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FREIGHT TRAIN RESISTANCE

ITS RELATION TO CAR WEIGHT

BY

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UNIVERSITY OF ILLINOIS
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BY EDWARD C. SCHMIDT, PROFESSOR OF RAILWAY ENGINEERING

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FREIGHT TRAIN RESISTANCE

ITS RELATION TO AVERAGE CAR WEIGHT

PART I

I. Introduction

1. *Preliminary.*—Train resistance varies not only with the train speed, but also with the average weight of the cars of which the train is composed. At a given speed the tractive effort required for each ton of weight of the train will be greater, for example, for the train which is composed of cars of 20 tons average gross weight, than for the train composed of cars which weigh, on the average, 50 tons each.

While this fact has been known for some years, it has found inadequate expression and but little application. In the establishment of their tonnage ratings, many railroads have altogether ignored it. In the tonnage ratings of a few roads, this variation of resistance with car weight is recognized to the extent of allowing a difference in rating between trains composed of loaded cars and those consisting entirely or partially of empty cars. Generally, in such systems, a certain amount is allowed arbitrarily to be added to the weight of empty cars in determining, for the purpose of rating, the weight of the train in which they are found. In such rating no distinction is made between loaded cars of various weights although such weights vary from 25 to 70 tons. A still smaller group of railroads have fully recognized the significance of the facts above stated in establishing their tonnage ratings, which, in such cases, are usually termed "adjusted" or "equated" ratings. Under these adjusted ratings, the actual weight of the train allotted to a particular locomotive varies according to the number of cars in the train. The ratings for the same locomotive, with trains of 40, 60, and 80 cars, for example, will be different in each of the three cases. This is, in effect, a variation of the rating with respect to the average car weights. Most of these adjusted ratings have been empirically determined. In the few cases where they rest upon experiments made to determine the variations in train resistance with respect to car weight, the data and results of such experiments have not been fully published.

Existing train resistance formulas likewise fail in most cases to take into account these variations of resistance with car weight, and probably much of the divergence among them is properly to be ascribed to this fact.

2. *Purpose of the Tests.*—In view of the facts just stated, it has seemed desirable to make the tests whose results are here recorded. They were planned to determine the resistance of freight trains under the usual conditions of operation; and they were designed to disclose at the same time, if possible, the relation existing, at any given speed, between train resistance and average car weight. Since the chief use of such information is in the production of locomotive ratings, the conditions of the tests have been made like those which prevail in normal freight train operation. The speed range, for example, is from 5 to 35 miles per hour; and the trains experimented upon were trains in regular service, and usual in their make-up. The track upon which the tests were made is believed to be representative of good main-line construction.

The tests have been conducted by the Railway Engineering Department of the University of Illinois as part of the research work of the Engineering Experiment Station. They were begun in April, 1908, and were completed in May, 1909. All tests were made by means of Test Car No. 17, a dynamometer car, owned jointly by the University of Illinois and the Illinois Central Railroad, and were carried out on the Chicago division of this road.

In Part I of this report, the aim has been to present as brief a statement of the results and conditions as is compatible with a clear understanding of the tests. It consists, accordingly, of a discussion of the results of the experiments, prefaced by a general statement of conditions and methods. The final results are exhibited in Fig. 11, in Table 8, and in equations 1 to 13, on pages 33, 34, and 35. A summary of the test conditions and the conclusions is inserted on pages 5 to 7. Part II of the report has been added in order to complete the record so that those interested in the details may verify or modify the results and conclusions presented in Part I. It consists of appendixes in which the aim has been to state fully all the conditions of track, weather, and train make-up, as well as to present the test data, the methods of calculation, and the results.

Throughout the report, the terms "resistance" and "train resistance" mean the number of pounds of tractive effort required for each ton of the train in order to keep it in motion on straight and level track, at uniform speed, and in still air. The report deals exclusively with the resistance of the train behind the locomotive tender. Locomotive and tender resistance are not discussed.

3. *Acknowledgments.*—The tests have been made possible through the interest and cooperation of Mr. William Renshaw, Mr. J. G. Neuffer, and Mr. R. W. Bell, who were successively superintendents of machinery of the Illinois Central Railroad, during the period of planning and conducting the work. Many other officials of the Chicago division of the road have rendered generous assistance in the investigation, which has entailed for them not a little inconvenience and labor. Such interest and assistance are thoroughly appreciated by those of the University staff who have been concerned with the work.

Throughout the tests, the operation of the dynamometer car and the making of the calculations have been under the direct supervison of F. W. Marquis, Associate in the Railway Engineering Department, Engineering Experiment Station. Much of whatever accuracy and reliability have been attained in the investigation is due to his intelligent and painstaking care in making the tests and in systematizing the work of calculation. He has also rendered great assistance in supervising the preparation of the tables and illustrations, and in the final checking of the manuscript.

II. Summary and Conclusions

4. *Summary.*—The report deals with the results obtained from tests of 32 ordinary freight trains, whose chief characteristics were as follows:

	Minimum	Maximum
Total weight, tons	747	2908
Average weight per car, tons	16.12	69.92
Number of cars in the train	26	89

The trains whose average weights were less than 20 tons or more than 60 tons were composed of cars of nearly uniform weight; while those whose average car weights were between 20 and 60 tons were either homogeneous or mixed as regards the weight of the individual cars.

The weather during the tests was generally fair. The minimum air temperature during any test was 34° F. the maximum 82° F. The approximate average wind velocity prevailing throughout one test was 25 miles per hour; during all the others it was less than 20 miles per hour.

The tests were made upon well-constructed and well-maintained main-line track, 94 per cent of which is laid with 85-lb. rail, the remainder being laid with 75-lb. rail. Except through station grounds, where screenings or cinders are used for ballast, the track is full ballasted with broken stone.

