1938.

NEW ZEALAND.

DERAILMENT OF SPECIAL EXCURSION TRAIN NEAR RATANA ON 26th MARCH, 1938.

(REPORT OF BOARD OF INQUIRY.)

Presented to both Houses of the General Assembly by Leave.

The Hon. the MINISTER OF RAILWAYS, Wellington.

SIR,— Wellington, 8th July, 1938.

By your warrant directed to us dated the 28th March, 1938, and extended on 20th April, 1938, 24th May, 1938, and 22nd June, 1938, we were appointed a Board of Inquiry and required and authorized to inquire into and report to you concerning the derailment of a special passenger-train near Ratana on the morning of 26th March, 1938, with specific reference to the following matters, namely :—

(1) What was the cause of the derailment of the said train ?

(2) Was any employee in the service of the Government Railways Department guilty of any dereliction of duty which directly or indirectly contributed to the said derailment ?

(3) Generally are there any circumstances in connection with the said derailment which call for comment, particularly in respect of the said rolling-stock and the permanent-way in the locality of the derailment ?

(4) What steps (if any) might be suggested to prevent a recurrence of a similar derailment ?

We have held an inquiry as directed by you, and now have the honour to report as follows :—

INTRODUCTORY.

A special passenger-excursion train, officially designated as "W 4," was scheduled to run from Wellington to New Plymouth, leaving Wellington at 9.40 p.m. on Friday, 25th March, 1938.

"W 4" consisted of engine AB 829 and six passenger carriages and a guard's van. The passenger carriages and guard's van, with their tare weights, were as follows :—

	Tons.	cwt.	qrs.
Car A 1791	21	8	0
Car A 1796	20	10	3
Car A 1797	22	16	2
Car A 1413	20	11	3
Car A 1572	20	1	0
Car A 1790	21	9	0
Van F 501	17	19	2

There were 197 passengers on the train when it left Marton, and, when allowance is made for the weight of the passengers, the gross weight of the train (exclusive of the locomotive) can reasonably be estimated at approximately 158 tons.

W 4 was in charge of Guard Thomas Henry White, and the engine crew consisted of Engine-driver Edward Clifton Percival and Fireman and Acting Engine-driver Kenneth Albert Millar. Fireman and Acting Engine-driver Millar acted as fireman.

The running of the train to Ratana was normal. At a distance of approximately 1 mile 15 chains north of Ratana there is a curve of 6·4 chains radius. At the commencement of the curve the train was derailed, and, as a result, six passengers were killed. Fireman and Acting Engine-driver Millar suffered extensive scalding and other severe injuries, to which he subsequently succumbed. Engine-driver Percival suffered severe though less serious injuries, and has since made a good recovery. Several passengers were injured, some severely.

THE INQUIRY.

An inspection of the track at the scene of the derailment was made by the Board on 11th April, 1938. On the same afternoon the locomotive, carriages, and guard's van that had comprised the service of the wrecked train were examined at East Town Workshops, to which they had been removed pending inspection by the Board. In the evening the Board travelled over the line between Turakina and the scene of the derailment, in order to ascertain the conditions of night travelling over that portion of the track. A further examination of the damaged rolling-stock and of the track was carried out by the Board on the following day.

Sittings of the Board commenced at Wanganui on 13th April, 1938, and continued at Wellington on the 26th, 27th, 28th, and 29th of the same month. On the last-mentioned day the hearing was adjourned *sine die*, the intention being to proceed as early as possible after the engine-driver's recovery, and the sittings of the Board were resumed at Wellington on the 14th June, 1938, and continued until the 28th June, 1938.

The sittings of the Board were duly advertised, and any persons desiring to communicate to the Board any matters relevant to the inquiry were invited to do so either by appearing in person at any of the sittings of the Board or by submitting written statements.

The Railways Department was represented before the Board by Mr. H. F. O'Leary, K.C., who had with him Mr. F. W. Aickin, Railway Law Officer. Mr. G. G. G. Watson appeared on behalf of the New Zealand Locomotive Engine-drivers, Firemen, and Cleaners' Association and for Engine-driver Percival, a member of the association. Messrs. C. M. Armstrong, F. J. Foot, and N. T. Gillespie appeared on behalf of the relatives of certain persons who were passengers on W 4 train and who were killed or died of injuries as a result of the accident to the train.

The following departmental witnesses were examined on oath :—
Albert Leslie Smith, Assistant Traffic Manager, Railways Department, Wanganui.
Oliver Langman Kidson, Train Control Operator, Railways Department, Wanganui.
George James Bertinshaw, Chief Engineer, Railways Department, Wellington.
John Dow, District Engineer, Railways Department, Wanganui.
William Theodore Langbein, Assistant District Engineer, Railways Department, Wanganui.
Cyril Arthur Gaylard, Porter, Railways Department, Turakina.
George Raymond Blockley, Surfaceman, Railways Department, Wangaehu.
James William Henderson, Ganger, Railways Department, Turakina.
Henry Wright Buckingham, Ganger, Railways Department, Wanganui.
William Edmonds, Inspector of Permanent-way, Railways Department, Wanganui.
Ernest William Hall, Train-examiner, Railways Department, Palmerston North.
Samuel Stanley Joines, Train-examiner, Railways Department, Palmerston North.
Hamilton Richard Cohen, Train-examiner, Railways Department, Marton.
James Brown, Stationmaster, Railways Department, Turakina.
James Courtney Bell, Engine-driver, Railways Department, Wangnaui.
Edward Samuel Creelman, Train-examiner, Railways Department, Wellington.
Herbert Rigden Lepper, Lifter, Railways Department, Wellington.
Sturz Barton Barltrop, Car and Wagon Inspector, Railways Department, Wellington.
George Reid, Engine-driver, Railways Department, Wellington.
Richard Henry Tripp, Engine-driver, Railways Department, Wellington.
Alexander Smillie Wansbrough, Designing Engineer, Railways Department, Wellington.
Reginald John Gard, Designing Engineer, Railways Department, Wellington.
Percy Roy Angus, Locomotive Superintendent, Railways Department, Wellington.
James Charles Jones, Engine-driver, Railways Department, Wellington.
Sibley Everest Gamby, Road Foreman, Railways Department, Auckland.
Francis Alfred Ellis, Acting Locomotive Foreman, Railways Department, Wellington.

In addition, the surviving members of the train crew, namely :—
Thomas Henry White, Guard, Railways Department, Wellington ; and
Edward Clifton Percival, Engine-driver, Railways Department, Wellington,

and the following passengers were examined on oath :—
James Laurie Winstone, Nurseryman, Otaki.
Henry Arthur Hare, Hotel Porter, Wellington.
Gordon James Mullins, Tramway Employee, Wellington.
Mary Agnes Irwin Hanning, Married Woman, Wellington.
Charles Allen, Factory Operative, Lower Hutt.
Beatrice Florence Wilkinson, Married Woman, Paraparaumu.
Frederick Harry Taylor, Apprentice Fitter-turner, Railways Department, Woburn.
William Henry Eden, Cleaner, Railways Department, Wellington.
Frederick William Billows, Messenger, Wellington.
Thomas Joseph Calnan, Storeman, Wellington.
Humphrey James Barnicoat, Medical Practitioner, Kimbolton.
James Arthur Lattimer, Salesman, Lepperton.
Hector Dawbin Bushby, Labourer, Crofton.
William John Markham McMillan, Accountant, Rotorua.
Dorothy Caroline Sims, Furrier, Wellington.
Archibald Hartley, Retired Watchman, Lower Hutt.
Patrick Gleeson, Labourer, Wellington.
Richard Gadd, Tram Conductor, Wellington.
Jean Ivy Sinclair, Tailoress, Island Bay.
Thomas Alexander Butchart, Clerk, Railways Department, Wellington.
David Keith O'Donnell, Cadet, Railways Department, Wellington.
Raymond Augustus Andrews, Brewer, Wellington.
Eric William Henry Russell, Process Worker, Wellington.
Henry William Bish, Leading Fitter, Railways Department, Wellington.
Harry Arthur Jones, Casual Platelayer, Railways Department, Taihape.
William Nixon, Cemetery Caretaker, Wellington.

Elsa Ramage, Married Woman, Wellington.
Herbert Henry James Bruce, Timber-classer, Pokaka.
Norma Weine, Married Woman, Wellington.
Alexander Joseph McDonald, Civil Servant, Wellington.
Charles Elliott Jack King, Clerk, Wellington.
Edward Arthur Lee, Chauffeur, Wellington.

By consent of counsel, statements made to the police by two passengers who were unable to attend personally before the Board were put in as exhibits, and admitted as evidence.

