m. on 7th January, and he reached Welwyn Garden City at about 9.30 a.m. On hearing from Signalman Betteridge what had happened, he obtained some testing instruments, including a 500 volt megger, and tested the control circuit of the outer distant signal and found it in order, with a minimum insulation resistance of 700,000 ohms on the 1,300 yards or so of pole line from the outer home signal to the outer distant. He also verified by examinations and tests which he carried out later under the direction of Mr. Bloomfield and of Mr. F. J. Beirne, the Maintenance Assistant to the Signal Engineer, that the outer distant circuit was properly interrupted at (i) to (v) (paragraph 57) when the relevant signal levers were normal in the frame. He also satisfied himself that the interlinking circuit (paragraph 60) was in order. He did not test the actual repeater circuits because Signalman Betteridge was so certain that they were working properly.

62. I also questioned Mr. Mosby and the Hatfield lineman, E. Marlborough, about the more elaborate tests and examinations which were made after the incident on 8th March (Driver Fowler). Lineman Marlborough arrived at Welwyn Garden City at about 8.30 a.m. and he was followed by Inspector Mosby at 9.0 a.m. Marlborough said that there was no condition of failure in the signalling when he arrived, and Mr. Mosby said that he proceeded with tests under the direction of Mr. Bloomfield and Mr. Beirne and a little later of the Signal Engineer of the Region, Mr. R. A. Green. The very thorough tests and examinations which were made during the next few days, form the subject of a report by Mr. Green to which I refer in the next paragraph, but I should mention at this point that Mr. Mosby and Lineman Marlborough stated that they had never experienced any trouble with this outer distant signal in the past, except on the occasion of the fire on 14th March 1956—see paragraph 46; they also said that, except for routine cleaning and lubrication, no adjustment or other attention to the signal or its associated electrical equipment had been found necessary after the accident on 7th January. Mr. Mosby added that he had considerable experience of electrically worked semaphores elsewhere and never in his recollection had any one of them ever shown a false clear indication. In concluding their evidence both Mr. Mosby and Lineman Marlborough were emphatic in their opinion that, in view of the tests which had been carried out, there could not possibly have been a false clear indication at the Welwyn Garden City Up Main outer distant signal either on 7th January or on 8th March.

63. At my request, Mr. R. A. Green prepared a report summarising the tests and examinations of the signalling equipment which were put in hand almost at once after the incident on the morning of Friday 8th March and were continued throughout the following week.

This report is attached as an Appendix. It records that the minimum insulation resistance in any section of the circuit between open circuit breaker contacts was 250,000 ohms in the 1,300 yards of overhead line between the outer home signal No. 34 and the outer distant signal, i.e. between (iv) and (v) of paragraph 57. Mr. Green was entirely satisfied with this result, especially as the weather had been wet. Examination of the signal arm circuit breakers disclosed no mechanical fault, and their internal insulation resistance was very good.

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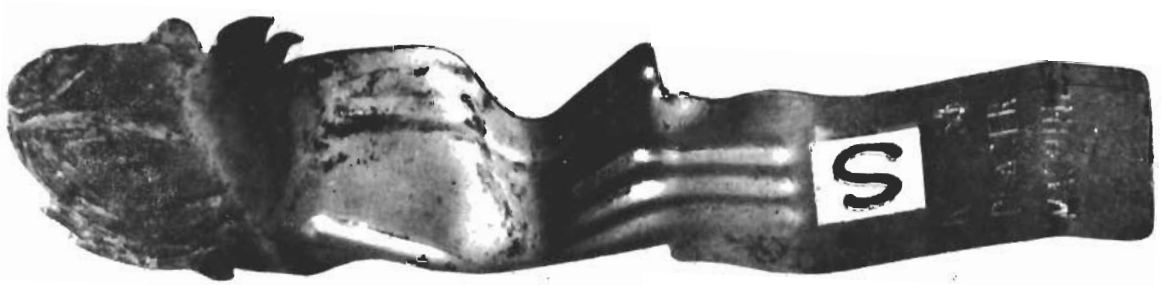
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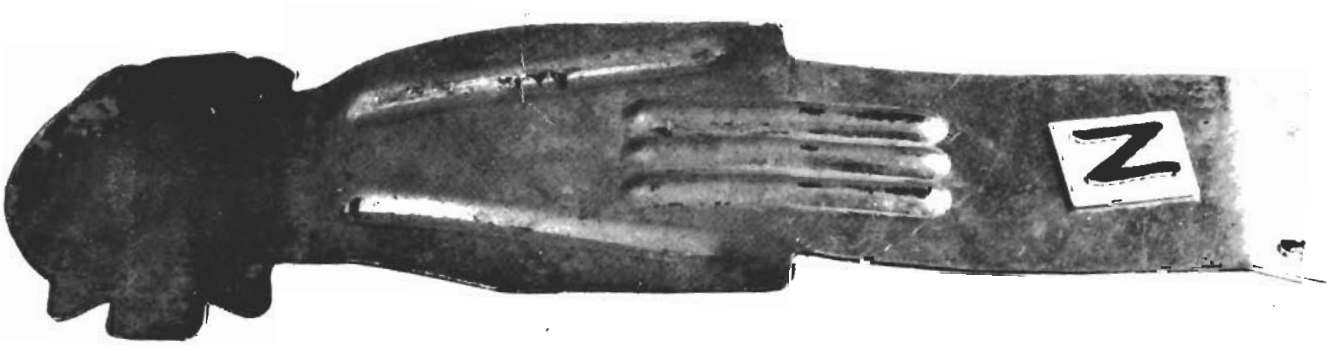
Z