5. *Conclusions.*—The results of the tests are presented in Fig. 10 and 11, pp. 31 and 33, in Table 3 on p. 35, and in the equations on p. 34. The curves, the table, and equations are each different expressions of the same facts. It is believed that by their use the probable total resistance of *entire* freight trains at various speeds may safely be predicted, when running upon straight and level track of good construction, during weather when the temperature is above 30° F., and the wind velocity is not more than 20 miles per hour, provided the *average* weight of the cars composing the train be known.

The results are applicable to trains of all varieties of make-up to be met with in service. They may be applied, without incurring material error, to trains which are homogeneous and to those which are mixed as regards individual car weight.

The results are primarily applicable to trains which have been in motion for some time. When trains are first started from yards, or after stops on the road of more than about 20 minutes' duration, their resistance is likely to be appreciably greater than is indicated by the results here presented. In rating locomotives, no consideration need be given this matter, except in determining "dead" ratings for low speeds, and then only when the ruling grade is located within six or seven miles of the starting point or of a regular road stop.

It is to be expected that some trains to be met with in service will have a resistance about 9 per cent in excess of that indicated by Fig. 10 and 11, due to variations in make-up or in external conditions within the limits to which the tests apply. If operating conditions make it essential to reduce to a minimum the risk of failure to haul the allotted tonnage, then this 9 per cent allowance should be made. This consideration, like the one preceding, is

important only in rating locomotives for speeds under 15 miles per hour. At higher speeds, the occasional excess in the resistance of individual trains will result in nothing more serious than a slight increase in running time. It should be emphasized that this allowance, if made, is to be added to the resistance on level track—not to the gross resistance on grades.

III. The Methods and Means Employed in Conducting the Tests

6. The tests were carried on by means of the dynamometer car referred to as Test Car No. 17, which, when not in use, is held at Champaign, a district terminus. The car was operated from time to time in the regular trains leaving this point, and the trains selected were partly in the northbound, partly in the southbound traffic.

The plan was to determine, for each of the trains experimented upon, the relation of its resistance to its speed. This information was to be expressed finally as a resistance-speed curve such as is shown in Fig. 1 and in the various figures given in Appendix 5. The trains were so selected that their average car weights would vary throughout as great a range as possible. As will later appear, this range proved to be from the weight of an empty gondola to that of a fully loaded car of 100 000 lb. capacity. It was the expectation that when the resistance-speed curves of the individual tests were brought together, their analysis would reveal the relations existing between train resistance and car weight.

7. During each test the following information was obtained:

(*a*) The drawbar pull of the locomotive upon the train.

(*b*) The train speed.

(*c*) A continuous record of the time elapsed from the beginning of the test.

(*d*) The pressure existing in the brake cylinder of the test car.

(*e*) The direction of the wind relative to the direction of motion of the car.

(*f*) The velocity of the wind relative to the car.

(*g*) A record of the location of the test car upon the road.
(*h*) Air temperatures and other weather conditions.
(*i*) Data concerning the train, such as its weight, etc.

The information cited under items (*a*) to (*g*) was obtained in the form of continuous graphical records upon the chart which is produced by the apparatus of the dynamometer car. By means of this chart any of the quantities mentioned may be determined at any point upon the road.

The curves of draw-bar pull and speed provide the information essential to the investigation. Supplemented by an accurate profile and a record of train weight, they enable net train resistance to be calculated at any position of the train upon the road. The time record provides a means of calibrating and checking the speed curve. The pressure in the brake cylinder was recorded merely to make it possible to distinguish those periods during the test when the brakes were applied to the train; it being obviously necessary to ignore such portions of the record when making the calculations. The relative wind velocity and relative wind direction were obtained by means of an anemometer and a wind vane mounted on the roof of the test car. When compounded with the known speed and direction of motion of the car, these data permit the determination of the actual wind direction and wind velocity with respect to the track. In Appendix 5, for each test, there are recorded this actual wind velocity and actual wind direction with respect to the track for each point at which train resistance was determined. It is probable that these wind data are, under some circumstances, subject to a considerable error. Considering the length of the run made with each train and the length of time it was on the road, it is believed that the wind data thus obtained are, nevertheless, more reliable than those which might have been recorded by stationary instruments located at one or two points along the track. Item (*g*), the location of the car upon the road, was defined by marking upon the test car record the position of mile posts and stations at the moment they passed the car. By means of this record, it is possible to correlate any position of the train with the road profile. Data concerning the train were obtained by one or two observers who had no other duties. With the one exception noted beyond, all trains were weighed, to determine their tonnage. In addition to its

weight, there was recorded for each train, its length[1], and for each car, its number, kind, stenciled "light weight", gross weight, capacity, and the initials of the owning road.

All test car instruments were calibrated before the tests, and their calibrations were frequently checked during the progress of the investigation. All observers were men experienced in the operation of the test car and many of them had participated also in the work of calculation and were consequently aware of the points at which alertness and care were especially needed. No effort has been spared, in conducting the tests, to insure accuracy in the data. These facts are here mentioned as having some significance to any one who may undertake to estimate the reliability of the results. Appendix 1 contains an illnstration of one of the test car charts and a detailed description of the car itself.

This report includes the data and results from tests of 32 different trains. For the purposes of this research, tests were made of twelve other freight trains; but their results were finally excluded from the report. Three of these additional tests were rejected because of uncertainty about the train weights; one, because of a break-down in the test car recording apparatus during the progress of the test; and eight were disregarded because the temperatures prevailing were below the range for which it was intended the results should apply, the low temperature in some cases being coupled with high wind.