The following exhibits were handed in:—

(*a*) Wellington Train Advice No. 848.
(*b*) Wanganui Train Advice No. 529.
(*c*) Guard's Mis/7 Running-sheets (2).
(*d*) Statement of schedule and actual running-times of W 4 special train.
(*e*) Composition of W 4 special train.
(*f*) Running-times of trains Nos. 571 and 573 which passed over curve at 131 miles on morning of 26th March, 1938.
(*g*) List of passengers injured and killed.
(*h*) Train-control diagram.
(*i*) Plan No. 51084, showing permanent-way renewed after derailment.
(*j*) Plan No. 51078, showing position of derailment marks on rails and sleepers.
(*k*) Plan No. 51085, showing sections of rails at and near point of derailment.
(*l*) Plan No. 51079: General plan showing position of derailed vehicles.
(*m*) Photographs of derailment.
(*n*) Plan No. 51080: Key plan to photographs.
(*o*) Plan No. 51081: Diagram of cant, slack, and curvature.
(*p*) Plan No. 51076, showing dimensions of curve board.
(*q*) Plan No. 51077, showing dimensions of speed board.
(*r*) Working Time-table.
(*s*) Plan No. 51082, showing alignment and longitudinal section of line near point of derailment.
(*t*) Plan No. 51083, showing points where previous derailments have occurred.
(*u*) Templates of tire-flanges and engine-wheel treads.
(*v*) Blue print showing tire profiles.
(*w*) Schedule (Loco. 135A), showing repairs to engine AB 829 during overhaul in workshops.
(*x*) Schedule showing repairs effected to engine AB 829 since general overhaul.
(*y*) Diagram showing make-up of train and weights and lengths of individual vehicles.
(*z*) Blue print X9701, showing construction of AB engine.
(*aa*) Blue print X9702, showing construction of AB engine.
(*bb*) Blue print X9878, showing construction of leading bogie of AB engine.
(*cc*) Schedule showing work undertaken on derailed vehicles when last in shops.
(*dd*) Plan showing results of night visibility tests of speed and curve boards.
(*ee*) Details of technical calculations showing overturning speeds, &c.
(*ff*) Graph showing rates of deceleration.
(*gg*) Copy of statement made to police by Basil Foley, a passenger on W 4 train.
(*hh*) Copy of statement made to police by John James Easterfield, a passenger on W 4 train.
(*ii*) Return of obstructions placed on line (allegedly maliciously) from 25th December, 1932, to 30th March, 1938.
(*jj*) Return of derailments of locomotives on main lines from 1st April, 1928, to 27th February, 1938.
(*kk*) Booklet setting out particulars of the Railways Department's medical examination of candidates for employment.
(*ll*) Letter from Railways Department setting out particulars of test weighings of certain AB class locomotives.
(*mm*) Copy of statements made to Detective Murray, of Wanganui, by the driver of W 4 train, Edward Clifton Percival.

RUNNING OF TRAIN FROM WELLINGTON TO TURAKINA.

The running-times scheduled for W 4 are somewhat easier than those for the New Plymouth express, except between Palmerston North and Feilding, where the running-times are the same, and between Feilding and Marton, where W 4 was allowed thirty-six minutes, as against thirty-eight minutes for the express.

According to the station bookings an aggregate time of thirty minutes was lost at stations between Wellington and Marton, inclusive, for traffic reasons or for taking water. The guard's bookings (twenty-nine minutes) agree with the station bookings within a minute. On this portion of the journey the driver lost three minutes' running-time on the Wellington – Tawa Flat section, and two minutes on the Longburn – Palmerston North section, and on other sections he made up twenty-eight minutes (guard's bookings) or thirty minutes (station bookings): a net gain of twenty-three or twenty-five minutes on the scheduled running time to Marton.

W 4 was booked out from Marton at 1.44 a.m. (guard's time) or 1.45 a.m. (station time)—that is, eight to nine minutes late. It was recorded at Turakina Station as having passed through at 2.3 a.m.

The train was then four minutes late according to its schedule, having gained four or five minutes on the twenty-three minutes allowed on the Marton–Turakina section and having made the run in one or two minutes less than the time allowed for the New Plymouth express.

There is, however, nothing in the recorded times of W 4 to indicate that, although time was lost and made up at different stages of the journey, the maximum speeds authorized by the Working Timetable were at any time exceeded on the journey between Wellington and Turakina.

OPERATING CONDITIONS BETWEEN MARTON AND POINT OF DERAILMENT.

For the sake of convenience we refer throughout this report to the point 27 ft. south of mile 131, at which the evidence indicates that the engine left the rails, as "the point of derailment." This does not imply that the cause of the accident was a simple derailment in the ordinary sense of the term. As will be seen later, the preponderance of evidence establishes that the cause of the accident was the operation of centrifugal force at a sharp curve, which caused the engine to overturn. The derailing of the engine was only an incident of the overturning, and was not the primary cause of the accident.

From Wellington to Marton the conditions of operation call for no special comment. From Marton onward, however, owing to grades and curves, the line becomes more difficult. Maximum speed limits are prescribed between Marton and Fordell, those applicable to express, mail, and passenger trains being as follows:—

	Miles per Hour.
Marton to mile 124, chain 20	45
Mile 124, chain 20, to mile 124, chain 70	30
Mile 124, chain 70, to mile 140, chain 60	35

In addition to the maximum speed-limit, a permanent speed-restriction to 25 miles per hour applies to all curves of less than 9 chains radius, and special further speed-restrictions to 20 miles per hour are imposed between mile 127, chain 60, and mile 128, chain 60, and between mile 130, chain 70, and mile 131, chain 30, where combinations of curves and grades occur. The accident occurred on a 6·4 chain radius curve, 27 ft. south of mile 131—that is, just after the train had entered the length covered by the last-mentioned restriction.

From Marton the line rises for about two miles, and then falls continuously for about eight miles to Turakina (mile 127, chain 13). The steepest grade is of 1 in 50, from mile 124 to mile 125, and the sharpest curve is of 14 chains radius.

Running through Turakina a speed of 35 miles per hour is permissible, but a train may be checked somewhat to facilitate the picking-up of the tablet. Moreover, a curve of $8\frac{1}{2}$ chains radius is met approximately 27 chains from the centre of Turakina Station. This curve is, of course, covered by the general restriction to 25 miles per hour that applies to all curves of less than 9 chains radius. Seven chains north of the end of this curve (at mile 127, chain 60) the first special speed-restriction to 20 miles per hour takes effect for a distance of one mile. The length covered by this restriction rises sharply up grade ranging from 1 in 44·6 to 1 in 56 to the summit (mile 128, chain 55), and includes curves of 10, $5\frac{1}{2}$, 12 (2), $8\frac{1}{2}$, 5, 8, 7, and 9 chains radius. The special speed-restriction ends at mile 128, chain 60, 5 chains north of the summit.

From mile 128, chain 55, through Ratana, and to the 6·4 chain radius curve at which the accident occurred the line is practically straight, being broken only by two very short curves of $13\frac{3}{4}$ chains and 80 chains radius respectively. It descends in comparatively easy gradients, and there is a length of about 13 chains of level track before the 6·4 chains radius curve is reached. With the exception of a short stretch of 5 chains between mile 128, chain 55, and mile 128, chain 60, this practically straight length of approximately 2 miles 15 chains is covered, as already stated, by a maximum speed-limit of 35 miles per hour.

The second special speed-restriction to 20 miles per hour to which reference has been made applies from mile 130, chain 70—that is, from 633 ft. south of the point of derailment, to mile 131, chain 30. Between miles 131 and 132 the line falls sharply down a grade of 1 in 38·5, with a close succession of curves, one being of 6 chains radius.

It appears that the maximum speed-limit of 35 miles per hour that applies to the straight and easy stretch between mile 128, chain 60, and mile 130, chain 70, must be considered together with the restriction to 20 miles per hour from the latter point, which has relation to the sharply curved and steep descent from mile 131. Apart from the existence of the steep and tortuous grades at both ends, there would be no necessity for imposing a maximum speed-limit of 35 miles per hour for a straight and easy stretch over two miles in length.

The 6·4 chains radius curve is marked by a radius board bearing the figure 6, which is placed approximately at the commencement of the transition curve leading to the true curve.

The special speed-restriction of 20 miles per hour commencing at 130 miles, 70 chains, is marked by a large speed board, the visibility of which under night conditions was tested from the footplate of an engine by departmental officers, and was also checked by members of the Board of Inquiry. On a dark night which was, however, free from mist or fog the board first became clearly visible at a distance of 1,070 ft. At shorter distances the board and the lettering thereon were partly obscured by a telegraph pole and by the shadow cast by the telegraph pole, but the board itself was continuously in view from the time at which it first became visible. The speed board is placed in a position 6 chains 49 links north of 130 miles, 70 chains—that is, its position does not coincide with the commencement of the length of line that it is intended to protect. This circumstance is, in the present case, merely a matter for comment, for the position of the board had no bearing on the happening of the accident to train W 4.

DESCRIPTION OF THE ACCIDENT.

Train W 4 left the rails at mile 130, chain 79, link 59, approximately 4 miles north of Turakina, shortly after it had entered the curve of 6·4 chains radius. The engine, tender, and leading car on leaving the rails fell outwards to the left against the side of the cutting and travelled over the sleepers and ballast and along the batter for a total distance of 142 ft. from the mark on the outer rail, which appears to indicate the point at which the left-hand leading-bogie-wheels of the engine left the rails. The couplings and brake-hose pipe between the first and second cars parted. The second car continued to run on the rails until it struck the rear right-hand corner of the derailed and tilted leading car. This caused it to be thrown off the rails to the right, and it was followed by the third and fourth cars, which also struck the leading car. The leading bogie of the fifth car was also derailed to the right. The sixth car and the guard's van remained on the rails. The leading end of the second car travelled 191 ft. beyond the point of derailment, or 304 ft. from its situation at the time when the engine left the rails—that is, its leading end came to rest approximately 50 ft. ahead of the position at which the front of the engine came to rest. The impact with the corner of the leading car tore out most of the front and half of the left-hand side of the second car. Part of the front and side of the third car and rather less of the fourth car were similarly damaged. The bogies of these cars were all torn off, and some were completely wrecked.

