ROLLS
RR
ROYCE

COOLING AND PERFORMANCE TESTS

ON PROTOTYPE RAILCAR

20 - 31 JANUARY 1957

Prototype Railcar Test Report

Summary

The designed tractive effort of the twin set was achieved, as the performance of the railcar set was almost exactly that predicted on TCM 1148.

The cooling system when new, is more than adequate for normal usage and has sufficient capacity to permit the train to be maltreated by adding additional parcels vans.

Mechanically the railcar gave only minor trouble, and design action has already been taken to eliminate any similar troubles on future cars.

Tests carried out by:- BR(m) Locomotive and Experimental Test Department, F/BBR/J. Rushworth, BLM/BBL and AFM/Tly.

Tests carried out on:- BR(m) Railcars E 50000, E56000

Introduction

From 20 to 31 January 1957 a number of tests were carried out to investigate the performance and the adequacy of the cooling arrangements of the prototype railcar. These tests were carried out on two routes, which were:-

1. Manchester Victoria to Rochdale which features several steep gradients including the Werneth incline of 1 in 27 which is three quarters of a mile in length.

2. Carlisle to Skipton which features climbs of approximately 15 miles in each direction with average gradients of 1 in 100.

Programme

The tests carried out were as follows:-

Date	Route	Train Formation	Remarks
20 January	Manchester Victoria o Rochdale	Motor coach (M.C.) plus driving trailer (D.T.) total weight 82 ton	Two runs in each direction, stopping at all stations. Two non-stop runs to Rochdale and one back to Manchester again non-stop. During some of the runs to Rochdale, a stop and restart was made at the bottom of the 1 in 27 rising gradient.
22 January	Carlisle to Skipton	M.C. plus D.T. Total weight 82 ton.	Stops were made at the bottom and top of the 1 in 100 ruling gradients, i.e. at Ormside, Ais Gill, Stainforth Sidings and Blea Moor.
23 January	Carlisle to Skipton	M.C. plus D.T. and two coaches. Total weight 139 ton.	- do -
24 January	Carlisle to Skipton	M.C. plus D.T. and two coaches Total weight 139 ton.	- do -
29 January	Carlisle to Skipton	M.C. plus dynamometer car. Total weight 87 ton	- do -
30 January	Carlisle to Skipton	M.C. plus D.T. and dynamometer car. Total weight 123 ton	- do -
31 January	Carlisle to Skipton	M.C. plus dynamometer car and two coaches. Total weight 144 ton	- do -

Test Procedure

With the exception of downhill running where coasting was employed, all tests were carried out where possible at maximum engine power with the throttle controller in the fully open position. The manually controlled transition from converter drive to direct drive and vice versa took place at 47 m.p.h. unless gradient conditions suggested otherwise. Before the tests started, the motor coach and driving trailer were loaded with 11 tons of brake blocks to represent a total of 200 passengers, although early in the tests 1 ton of blocks was removed from the driving trailer owing to its bad riding characteristics. The loaded weights of the vehicles were therefore:-

Motor Coach	41 tons + 5 tons	=	46 tons
Driving Trailer	31 tons + 5 tons	=	36 tons
	Total	=	82 tons

During the tests a variety of tail loads were attached with the particular object of checking the torque converter fluid temperature at full engine power and low speeds.

During the first half of the test programme, i.e. until January 24, readings were taken as follows:-

1. As a check on performance of the railcar the times taken to travel between adjacent quarter mile posts and other landmarks were recorded. At the same time readings of the railcar speedometer were recorded. From these observations speed and time distance graphs were plotted.

2. As a check on the temperature of various parts of the cooling system the following observations were made:-

   Every five minutes, on changing from converter to direct drive and vice versa, and at recognized landmarks:-

   Coolant temperature in and out of the radiator, air temperature entering the radiator, converter fluid temperature*, and temperature of the ambient air on both sides of the car.*

* Note: Readings of the items marked * were taken only after Monday 21 January.

   At the bottom and top of selected inclines with engines idling:-

   Watch panel gauges which were:- engine lubricating oil pressure, converter fluid pressure, converter fluid temperature at converter outlet to heat exchanger and engine coolant temperature.

During the remainder of the test programme, a dynamometer car was used to record the various readings which were:-

A. The speed, acceleration, drawbar pull and gradient for any given instant during the test were recorded on a master graph. At the same time note was made of the time at which power pack readings were taken. The railcar tractive effort and rolling resistance were deduced from measurements of drawbar pull during acceleration and coasting tests.

B. Every three minutes and on changing from converter to direct drive:-

i. Ambient temperature

ii. Engine lubricating oil pressure and temperature.

iii. Temperature and pressure of converter fluid at inlet and exit to and from heat exchanger.

iv. Converter fluid base pressure.

v. Temperature of air entering radiator matrix.

vi. Temperature of coolant entering and leaving radiator matrix.

Readings were taken by a team made up of Rolls-Royce and British Railways staff.

Results

Railcar Performance

The speed distance and gradient distance relationship for selected test runs have been plotted in graphical form. The graphs are as follows:

Figure	Route	Train Combination	Remarks
1.	Manchester Victoria to Rochdale	M.C. plus D.T.	Balancing speed on 1 in 27 gradient was 14 m.p.h.
2.	Carlisle to Ais Gill	M.C. plus D.T.	Average speed from standing start at Grissburn to Ais Gill 41.75 m.p.h.
3.	Settle Junction to Ais Gill	M.C. plus D.T.	Direct drive engaged $2\frac{1}{2}$ miles after Stainforth Sidings and retained during rest of climb.
4.	Carlisle to Ais Gill	M.C. plus Dynamometer car + 57 ton	Floor charred by exhaust heat.
5.	Ais Gill to Skipton	M.C. plus Dynamometer car + 57 ton	Coasting to estimate tractive resistance.

Figure 6 shows the designed and measured tractive effort of the motor coach and the deduced rolling resistance.

Cooling System of the Engine-Converter Unit

For the purposes of this report it is only intended to publish the readings taken on the Manchester to Rochdale route and on the Skipton to Carlisle route for 29 and 31 January, i.e. when the train formation was motor coach plus dynamometer car and motor coach plus dynamometer car plus two passenger coaches respectively. These readings are typical of the average and extreme conditions that the railcar is likely to encounter in service. The remainder of the readings taken are to be passed to AFM/Tly.