IV. Test Conditions and Train Data

8. *The Trains Tested.*—The test trains were all of such make-up as naturally resulted from the traffic conditions in the Champaign yards. For most of the tests the test car was simply coupled into the trains selected by the trainmaster, solely with reference to his convenience in operating and in returning the test car. As the investigation progressed, it became apparent that the accumulated data left certain gaps in the range of average car weights. There were at this stage, for example, few trains experimented upon with average car weights near 25 to 30 tons, and none with an average car weight of 70 tons. The last six or eight

[1] Train length was determined by counting, during the test, the number of rail lengths corresponding to the length of the train and multiplying this number by 30 feet, which is the rail length for this track.

trains were therefore made up especially to supplement the data at these points. It should be understood, however, that nothing in this process resulted in a train make-up which was in any respect unusual. All the trains tested are, therefore, such as one might expect to find upon any road where the traffic conditions are normal. They include trains made up almost entirely of empty gondolas[1], others with considerable variation in both load per car and kind of car, and still others composed almost entirely of loaded box cars or of loaded gondolas.

Test S-1018 demands special mention in this connection. The train for this test included Illinois Central Railroad locomotives No. 423 and No. 732, weighing respectively 145 200 and 223 600 lb. Their combined weight constituted 13.6 per cent of the total train weight. These locomotives with their tenders were being hauled "dead" and had the main rods disconnected, as is usual in such cases. The first is of the 2-6-0 type, the second of the 2-8-0 type, and they and their tenders had therefore together 17 axles in operation. For the purpose of determining the average car weight for this train, these two locomotives were assumed to be equivalent, in their resistance, to a number of cars having a like number of axles, i. e., 4¼ cars. The results of the calculations warrant the belief that this view of the situation has resulted in no material error. A study of Table 1 will make clear the diversity in the composition of the trains.

All trains except No. S-1016, S-1018, S-1030A, and S-1030B were weighed upon one of the two track scales at Champaign. This weighing was done in the usual manner, by pulling the train over the scales and weighing the cars successively without uncoupling them. These track scales were in good condition and were each inspected four times during the test period. These inspections disclosed a maximum error in one scale of- ⅓ per cent, in the other of—½per cent. The train in test S-1016, composed entirely of empty cars, by an error in arrangements, left the yards without being weighed. The weights stenciled on the cars were accepted as correct in this case. The train in test S-1018 was weighed upon track scales in the Chicago yards; and the trains of

[1] In all parts of the report except Appendix 2, cars are designated as box, stock, gondola, flat, and tank cars. The term box car is made to include refrigerator cars, the test car and the caboose. The term gondola includes all unroofed cars with sides, such as coal cars, hopper cars, etc. In the tonnage records in Appendix 2, further distinctions are made.

tests S-1030A and 1030B were weighed in the yards at Centralia. In test S-1021, after leaving the yards, two cars were added to the train, for which the weights were determined from the stenciled weights and the way-bills. In tests S-1030B and S-1048 the weights of one and two cars respectively were similarly determined, and in test S-1061 the stenciled weight was used for one empty car. Obviously no important errors in the total tonnage have resulted from possible inaccuracies in the weights of these cars.

All cars of all trains were of course provided with the usual four-wheeled truck. Presumably the majority of the cars had journals conforming to the specifications of the Master Car Builders' Association, which for some years have required that freight car journals be either 3¾ in. by 7 in., 4½ in. by 8 in., 5 in. by 9 in. or 5½ in. by 10 in. in size, depending upon the car capacity. It is safe to assume that all trucks were provided with wheels of 33-in. standard diameter.

Throughout each test, observations were repeatedly made to discover such irregularities as hot journal boxes, brakes which were not free from the wheels, and trucks which did not freely follow the track. Such things occurred to the usual extent; a hot-box or two or an unreleased brake being occasionally found on some of the trains, while others were entirely free from such defects. The record of such matters was given consideration in making the calculations; but, as was anticipated, the results showed no discrepancies which could be explained by such causes.

The range over which the train data for all of the tests varied is as follows:

	Minimum	Maximum
Total train weight, tons	747	2908
Average weight of cars composing the train, tons	16.12	69.92
No. of cars in the train	26	89
Train length, feet	1120	3480

Complete information concerning each train is given in Appendix 2.

9. *The Track.*—The track upon which the experiments were carried on extends from Gilman to Mattoon, Illinois, a distance of 91 miles, and lies upon the Chicago division of the main line of the Illinois Central Railroad. Until about ten years ago this was a single track road, and one of the oldest in the State. At that time a second track was constructed, and the roadbed for both tracks is now well settled and in good condition. The maxi-