Although the high insulation resistance of all parts of the circuit under the pressure of a 500 volt megger seemed to preclude any possibility that a false feed could have reached it, Mr. Green decided to remove and examine the arm circuit breakers and the connecting insulated wires between the overhead line and the two circuit breakers of the outer home, and between the line and operating relay at the distant signal location via the circuit breaker of the Welwyn North starter No. 16. He explained that he concentrated the detailed examination on this section of the circuit because there had been no doubt all along that the outer home signal had been at danger on both the occasions, and he was satisfied that the contacts of the two circuit breakers in series had been open. The report describes the two very small bare spots which were found in the wire which runs from the circuit breaker of the lower arm of the outer home to the overhead line to the outer distant, and is taken down the lattice post in the angle of one of the vertical members (see Fig. 6). These bare spots were caused by cracks in the age-hardened insulation, and the report goes on to say, how the possibility that a false feed might have reached the circuit from a battery in the neighbourhood was considered and discounted.

The report concludes with the expressed opinion of the Signal Engineer that the tests indicated that there was no possibility of false energisation either of the Up Main auto distant signal control relay, or of its operating motor. It also refers to the "false clear" outer distant signal indicator which was specially designed and installed in Welwyn Garden City signal box on Sunday 10th March as an overriding precaution.

64. Mr. Green stated at my Inquiry that his line of approach in cases of this kind was to assume that his apparatus could be at fault until he had proved beyond all reasonable doubt that it was in order, and he went on to describe the long sequence of tests which were carried out and how Mr. Beirne had personally repeated, as an independent check, all the tests which had been carried out by Mr. Mosby. The following points also emerged from Mr. Green's and Mr. Beirne's statements, and from my discussions with the former when I examined the dismantled equipment in his office: —

(a) A test of the distant signal relay showed that its actual "pick-up" and "drop away" values of current and voltage were very close to the designed values. The internal insulation of the relay was also very good, and it was established that the contacts could not be closed by any reasonable degree of shock or vibration. (I noted at one visit to the site, that no perceptible vibration of the shelf in the relay cupboard was caused by trains passing at speed on either the Up or the Down line).

(b) There was no possibility of a leakage to the relay from the repeater circuit of the Welwyn North starter No. 16, which showed an "infinity" insulation resistance on test.

(c) The Down line electrically worked facing trap points close to the Up Main outer distant signal were not moved during the critical periods on 7th January and 8th March. Nevertheless their circuits and those of the Up facing points were tested for leakage with satisfactory results.

(d) There was no possibility that the relay could have been falsely operated by 50 cycle A.C. current induced by the 110 volt signalling supply line on the east side of the tracks. It was calculated that, owing to the impedance of the 1,000 ohm. coil, a 50 cycle A.C. pressure of several hundred volts would have been required to operate the relay.

(e) The Up outer distant signal repeater circuit at Welwyn Garden City was in order, as also was the associated polarised relay in the "Line Clear" circuit of the Up Main block (paragraphs 55 (b) and 60).

(f) This group of signals and the associated circuits had not been subjected to any renewals since the accident on 7th January. Signal renewal work in the neighbourhood of Welwyn Garden City during that period had been confined to the Down line.

IV. Emergency Detonators.

65. The working of the emergency detonator placers at Welwyn Garden City signal box, which are connected by ordinary rodding to stirrups near the centre of the lever frame, is shown by Fig. 7. The machine for the Up Main puts two detonators on the right hand rail, 6½ ins. apart, and a similar design of machine, but with the detonators 3 ins. apart, has been adopted as a standard for British Railways. The detonators are of the Clayton's machine type, each mounted on a strip of tinned plate which is an easy fit in the slots of the holder of the machine—see the two photographs; they are pushed in up to the shoulders of the strips, and the ends are then bent upwards or downwards to retain them. The specification for these machine type detonators requires that each should contain not less than 60 grains of gunpowder, compared with 110-130 grains for detonators which are placed on the rail by hand.

66. It was found after the accident on 7th January 1957 that the detonators had been run over and exploded, and the strip of the "north" detonator, the first one reached by an Up train, was still flat and straight, but the strip of the "south" detonator was torn at the shoulder and bent and twisted into the shape shown by the photographs. Since no notice was taken of the detonators by either of the enginemen, this damage suggested at first that the strip of the "south" detonator might have been crumpled by striking a wheel, possibly behind the engine, as the machine was operated, and that the

signalman might have been incorrect in stating that he had put the detonators on the line before the engine reached them. Mr. Beirne, however, referred to a fairly recent test at Doncaster, at a speed of 70—80 m.p.h., in which the explosion of the first detonator of a pair in an emergency machine had buckled the strip of the second and pulled it off the rail.

In all the circumstances further investigation of the behaviour of emergency detonators was considered desirable, and a trial was carried out on 28th January 1957 in which an engine of the A2/3 Class, hauling two coaches, was run from Hitchin to Finsbury Park, as nearly as possible at a constant speed of 60 m.p.h. The emergency detonator machines were worked for this train at 23 signal boxes, at which there were two machines with detonators 24 ins. apart, 12 machines with detonators 6½ ins. apart and 9 machines with detonators 3 ins. apart. At 11 of the 23 signal boxes the detonators were put on to the rail before the train arrived, and at the remaining 12 boxes the machines were worked in an attempt to get the detonators under the wheels after the front of the engine had passed them.