POINT OF DERAILMENT.

We have fixed the point of derailment at mile 130, chain 79, link 59. This point is 110 ft. north of the commencement of the 6·4 chain radius curve. There are no marks on the rails or sleepers south of this point. At this point, what has been described as a "scrape-mark" about $\frac{1}{2}$ in. wide commences on the outer side of the head of the outer rail. This mark extends for a distance of 20 in., at which point, or just beyond which point, occurs the first screw-spike head, which bears evident marks of having been struck by the flange of a wheel. At 2 ft. 9 in. north of the beginning of the scrape-mark is a diagonal mark about 12 in. long across the top of the same rail. The scrape-mark was obviously caused by the inner side of the flange of the leading left-hand bogie wheel of the engine, and the diagonal mark was probably caused by the flange of the second bogie wheel, but the latter mark may have been caused by the passage of one of the driving-wheels. The diagonal mark ends over a sleeper, the second from the point of derailment. On this sleeper, beyond the outer rail, appears a mark evidently made by the flange of a wheel running over the sleeper. This mark was presumably made by the leading bogie wheel. The next sleeper bears two parallel marks, and the next again three parallel marks. From this point on, for a distance totalling 37 ft. from the point of derailment, all the sleepers are badly smashed at the left-hand end, but no corresponding marks appear on the sleepers between the rails for this distance. At the next sleeper beyond this distance a mark appears between the rails, which may have been caused by any of the wheels of the following part of the train, as from this point onward the sleepers for a considerable distance were all damaged by the passage of the different vehicles. At a point 34 ft. north of the point of derailment the fishplate bolts were broken, the fishplates displaced, and the following length of the left-hand rail displaced towards the centre of the track. At its northern end this length of rail was still fully attached to the rest of the track.

POSSIBLE CAUSES OF ACCIDENT.

The possible causes of the accident may be grouped under six heads :—

(1) Defect in track.
(2) Obstruction on track.
(3) Operating factors.
(4) Defect in engine.
(5) Defect in rolling-stock.
(6) Excessive speed.

We propose to deal with these possible causes *seriatim*.

(1) Defect in Track.

There had been no substantial fall of rain for five weeks, and there was no subsidence of the track. The clay formation was described as being exceptionally hard. The track had been relaid in 1930, and realigned in February, 1938. In order to ease the approach to the curve a transition curve had been put in in 1930, and this had later been lengthened and improved. The wear on the rails was well within the margin of safety. Variations in cant, gauge, and curvature of the track were also well within permissible working-limits. The track was frequently inspected, and at 4.30 p.m. on the day before the accident occurred a surfaceman took his velocipede off the track within a few yards of the point of derailment in order to allow a train to pass. He particularly noticed that the train took the curve smoothly.

We are satisfied that the condition of the track in no way caused or contributed to the accident to train W 4. The damage done to the track, to which we have already referred, occurred as a result of the accident, and was all north of the point of derailment.

(2) Obstruction on Track.

The possibility of the presence of an obstruction on the track cannot be absolutely ruled out. Against this possibility, however, weight must be given to the following considerations :—

An examination of the records of cases in which an engine travelling at a moderate speed struck an obstruction on the line shows that the result was a simple derailment of two or more bogie wheels without causing the engine to overturn or even to leave the track. In fact, unless the obstruction struck was very large and heavy, an engine would be unlikely to overturn. In the present case a

careful search among the wreckage and debris was made, but it disclosed no trace of any obstacle that could have overturned an engine that struck it. We have already indicated that a small object would not be likely to cause overturning of an engine. Then again, a southbound goods-train (No. 573) passed over the curve within half an hour of the time of the derailment of train W 4, and negotiated the curve without any difficulty. It is extremely unlikely that any maliciously disposed person would have chosen that particular half-hour—about 2 a.m.—to place an obstruction on the line. Further, the accident occurred at the spot at which one would have expected it to happen if the cause were excessive speed. Even if an obstruction had been placed on the track and had caused a derailment the results would not have been what they were in the absence of such a contributing factor as high speed. It is worthy of note that when another engine struck an obstruction on the line at this curve a few years ago only the leading bogie of the engine was derailed. The evidence in that case indicated that the engine was proceeding at the authorized speed. We are therefore of the opinion that the accident was not caused by or contributed to by the presence of an obstacle on the track.

(3) Operating Factors.

Engine-driver Percival had not driven over the section of line between Marton and Wanganui for about eight years. At that time he had made four trips as driver of a night train that ran between Wellington and New Plymouth. He states, however, that he had no hesitation in accepting the assignment for train W 4, and that he was confident that his knowledge of the track was sufficient. He was supplied with a copy of the Working Time-table, which indicated the points between which speed-limits and speed-restrictions operated. A number of experienced drivers agreed that when a driver had driven on a few occasions over a section of track he was able to remember that section for an indefinite number of years afterwards. The practice of the Department is to permit without hesitation a driver to decline an assignment if he considers that he is not sufficiently familiar with the section of line over which the train is to run. It was admitted by Driver Percival and the other drivers who gave evidence that it was not held against a driver in any way if he declined an assignment on the ground that he was not familiar with a section of the line.

The driver had had a time relief of twenty-four hours before he commenced duty on the night of 25th March, 1938.

So far as the time-table for train W 4 is concerned, we are satisfied that it could be maintained without it being necessary at any point to exceed the authorized speeds set out in the Working Time-table.

The white paint on the speed and radius boards at the 6·4 chains radius curve had become somewhat dingy, but at night-time, in the bright light of an electric headlight, this defect was less noticeable than in the daytime. No complaints had ever been made by drivers to the Department as to the condition or positions of the radius board and the speed board. We are satisfied that the operating factors to which we have referred in no way caused or contributed to the accident.

(4) Defect in Engine.

Engine Ab 829 had run 60,589 miles since it had last been in the workshops for complete overhaul. The running distance between overhauls for this class of engine in the Wellington District is 80,000 miles. This is regarded as being somewhat on the low side, and the mileage of 80,000 between overhauls is now being increased to 90,000 for Ab class engines in the Wellington District. All engines are frequently inspected by experienced officers of the Department, and engine-drivers are required to report any defects that come under their notice. Drivers are also required to satisfy themselves that their engines are in good running-order before they take them out. The brakes are examined and tested before the commencement of a journey and whenever any part of the train is detached. We have the evidence of Engine-driver Percival that engine Ab 829 was in good running-order on the night of 25th/26th March, 1938, and that the brakes were working perfectly up to the time that the accident occurred.

An examination made by the Board, as well as the evidence of the appropriate departmental officers and records, showed the engine to be in good running-order, apart from damage that had clearly resulted from the accident itself. The clearances were ample, tire-flanges were good, and the spring-compensating gear was intact. The bogie springs, one of which was found damaged on removal, were tested, as found, under the instructions and in the presence of the Board, by graduated loading and unloading in the usual manner. The moderate differences in the results given by the two springs are adequately explained by the one showing damage that was attributable to, and not a cause of, the accident. Under the Board's instructions the steam-dome was opened. The type of regulator-valve in use is designed to be self-closing in the event of any possible failure of the connections; but the opening of the steam-dome showed that there had been no failure. The valve was closed and the connections in good order. None of the evidence submitted suggested any failure of the brakes, but the Westinghouse equipment was examined throughout under the Board's instructions, and to the extent that it was not damaged in the accident it was found to be in order.

The result of the entire investigation was definitely to exclude the possibility of the derailment having been due to any defect in the locomotive.

(5) Defect in Rolling-stock.

Evidence was given of the periodical overhauls of the rolling-stock and of the inspections made before the despatch of a train. The inspection covers all the running-gear and brakes. The rolling-stock of train W 4 was in sound running-condition, and no defects were observable apart from the damage caused by the accident. We are satisfied that the accident was not caused or contributed to in any way by any defect in the rolling-stock.

(6) Excessive Speed.

The evidence concerning speed may be dealt with under four heads :—

(*a*) Evidence regarding the time of the accident ;

(*b*) The evidence of the passengers and the Guard ;

(*c*) The evidence of the driver ;

(*d*) Evidence as to the condition of the wreck and the relative positions of the vehicles as ascertained after they had come to rest.

We propose now to consider these items in the above order.

(*a*) We have devoted considerable thought to the possibility of establishing the time at which the accident happened. The Turakina Station record shows that the train passed through Turakina at 2.3 a.m. There is confirmation of the accuracy of this record in the corresponding records of Fordell Station to the north and Marton Station to the south, the latter having been signalled immediately after W 4 passed through Turakina in connection with the southward departure of the goods-train (No. 573). There is ample evidence that W 4, though it had been making up a few minutes of lost time after leaving Marton, passed through Turakina at a normal speed, which may reasonably be taken as being 30 miles per hour. At this pace, with allowance for a speed-restriction to 25 miles per hour at a curve, it would reach the point where the Turakina grade special speed-restriction begins to operate in a few seconds over one minute, the distance being half a mile for all practical purposes. The next mile up the steep grade of the Turakina Hill would be, and we believe was, traversed approximately in accordance with the special speed-restriction of 20 miles per hour, and occupied three minutes. This gives the time of topping the grade and entering the Ratana Flat as 2.7 a.m. The distance from the top of the hill to the scene of the accident is 2 miles 25 chains. Taking in descending order, the times given by witnesses as the time at which the accident occurred, we find that :—

(i) The guard recorded 2.18, a period of eleven minutes, or an average speed of 12·54 miles per hour from the top of Turakina Hill. This is palpably absurd.