TABLE 1

A Summary of Test Conditions and Train Data

Test No. Laboratory Serial No.	Test Date	Weather Conditions						Train Data										
			Air Temperature Degrees F.		Average Approximate Wind Velocity miles per hour	Range of the Direction of the Wind with Respect to the Track		Train Length, feet	Weights		Total Number of Cars in the Train	Train Make-Up						
												Conditions of Loading			Kind of Cars—In Percentages of the Total Number of Cars			
			At Beginning of Test	At End of Test		From	To		Gross Train Weight tons	Average Gross Weight Per Car tons		Number of Empty Cars	Number of Loaded Cars	Loaded Cars in Percentage of Total Number	Box Cars per cent	Gondola Cars per cent	Flat Cars per cent	Tank Cars per cent
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
S-1013	4-27-08	Wet	42	44	19	+35°L	90°L	2784	2549	38.04	67	10	57	85	82	13	0	5
S-1015	4-29-08	Fair	40	48	10	+25°L	−80°L	2520	2189	36.08	60	8	61	88	88	6	16	10
S-1016	4-30-08	"	44	48	10	+15°R	+60°R	3030	1161	16.12	72	72	0	0	3	97	0	0
S-1017	5- 1-08	Wet	48	54	16	+45°L	−80°L	2670	2532	38.44	66	13	53	80	95	5	0	0
S-1018	5- 2-08	Fair	40	45	11	+10°R	+85°R	2130	1353	25.40*	49*	34	15	31	61	6	16	17
S-1019	5- 9-08	"	44	62	25	+20°R	+45°R	3480	1572	17.72	89	75	14	16	34	58	7	1
S-1021	5-13-08	Wet	66	70	17	+60°R	+80°R	2400	2908	46.16	63	10	53	84	32	60	5	3
S-1023	5-23-08	Fair	62	74	17	+75°R	−80°R	2320	2243	38.72	58	17	41	71	45	52	0	3
S-1027	7- 2-08	Wet	64	80	14	−50°R	+70°R	1710	2185	47.44	46	3	43	94	22	76	3	0
S-1030A	7- 8-08	Fair	60	68	6	+20°R	+65°R	1380	2036	59.88	34	2	32	94	6	94	0	0
S-1030B	7- 8-08	"	68	72	7	+20°R	+65°R	1650	2342	57.12	41	3	38	93	20	80	0	0
S-1031	7-22-08	"	70	82	5	+ 0°	+40°L	1425	747	20.72	36	30	6	17	94	3	3	0
S-1033	9-26-08	"	66	82	12	+ 5°L	+15°R	1710	2275	51.70	44	2	42	95	5	95	0	0
S-1034	10-3-08	"	42	60	4	− 0°	+85°L	3015	1250	16.56	76	76	0	0	1	99	0	0
S-1036	10-10-08	"	40	62	6	+15°R	−15°R	2010	1961	37.72	52	8	44	85	73	25	2	0
S-1038	10-15-08	"	58	72	16	+ 5°L	+25°L	1650	2144	52.28	41	3	38	93	22	78	0	0
S-1040	10-24-08	Wet	57	53	11	+15°R	+40°R	1830	2152	45.76	47	2	45	96	49	49	0	2
S-1043	11-7-08	Fair	38	53	8	+ 5°R	+65°R	2580	1118	16.92	66	65	1	2	24	74	0	2
S-1048	11-28-08	"	36	39	6	+ 5°R	+30°L	a2175	2443	45.24	54	8	46	85	37	63	0	0
								b2100	2355	45.24	52	8	44	85	38	62	0	0
S-1050	1-23-09	"	53	66	8	+ 0°	−25°R	1620	1618	40.44	40	16	24	60	75	25	0	0

S-1052	1-28-09	Wet	36	40	11	−45°L	+70°L	2430	1514	24.80	61	44	17	28	61	38	1	0
S-1057	3- 6-09	Fair	34	40	10	+20°R	−35°L	1830	2107	41.32	51	8	43	84	49	43	6	2
S-1061	3-13-09	"	41	38	7	+45°L	−85°L	1785	2252	51.20	44	3	41	93	5	84	11	0
S-1063	3-19-09	Wet	30	40	12	+30°R	+40°R	3060	1484	20.04	74	70	4	5	7	93	0	0
S-1070	4-17-09	Fair	58	71	4	+ 0°	−65°L	2400	1622	24.60	66	49	17	26	58*	42	0	0
S-1072	5- 1-09	"	35	37	17	+70°L	90°L	1200	1859	66.40	28	1	27	96	4	96	0	0
S-1073	5- 4-09	"	53	63	10	+25°L	+70°R	1200	1880	67.16	28	1	27	96	4	96	0	0
S-1074	5- 7-09	"	45	60	10	+65°L	−80°L	3180	1340	16.56	81	81	0	0	2	98	0	0
S-1076	5-11-09	"	51	67	16	+40°R	+75°R	1120	1818	69.92	26	1	25	96	4	96	0	0
S-1077	5-14-09	"	64	70	13	−25°R	−75°R	2145	1505	28.40	53	35	18	34	74	26	0	0
S-1079	5-18-09	"	65	68	18	+65°R	−85°R	2070	1685	33.04	51	14	37	73	90	10	0	0
S-1080	5-21-09	"	50	70	11	+ 0°	+45°L	2550	1347	21.40	63	57	6	10	16	84	0	0

Notes: 1. Columns 7 and 8—Direction is designated by the angle made with the track. A wind any component of whose velocity helps the train forward is marked +; winds with opposing velocity components are marked −. Winds from the right side of the track are designated as R, from the left side as L. Thus + 40°R means a wind blowing from the rear and from the right hand side, whose direction makes an angle of 40° with the track.

2 *Columns 11 and 12—Train has two "dead" locomotives and tenders in addition to cars noted.

3. *Column 16 –includes 15 stock cars classed as box.

4. All data apply to the train only—engine and tender are excluded.

5. Columns 9 to 19: a.—from Champaign to Rantoul: b.—from Rantoul to Gilman.

mum grade against northbound traffic is 29 ft. per mile and against southbound traffic, 31.9 ft. per mile. In all the 91 miles there are only 7850 ft. of curved track.

Through station grounds the tracks are ballasted with screenings or cinders; all other portions of both tracks (about 83 of the 91 miles) are full ballasted with broken limestone. The crossties are of oak, laid 20 in. center to center. About 10½ miles of the west track are laid with 75-lb. A. S. C. E rail, put down in 1894 and 1895; while the remainder of the west track and all of the east track are laid with 85-lb. A. S. C. E rails, the oldest of which was put down in 1900. During eight months of the year there is employed in maintaining this portion of the road a force of men which averages one man per mile of track; during the other four months this force is reduced to one man for each two miles. Further details concerning the track are given in Appendix 3. As regards both its construction and maintenance this track is such as one may expect to find upon the main lines of first-class railroads.

These 91 miles of track were especially surveyed, immediately preceding the tests, by the Railway Engineering Department of the University for the purposes of this and similar investigations. The levels were run on the east track and readings were taken to 0.1 ft. at stations 300 ft. apart; and turning points were taken at every fourth station where levels were read to 0.01 ft. The results of the survey are expressed in a profile drawn to a scale of ¼ in. to 100 ft., which was used in making the test calculations.

10. *The Weather Conditions.*—In Table 1 the weather prevailing during each test is designated as either fair or wet, wet weather meaning either continuous or intermittent rain. During 7 of the 32 tests the weather was wet. The lowest air temperature recorded at any time during any test is 34° F.; and the highest recorded temperature is 82° F.