67. I subsequently examined the exploded detonators which were laid out, in order in their pairs. In 9 of the 11 instances in which the detonators were on the rail before the train arrived (one 24 ins., five 6½ ins. and three 3 ins.) both the detonators were cleanly crushed and exploded and the tinned plate strips had kept their shape.

In the remaining two instances, one with the detonators 6½ ins. apart and the other with the detonators 3 ins. apart, the "north" detonators were again cleanly crushed and exploded with very little distortion of the strips. The "south" strips, however, in both cases were buckled and bent away from the rail to such an extent that the detonators became detached from the strips and were not run over and exploded. Since it was certain that the detonators had been on the rail before the train reached them, it was equally certain that the buckling of the strips could only have been caused by the blast of the explosion of the north detonators, and the general appearance of the buckled strips was not very different from that of the south detonator strip at Welwyn Garden City after the passage of Train No. 113 on 7th January 1957. I should also mention that when the detonators were put on the Up Main line at Welwyn Garden City in front of Driver Fowler's train on 8th March 1957, the north detonator was cleanly exploded, but the south detonator strip was buckled in a very similar way, pulling its detonator off the rail before the wheel could reach it.

68. Reverting to the trial run, it was evident that the signalmen had succeeded in getting the detonators cleanly under the wheels in some of the 12 instances in which this was attempted, but in one of them in which both the detonators were exploded, the strip of the second detonator had been buckled. In other instances one or other or both of the detonators had evidently fouled a wheel or wheels and their strips were folded back (in one case double), but the character of this folding or bending was regular and was quite different from the buckling and distortion of the "south" strips by the explosion of the "north" detonators which has been described in paragraph 67.

69. There were three instances during the trial in which the explosion of the detonators was not heard by either of the enginemen or by Chief Inspector A. G. Dixon who was also on the footplate. In the first case, at Woolmer Green (6½ins. apart), the detonators had been cleanly exploded, but it was considered probable that they might have gone off under the wheels of the leading coach from which they were heard distinctly. In another case, at Barnet South (6½ins. apart), the detonators had evidently fouled some wheels and only one of them had gone off, probably without its full force; it was heard fairly clearly in the leading coach.

In each of these two cases the signalman had been told to make an attempt to get the detonators under the wheels after the engine had reached them, but in the remaining case at Potters Bar (3 ins. apart), the detonators had been on the rail before the arrival of the train, and both of them were exploded cleanly by the leading wheels of the engine. Although they were not heard on the footplate, they were heard very clearly in the leading coach.

V. Conclusions

70. The Up express train from Aberdeen No. 113, and the Up local train No. 1565, which were in collision on 7th January, were approaching Welwyn Garden City at about the same time on the Up Main and the Up Slow lines; both trains were booked to run forward on the Up Main line, and precedence was given to No. 1565. I should mention first of all that with the Welwyn type of control, the time factor alone ruled out any possibility that Signalman Betteridge could have cleared all the Up Main line signals for Train No. 113 and then changed his mind at the last moment to give precedence to the other, i.e. after Train No. 113 had passed the outer distant signal in the clear position. Apart however from that, Signalman Betteridge's account of his actions in the signalling of the two trains was simple and straightforward, and I am satisfied that he was truthful in stating that he accepted Train No. 113 from Welwyn North on the Up Main line and allowed it to approach the outer home signal No. 34 at danger, with the inner home No. 33 at danger 449 yards beyond it to protect the movement of Train No. 1565 from the Up Slow line to the Up Main through crossover No. 37. Nor after the trials which have been described in paragraphs 66-69, have I any hesitation in accepting his statement that he put the detonators on the rail when he received "Train Entering Section" from Welwyn North or very soon after, and that they were exploded normally under the leading wheels of the engine.

It was confirmed later by Relief Signalman Dolby that this was the regular practice at Welwyn Garden City box when it was required to stop a fast train at night with the line clear to the inner home signal only.

The block controls and the sequential locking ensured that the signals had been put to danger behind the previous train on the Up Main line, No. 111; furthermore, levers 34, 33 and 31 were locked normal by the reversal of the crossover. The outer and inner homes and the inner distant, therefore, were "on" when they were passed unobserved by Driver Knapp on the engine of Train No. 113, but the starter No. 32 had been cleared for Train No. 1565 to proceed into the forward section. Because Train No. 113 had occupied track circuit CD before Train No. 1565 had cleared it, Signalman Betteridge had no means of knowing whether it would be safe to replace signal 32 in a last minute attempt to stop the express; he was in an unenviable position, but in leaving the signal "off" he made the only possible decision, and as things turned out this signal also was not seen by Driver Knapp. In giving precedence to the local business train he complied with his instructions, and he was in order under the Acceptance Regulations in permitting Train No. 113 to approach the outer home signal No. 34 at danger with a movement in progress through crossover No. 37. I conclude that Signalman Betteridge is entirely free from responsibility for the collision, and indeed that he did everything he could to prevent it.