(ii) Mr. Winstone fixed the time at 2.15, which gives a period of eight minutes and a speed of 17·25 miles per hour—almost equally absurd.

(iii) Mrs. Wilkinson, whose watch was five minutes slow, and who knew of this error and allowed for it but did not look at the watch until after the lapse of an estimated interval of two or three minutes after the accident, made, after these adjustments, the time 2.12 or 2.13. This is not very definite, but assuming it to be definite, it results in a speed on the critical stretch of 23 miles per hour—only two-thirds of the regulation speed.

(iv) Mr. Allen, whose watch was found shortly after the accident to have stopped at 2.12 a.m., stated that the main spring had been broken, probably as a result of the watch falling to the floor, where it was picked up after the accident. As the watch had been half a minute slow by the railway clock at Palmerston North, this makes the time 2.12½. Of course we have not sufficient evidence to be certain that the watch stopped instantly at the moment of impact ; but assuming that it did, this gives an elapsed time of 5½ minutes and a speed of 25·1 miles per hour. Mr. Allen did not guarantee his reading of the watch within half a minute, and even if his time be taken as 2.12, the speed works out at only 27·6 miles per hour.

(v) The guard, under cross-examination, admitted that his entry of 2.18 must be wrong, and it was suggested, and he agreed, that he might have made a mistake of five minutes, and that the entry should perhaps have been 2.13. The assumption of this time would result in a speed of 23 miles per hour—quite incredible. If the guard's record of 2.18 is disregarded, and it must be, then there seems no more reason for assuming 2.13 than 2.8 or any other time.

The evidence of the other witnesses as to time was so indefinite, owing to their having looked at their watches at times unrelated to any fixed or fixable points or incidents that it can be disregarded. Counsel for the New Zealand Locomotive Engine-drivers, Firemen, and Cleaners' Association and the driver, after traversing all this evidence and analysing it, argued that no period less than ten minutes could be assumed for the passage of the train from Turakina to the scene of the accident. Examining this contention in the light of the computations we have made, we obtain a result of six minutes for the Ratana Flat, or an average speed over this straight and downward sloping length of 23 miles per hour. In view of the evidence of the tablet porter at Turakina that times are always booked to the nearest minute, counsel assumed the Turakina time to be 2.2, but such an assumption does not appear any more warranted than 2.4. Even if 2.4 were taken, thus making the time at the hill-top 2.8, and if 2.12 were taken as the time of the happening of the accident, we would then have a speed over the Ratana Flat of 34·75 miles per hour, which is considerably less than the speed sworn to by both the driver and the guard, and quite at variance with the probabilities. It is not reasonable to assume that a train which was timed as an express, which had run for 130 miles at express speed, and which, though slightly behind schedule, was steadily making up the lost time, would, on one of the best stretches of the line, have dropped down to a speed less than the authorized speed. There is a great deal of evidence concerning speed—some in support of normal speed, some in support of high and excessive speed, but none in support of slow speed. In view of all these circumstances, we consider that all evidence given by witnesses as to the time of the occurrence of the accident must be disregarded.

(*b*) It was quite apparent that the memories of some of the passengers were somewhat confused, and that they were unable to distinguish between the sensations they experienced while rounding the sharp curves on the Turakina grade, where undoubtedly there would be the normal swaying of the train from side to side, even at its restricted pace, and their imagined sensations of swaying much closer to the scene of the accident. It can be confidently stated that the condition and alignment of

the track from the 14 chains curve south of Ratana to the scene of the accident were such that, in the words of the guard, no sensation of excessive speed would have been apparent even at 50 miles per hour, and possibly at a very much higher speed. The line is almost entirely straight and is in first-class condition, but certain passengers more observant than others, particularly in the front carriage, referred to the "drag" of the 6·4 chains curve, which was really the horizontal acceleration due to the train being forced out of the straight line along which it had until then been travelling. They also referred to the vehicle "sliding" under them when the final phase arrived. The driver himself speaks of the engine sliding. Such an expression as "sliding" is not consistent with the sensation created by a train bumping over an obstruction, but it is quite consistent with that created by overturning under the influence of centrifugal force, as is also the evidence concerning cups and other objects sliding across the floor of the leading car.

There is a good deal of conflict of evidence among the passengers as to the running of the train all the way from Wellington, but, in our judgment, nothing was disclosed which indicated that the train at any point between Wellington and Ratana was driven otherwise than as an express train would normally be driven. In this connection it is noteworthy that many of the passengers who spoke of swaying and discomfort were occupying seats over the wheels, or were sitting on the arms of seats, whereas other passengers who were seated near the centre of a car experienced no sensation of swaying or discomfort.

(*c*) In so far as the evidence of the driver himself is concerned, it is unnecessary to traverse his statements regarding the journey from Wellington to Turakina. We find him passing through Turakina in a perfectly normal way, picking up the tablet and climbing the hill at normal speed. There is no reason why his speed should not have been normal. First and foremost, he was bound by a speed-restriction, and there is no reason to suppose that he forgot it. Even if he did forget it, the number and sharpness of the curves would have soon brought it to his notice. The hill is very steep, and, even with a relatively light train, would not permit of any excessive speed. On the other hand, train W 4 was not so heavy as to have prevented the driver, with reasonable ease, from mounting the hill at the recognized speed; and, according to his evidence, he did so. It is quite impossible for any man to recollect every action that he performs in connection with his daily work. The driver states that he carried on without shutting off steam until he reached Ratana: but whether he carried on with a full throttle or reduced on topping the hill, and if so to what extent, cannot be ascertained. At all events, his own view is that he gradually increased speed to 40 miles per hour, which, in the locality, is perfectly safe, even if somewhat in excess of the maximum speed-limit prescribed.

In view of the fact that there was a certain amount of haze of a low-lying nature, so that distant and elevated objects were visible and the track under the locomotive and small nearby objects were less clearly visible, the difficulty of judging speed, at no time an easy process, was accentuated. There were also banks of low-lying fog at intervals along the Ratana Flat.

Numerous witnesses, including the drivers who gave evidence, expressed their ability to judge speed within a margin of plus or minus 2 miles: but, when making these statements, they were considering occasions on which they were concentrating on the special question of judging speed. In ordinary running undoubtedly a driver performs many of his actions subconsciously, and "feels" that his speed is safe. In the present case the driver was doubtless carrying on at a speed which he felt to be perfectly safe, and did not consciously and by any mental process estimate his speed at any definite number of miles per hour. At a period when, owing either to darkness, fog, or other causes, objects close to the line—for instance, fences—are not visible, and when the engine is running freely, as it would be down the gentle grade of Ratana Flat, it is very easy to be deceived.

The sound of clicking over the rail-joints is often quoted as a means of judging speed. In the present instance this was not available, for the rails in the locality are not of even length for a considerable distance. Taken consecutively back from the point of derailment to Ratana, we find the lengths of the rails to be as follows: 5 of 42 ft., 1 of 24 ft., 160 of 36 ft., 1 of 21 ft., 1 of 24 ft., 1 of 36 ft., 1 of 18 ft., 1 of 25½ ft., 15 of 36 ft., 1 of 16 ft., 1 of 36 ft., and 1 of 24 ft.

The beat of the engine is one of the aids used by a driver in judging speed. This aid was not available in the present case, if, as we believe, the engine of train W 4 was drifting, with closed throttle, after it had passed Ratana.

Members of the Board themselves experienced on the Ratana Flat the conditions of a train running at practically the same schedule as W 4, with a driver who had just been reminded of the different restrictions along the section north of Turakina. This train crossed the Ratana Flat at over 50 miles per hour, and the pace caused no sensation of excessive speed or anxiety, and it presented to the driver no difficulty whatever in reducing to the proper speed at the end of the straight.

When the driver of W 4 spoke of shutting off at Ratana it is improbable that he intended to indicate, or in fact could possibly remember, that he shut off directly in front of the station building. Even if he carried on for another quarter of a mile he would still, with perfect propriety, consider himself as at or about Ratana. Indeed, in one portion of his evidence he spoke of shutting off after passing Ratana. He then states that he drifted at gradually decreasing speed; but, in point of fact, the grades of the line in this locality are such that, provided the speed at Ratana was 40 miles per hour, it would, on some portions of the line, actually increase instead of decreasing, though the general average would probably result in the speed remaining very much the same as it was when the driver shut off. When he considered he was about three-quarters of a mile beyond Ratana, which would be 30 chains from the curve, he made a slight application of the brakes. As to the length and strength of this application we think it is far more reasonable to accept his spontaneous first estimate rather than the possible value that he placed upon it during cross-examination. His first estimate was that he made a 4 lb. or 5 lb. application over a period of two or three seconds, which is in accordance with the evidence of other witnesses, and which would be a perfectly normal operation for a man

testing the "feel" of the train at a time when he knew that within a short distance it would be necessary to make a substantial reduction in speed. He was then of the opinion that he was about 30 chains from the curve. His evidence is that the crash occurred practically simultaneously with the release of the brakes, which indicates that he was about 200 ft. from the point of derailment when he applied the brakes, and that, accordingly, he had misjudged his position by about 27 chains. Expressed in another way, the driver had underestimated his speed to such an extent as to cause him to think that he had travelled a distance of 60 chains when he had in fact travelled a distance of 87 chains. On this basis his 40 miles per hour becomes 58 mile per hour. As previously stated, with a ground haze and banks of low-lying fog hiding the fences and small objects which would be within the beam of the headlight, it would be a very easy matter to lose track of one's actual position. The driver's principal sensation at the time of the accident was that of the engine sliding from under him, which is what would almost certainly be the case when, under the influence of centrifugal force, it overturned.