The column headed "average wind velocity" in Table 1 presents the averages of the calculated wind velocities derived for each point or section of the test in question for which the train resistance was determined. An inspection of the tables in Appendix 5 shows a considerable variation between the wind velocities at different points during the same test. The approximate maximum average wind velocity prevailing during any test was 25 miles per hour; the minimum was 4 miles per hour. The

actual wind direction (with respect to the track) varied during the tests, as would be expected, through the entire 360°. The tables in Appendix 5 show this direction for each point at which train resistance was computed; but it seems impossible to make any useful generalization of the data there presented.

It was intended to so select the tests that the weather conditions, the temperatures, and the wind velocities would be such as usually prevail in most parts of the country from the middle of spring until the middle of autumn when the basic or "summer" tonnage ratings are in force—such conditions, in short, as would give rise to no appreciable difficulties in train operation.

V. Methods Employed in Calculating the Results.

11. The immediate purpose in making the calculations was to produce for each test a curve showing the relation between resistance and speed, for as great a variety of speeds as the data would permit. This involves calculating the train resistance at various positions of the train upon the track, and the first step towards this end is the inspection of the test car record in order to select suitable points or sections at which the resistance may be calculated. The considerations of first importance in this selection are that the points represent finally as great a speed range as possible, and that the speeds be approximately evenly distributed within this range. Points and sections were selected only where the entire train was running and continued to run upon straight track; resistance due to track curvature is therefore entirely eliminated. The data essential to the process of calculation are the draw-bar pull of the engine, the train speed and its acceleration, the tonnage, and the profile. The pull and the speed, as previously stated, are determined from continuous curves drawn on the test car chart. Two processes have been used, designated here as Method 1 and Method 2. By Method 1, the momentary values of pull, speed, acceleration, and grade were determined for a particular position of the train upon the road; by Method 2 the average values of these quantities were determined for the period during which the test car was passing over a definite section of the track.

12. *Method 1: Resistance at a Point on the Road.*—The point having been chosen, the pull and the speed were found by direct

readings from the chart. This pull divided by the tonnage gives the gross train resistance at this speed, and this gross resistance was next corrected for both acceleration and grade resistances. The acceleration was determined by graphical methods from the speed curve, and the grade was found by correlating the train's position with the profile. The points were all so selected that at the moment under consideration, the entire train was on a nearly uniform grade. Method 1 results in momentary values of train resistance at the points considered.

13. *Method 2: Average Resistance Over a Section.*—By this method the average value of train resistance was determined for the period during which the test car at the head of the train was passing a selected section of the track. This track section corresponds to a certain length or section on the test car record. It was so selected that the speed of the car when entering was nearly equal to its speed at exit, and further so that no considerable variations in speed occurred during transit over the section. The sections chosen have varied in length from about $\frac{1}{4}$ mile to 1 mile. The variations in speed in passing the section have generally amounted to less than 2.0 miles per hour, and the maximum variation over any selected section is 11.7 miles per hour. In only 58 cases out of a total of 560 does this speed variation exceed 5.0 miles per hour. These portions of the chart having been chosen, the average pull was next found by determining the average ordinate of the curve of draw-bar pull, and the average speed was found by means of the section length and the time record. Gross resistance in pounds per ton was next derived by dividing this value of pull by the tonnage, and this gross resistance was then corrected for the resistances due to acceleration and grade, as in Method 1.

In this case the average acceleration is found by consideration of the speeds at entrance to and exit from the section. In order to correct for grade, the elevation of the center of gravity[1] of the train was determined for that position of the train at which the test car entered the section, and again for the position at which the car left the section. The difference between these elevations

[1] The location in the train of its center of gravity was determined thus: Assume a train which weighs 1800 tons, is 2400 feet long, and is composed of 60 cars. By inspection of the tonnage record we find that one half of this weight (900 tons) lies in the first 25 cars. Hence the center of gravity is located $\frac{25}{60} \times 2400 = 1000$ ft. from the front end.

establishes the effective average grade, which either helps or opposes the locomotive while the train passes the section. These elevations of the center of gravity of the train may not be determined with sufficient accuracy unless the train at the moment is on a practically uniform grade. The section limits were therefore so chosen.

Method 2 results in a value of *average* train resistance for the *average* speed at which the train passes the section under consideration. It would be rigidly correct if train resistance varied uniformly with speed, in other words, if the curve showing the relation of resistance to speed were a straight line. This, of course, is not the case, and the process therefore gives results which are slightly in error. However, as stated above, the section was so chosen that the difference between the speeds at entrance to and exit from the section was small; and for the speed range represented by this difference, the curve of train resistance deviates but little from a straight line. Such error as does result from the process is, therefore, very small and is of no moment whatever when compared with variations, due to natural causes, which occur in the resistance itself.

14. *Comparison of the Two Methods.*—The two methods are fundamentally alike. Although the first is the less laborious, it requires the determination of acceleration at a point on the speed curve, which it is sometimes difficult to make accurately. For this reason the second method is generally preferable. Method 2 is also to be preferred because it deals with average values and therefore tends to eliminate from the results the incidental momentary variations which occur in the resistance itself. Consequently, the second method has been employed whenever possible, and the first method has been resorted to, as a rule, only in those cases where the limitations imposed in the selection of sections for Method 2 would have resulted in too few values from which to plot the resistance curves. Of all the individual resistance values incorporated in the report, only 32 per cent were determined by Method 1. The care exercised in the calculations, and a study of the plotted values obtained by both processes, seem to warrant the conclusion that their results are equally reliable. In Fig. 1 and in the figures in Appendix 5, the circles represent values derived by Method 1, and the circular black spots represent values obtained by Method 2.