Manchester Vuctoria to Rochdale 20 January

The maximum temperature readings taken during the day were:-

	No.1 Engine	No.2 Engine
Engine coolant out of radiator deg.C.	50	54
Engine coolant into radiator deg.C.	73	74
Air entering radiator deg.C.	20	20
Watch Panel (Engine idling)		
Coolant temperature (engine coolant rail) deg.C.	87	82
Converter fluid temperature deg.C.	78	80

Carlisle to Skipton 29 - 31 January

The temperature of the coolant entering and leaving the radiator and of the converter fluid entering and leaving the converter both for the No.1 engine unit are plotted in graphical form. The graphs are as follows:-

Figure	Route	Train Combination	Full Results in Table
8.	Carlisle to Ais Gill and Ais Gill to Carlisle	M.C. plus dynamometer car	1 2
9.	Ais Gill to Skipton and Skipton to Ais Gill	M.C. plus dynamometer car	1 2
10.	Carlisle to Ais Gill and Ais Gill to Carlisle	M.C. plus dynamometer car and two coaches	3 4
11.	Ais Gill to Skipton and Skipton to Ais Gill	M.C. plus dynamometer car and two coaches	3 4

Conclusions

General

It has been assumed that the problem of floor heating, the noise of the power unit, and the ride of the vehicle are outside the scope of this report, as these problems have been fully dealt with elsewhere.

Railcar Performance

The predicted performance of the railcar set as shown on our graph TCM 1148 (See Figure 7) appears to have given a reliable guide to the BR(m) Locomotive and Experimental Testing Unit in their preparation of time schedules. Therefore the assumptions relating to power taken by auxiliaries (i.e. 11 hp) final drive efficiency (i.e. 95%) and the modified Onions formula for tractive resistance on which this predicted performance was based may be quite safely used for other similar railcar applications.

The drawbar pull and T.E. curves show that unity torque ratio occurs at 49 m.p.h. This is what was expected for the new wheel condition, but when the wheels became worn, the rail speed corresponding to the same number of wheel revolutions will decrease and in the limit become 45 m.p.h. The lock-out speed of 47 m.p.h. is therefore an average figure for all conditions of wheel wear. It should be noted that the speedometer generator output which controls the automatic lock-out mechanism, is frequently readjusted to take account of wheel wear.

Manchester Victoria to Rochdale

For suburban routes such as this one, where converter drive was used exclusively when travelling towards Rochdale, it would seem that BR(m) could usefully employ a railcar equipped with the much cheaper and simpler CF converter. Even when travelling back to Manchester the driver only engaged direct drive on two occasions. The several restarts on the Werneth incline were satisfactory, as no wheelslip was experienced on this 1 in 27 gradient with dry rail conditions. It is on such varying terrain as this route that the converter equipped car should show a considerable advantage over one equipped with a stepped ratio gearbox.

Manchester to Carlisle

Although no testing was carried out on this run it is worth recording that the railcar set has the ability to climb over Shap Fell in direct drive. This route includes a stretch of 1 in 75 for about two miles near its summit and the speed of the train never fell below 44 m.p.h. in converter drive. Had we been familiar with the route and not running behind time it would not have been necessary to engage converter drive at all.

Carlisle to Skipton

The climbing performance of the train when running from Skipton towards Carlisle was superior to the climbing performance when travelling from Carlisle to Skipton. This was mainly due to a following wind of 17 m.p.h. from the S.E. On the outward journey from Carlisle the balancing speed of the twin set on a 1 in 100 gradient was of the order of 44 m.p.h. in converter drive whereas on the return journey it was 47 m.p.h. In fact on the return trip the train climbed the 1 in 100 gradient in direct drive. It would seem therefore that the train is affected quite a bit by wind, and that it will climb a 1 in 100 gradient in direct drive fully loaded with just a little help. Running light or part loaded this gradient should be climbed easily in direct drive.

The performance of the train when pulling two additional passenger coaches is of more than academic interest as some regions of British Railways sometimes attach light parcels vans to their diesel trains. When pulling the two additional coaches the train is able to climb a 1 in 100 gradient at about 31 m.p.h.

Cooling System of the Engine-Converter Unit

The following conclusions are based on the performance of No.1 engine-converter unit.

Temperature of engine coolant

The temperature of the coolant entering the radiator was for much of the time within the range of 68°C. to 72°C. when the train was under power and pulling a variety of loads. Although the point of temperature measurement was some way from the engine, the constancy of this temperature irrespective of train load indicates that the thermostat was quite active and perhaps never fully open.

The coolant leaving the radiator exhibited quite a wide variation in temperature under the same conditions. For the journey from Carlisle to Ais Gill when the train was made up of M.C. plus Dynamometer car and two coaches the temperature variation of the coolant leaving the radiator was from 55°C. to 32°C. This variation was directly affected by the engagement of converter or direct drive as might be expected. Engagement of direct drive tended to lower the average temperature of the coolant, as the heat exchanger would then tend to work in reverse and allow the converter to act as an additional radiator for the engine. Thus the lower temperature of the coolant leaving the radiator substantiates the suggestion that the thermostat reduced the water flow through the radiator, when direct drive was engaged.

It would have been interesting to have some positive indication of the position of the thermostat during the tests as it would seem that under the most extreme conditions of load, i.e. two additional passenger coaches, the following is true:-

i. When working in direct drive the thermostat is never fully open.

ii. When working in converter drive it is probable that the thermostat is rarely fully open.

It should be borne in mind however that these tests took place in January at an average temperature of 50°F. which may not affect hypothesis i but will of course have a marked effect on hypothesis ii.

Temperature of Converter Fluid

The highest temperature recorded for the fluid leaving the converter en route for the heat exchanger was 80°C. (176°F). This result is extremely satisfactory in view of the loading conditions which were tried and the Twin Disc recommendation that for normal usage the fluid temperature should not exceed 105°C, 120°C. being the absolute maximum.

The effect on the temperature of the converter fluid when changing from converter drive to direct drive was not quite as immediate as one might expect.. Following such a transition the temperature of the fluid would drop but there was no immediate indication of the impending change in function of the heat exchanger and converter to that of an auxiliary engine radiator. The inlet and outlet temperatures, although dropping, maintained their differential for about five minutes, after which time they converged, became equal, and then diverged with the inlet temperature to the heat exchanger being the lower, i.e. the converter and heat exchanger became an auxiliary engine radiator. As the inlet and outlet temperatures initially dropped in unison, it suggests that there was a little circulation of the fluid but that the main cooling effect is one of radiation from the body of the converter and heat exchanger. However, as there was circulation of the converter fluid, the pump wheel must be turning under these conditions, which confirms that a measurable amount of clutch drag does take place.

The performance of the cooling system when new can be judged to be more than adequate for normal usage. The extreme conditions of loading during the tests, i.e. with overload of passengers and tail load of 57 tons, should more than offset the favourable testing conditions of a low ambient temperature. In addition, there appears to be ample overlap for maltreatment of the train by B.R. such as adding parcels vans.