This is an appropriate place to say that, throughout his entire evidence, the driver displayed a frankness and sincerity which is to be commended. His general evidence is more consistent with the ascertained facts and with other evidence on which reliance can be placed than that of any other single witness who deposed to the matters covered by him. It would appear that the only point in which the driver was at fault previous to his losing track of his actual location was the estimation of his speed at Ratana at 40 miles per hour. His candour is manifested by his free admission (and this applies also to the guard) as to the speed in this locality, for both men knew, and had ample opportunity to have the matter brought before them, that the train should not then have been travelling at more than 35 miles per hour.

(*d*) We come now to the evidence which the wreck itself provided.

The opinion of Mr. Wansbrough, who carefully examined the site and the wreckage and investigated the characteristics of friction, decelerating bodies, &c., was that the vehicles could not have reached the position which they did reach after the derailment unless their speed at the time of the derailment of the engine had been at least 50 miles per hour. The engine was derailed, it bumped on its left-hand set of wheels over the sleepers for a considerable distance, then ran along the clay of the formation, a track totally unsuitable for such traffic. Its left-hand side then struck the batter of a clay cutting, along which it was deflected, ploughing into the clay as it went. It gradually buried its forward end in the ground until it came to rest at an angle of about 45°, with nearly half its buffer-beam, cow-catcher &c., entirely buried not in soft earth, but in hard clay. At a point, not precisely fixable, between their position at the time of the derailment of the engine, and their position at the time at which the engine, followed by the leading car, came to rest, the second and succeeding cars were wrenched apart from the leading car, severing the couplings and the Westinghouse-brake hose between the leading car and the second car. The second car struck the uptilted buffer-beam of the leading car with sufficient force to tear off more than half of its front wall and all the side of its leading compartment. This semi-oblique force was sufficient to drive the second car over to the right of the line, breaking the fishbolts and displacing one of the rails in the process. The third struck the same object, was subjected to almost the same destruction, and in its turn was forced over to the right. By the time that the fourth car arrived at the immovable body its speed, and that, of course, of all the following portion of the train coupled to it, was considerably diminished, and the damage it received was consequently less, but it also was forced over to the right. These cars, in addition to having their superstructures subjected to terrific blows against the leading car, had their bogies smashed, in some cases completely wrecked, and had to travel the remainder of the distance sliding along the ground and against the batter on the right-hand side of the track. The total distance travelled by the second car and the following vehicles, after they had reached the positions which it is probable they occupied when disconnection from the engine and leading car took place, was over 250 ft. and may have been over 300 ft. This distance was travelled in spite of the fact that the brakes were automatically operating to the fullest extent possible in the circumstances, and in spite of the fact that three of the cars were subjected to the battering previously described. Neither the progress of the engine and the first car nor that of the rest of the train, in the circumstances respectively applying, would have been possible except with an initial speed in excess of 50 miles per hour.

COMMENTS ON TECHNICAL EVIDENCE.

Train disasters attributable to overturning due to excessive speed on curves are, fortunately, extremely rare; a fact remarked upon by the Inspecting Officer of the Board of Trade when reviewing the circumstances of the catastrophe at Salisbury, on the London and South Western Railway, in 1906—an accident that in its main features bears a remarkable similarity to that now under consideration.

It follows that where overturning is suspected the technical analysis must necessarily be pressed much further than a mere review of the facts that may be disclosed by inspections of track and mechanical equipment and a consideration of the conflicting statements and impressions of persons who may have been directly or indirectly concerned in or affected by the accident.

The most important contributions towards such an analysis have been submitted by Messrs. Wansbrough and Gard, Designing Engineers in the Civil and Mechanical Engineering branches respectively.

In respect of the particular question of the overturning speed of the Ab engine, the detailed computation based on the actual characteristics of the engine was naturally provided by the Designing Engineer in the Mechanical Branch. Mr. Gard's estimate of the speed at which the locomotive concerned would overturn as being approximately fifty miles per hour on a 6·4 chains curve has been reached by following established principles, is based on adequate data in respect of the design and the sprung and unsprung weights of the engine, and can be accepted as substantially correct.

The same witness's demonstration that in this particular instance the derailing speed would be higher than the overturning speed of the engine depends for its validity on the figure assumed for the coefficient of friction between the steel flange of the tire and the steel rail against which it is sliding under pressure. The higher the coefficient of friction the greater is the tendency for the flange to mount the rail on striking a curve. At very slow speeds the value of this coefficient approaches that of static friction, which (as between rail and tire under dry conditions) is generally taken as 0·25, a fact which no doubt has some bearing on the derailments that sometimes occur at low speeds on very sharp curves or turnouts. As the speed rises, however, the coefficient of friction first drops very rapidly, and then more slowly. Mr Gard has used the value 0·2, against which the only criticism that can be levelled is that it is, if anything, somewhat higher than is compatible with the known behaviour of steel tires sliding on steel rails except at the lowest speeds. It is probably much in excess of the true figure, which is unlikely to have been higher than about 0·14 or 0·15, and may have been even less if there were mist or dew on the rails. But, even assuming the value 0·2, it is shown that with a speed in the proximity of the overturning speed and at a time previous to the actual overturning the concentration of weight that was being thrown, as a result of the operation of centrifugal force, on to the outer wheels was more than sufficient to counteract the forces tending to make the flange of the tire mount the rail.

It may be observed that simple derailment, even on a curve, does not involve overturning. Overturning, however, inevitably involves derailment; and we concur in Mr. Gard's conclusion that, in the circumstances of the present case, derailment was a consequence and not the cause of—or even a contributory factor in—the overturning.

The introduction of Spiller's formula in this connection may perhaps have tended to obscure rather than to clarify the issue. Spiller's formula, however, does not purport to give, for any specific locomotive, the precise speed at which that locomotive will necessarily derail on a given curve. This is clear enough from Mr. Wansbrough's evidence, and was in effect admitted by the author of the formula himself in the discussion that followed the reading of his paper before the Institution of Civil Engineers in 1908. But, as was also indicated in sufficient detail in Mr. Wansbrough's evidence, Spiller's formula can be, and is legitimately, applied in the form of a general rule to indicate what may be regarded in practice as an approximation to the limit of safety (which is the approach to danger) for ordinary traffic purposes. Further, though (also in practice) a lower and safer restriction is commonly imposed, that is not to say that Spiller's formula is to be accepted as defining the actual speed at which a particular engine will derail on a particular curve, because, quite definitely, it does not. It does, however, sufficiently justify the Department's practice in respect of speed-restrictions on curves; and that, as we understand Mr. Wansbrough's evidence, was all that he claimed for it.

In his calculation made to establish the probable train-speed by a consideration of the position of the cars that were disconnected from the engine and the leading car, and disregarding the position of the engine, Mr. Wansbrough assumed that the engine and the leading car had reached, or almost reached, their final position before the division of the train and the consequent automatic emergency application of the brakes took place. We are of the opinion that this assumption, though erring on the conservative side, cannot be accepted: for, if it were correct, the remainder of the train when disconnected could not have possessed the momentum necessary to carry it on to its final position and also to create the destruction that resulted. It seems quite likely that when the engine overturned the leading car, the rear end of which had then just reached the circular curve, was approaching its overturning speed, and that the pull of the tender coupling completed the overturn. The evidence of passengers in the leading car is consistent with a state of overturning; and if this happened the breaking of the Westinghouse hose must have practically synchronized with the time of derailment. If the parting of the train did not occur simultaneously with the first derailment, then it must have happened not later than the time at which the engine struck the left-hand batter, when and after which there would be a violent deceleration which, had the following portion of the train shared in it, would have brought it to a standstill much sooner than was the case.

Again, as a secondary process for estimating the approximate speed of the train at the instant of leaving the rails, Mr. Wansbrough's quotation of values assumed by the late Professor Robert Julian Scott for retarding factors acting on a derailed train may perhaps be of more academic interest than practical value so far as the present case is concerned, for it is beyond all reason and experience to imagine that a locomotive and carriages after derailing at or about 25 miles per hour would proceed in such a fashion, for such a distance, and with such disastrous effects on the stock concerned, as did the train now under consideration.

The retarding forces acting on the cars were of a threefold character:—

(1) The ordinary retardation due to heavy braking, which in the case of the last car and van and almost all the fifth car was all they contributed to the total stopping force. In this connection it is appropriate to mention here that at a speed of 25 miles per hour the brakes alone would have brought the vehicles to a standstill on the rails in less then 250 ft.

(2) The second, third, and fourth cars travelled on the rails from approximately their positions at the time of derailment of the engine to a point in the vicinity of the point of derailment, and then travelled over the sleepers and ballast to the positions at which they finally came to rest. They travelled with brakes on until they had their bogies torn off by the impact with the leading car, and thereafter they slid on their undergear, a surface as unfitted for sledging as could well be imagined. Furthermore, for part of the distance they were subjected to the additional retardation due to friction against the batter of the cutting; and they were being pushed, not pulled.