71. Driver Knapp claimed that the Welwyn Garden City Up Main outer distant signal was showing a green light below the green light of the Welwyn North starter, and if this was true the clear indication can only have been a false one, as the result either of a danger side failure of the signalling equipment or of malicious or mischievous interference. No defect, however, which could have been dangerous was found either in the signal or in its associated electrical circuits after thorough examinations and tests by the Signal Department. Moreover, if an inexplicable failure had occurred to cause a false clear indication it could have only taken place during the four minute interval between the acceptance of the train at 7.6 a.m. and its passage past the signal at about 7.10 a.m., unless there had been the coincidence of an equally inexplicable wrong side failure in the separate "Line Clear" circuit to Welwyn North, the continuity of which requires, through the repeater circuit, that the arm of the Up Main outer distant should be properly in the caution position. This "Line Clear" circuit was also examined and tested and found in order, and there was no mechanical or electrical defect at the signal location which could have resulted in the movement of the outer distant arm away from the caution position when the Welwyn North wire-worked starter above it was cleared on receipt of the "Line Clear" release from Welwyn Garden City.

72. Even more thorough tests and examinations, with a series of independent checks of the insulation resistance, were made by the Signal Department after Driver Fowler had claimed that he had received a false clear indication at the same distant signal in daylight on the morning of 8th March which had led him to pass the outer and inner homes at danger. Again no fault was found in the equipment which could have had this result, and again if there had been an intermittent and inexplicable danger side failure it could only have taken place during the interval, in this case approximately two minutes, between the acceptance of the train from Welwyn North and its arrival within sight of the distant signal.

73. Driver Fowler, in order presumably to excuse himself and Driver Knapp for having passed signals at danger, sought to show that the outer distant was dangerously unreliable by mentioning the names of several other drivers and one New England goods guard who, as he had heard, had seen the distant signal in the clear position when it should have been at caution on various occasions before and after the accident. Every one of these second or third hand reports was thoroughly investigated, as has been recorded in paragraphs 45-54, and four of the reported incidents were found to be imaginary or irrelevant. Nor do I consider that the statements which were made by Driver Lupton, Driver Rolt and Guard Houghton gave any support to Driver Knapp's and Driver Fowler's claim that they had been misled by a false clear indication, and I am not altogether convinced of the honesty of the evidence of Driver Fowler who, if his statements were true, made a remarkably rapid stop from a speed of 60 m.p.h. when he caught sight of the inner home at danger, having failed for no good reason to observe the outer home. Driver Lupton's statements became confused when it was proved to him that he was only turned from Up Main to Up Slow at Welwyn Garden City on one day of the November week in question, and Guard Houghton, who I understand was brought to give evidence at Driver Lupton's request, was plainly untruthful. I have no doubt that Driver Rolt was straightforward, but I am satisfied that the whole object of his written report (paragraph 52) was to bring to a head his and other drivers' disapproval of the new inner distant, rather than to complain of a false clear indication at the outer distant.

74. The statements of these trainmen were not accepted by Signalman Betteridge, Relief Signalman Dolby and Relief Signalman Hatton, one or other of whom had been on duty at Welwyn Garden City on the occasions mentioned. All of them had considerable experience of this box, Betteridge as a regular man, and they expressed full confidence in the working of this distant signal and its repeater. None of them had experienced or heard of a false clear indication, either as a result of a wrong side failure of the equipment or of malicious or mischievous interference of any kind, and Dolby who was on duty on the morning of 8th March did not conceal a certain measure of contempt for Driver Knapp's and Driver Fowler's allegations. I am satisfied that the exhaustive tests and examinations of all the relevant circuits and other equipment were carried out by the Signal Department with

complete honesty of purpose and determination to find any defect there might be, and in my opinion these tests have proved that the confidence of the signalmen in the proper and safe working of the signal was not misplaced. Moreover, the working of the signal was under practically continuous check through the Line Clear circuit, and I should also mention that the special indicator which was installed on 10th March and has since been tested regularly, has never shown a "false clear", except on one occasion as the result of a lightning stroke which did not affect the working of the signal.

75. After considering the whole of the evidence, I conclude that there was nothing wrong with the Welwyn Garden City Up Main outer distant signal or its lights during the whole of the period under review, and that it was properly at caution when Driver Knapp passed it in mist and semi-darkness a minute or two before the collision on 7th January, and when Driver Fowler, also with Train No. 113, passed it in daylight on 8th March.

76. Thus if Driver Knapp saw the outer distant at all he misread it, and then, by his own admission, he continued forward for 1¾ miles at speed into the next section without observing any of the other four signals of Welwyn Garden City box, as was his duty even if he had seen a clear outer distant signal, and especially so if he had had nothing more than a fleeting glance of it, as he stated. I find it difficult to ascribe his failure to see or interpret the signals clearly to anything but lack of vigilance under weather conditions which required some care in the observation of signals but which by all accounts were not really difficult. The signalmen and other staff on the ground described the weather as hazy or misty with visibility of 200 yards or more in the half-light, and the drivers, Gray and Thurston, of the two Up trains, Nos. 111 and 1565, who passed the outer distant signal at about 7.2 a.m. and 7.6 a.m. respectively, saw the yellow light of the signal at caution at a range of about 250 yards when they were half way across the viaduct. They also saw the outer homes (Gray—Up Main and Thurston—Up Slow) just after they had passed through the overbridge which is 242 yards from the signals.