Reliability of Power Unit and Controls

Throughout the tests there were only two mechanical failures. They were:-

i. Leaking unloader valve as a result of the valve seat being damaged by swarf. This defect was minor and was in no way detrimental to the running of the train. On future cars an additional filter is to be inserted in the pneumatic system to reduce the risk of such damage by swarf.

ii. On two occasions the No.1 engine shut down for no visible reason. The reason for this has since been attributed to the poor quality micro-switches used by Teddington in their watch panel. Future cars will not have such switches.

B.BL

BLM/BBL

TABLE 1

Date: 29 January 1957
Route: Carlisle to Skipton
Train Formation: M.C. plus Dynometer Car, M.C. leading

Stop Ormside 11.58½ a.m.
Depart Ormside 11.59½ a.m.
Stop Ais Gill 12.18½ p.m.
Depart Ais Gill 12.41½ p.m.

* Suspect readings due possibly to location and wiring of thermocouples and g

Time	Reading	Con. Inlet Temp.	Con. Outlet Temp. No.1	Amb. Temp. L.H. *	Amb. Temp. R.H. *	Eng. Oil Press No.1	Con. Inlet Press No.1	Con. Outlet Press No.1	Base Press No.1	Ba Pr No
11.19	1	68	74	8	11	52	54	85	57	63
11.22	2	64	67	9	14	52	60	92	62	67
11.25	3	60	64	10	13	50	57	60	59	65
11.28	4	46	51	8	13	49	57	60	60	67
11.31	5	48	44	7¾	10¼	50	59	63	62	67
11.34	6	50	39	7	8	30	47	52	50	52
11.37	7	51	39	6½	10¼	51	60	64	63	67
11.40	8	51	39	7	8	30	47	52	47	53
11.43	9	62	64	6½	10½	27	50	55	50	55
11.46	10	65	68	11	14	47	52	55	54	59
11.49	11	48	54	9	11	28	48	55	50	52
11.52	12	59	64	10	11½	47	55	59	58	65
11.55	13	46	52	8	11½	29	47	52	50	53
11.58	14	52	51	9	11	29	47	52	49	53
12.00	15	70	74	11	13	50	57	90	62	67
12.03	16	65	68	13	15	52	61	92	61	67
12.06	17	60	64	10	15	47	53	57	55	60
12.09	18	44	50	8	14	47	56	60	58	60
12.12	19	45	46	7	14	47	51	57	55	58
12.18	20	50	42	9	12	26	47	54	49	55
12.42	21	69	72	12	17	52	58	91	62	67
12.45	22	53	59	9	14	52	60	64	62	66
12.48	23	42	47	8	12	51	59	64	62	66
12.51	24	46	44	7	10½	51	59	63	62	66
12.54	25	51	41	6	12	30	45	50	48	54
12.57½	26	54	42	6	10	32	47	50	49	53
1.00	27	53	41	6	8	33	46	50	49	54
1.03	28	52	41	6	8	35	45	50	48	53
1.06	29	50	40	6	8	53	59	63	62	66
1.09	30	50	39	7	12	51	57	61	60	69
1.12	31	46	38	6	12	34	47	51	49	53
1.15	32	52	39	6	11	35	47	50	48	53
1.18	33	53	39	6	9	35	46	52	50	54

TABLE 2

Date: 29 January 1957
Route: Skipton to Carlisle
Train Formation: M.C. plus Dynamometer car, M.C. leading

Stop Stainforth 3.42 p.m.
Depart Stainforth 3.43 p.m.
Stop Appleby 4.30 p.m.
Depart Appleby 4.33½ p.m.

⌘ Suspect readings due possibly to location of wiring of thermocouples and gauges.

Time	Reading	Con. Inlet Temp.	Con. Outlet Temp. No.1	Amb. Temp. L.H. ⌘	Amb. Temp. R.H. ⌘	Eng. Oil Press. No.1	Con. Inlet Press. No.1	Con. Outlet Press. No.1	Base Press. No.1	Base Press. No.2
3.24	1	71	74	15	19	53	62	92	62	66
3.27	2	54	60	14	14	50	56	59	58	61
3.30	3	45	50	11	13	50	57	60	60	69
3.33	4	48	45	10	14	50	58	62	60	68
3.36	5	50	42	9	12	32	46	50	50	53
3.39	6	50	41	7	13	50	57	60	60	60
3.42	7	50	50	7	16	33	50	53	51	54
3.43½	8	70	74	7	18	51	59	90	62	65
3.46	9	66	68	9	18	52	61	92	61	65
3.49	10	58	63	9	17	47	53	56	55	59
3.52	11	65	68	8½	16	51	61	92	61	66
3.55	12	66	69	8	17	51	61	92	61	66
3.58	13	54	60	8	14	47	49	53	50	56
4.01	14	42	48	8	13	50	59	62	62	67
4.04	15	41	45	7	10	50	59	62	62	69
4.07	16	44	42	5	10	50	58	62	62	65
4.10	17	62	60	4	10	27	48	55	54	57
4.13	18	55	53	4	10	30	47	50	49	57
4.16	19	53	45	3	9	32	48	51	50	57
4.19	20	55	44	3	7	34	47	51	50	57
4.22	21	50	41	3	6	35	47	51	50	57
4.25	22	50	40	3	6	37	47	51	49	56
4.28	23	48	38	3½	6	40	47	51	50	56
4.34	24	66	70	6	9	53	58	86	60	67
4.37	25	56	60	4	8	38	47	52	50	54
4.40	26	59	64	4	7	50	55	60	60	71
4.43	27	43	50	5	7	53	59	63	62	69
4.46	28	47	43	4	7	35	46	50	49	55
4.49	29	50	39	4	6	52	60	64	63	66
4.52	30	49	38	3	7	32	48	52	50	56
4.55	31	50	38	3	8	53	62	65	64	67
4.58	32	47	37	2	6	31	50	54	51	54
5.01	33	51	38	1	4	33	48	52	50	53

Date: 31 January 1957
Route: Carlisle to Skipton
Train Formation: M.C.plus Dynamometer Car and Two Coaches, M.C. leading

Stop Ormside 12.17 p.m.
Depart Ormside 12.17¾ p.m.
Stop Ais Gill 12.47½ p.m.
Depart Ais Gill 12.48½ p.m.