(3) There were the very heavy blows against the rear buffer-beam of the leading car, which wrecked the upper walls of nearly half the leading compartment of each of the three following cars and tore off and broke into scrap iron the bogies and other undergear. This involved the dissipation of a great amount of energy for which a precise retardation value in feet per second per second cannot be assessed, but which nevertheless must be considered.

Without controlled tests it is not, in fact, possible to determine closely what the resistance might be in such circumstances. However, experiments on sanded catch sidings on the Burma (Metre Gauge) Railways in 1901–2 (I.S.R. Technical Paper No. 115) showed that with only 2 in. of sand on the rails, and *without any derailment* of the vehicles, the retarding effect, exclusive of the normal running resistances, ranged from approximately 9 per cent. to 12 per cent. The retardation over ballast and sleepers of a train derailed, though still on its wheels, would be very much higher; and for a train that was not only derailed but upset it would be vastly higher still.

It appears that the sum of these decelerating forces must be considered as acting, at the least, for a distance of over 250 ft. and probably of over 300 ft. The second car came to rest at a point 304 ft. distant from the position that it had occupied at the time of the derailment of the engine. However, whether 250 ft. or 300 ft. is adopted, the arithmetical result as to initial speed is not greatly affected, for the decelerating forces operating during the fraction (probably two-thirds) of a second that was occupied in travelling the first 50 ft. were less than at any other part of the action, and would not make any substantial difference in miles per hour.

We have applied degrees of retardation varying, in accordance with the continually increasing obstacles to progression, between that due to emergency braking on rails and that due to the maximum retarding effect probable (this latter acting only for the last second or less). The result is that we see no reason to consider excessive the speed estimate of 50 miles per hour arrived at by Mr. Wansbrough for the train on entering the curve: in fact, we lean rather towards the view that the speed was even higher.

Attacking the problem from a consideration of the progress of the locomotive, and adopting a conservative value for the shearing of the clay involved in the burying of the front of the engine up to the buffer, we have arrived at a figure which harmonizes reasonably with that obtained from the other calculations.

Without attempting to assess the actual values of the retarding forces, to which we have referred, we are satisfied that there are good grounds for the view that the approximation adopted by Professor Scott was, indeed, very conservative; that higher values would be appropriate in the present case; and that the observed results of the accident to train W 4 are compatible with an initial speed possibly more, but certainly not less, than about 50 miles per hour. Professor Scott's values were worked out for submission to a Board of Inquiry that investigated a derailment that took place at Opapa in 1925. At Opapa, under conditions extraordinarily similar to those found at Ratana, the locomotive after derailing travelled 120 ft., as against 142 ft. at Ratana, and the second and succeeding cars travelled 255 ft., as against 304 ft. at Ratana.

The fact that at Opapa there was a total of nine vehicles running down a steep grade, as against a total of seven vehicles at Ratana running on a level stretch of track, would lead, if equal speeds and conditions otherwise similar are assumed, to the expectation of greater travel at Opapa than at Ratana. As the reverse ratio of travel existed, it seems a reasonable conclusion, though we do not stress it, that the initial speed at Ratana exceeded that at Opapa, which, according to Professor Scott's values, was 50 miles per hour.

COMMENTS ON OTHER MATTERS.

After the accident a number of rumours gained currency, and circumstantial statements were made by witnesses regarding the subject-matter of these rumours. In particular, it was suggested that a third man travelled on the engine, that alcoholic liquor was consumed on the engine by the engine-crew, and that an emergency signal of three whistles for brakes was given immediately before the accident occurred. We have fully investigated the grounds for these rumours and statements, and are completely satisfied that they are unfounded. We find specifically that no person except the members of the engine-crew travelled on the engine at any stage of the journey, that no alcoholic liquor was consumed by the members of the engine-crew while they were on duty, and that they were not in any way under the influence of alcohol when they booked on for duty. We find also that the so-called emergency signal was nothing more than the sound made by escaping steam after the locomotive had crashed into the bank.

FINDINGS ON SPECIFIC QUESTIONS.

We have dealt with the salient features of the evidence, and now answer the specific questions addressed to us as follows:—

(1) *Question:* What was the cause of the derailment of the said train?

Answer: The cause of the derailment was the overturning of the engine, due to it entering a curve of 6·4 chains radius at a speed of approximately 50 miles per hour.

(2) *Question:* Was any employee in the service of the Government Railways Department guilty of any dereliction of duty which directly or indirectly contributed to the said derailment?

Answer: Engine-driver Percival drove the engine at a speed of approximately 50 miles per hour over a section of the line in respect of which a maximum speed-limit of 35 miles per hour is imposed, and over part of which a special speed-restriction to 20 miles per hour applies. He was sufficiently familiar with the line between Marton and Wanganui, but, owing to the presence of haze and banks of fog on the Ratana Flat, he misjudged his speed and position after passing Ratana. In strict

compliance with the instructions contained in the Working Time-table the driver should not have driven over the Ratana Flat at a speed in excess of 35 miles per hour. He considered that he was travelling at 40 miles per hour, which would not, in fact, have been a dangerous speed. He ought to have exercised prudence and reduced speed considerably when he ran into a bank of fog at a position which he estimated to be half a mile beyond Ratana, but which actually was about three-quarters of a mile beyond that station. At this time he was looking out for the speed-restriction board near the 6-4 chains radius curve, but did not expect to see it until he had proceeded for another 50 chains. He did not, in fact, see the speed board at all, owing to the bank of fog reducing visibility to a distance of about a chain, and possibly, also, to his having turned his head for a moment to give an instruction to his fireman. The driver made a short, light application of the brakes when he thought he was about 30 chains from the curve, but this application was, in fact, insufficient to effect a substantial reduction in speed. At that time the engine was within 200 ft. of the point of derailment, and the derailment occurred almost immediately after the brakes had been released.

Engine-driver Percival is a steady, competent, experienced driver, with a first-class record. We do not consider that he was guilty of culpable negligence, but we are of the opinion that, though he admittedly travelled over the Ratana Flat at a speed that he himself estimated to be 5 miles per hour in excess of the maximum authorized speed of 35 miles per hour, his miscalculation of his speed and location when he was within 200 ft. of the point of derailment was due to an honest error of judgment, to which the presence of haze and fog contributed. His failure to reduce speed considerably as a measure of prudence when the train ran into a bank of fog is attributable to the same error of judgment, which led him to believe that he was then at least 30 chains from the curve.

(3) *Question:* Generally, are there any circumstances in connection with the said derailment which call for comment, particularly in respect of the said rolling-stock and the permanent-way in the locality of the derailment?

Answer: We are satisfied that the engine, cars, and guard's van were in first-class order and condition, and that the permanent-way was well laid and maintained and perfectly safe to travel over at the authorized speeds.

(4) *Question:* What steps (if any) might be suggested to prevent a recurrence of a similar derailment?

Answer: In view of our finding that the derailment was primarily due to an error of judgment on the part of the driver as to the speed at which the train was travelling, the only suggestion that we can properly offer in answer to this question is in regard to the equipment of locomotives with speedometers. We deal, however, in the next section of this report with a number of suggestions in respect of other matters which can more properly be considered apart from the specific question that we are now required to answer. Our comments and recommendations on the suggestion regarding the equipment of locomotives with speedometers are as follows:—

The Board has considered the question of equipping locomotives with speedometers or, perhaps preferably, speed-recorders. A speed-recorder is an instrument which combines the functions of a speedometer and a recording-device.

Considered only in the light of the statements made by experienced locomotive-drivers in the course of the inquiry, it might be concluded that there was no very strong reason and no urgent demand for such equipment.

On the other hand, the official attitude of the New Zealand Locomotive Engine-drivers, Firemen, and Cleaners' Association is definitely in favour of fitting speedometers. The association has recently made appropriate representations to the Department, and its views are entitled to respect. Those drivers who were called upon to give evidence expressed confidence in their own ability to judge speed within about plus or minus 2 miles per hour. If this could be accepted as representative of the average engine-driver's ability to judge the speed of his engine in terms of miles per hour, the case for expenditure on the purchase and maintenance of speedometers would have little to support it.

However, in everyday practice trains must frequently operate under conditions prejudicial to any rapid and accurate judgment of speed, such as the strict observance of restrictions over difficult sections necessarily demands. It is certainly open to question whether even the most experienced men can judge their instantaneous train-speed with any approach to accuracy under unfavourable conditions of, for example, storm or fog. We incline to the view also, that the expectation of accuracy of judgment within a margin of 2 miles per hour either way is too optimistic for general acceptation, even under fairly good conditions and in daylight.

Confirmation of this view is found in the report on a recent very disastrous accident on the East Indian Railway. The Judge (Sir John Thom) who held the subsequent inquiry found that the train was travelling in the region of 55 miles per hour over a section having a speed-restriction of 45 miles per hour, and commented as follows:—

> "It would not be reasonable in the circumstances to hold that the driver of the train was culpably negligent in that he was driving at an excessive rate of speed. It is a matter of general admission that without a speedometer it is impossible for a driver to regulate his speed exactly.
>
> "Some witnesses have deposed that it is impossible for a driver to determine within 5 miles an hour what the exact speed is. One witness has said that it is impossible to determine the speed within 7 miles an hour, and another, within 10 miles an hour. There can be no question that it would be quite unreasonable to expect a driver, especially at night, to maintain an exact speed of 45 miles an hour. He might be travelling at 50 miles an hour or over, and yet be under the impression that he was well within the restricted speed. . . . "

The present Board of Inquiry concurs generally in the view expressed above in Sir John Thom's report—namely, that "without a speedometer it is impossible for a driver to regulate his speed exactly." We think, though, that the term "speed-recorder" or "recording-speedometer" would be preferable to the word "speedometer," because a recording-instrument, apart from affording a check upon individual operations, provides valuable data for the examination of engine performances and for the amendment or revision of schedules.