I think it is probable that the view of the outer distant and the outer home signals was much the same when Train No. 113 crossed the viaduct at about 7.10 a.m., in spite of Driver Knapp's statement that he caught sight of the Welwyn Garden City Up Main outer distant when he was about an engine length from it, though it is possible that the inner home gantry was only visible at short range on account of smoke and steam from the engine which was standing or shunting on the Hertford line. The weather was evidently clearer south of the station and Driver Thurston saw the Up Main starter No. 32 at a range of nearly 600 yards. It is possible that the failure of Driver Knapp and Fireman Tyers to hear the detonators at the signal box may also have been due to lack of alertness, but I should mention that when Brigadier Langley and I viewed the signals from an engine of the same class the Welwyn Garden City detonators were exploded under the leading wheels, and neither of us thought that the sound was at all loud above the ordinary noise of the engine at speed. Again in one instance during the special detonator trials a properly exploded pair of detonators were not heard at all by any of the three men on the footplate.

77. Since there was nothing wrong with the outer distant, the full responsibility for the collision must rest with Driver Knapp, though I am not satisfied that he received the assistance in the observation of signals which he might have expected from Fireman Tyers in the circumstances. Driver Knapp is a fit and abstemious man of regular habits, and his sight, including his colour vision, were found to be normal after the accident. He was stated to be steady and conscientious in character and his record is fair, but his general outlook did not strike me as particularly alert or receptive. His knowledge of the route for which he had signed was, I think, adequate, but his experience of driving fast passenger trains was limited, and I think he may not have appreciated the degree of vigilance which was required of him for express running under the particular weather conditions.

VI. Remarks and Recommendations

78. Train No. 113 is normally worked forward from Peterborough by a top link driver, but there can be no criticism of the substitution of Driver Knapp when the booked driver was late in reporting for duty at the New England Motive Power Depot, because Knapp had signed to confirm his knowledge of the route, after he had had ample opportunity to learn it; he also had considerable experience of the route as a fireman.

The collision in fact was brought about by one of the types of unpredictable human failure for which the safeguard of Automatic Train Control has been designed. The East Coast Main line has been used for some years for the trials of the British Railways system of Automatic Train Control, and there are now track magnets at distant and multi-aspect signals, including the Welwyn Garden City distants, for the whole of the 105 route miles of the Up and Down Main lines between King's Cross and Grantham. For the purpose of the trials, however, comparatively few of the engines which work on the route have been fitted with the receiving equipment, and neither Driver Knapp's nor Driver Fowler's engine was one of them.

The present position is that the British Transport Commission received the formal approval of the Minister of Transport and Civil Aviation to this Automatic Train Control system towards the end of last year, after the results of the long continued trials had proved the reliability of the equipment and after final inspection, and they have since been going ahead with their plans to provide Automatic Train Control equipment on all the main traffic routes as quickly as possible. It is their intention to

equip more than 1,300 miles of route and some 10,000 motive power units by the end of 1962, and in this programme first priority has been given to the East Coast route to Scotland, which runs through Welwyn Garden City, and its locomotives, in view of the considerable mileage which has already been equipped, and the experience which has been gained by the men.

79. The bracketted signal group comprising the Welwyn North Up Main and Up Slow starters and the Welwyn Garden City Up Main outer distant and Up Slow distant, which was retained for some time after the accident, was conspicuously sited and should not have been difficult to locate in misty or foggy weather, because it was preceded by several distinctive landmarks by which a driver could locate himself by sight and sound, namely, the two tunnels, the Welwyn North station, which is well lit at night, and the long viaduct. Several drivers said in fact that it was a good group of signals to see, and there was no criticism of the oil lights. I am also satisfied, as I have stated, that there was the strongest evidence to prove the continued reliability of the working of the Welwyn Garden City Up Main outer distant, notwithstanding the suggestions which were made to the contrary.

This signal, however, had been an object of discussion and possibly suspicion among East Coast engine crews, and particularly at the New England Motive Power Depot, ever since Driver Knapp stated that it had been clear for him on the occasion of the collision in January. I discussed this aspect of the case with the Regional officers, and as a practical step to re-establish the confidence of the men in the signalling at Welwyn Garden City, the group has now been replaced by a multi-aspect colour light with a junction indicator and complete modern controls, which will eventually be incorporated in a comprehensive scheme for colour light signals and continuous track circuiting on the route as a whole.

I see no reason to criticise the Up Main inner distant signal which was installed last September at Welwyn Garden City to give an early indication of the position of the starting signal ahead, and there are many examples of this arrangement elsewhere in the country. It was evident, however, that a good many drivers considered that this distant arm was misleading, and it has been removed.

80. The emergency detonators at Welwyn Garden City signal box were properly exploded under the engine of the express, but they failed to prevent the collision. As a consequence, I have received suggestions from members of the public that it is wrong to rely in modern times on "old-fashioned" detonators in emergencies of this kind, and that it would be better to use Very lights in signal boxes or even electric signalling lamps with a narrow concentrated beam which could be "aimed" at the train and thus have a better chance than an ordinary oil hand lamp of attracting the attention of the enginemen or the guard, or even of a passenger to the necessity for an immediate stop.