Time	Reading	Con. Inlet Temp.	Con. Outlet Temp. No.1	Amb. Temp. L.H.	Amb. Temp. R.H.	Eng. Oil Press. No.1	Con. Inlet Press. No.1	Con. Outlet Press. No.1	Base Press. No.1	Base Press. No.2
11.33	1	70	74	10	10	52	61	91	61	64
11.36	2	66	70	10	9	52	61	91	61	67
11.39	3	66	69	10	9	51	61	92	61	67
11.42	4	66	69	11	9	51	62	92	61	67
11.45	5	66	69	10	9	50	62	92	61	67
11.48	6	46	52	9	10	48	56	59	59	63
11.51	7	44	46	8	9	48	58	61	61	66
11.54	8	49	41	8	8	50	60	64	63	66
11.57	9	49	40	8	9	48	55	59	59	58
12.00	10	54	52	8	8	26	47	53	49	53
12.03	11	64	68	8	8	51	60	90	60	66
12.06	12	66	68	8	8	51	62	92	61	66
12.09	13	62	64	8	8	52	63	93	62	67
12.12	14	66	69	8	10	51	61	92	61	67
12.15	15	57	62	8	10	48	54	57	56	61
12.18	16	72	79	8	10	49	59	88	59	63
12.21	17	69	72	8	11	50	60	90	60	65
12.24	18	69	72	8	11	50	60	90	60	65
12.27	19	68	71	9	9	50	60	91	61	66
12.30	20	68	71	10	10	50	61	91	61	66
12.33	21	66	70	10	8	50	60	90	60	65
12.36	22	67	70	10	8	49	60	90	60	65
12.39	23	68	72	10	8	49	60	90	60	65
12.42	24	68	71	9	8	49	61	91	61	66
12.45	25	69	72	8	9	49	60	90	60	65
12.49	26	72	80	9	8	49	58	89	59	62
12.52	27	63	67	8	8	47	55	59	58	66
12.55	28	42	49	8	9	47	56	59	58	67
12.58	29	36	46	8	8	49	57	60	60	69
1.01	30	50	54	8	8	26	47	53	52	56
1.04	31	50	54	7	8	28	49	53	51	56
1.07	32	52	48	7	7	30	50	53	50	55
1.10	33	53	44	7	7	32	48	54	51	56
[illegible]	[illegible]	[illegible]	[illegible]	7	7	35	49	54	52	56

TABLE 4

Date: 31 January 1957
Route: Carlisle to Skipton
Train Formation: M.C. plus Dynamometer Car and Two Coaches, M.C. leading

Stop Stainforth 3.46 p.m.
Depart Stainforth 3.46½ p.m.

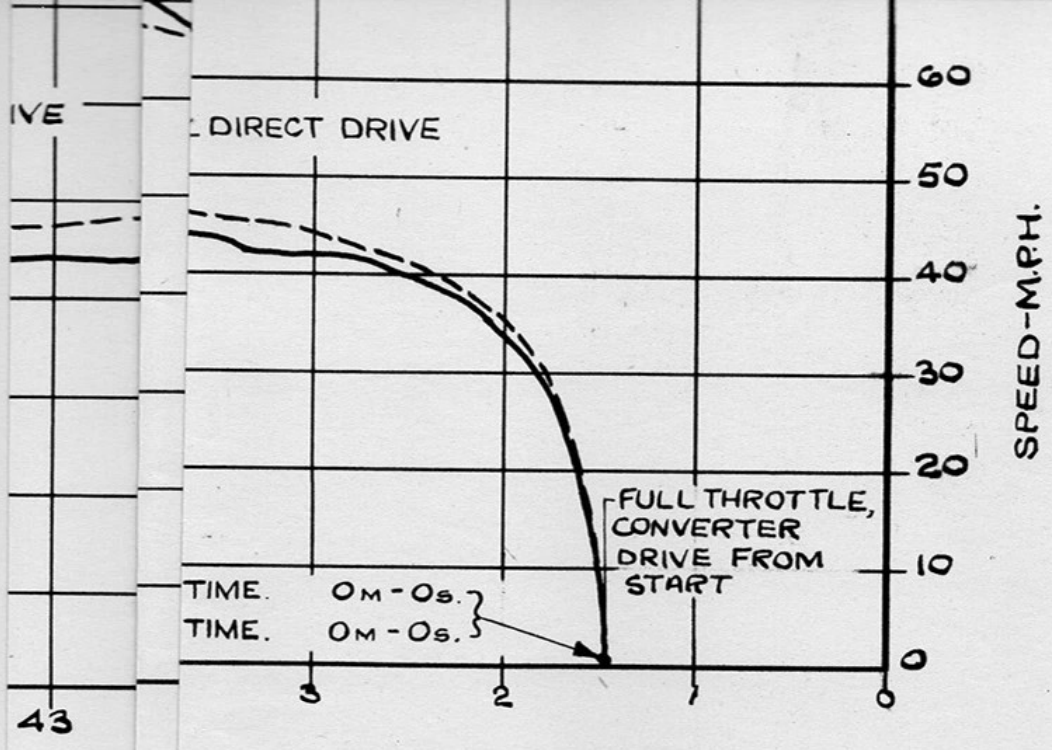
Slow at Ais Gill to 15 m.p.h.