It is understood that the Department is already equipping a limited number of engines with speed-recorders. The question for immediate consideration, therefore, is whether this should be treated as an experimental measure or as the initiation of a definite policy.

We are of the opinion that it is desirable to equip with speed-recorders all engines used for hauling express, mail, and passenger trains. The speed-recorders should be of a type proved after adequate trials to give sufficiently accurate and dependable results under ordinary service conditions; and we recommend accordingly.

We are not satisfied that it is either necessary or desirable to extend this equipment to engines working exclusively on mixed or goods trains, and therefore make no recommendation in that direction.

FURTHER SUGGESTIONS.

Position of Speed Boards.

The position of the speed board near the 6·4 chains radius curve at which the derailment in the present case occurred is, as we have stated, 429 ft. beyond the commencement of the length of line that it is intended to protect. Radius boards are always placed at the beginning of the curves to which they relate, and we think it desirable that speed boards should similarly be placed at or, if necessary, before the commencement of the lengths of line that they are intended to protect. Care should be taken to ensure that these boards are so placed as to be clearly visible for as great a distance as possible.

We desire to make it clear that the position of the speed board in question had no bearing on the derailment of train W 4. It is even probable that the imposition of a special speed-restriction to 20 miles per hour from a point 429 ft. south of the present location of the speed board is unnecessary. The point that we desire to stress is the desirability of placing a speed board in a position that coincides as nearly as practicable with the point at which the Working Time-table requires the special speed-restriction to become effective.

Standard Schedules.

It appeared during the course of the inquiry that the Chief Engineer's Branch, which has no responsibility for the actual operation of trains, not only determines the speed-restrictions, which is the legitimate duty of that branch, but also prepares the detailed running schedules for the use of the operating branches. This seems anomalous, in that the Civil Engineering Branch is no more concerned with the actual operation and performance of the locomotives and rolling-stock than the Locomotive Superintendent is with the maintenance of the way and works.

This procedure does not actually relieve the Locomotive Superintendent of any responsibility; it rather makes his responsibilities more onerous, because the train-running schedules are drafted, with speed-restrictions as their basis and chief concern, by officers who do not possess first-hand knowledge or experience of the economics of locomotive operation, or of the practical handling of trains over difficult country such as is characteristic of most of the New Zealand railway system.

One result of this procedure was disclosed in some very frank evidence that was given before the Board in the course of this inquiry, when it was stated that, in actual practice, drivers did not feel bound to give any "slavish adherence" to the standard schedules prepared by the Chief Engineer's Branch, but relied more upon their own knowledge and experience in train-handling.

It seems desirable to observe, therefore, that some amendment of the existing procedure in the preparation of standard running schedules is called for, in order to remove any possible justification for not adhering strictly to the limits prescribed, and would be in the interests of economical operation as well as of safety.

It is for the Chief Engineer to prescribe the maximum permissible speeds over those sections which, by reason of difficulties (*e.g.*, curves and steep descents combined) due to exigencies of location or of maintenance, demand special restrictions; but the manner in which the engine-run as a whole is to be shaped, so as, on the one hand, to meet the requirements of the Traffic Branch, and, on the other, to ensure due observance of the necessary restrictions of the Way and Works Branch, is essentially a matter for the responsible operating officer—namely, the Locomotive Superintendent.

All-steel Passenger-cars.

We received a number of communications urging that we should recommend the replacement of the passenger-cars now in use on the New Zealand Railways by cars of all-steel construction. The matter was not strictly within the order of reference laid down for us, but, in view of the statements made to the effect that a derailment would be attended with less serious consequences if the cars were of all-steel construction, we were of the opinion that the matter was so closely related to the requirement of your warrant that we should report on any measures that might be suggested to prevent the

occurrence of a similar derailment as to justify us in considering the question. We accordingly asked the General Manager for a report on the matter, and received the following memorandum from him :—

"With reference to the letter from the New Zealand Tourist League to the Chairman of the Board of Inquiry in regard to the use of all-steel cars, I desire to say for the information of the Board that the new carriages which we are now building, or have been building for a number of years, are virtually the equivalent of all-steel cars. The underframes are of steel sections welded together, which gives the effect of a one-piece unit. The ends of the cars, extending right up to the roof and over the entrance doorways, are entirely of steel, this form of construction providing a very strong and massive anti-collision end. Body-work in between these anti-collision ends is of timber reinforced with steel and provided with steel panels. In addition we are now fitting automatic couplers, which are of very strong construction and are not easily broken apart as the result of a collision or derailment, as very often occurs with the standard type of buffer which we have hitherto used.

"The League is not correct in its statement that in most countries wooden carriages are no longer built. In many countries, including England and South Africa, semi-wooden cars are built on the lines of the construction which this Department has been adopting over recent years. In mountainous countries like New Zealand it is not possible to adopt very heavy steel construction throughout the car bodies, as the effect of the increased weight of such cars would place great limitations on the number of cars which could be hauled over the various gradients; and this point is, of course, one of great importance.

"Whilst it is possible to adopt a light form of steel construction for our passenger-cars which would not exceed the weight of the present construction, it is doubtful whether any benefit would be gained in the strength of the vehicle, if we take into account the very strong nature of the steel ends which are now provided, and which may have to be reduced in strength to keep the weight within present limits with the added weight included in the steel-body work. If the League investigated this matter further it would find that many of the latest trains, for instance, the 'Silver Jubilee,' which has been operating in England at very high speeds for some time, and which is considered one of the fastest trains in the world, are built on the semi-steel principle and very much on the lines of our present-day cars.

"In the case of rail cars the matter is somewhat different, as these are not subject to the heavy buffing shocks which take place in a train of cars hauled by a separate locomotive, and it is therefore possible to provide for a suitable light-steel construction for rail cars without exceeding very much the weight of one made in timber.

"For various other reasons steel construction has been found a better form of construction than wood for rail-car body-work generally."

In *The Engineer* of 13th May, 1938, the circumstances of a collision between two trains on the Rhodesian railway system on 4th April, 1938, were reviewed. Sir Nigel Gresley, Chief Mechanical Engineer of the London and North-eastern Railway, who is a recognized expert, stated that it was his belief that more lives would be lost in a collision between trains with heavy steel coaches than in a collision between trains of more flexible construction. With heavy steel coaches the impact would be more sudden and severe. "A solid steel coach," he said, "cannot collapse, and act as a buffer for other coaches. In the Rhodesian collision some of the passenger coaches were badly smashed, but many travellers in the remaining coaches escaped uninjured. With heavy steel coaches the shock would be transmitted throughout the train. All-steel coaches are intensely hot in summer and very cold in winter, unless expensive air-conditioning plant is installed."

We concur in the expressions of opinion quoted above, and desire to add that, in our opinion, the substitution of electricity for gas as a lighting medium for passenger cars has removed, or, at all events, very considerably reduced, the risk of fire that formerly was present in all cases in which a train was seriously damaged as the result of a collision or derailment.

PLANS AND DIAGRAMS PREPARED BY BOARD.

We submit herewith for ready reference a reduced scale plan and profile of the line from Turakina to the site of the accident, together with a diagram which shows the limits of speed prescribed for this section.

On this diagram are shown also certain operating-speed curves, which have been prepared for the purpose of illustrating, first, the operation of a passenger-train which is controlled as closely as possible within the authorized speed-limits, after it has run through Turakina; and, secondly, what may occur in practice. It will be observed that, provided that the visibility is good, that the track and mechanical equipment are in sound order, and that the driver is familiar with the road, a train having the composition of W 4 (for which these curves have been prepared) could be worked across the Ratana Flat with safety up to speeds approaching 60 miles an hour, and yet be under full control for the purpose of negotiating at 20 miles per hour the curve and grade in the vicinity of the scene of the accident.

Similarly, it is possible to illustrate what we believe to be a fair approximation to the operation of W 4 between Turakina and mile 131. It is to be observed, however, that a locomotive does not work under the conditions of a stationary power-plant: it is necessarily a very flexible machine, and its actual performance between stations is, within the limits of its capacity, under the sole control of the engine-crew.

In preparing these speed curves a consistent basis had to be found for computing the engine-power and train speeds over the varying grades. As usual, in the absence of dynamometer car records for the engine and stock actually concerned, it has been necessary to fall back upon data derived from

dynamometer car experiments made elsewhere. These are not laboratory experiments, but service tests carried out under controlled conditions, and the results have been successfully employed for engine-rating and similar problems. They are believed to be, therefore, a fair basis for estimating, within the limits of practical operation, performances that may reasonably be expected under ordinary service conditions.

We also submit a diagram showing deceleration curves for (*a*) the engine and leading car and (*b*) the remainder of the train, from the time of derailment of the engine until they came to rest.

GENERAL.