15. *General Considerations.*—Even in freight train operation the tractive effort required to produce acceleration in the speed is frequently greater than that required to overcome all other resistances combined. To produce, for example, an acceleration of 0.1 mile per hour per second, requires a tractive effort of about 9 lb. per ton, in addition to that required by net train resistance and grade resistance. Since the acceleration resistance may constitute so large a proportion of the gross resistance, it is important that its determination be made with great care. This fact has been impressed upon all who were concerned with these tests. In calculating the acceleration resistance, both the force required to produce acceleration in the rotation of the wheels and axles, and the force required to produce the acceleration in the motion of translation of the train as a whole were determined.

The test car records make it possible to distinguish those portions of each test where the brakes were applied. Such places, few in number, were of course avoided in selecting points and sections for determining resistance. The records also show where hot-boxes and unreleased brakes were discovered in the train, and such defects were given consideration in making the calculations. They occurred infrequently and their effect could not be distinguished in the results. While therefore such portions of the record were avoided if convenient, sections and points on the charts, otherwise suitable for calculation, were not rejected on these accounts.

16. *The Effect of Stops in Limiting the Selection of Points and Sections.*—Early in the progess of this work, when low air temperatures were first encountered, it became apparent that when the train was first started from rest, its resistance, calculated for a number of points at which the speed was the same, was occasionally unusually high. This was true not only for those portions of the run made immediately after leaving the yards; but also for those portions immediately following stops on the road. In a certain test, for example, the values of net resistance, calculated at various points, at all of which the speed was 20 miles per hour, varied between 6.8 lb. and 5 lb. per ton—a difference of 27 per cent– for points selected within the first 9 miles of the run; whereas values of resistance at the same speed, determined later in the test, differed by only 10 per cent. The air tem-

perature during this test (not included in the report) varied between 22° and 26°.

For a number of tests such resistance values were plotted with respect to the distances from the yards of the points to which they apply. This process disclosed a surprisingly regular decrease in the resistance until a distance of approximately ten miles was reached, after which the resistance had settled down to a fairly uniform value. Similar variations were found to occur to some extent during tests when the air temperature was as high as 50° or 60°. This study[1] led to the conclusion that this difference in resistance was due to variations in the conditions of lubrication of the car journals, and that such variations were chiefly caused by changes in journal temperature. All this is, of course, in accord with the common belief of those experienced in train operation. The reason for discussing it in this place is that the facts stated have influenced the procedure in making calculations for this series of tests.

Since the variations in resistance are so great during the early part of the run, no point or section has been selected for calculation within about the first ten miles of any test. If other points or sections, located farther from the start, were near stops, such points were rejected unless further investigation proved that at these places the train resistance had become nearly uniform in value. Fortunately, the operating conditions were such as to entail few stops on the road, and the selection of points and sections for the calculations has not been unduly limited on these accounts[2].

The effect of these limitations is to make the results of this investigation primarily applicable to trains which have been in motion for some time. Since, however, stops are not usually made upon ruling grades, and since if stops are made at other places on the road, the locomotive has available tractive power in excess of the requirements, the results of these tests are generally applicable in the solution of tonnage rating problems, except where the ruling grade occurs near a yard or other point where the trains are made up. In such cases the tonnage determined from the resistance curves here presented may prove to be somewhat too great.

[1] Further investigation of this matter is in progress, and the results will probably be published soon.

[2] During the 32 tests included in the investigation only 68 stops, all told, were made after leaving the yards. Of these, one was of 55 minutes duration, nine lasted between 20 and 40 minutes, twenty-two between 10 and 20 minutes, and thirty-six less than 10 minutes.

17. *The Derivation of the Resistance Curves.*—The calculations result, for each test, in a series of values of net train resistance at a variety of speeds. These values of resistance were plotted with respect to speed, and gave such a diagram as in Fig. 1.

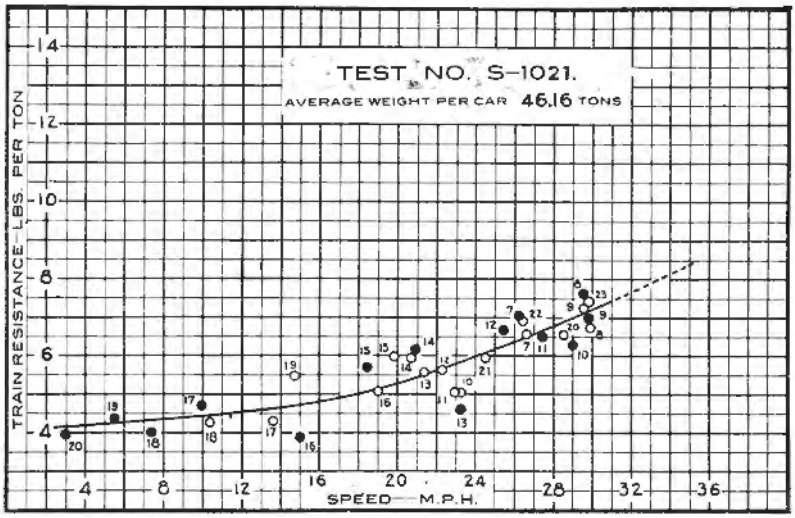

FIG. 1 THE RELATION OF RESISTANCE TO SPEED FOR TEST S-1021

The curve, such as is shown there, was next drawn to express, for the test in question, the relation existing between resistance and speed. In order to draw this curve, the plotted points were assumed to be arranged in a number of groups, and for each group the averages of the values of speed and of resistance were determined. By these averages a new point or "center of gravity" of the group was then plotted. The curve was drawn by confining attention to the few points thus determined. The groups of points were arbitrarily selected so that the resulting "centers of gravity" would be distributed nearly equidistantly throughout the speed range. All curves presented in the report, except those exhibited in Fig. 11, were drawn by this process.