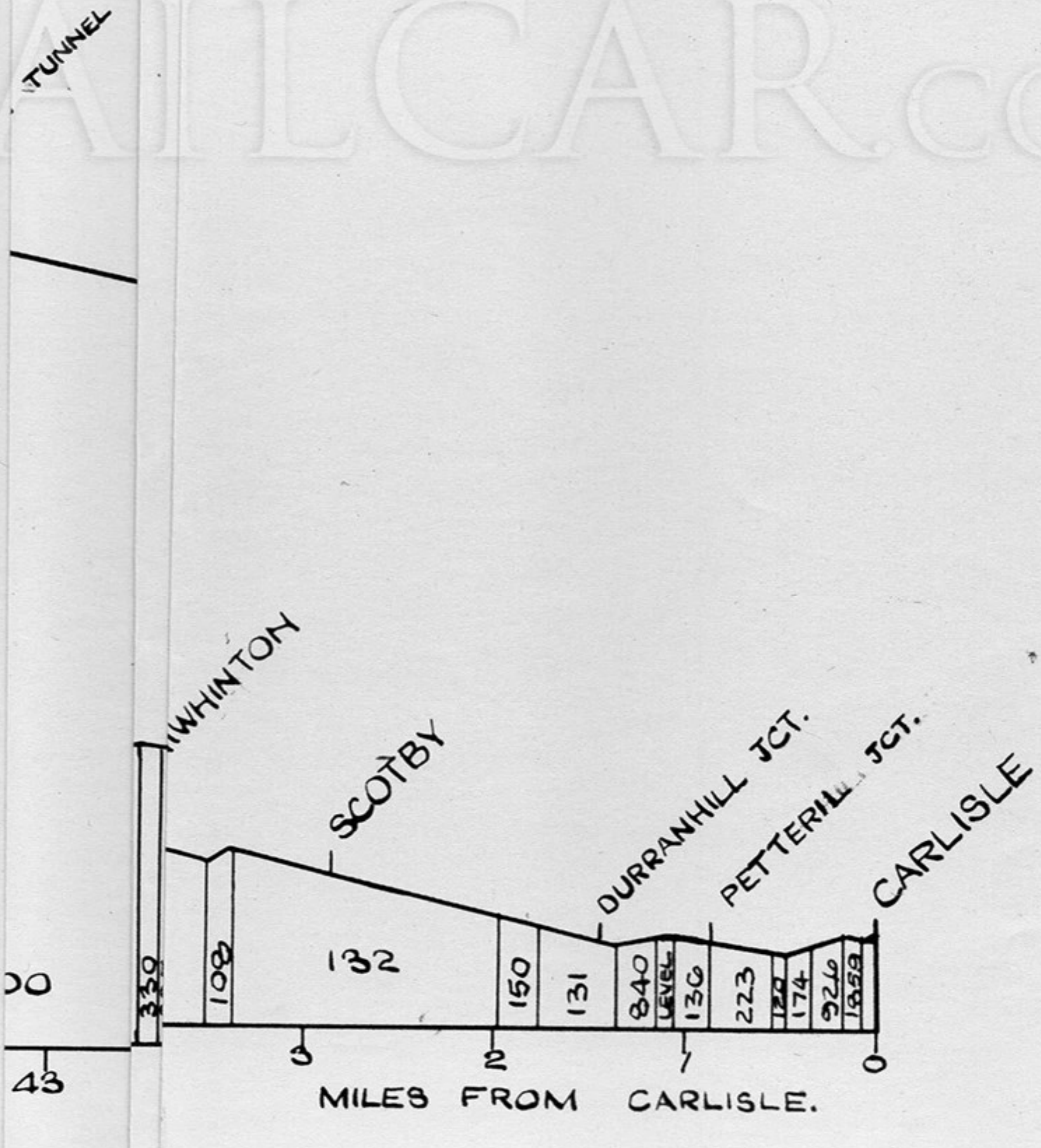
Time	Reading	Con. Inlet Temp.	Con. Outlet Temp. No.1	Amb. Temp. L.E.	Amb. Temp. M.E.	Eng. Oil Press. No.1	Con. Inlet Press. No.1	Con. Outlet Press. No.1	Base Press. No.1	Base Press. No.2
3.24	1	72	77	12	13	52	58	90	62	64
3.27	2	66	68	12	14	52	61	92	61	65
3.30	3	67	68	11	14	51	61	91	61	65
3.33	4	68	72	10	14	51	61	91	61	65
3.36	5	68	72	10	14	50	61	91	61	65
3.39	6	58	64	10	15	48	57	60	60	65
3.42	7	41	48	9	14	50	59	62	62	65
3.45	8	52	54	9	12	25	44	50	45	53
3.47	9	73	80	9	12	48	58	87	58	62
3.50	10	70	73	10	12	50	60	90	60	64
3.53	11	70	73	10	13	50	60	90	60	65
3.56	12	70	73	10	14	49	60	90	60	65
3.59	13	70	73	10	14	48	60	90	60	64
4.02	14	70	73	9	14	48	60	90	60	64
4.05	15	70	74	9	14	48	60	90	60	64
4.08	16	70	74	9	14	48	60	90	60	64
4.11	17	60	66	9	12	46	56	59	59	69
4.14	18	42	48	9	12	47	57	60	60	68
4.17	19	39	47	8	11	25	45	50	47	56
4.22	20	64	64	8	11	27	50	54	53	56
4.28	21	54	48	8	10	31	49	53	52	59
4.34	22	50	40	8	9	36	50	53	51	56
4.39	23	49	38	8	9	52	59	62	62	70
4.42	24	48	38	8	10	35	46	50	48	53
4.45	25	62	66	8	10	52	62	92	60	66
4.48	26	45	52	8	11	52	60	63	63	66
4.51	27	40	45	8	12	29	45	50	47	55
4.54	28	46	42	8	12	51	59	63	63	65
4.57	29	49	40	8	12	49	57	60	60	60
5.00	30	50	40	8	12	51	58	62	62	66
5.03	31	50	40	8	12	29	44	49	47	59
5.06	32	52	40	8	12	30	45	50	47	56