I appreciate the intention of these suggestions, and I have discussed them with the Railway officers. The fact remains, however, that the use of the detonator as an emergency warning on nearly all the railways of the world has stood the test of time, and there have been many occasions in which the emergency detonators at signal boxes have saved the situation at the last moment. Moreover, a great deal has been done, especially in recent years, to provide elaborate and very costly equipment, including track circuiting and all kinds of special controls to guard against signalmens' errors, and automatic train control to guard against the type of driver's mistake which was responsible for this accident. I do not, therefore, consider that there is any need to provide additional warning equipment in signal boxes in the hope that it might serve to attract attention on the rare occasions when detonators are not heard on the footplate.

81. It is not clear, however, why detonators with only one half of the normal gunpowder charge are used in the signal box machines, and as I have stated the sound of their explosion is by no means startling in the cab of a fast running steam locomotive. I think this is a matter which should be thoroughly reviewed on an "all line" basis, taking all forms of motive power into consideration, and I do not think that the possible risk to staff on the ground from the explosion of a heavier charge in rare emergencies should be given undue weight.

Nor do I consider that the close spacing, 6½ins. or 3ins., of the two detonators in the machines is satisfactory, because there is a strong tendency for the "strip" of the second detonator to be severely buckled by the explosion of the first, so much so as to remove the second detonator from the rail before it can be crushed by the wheel and exploded. I recommend that this point also should receive attention.

82. It is probable that the casualities in this accident would have been less serious if the rearmost coach of the local train had been marshalled with its brake compartment in rear, in accordance with the standing instructions that this should be done where practicable. After a special investigation, the Operating Superintendent concluded that there had in fact been opportunities to restore the proper marshalling of this set train formation since the abnormal stock working during the Christmas Holidays,

and he has issued an appropriate reminder to all the Districts in the Eastern Region, and has arranged for checks by the supervisory staff. The marshalling of brake compartments at the extreme front and rear of passenger trains is a very sensible safety precaution, but it is a point which may tend to be overlooked, especially when regular train formations have been disturbed, and it may be desirable to remind the staff in the other Regions of its importance.

I have the honour to be,

Sir,

Your obedient Servant,

G. R. S. WILSON,

Lieutenant-Colonel.

The Secretary,

Ministry of Transport and Civil Aviation.

APPENDIX

Welwyn Garden City. Signals Passed at Danger.
Friday, 8th March 1957

Report of Examination and Test of Signal Equipment

The Lineman for this Section, Lineman Marlborough, was advised at Hatfield at about 7.50 a.m. by the lad at Welwyn Garden City Box that No. 113 train had run past the Up Outer and Inner Home signals at danger and that one of the train crew had stated that the Outer Distant was OFF when they passed it. He informed his Inspector at Finsbury Park and caught the 8.20 a.m. from Hatfield to Welwyn Garden City. He went straight to the box, arriving at 8.30 a.m. approx., and the Signalman told him the indicators were in order and had been in order for a following train which stopped at the Outer Home. He watched the Up Outer Distant indicator until Chief Inspector Mosby arrived at about 9.0 a.m., and noted that it responded correctly.

Mr. Beirne, Maintenance Assistant at Head Office, and Chief Inspector Mosby carried out the tests shown in the attached sheet 'A' immediately after arrival and found no cause why the Outer Distant signal should have been OFF with the Home signals ON.

On the following day, Saturday 9th March, Chief Inspector Mosby carried out further tests of insulation resistance of line wires and wires to circuit breakers, etc. between the Welwyn Garden City Up Main Outer Home signal and Welwyn Garden City signal box and the lowest insulation resistance was 2.5 megohms.

Although the results of all the tests taken on Friday and Saturday were satisfactory, in view of the previous incident on the 7th January 1957 it was decided to remove, for detailed examination, the circuit breakers and wiring to the Distant control circuit between the Outer Home and Distant, and this work was carried out on Sunday, March 10th.

Examination and further tests of the equipment removed revealed no faults. Inspection of the wires revealed two tiny spots where the insulation had split but this may have been caused by the act of removing the wire from inside the Outer Home signal structure. As a result of this inspection it was decided to extend the scope of the tests to ascertain whether it would have been possible to energise the Outer Distant Control relay through contact with the structure of the Up Outer Home signal. Since the Outer Home was ON the circuit would be disconnected at the circuit breaker attached to the Outer Home arm, therefore, the only spot through which this could possibly have occurred was the spot on the wire from the bottom circuit closer which passed up the signal post to the overhead line. For such a circuit to be established it would have been necessary: —

1 for good electrical contact to have been made between the spot and the structure of the signal which was heavily painted and had rust bubbles in places,

and

2 for an earth to have been present on a battery of adequate voltage, the return of which was connected to the same return as the Distant control relay.

Accordingly, further tests (attached Sheet 'B') were made on Tuesday, 12th March. From these tests it will be seen that even supposing an earth fault on a battery had existed and a contact between the wire and the structure had been present, the resistance of the contact would have been of such a high order as to rule out the possibility of false operation of the distant control relay. It is, of course, not at all certain that the two wires, each with a small 'bare' spot, were on the outside of the bunch of wires which passed up the signal and therefore in a position to have come into contact with the structure.

Tests for a possible earth on a battery have been carried out between Welwyn North Up Main Outer Distant and Welwyn Garden City Down Distant where batteries are connected to the same return as the battery which operates the distant control relay. In no case was an earth fault in a battery found.

The many tests which have been carried out have found no circuit through which the Outer Distant signal could have been falsely cleared, either by false energisation of the distant control relay (G.R) or false energisation of the Outer Distant operating motor.