All reasonable precautions have been taken to attain accuracy in the calculations. In determining each value of resistance, each step in the process was duplicated at a different time and generally by a different person. The transcription of all tables, the plotting of points and the drawing of curves have been similarly checked.

VI. The Results of the Tests

18. *Results of the Individual Tests.*—The immediate result of each test is a curve which shows for the train under consideration the relation existing between train resistance and speed. Fig. 1 is such a curve derived from test S-1021; similar curves for the other tests are exhibited in Appendix 5. Fig. 1 is fairly representative of the entire group of curves, and such discussion of it as follows is general in its application.

The plotted points[1] show unmistakably an increase in resistance as the speed increases, and the curve drawn represents the mean relation between resistance and speed. In Fig. 1 the maximum variation from this mean of any calculated value of resistance is about 20 per cent; the next largest variation is 16 per cent and other calculated values of resistance differ from the values determined from the curve by generally less than 10 per cent. In a majority of the tests the maximum variation is less than in Fig. 1, and the general agreement between the calculated values of resistance and the ordinates of the curve is better than in the test chosen for illustration.

It has been thought desirable to express more specifically this variation between the calculated values of resistance and the mean values as derived from the curves drawn. To this end, for all tests, all calculated values of resistance for speeds between 8 and 12 miles per hour were compared with the ordinates of the curves at the corresponding speeds and the percentage difference was determined in each case. These percentages were then arranged in two groups and averaged. The one group included the results from all points lying above the curve, the other from those lying below it. The whole process was next repeated for speeds between 28 and 32 miles per hour. The results are as follows:—

Average Deviation (for all tests) of Calculated Resistance from the Mean Values Derived from the Curves—Expressed in Percentage of the Mean Values.

Speed	Above the Mean	Below the Mean
8 to 12 m. p. h.	6.4 per cent	7.6 per cent
28 to 32 m. p. h.	5.6 per cent	6.6 per cent

[1] The numbers shown near the points are the item numbers of the tables in Appendix 5. The tables exhibit the calculated values of resistance and speed, which are the co-ordinates of the plotted points.

Such variation seems not unduly great for this class of experimental work.

These differences may be due in part to accumulated errors in instruments or in the calculations. In all cases, however, where the calculated value of resistance varied by an unusual amount from the mean, all calculations leading thereto were repeated a second time and errors thus discovered have been eliminated from the report. The explanation for such differences need not be sought further than in the variations which actually occur from time to time, in the resistance itself. Variations in such components of train resistance as flange friction and wind resistance are probably sufficiently great to account for the differences discussed above. The data do not permit the influences of such components of resistance to be differentiated.

The curve drawn for each test has been accepted as representing the average values of net train resistance with a degree of accuracy sufficient for the purpose of rating locomotives. Such temporary excess of resistance as may be expected to occur will generally be absorbed in that reserve in the tractive effort of the locomotive which must be allowed in any system of tonnage rating.

19. *Results of All the Tests.*—The resistance curves for the individual tests have all been brought together on one sheet, a reproduction of which is shown as Fig. 2. The curves there drawn are duplicates of those separately shown in Appendix 5[1]. Fig. 2 displays the immediate results of the whole research. The lower curves give values of resistance varying from 3 lb. to 5½ lb. per ton, while the upper curves show resistance values varying from 7 lb. to 14 lb. per ton. Resistance values at the lower speeds differ by 100 per cent, and values at higher speeds differ by as much as 200 per cent. If further analysis had not revealed the cause of the great variation in resistance here shown, Fig. 2 would have remained a useless exhibit.

The explanation of this variation has been sought in the test conditions enumerated below, each of which, it was conceived, might have contributed in some degree to bring about the differences disclosed in Fig. 2:

(*a*) Weather and temperature conditions.

(*b*) Wind velocity and direction.

[1] The numbers shown on the curves are the last two figures of the test numbers. The curve marked 43 is derived from test S-1043.