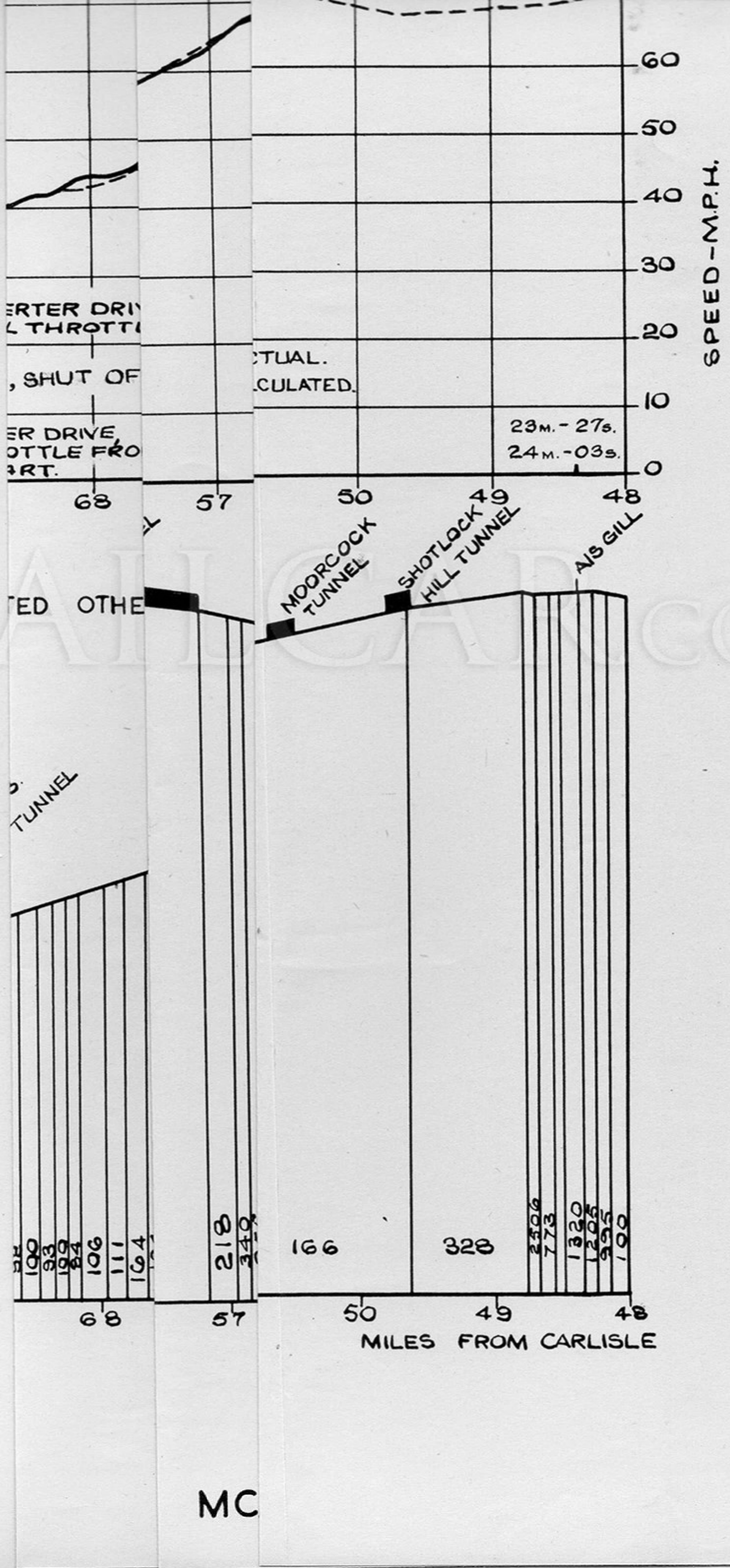

12
13
14
15
3M. 27S.
1M. 54S.
2M. 38S.
1M. 04S.
BRAKING.
SHUT OFF
BRAKING.
SHUT OFF
BRAKING.
12
13
14
15
16


SHUT OFF.
BRAKING.
FULL THROTTLE.
SHUT OFF &
BRAKING.
12
13
14
15
16

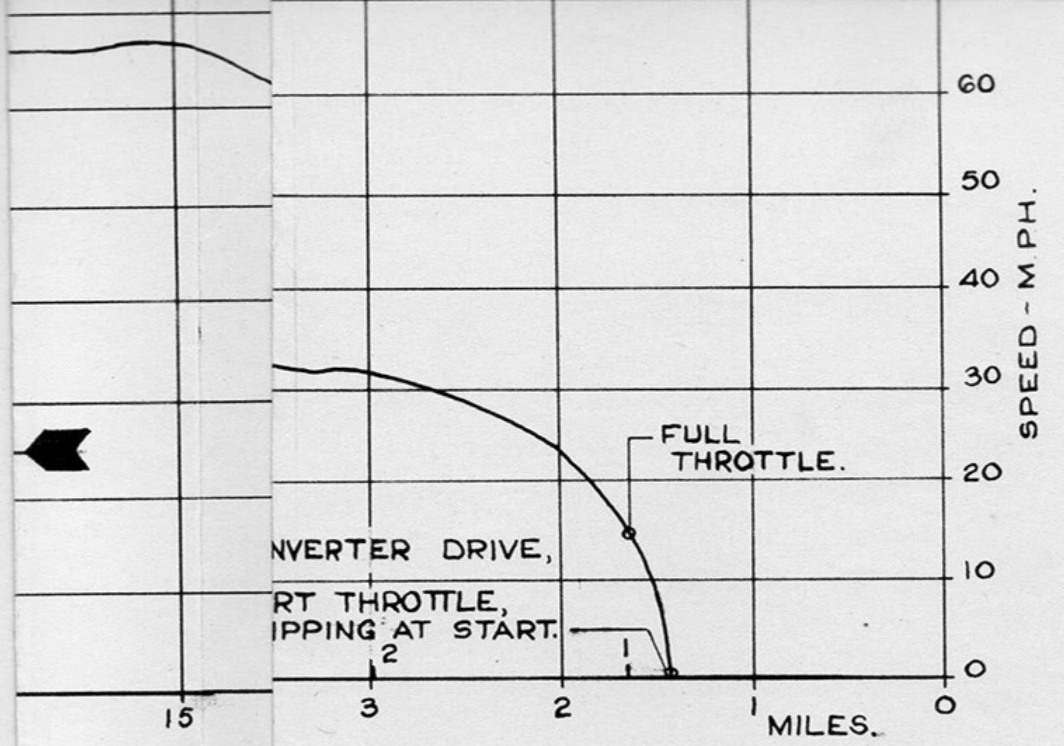
MIDALE.

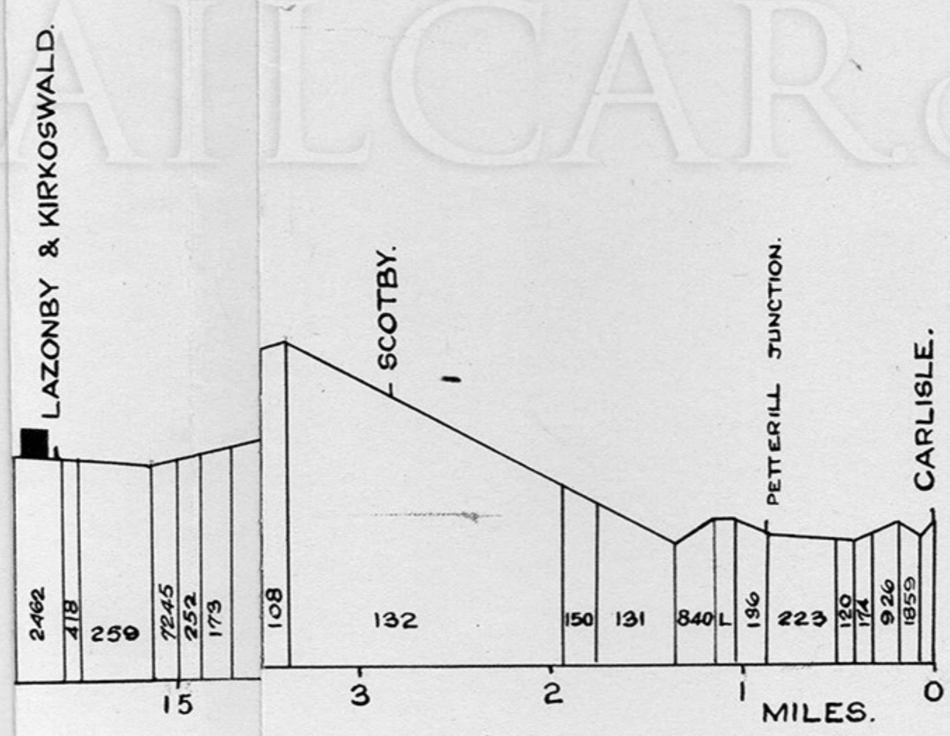

IVE
DIRECT DRIVE
60
50
40
30
20
10
0
SPEED-M.P.H.
FULL THROTTLE, CONVERTER DRIVE FROM START
TIME. Om - Os.
TIME. Om - Os.
43
3
2
1
0