A special indicator was installed in Welwyn Garden City signal box on 10th March 1957 which will sound an alarm should the Outer Distant arm be in the OFF position or the Outer Distant control relay be energised with the Inner and Outer Homes in the ON position.

R. A. Green
Signal Engineer, Eastern Region.

King's Cross Station, N.
April 1957

WELWYN GARDEN CITY: SIGNALS PASSED AT DANGER
8TH MARCH 1957

TEST	WEATHER	RESULT
From Outer Home signal Circuit breaker bottom arm including all wiring to Outer Distant control relay with Welwyn North Starter No. 16 OFF.	Wet condition on pole route. Rain, drizzle.	Insulation resistance 0.25 megohms to earth.
Welwyn North No. 16 circuit breaker to Outer Distant control relay.	Drizzle.	Insulation resistance 1.0 megohms to earth.
Circuit breaker on top and bottom arms on Outer Home and on Welwyn North No. 16 examined and tested.	Drizzle.	Insulation resistance of each circuit breaker: — Contact to each other—'Infinity'. Each contact to case—'Infinity'.
Megger test on open line wires between Outer Home and Outer Distant control relay when rain ceased and pole route drying out.	Fine.	Insulation resistance 0.38 megohms to earth.
Examination of all line wires on pole route between Outer Home and Distant.	Fine.	All lines clear and secure on insulators.
Voltage to earth at relay.	Drizzle.	Nil.
Voltage across control relay with 34 signal ON.		Nil.
Battery 'positive' at Welwyn Garden City, voltage to earth.		Nil.
Functional tests at box of all U.M.O.D. and U.M. Block controls.		All controls effective.

All mechanical fittings on the Up Outer Distant post examined and found to be free of any possible obstruction.

All insulation tests made with a 500 v. megger.

Welwyn Garden City: Signals Passed at Danger
8th March 1957

Tests Carried Out on Tuesday, 12th March.	Using light contact pressure	Using heavy contact pressure
Resistance of a clean wire touching the structure (painted) in the vicinity of the 'spot'.	over 50 megohms	50 megohms
Resistance of a clean wire touching the structure (rust bubble) in the vicinity of the 'spot'.	50 megohms	15 megohms
Similar tests were taken in the vicinity of the 'spot' on the other wire with the following results: —		
Resistance of a clean wire touching the structure (painted) in the vicinity of the 'spot'.	over 50 megohms	8 megohms
Resistance of a clean wire touching the structure (rust bubble) in the vicinity of the 'spot'.	over 50 megohms	1 megohm

Damp weather conditions prevailed.

All insulation tests made with a 500 v. megger.

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EASTERN REGION

COLLISION AT WELWYN GARDEN CITY ON 7th. JANUARY, 1957

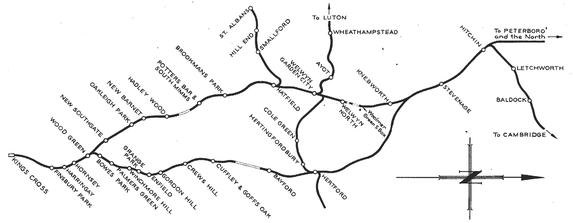


FIG. 1 LOCATION PLAN

SCALE: ¼ INCH TO 1 MILE

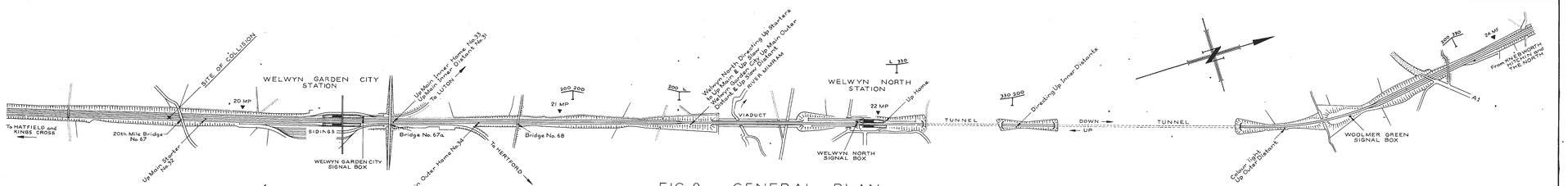


FIG. 2 GENERAL PLAN

SCALE: 6 INCHES TO 1 MILE

YDS. 100 50 0 100 200 300 400 500 600 700 800 900 1000 1100 1200 1300 1400 1500 1600 1700 1800 1900 2000 YDS.