We desire to express our appreciation of the very able assistance that we received throughout the inquiry from Mr. H. F. O'Leary, K.C., and Mr. F. W. Aickin for the Railways Department, and Mr. G. G. G. Watson for the New Zealand Engine-drivers, Firemen, and Cleaners' Association. The fact that the Association was represented by counsel made it possible for the fullest and most searching investigation to be undertaken.

We desire to thank the General Manager of the Railways Department and his staff for the facilities placed at our disposal, and for the readiness with which all information for which we asked was supplied.

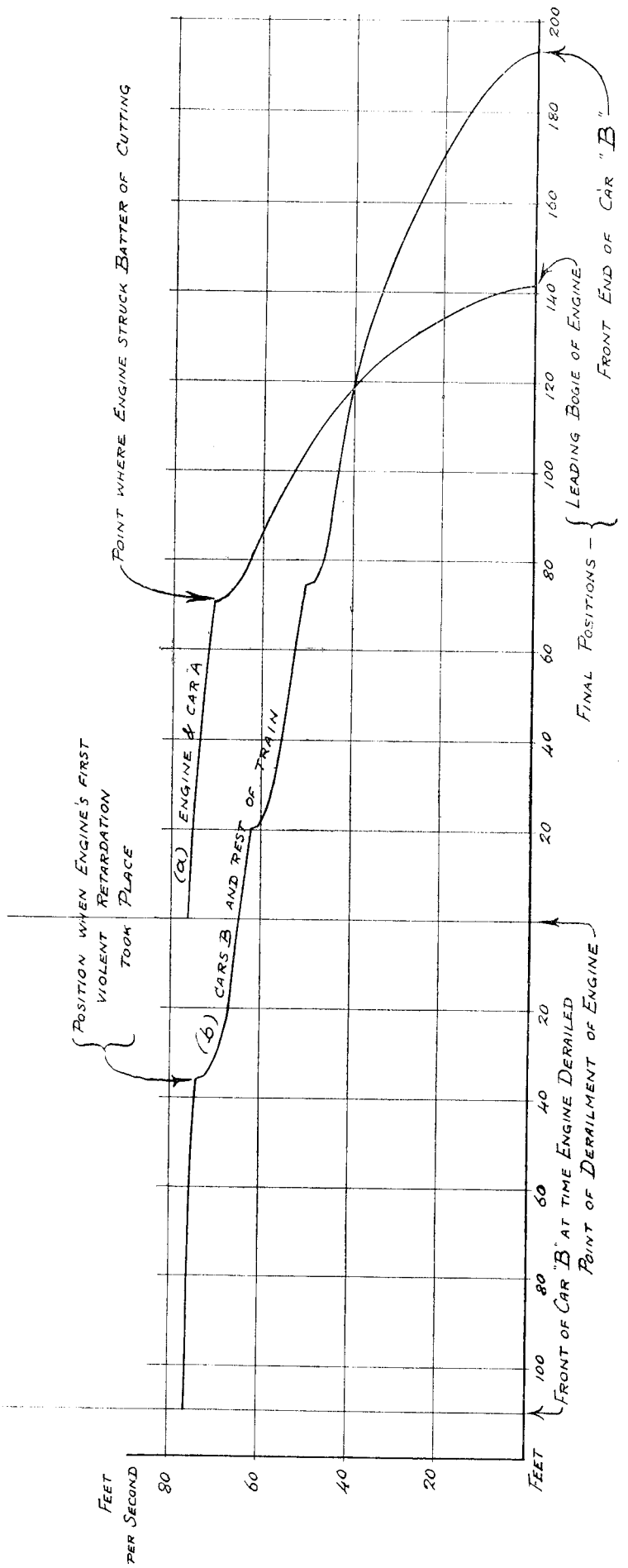
Our thanks are due also to Mr. J. G. Whetton, who acted as Secretary to the Board. His duties were onerous and were performed with unfailing efficiency and courtesy.

We desire also to place on record our appreciation of the courtesy of the Commissioner of Police, who made available to us the statements and information collected by the police after the accident.

Section 63 (6) of the Government Railways Act, 1926, empowers the Board, if it thinks it proper to do so, to direct the payment of costs. We fix the costs to be paid by the Crown to the New Zealand Engine-drivers, Firemen, and Cleaners' Association at 150 guineas.

We return herewith your warrant of 28th March, 1938, together with the respective warrants extending the date on or before which we were required to report.

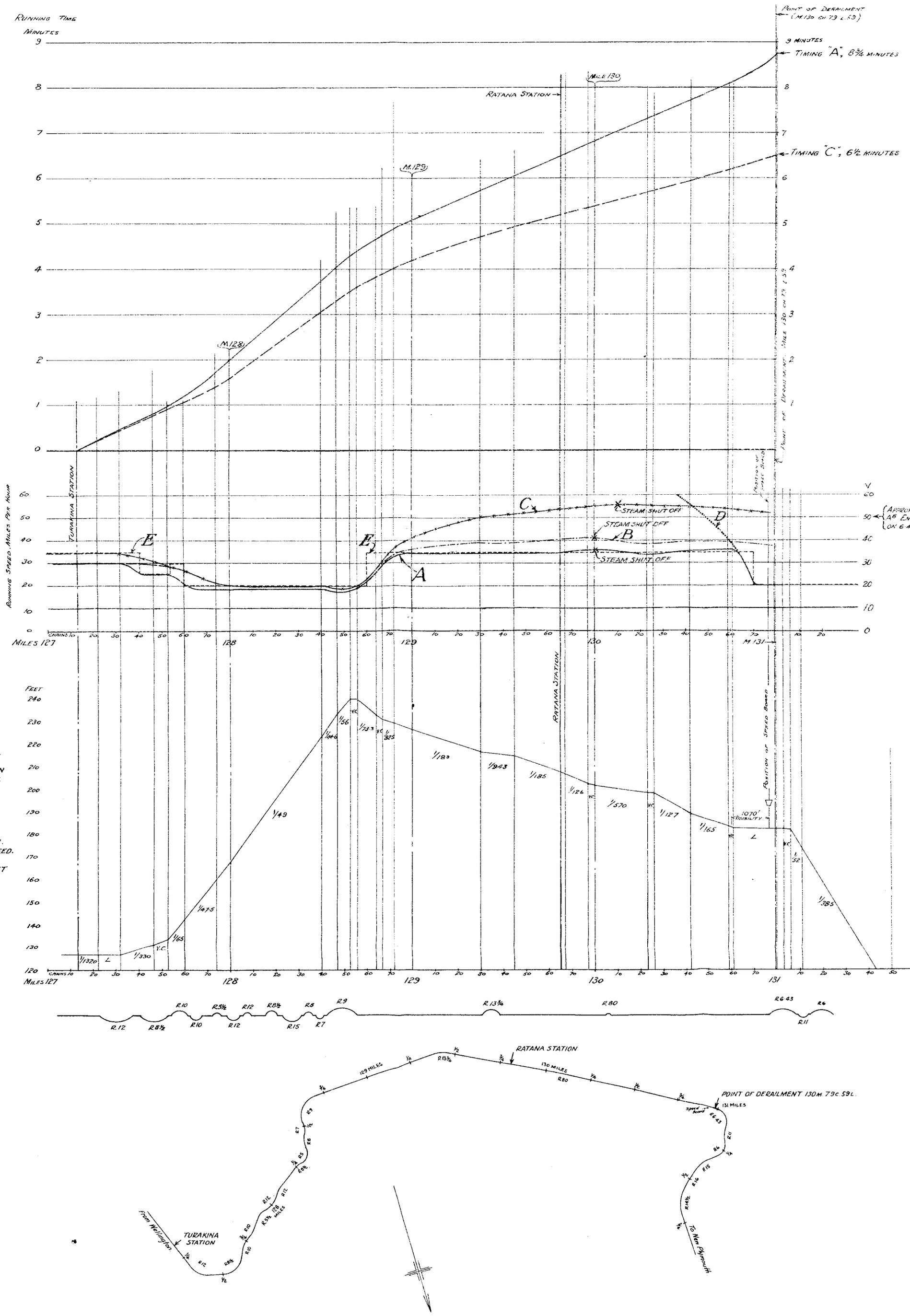
We have the honour to be,
Sir,
Your most obedient servants,
(Sgd.) F. V. Frazer, Chairman
(Sgd.) F. W. Furkert, Member } Board of Inquiry.
(Sgd.) H. L. Cole, Member



Approximate Cost of Paper.—Preparation, not given; printing (1,000 copies),, including graph and map, £27 10s.

By Authority: E. V. Paul, Government Printer, Wellington.—1938.

Price 9d.]



——— FULL LINE "A" – TRAIN RUNNING TO SPEED RESTRICTIONS.

–·–·– CHAIN DOTTED LINE "B" – APPROXIMATION TO SPEED AT WHICH DRIVER THOUGHT HE WAS RUNNING.

–×–×–×– CROSS & DASH LINE – "C" – PROBABLE SPEED.

····· DOTTED LINE "D" SHOWS WHERE BRAKES SHOULD BE APPLIED IN ORDER TO REDUCE SPEED TO 20 M.P.H. FROM ANY GIVEN RUNNING SPEED.

– – – – – BROKEN LINE "E" REPRESENTS PERMANENT SPEED RESTRICTIONS

PLAN TO ACCOMPANY REPORT OF BOARD OF INQUIRY – RATANA RAILWAY ACCIDENT