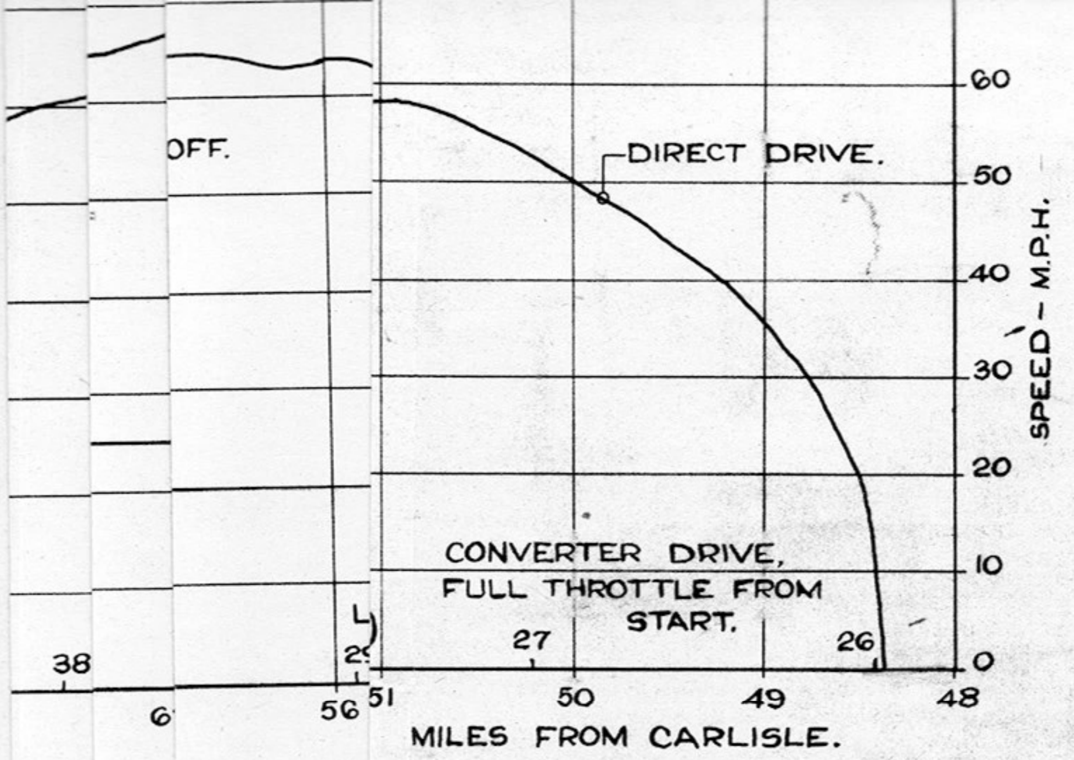

TUNNEL
WHINTON
SCOTBY
DURRANHILL JCT.
PETTERIL JCT.
CARLISLE
00
330
108
132
150
131
840
LEVEL
130
223
120
174
926
1859
43
3
2
1
0
MILES FROM CARLISLE.



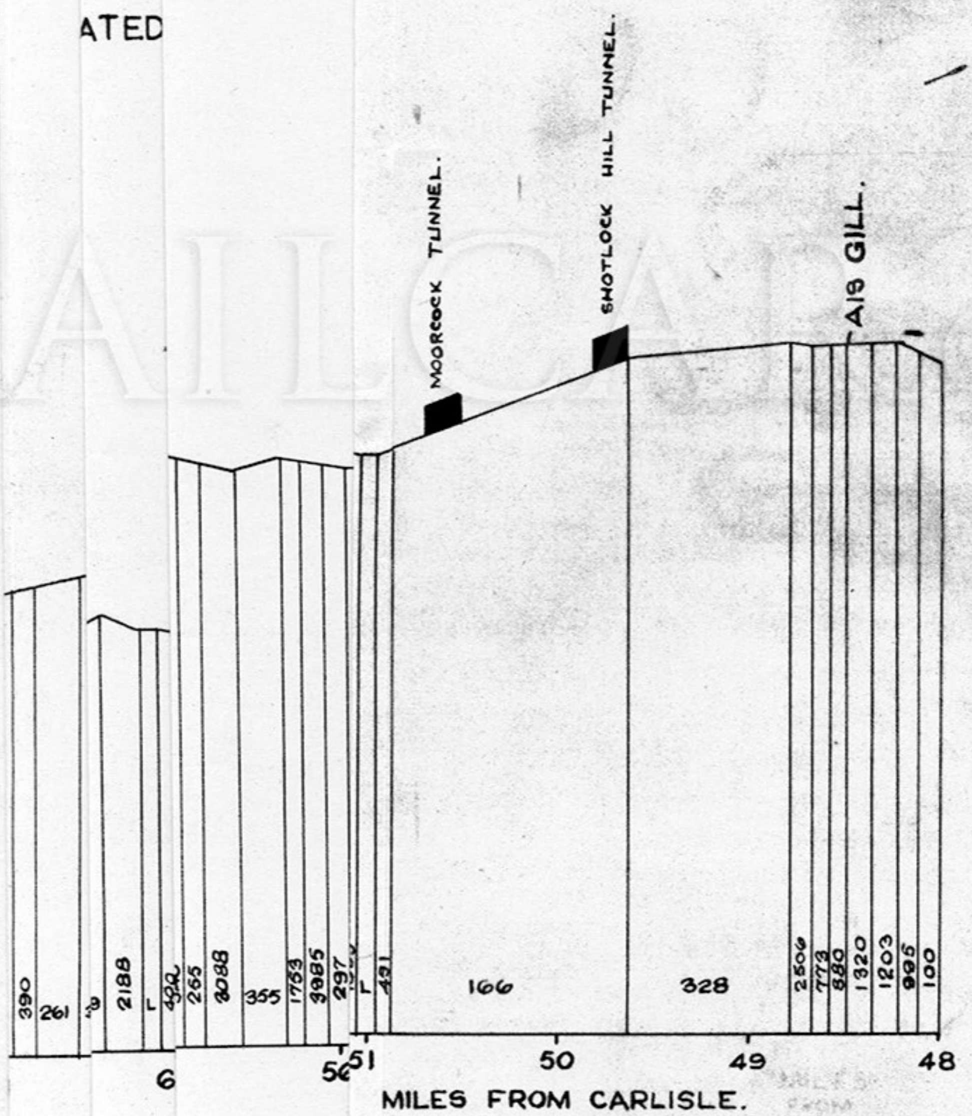
SPEED-M.P.H.
60
50
40
30
20
10
0
ERTER DRIV
L THROTT
, SHUT OF
ER DRIVE,
OTTLE FRO
ART.
CTUAL.
CULATED.
23M. - 27S.
24M. - 03S.
68
57
50
49
48
MOORCOCK TUNNEL
SHOTLOCK HILL TUNNEL
AIS GILL
TED OTHE
TUNNEL
100
93
106
111
164
218
166
328
773
1320
MILES FROM CARLISLE
MC