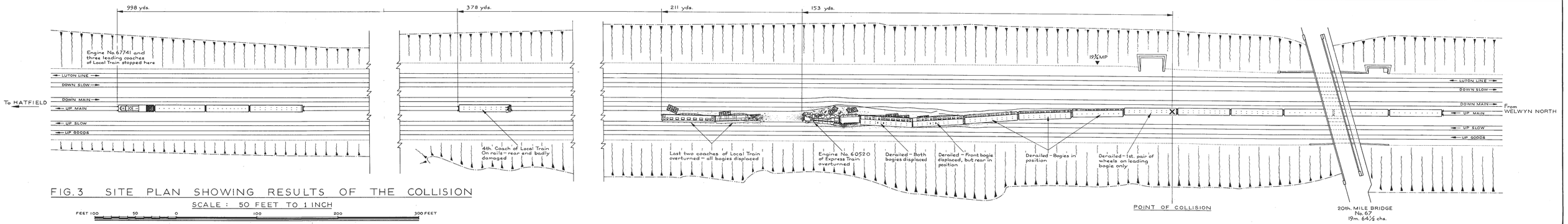


FIG. 3 SITE PLAN SHOWING RESULTS OF THE COLLISION

SCALE: 50 FEET TO 1 INCH

FEET 100 50 0 100 200 300 FEET

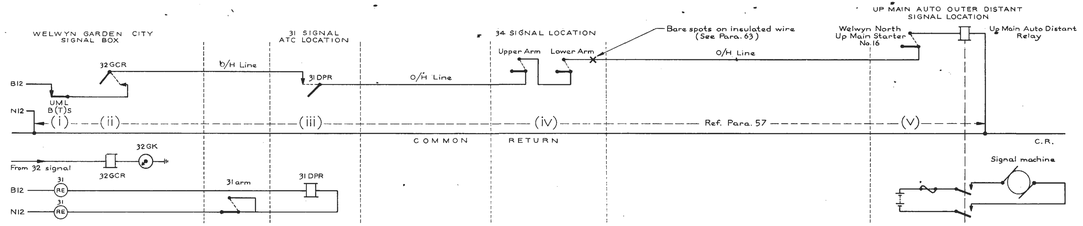


FIG. 6

CONTROLLING CIRCUIT OF WELWYN GARDEN CITY UP MAIN AUTO OUTER DISTANT SIGNAL

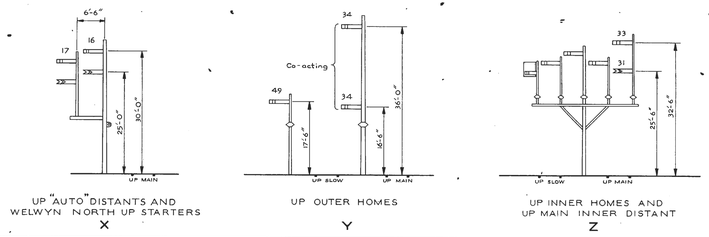


FIG. 5

SIGNAL ELEVATIONS WELWYN GARDEN CITY

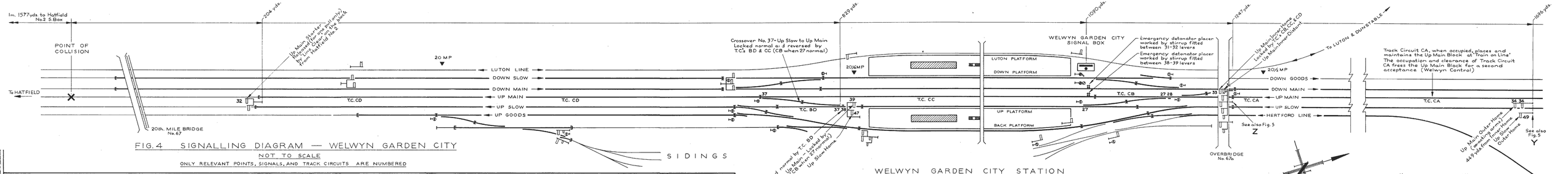
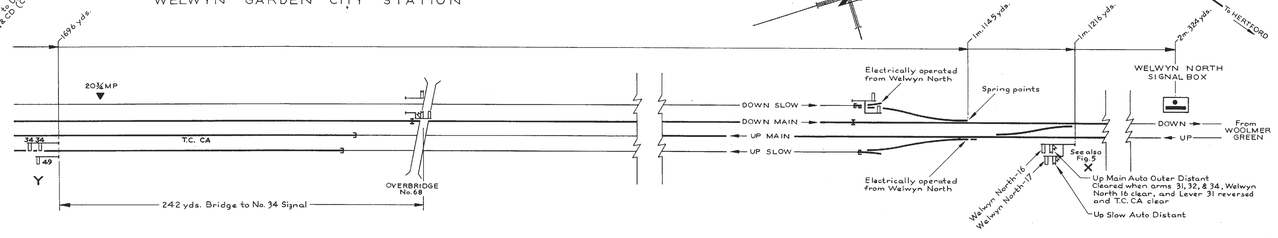


FIG. 4 SIGNALLING DIAGRAM — WELWYN GARDEN CITY

NOT TO SCALE

ONLY RELEVANT POINTS, SIGNALS, AND TRACK CIRCUITS ARE NUMBERED



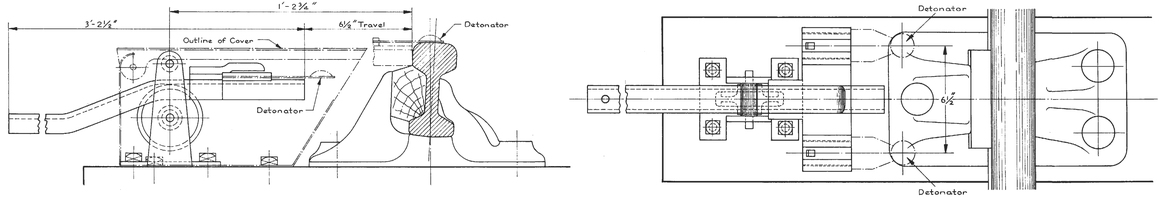


FIG. 7 DETONATOR PLACING MACHINE