60
50
40
30
20
10
0
SPEED - M.P.H.
FULL THROTTLE.
NVERTER DRIVE,
RT THROTTLE,
IPPING AT START.
15
3
2
1
0
MILES.


LAZONBY & KIRKOSWALD.
SCOTBY.
PETTERILL JUNCTION.
CARLISLE.
2462
418
259
7245
252
173
108
132
150
131
840 L
136
223
120
174
926
1859
15
3
2
1
0
MILES.

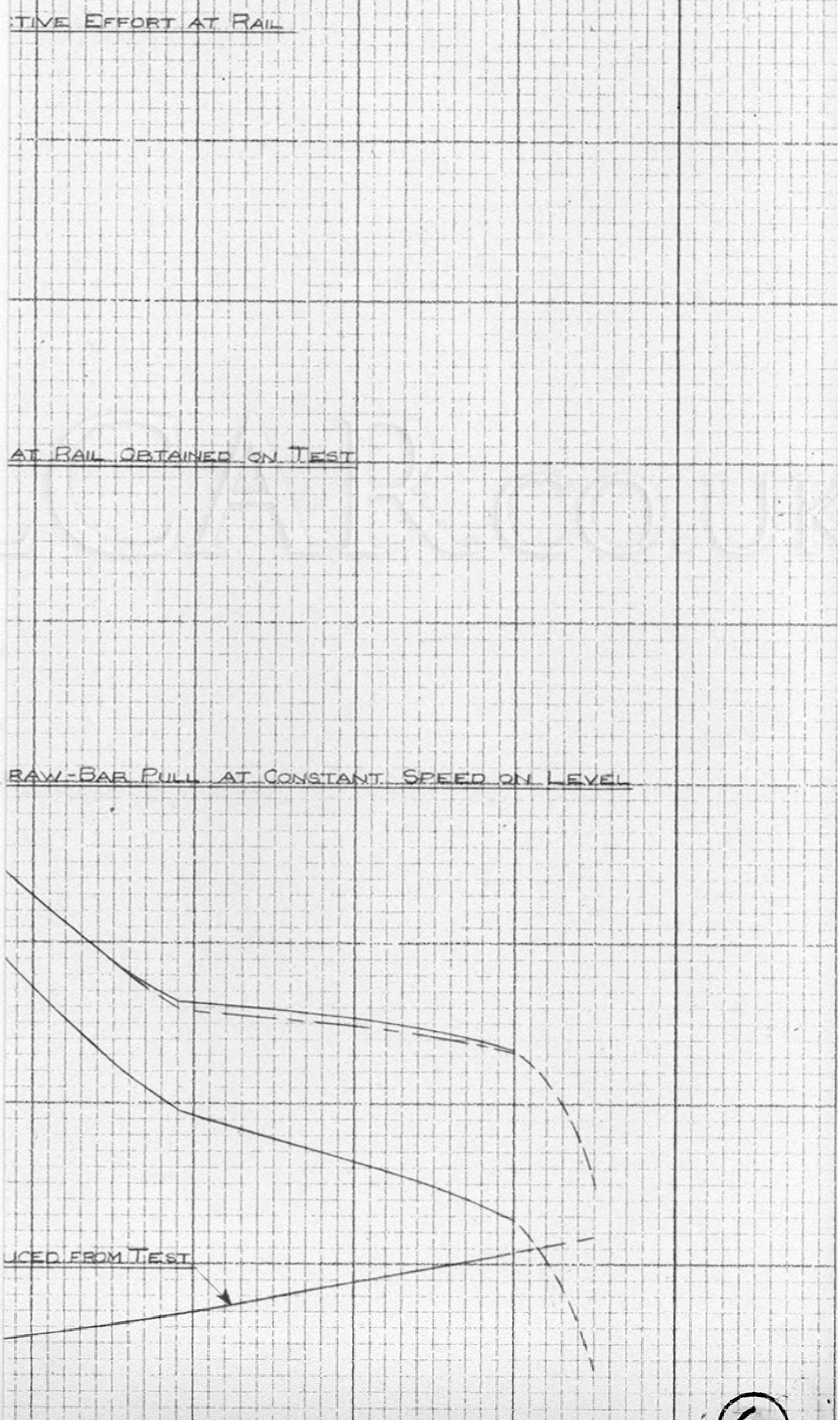

OFF.
DIRECT DRIVE.
CONVERTER DRIVE,
FULL THROTTLE FROM
START.
SPEED - M.P.H.
60
50
40
30
20
10
0
38
27
26
56
51
50
49
48
MILES FROM CARLISLE.

ATED


MOORCOCK TUNNEL.
SHOTLOCK HILL TUNNEL.
AIS GILL.
390
261
2188
L
265
3088
355
1763
3985
297
L
491
166
328
2506
773
880
1320
1203
995
100
56
51
50
49
48
MILES FROM CARLISLE.

DY

RISTICS OBTAINED WITH
METER CAR



RFORMANCE - POWER CAR (2 ENGINES)
TRAILER + OPTIONAL MAIL VAN

ENGINE - 227 H.P. (NETT) AT 1880 R.P.M.
RIES DFR CONVERTER - Ms 500 LB. FT.

DRIVE RATIO - 2·88:1 ; EFFICIENCY 95%
L DIAMETER - NEW WHEELS 36"
WORN WHEELS 33·5"

VEIGHT OF POWER CAR	- 44 TON 8 CWT	(PC)
VEIGHT OF DRIVING TRAILER	- 37 TON 12 CWT	(DT)
VEIGHT OF MAIL VAN	- 32 TON	(MV)
POWER CAR WITH OVERLOAD	- 52 TON 4 CWT	PC+DT+Ov.
DRIVING TRAILER WITH OVERLOAD	- 46 TON 16 CWT