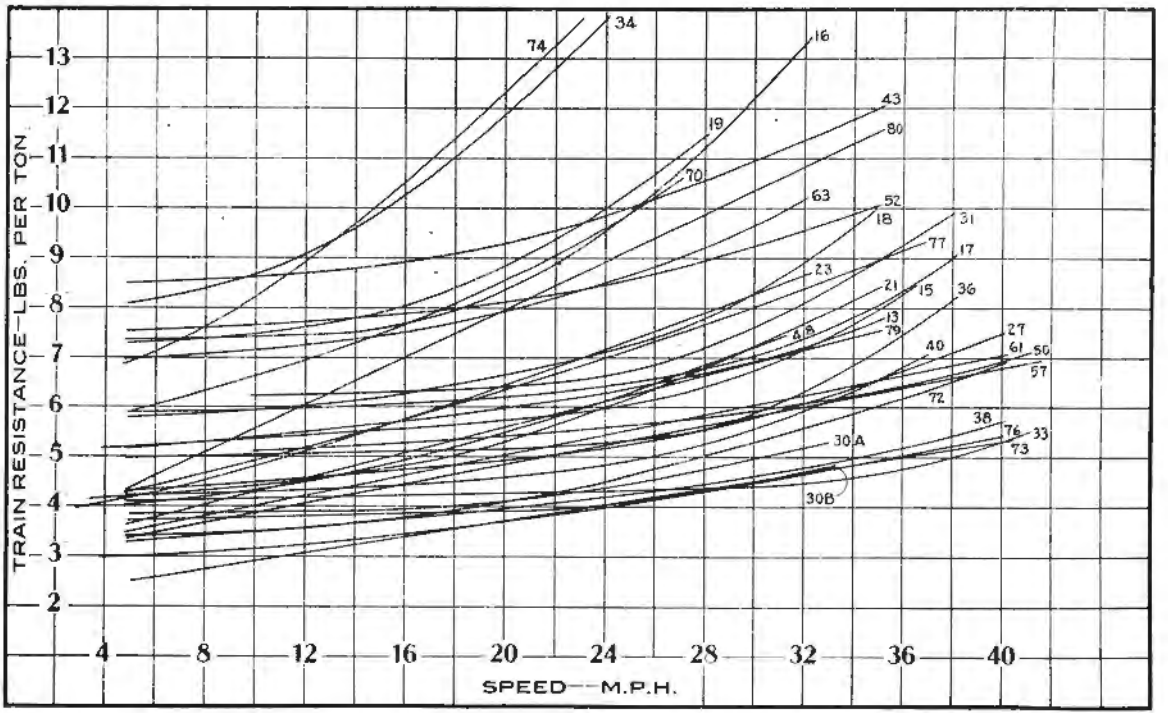

FIG. 2 CURVES SHOWING THE RELATION BETWEEN RESISTANCE AND SPEED FOR EACH OF THE TESTS

(*c*) Kind of cars composing the train.
(*d*) Position of the loaded cars in the train.
(*e*) Defects in train equipment.
(*f*) Average weight of the cars in the train.

The first five conditions are either uncontrollable or were purposely not controlled during these experiments. Attempts to explain the differences between the curves of Fig. 2 by reference to one or the other of these five factors have been altogether unsuccessful. While it is true that difference in wind velocity, for example, might be accepted as a plausible explanation of the differences between two or three curves selected at random from Fig. 2, such explanation will not hold when applied to two or three other curves similarly chosen; and it fails altogether to explain such differences when it is applied to the whole group. The same remarks apply to attempts to explain the differences between the curves of Fig. 2 by referring them to any other of the first five items cited above.

Item *f*, however, has furnished the clue whereby the apparent confusion in the results of the tests, as exhibited in Fig. 2, has been explained. It may be stated at once that the difference in train resistance for various tests is believed to be due chiefly to differences in the average gross car weights existing during the tests. An explanation of the process which led to this opinion follows immediately below. As was stated at the outset, this conclusion was anticipated when the work was begun, and the average car weight was therefore controlled during the experiments, and made to vary through the widest possible range.

20. *The Effects of Car Weight on Resistance.*—The four upper curves of Fig. 2 are derived from trains in which the average weight per car was about 16 or 17 tons. The lowest curves are those derived from trains in which the car weight was nearly 70 tons. These facts serve as a rough indication of the part played by car weight in effecting changes in train resistance. This influence is more definitely brought out in the following discussion.

If from each of the curves of Fig. 2 the value of resistance is determined at one speed, say 5 miles per hour, these values of resistance may then be plotted with respect to their corresponding values of car weight; and, since the speed is common, its influence is eliminated and the resulting diagram may be expected to reveal the relation existing between train resistance and aver-

age weight per car. Table 2 was prepared to facilitate this process. In it the tests are arranged in the order of the average car weights. These weights are given in the second column and in the succeeding columns are set down the resistance values obtained from the *curves* of the individual tests, for each of seven different speeds. Table 2 therefore presents the values of the coordinates of seven points on each of the curves of Fig. 2 and hence, like Fig. 2, summarizes the immediate results of all tests[1].

TABLE 2 VALUES OF RESISTANCE AT VARIOUS SPEEDS, DERIVED FROM THE CURVES FOR THE INDIVIDUAL TESTS. THIS TABLE PROVIDES THE CO-ORDINATES OF THE POINTS PLOTTED IN FIG. 3 TO 9.

Test No.	Aver. Weight per Car tons.	Train Resistance—pounds per ton.						
		5 m. p. h.	10 m. p. h.	15 m. p. h.	20 m. p. h.	25 m. p. h.	30 m. p. h.	35 m. p. h.
S-1016	16.12	7.35	7.40	7.62	8.37	9.91	12.22	
S-1034	16.56	8.10	8.70	9.92	11.90	14.30		
S-1074	16.56	6.92	8.23	10.10	12.32	14.70		
S-1043	16.92	8.50	8.61	8.85	9.30	10.00	10.95	12.01
S-1019	17.72	7.30	7.47	7.90	8.85	10.32		
S-1063	20.01	6.98	7.13	7.43	7.90	8.63	9 63	
S-1031	20.72		6.24	6.30	6.40	6.73	7.60	8.94
S-1080	21.40	4.40	5.57	6.75	7.94	9.15	10.35	11.55
S-1070	24.60	5.93	6.63	7.47	8.57	9.90		
S-1052	24.80	7.55	7.63	7.80	8.10	8.55	9.20	10.05
S-1018	25.40	5.80	5.95	6.20	6.63	7.22	8.26	10.02
S-1077	28.40	4.32	4.91	5.58	6.34	7.15	8.01	8.98
S-1079	33.04	3.66	4.30	4.92	5.60	6.22	6.89	7.55
S-1015	36.08	5.20	5.36	5.52	5.70	6.02	6.71	7.95
S-1036	37.72	4.98	5.03	5.12	5.15	5.31	5.88	7.15
S-1013	38.04		5.40	5.65	5.95	6.32	6.90	7.68
S-1017	38.44	5.90	5.95	6.02	6.20	6.48	7.01	8.03
S-1023	38.72	4.16	4.80	5.56	6 40	7.30	8.25	
S-1050	40.44		5.10	5.25	5.40	5.62	5.90	6.33
S-1057	41.32	3.40	3.88	4.35	4.83	5.31	5.80	6.30
S-1048	45.24	4.05	4.35	4.80	5.48	6.30	7.23	
S-1040	45.76	4.22	4.30	4.40	4.58	4.90	5.52	6.53
S-1021	46.16	4.21	4.41	4.72	5.20	6.15	7.20	8.40
S-1027	47.44	4.31	4.48	4.67	4.90	5.22	5.70	6.55
S-1061	51.20	3.50	4.00	4.51	5.01	5.51	6.01	6.53
S-1033	51.72	4.10	4.15	4.20	4.25	4.32	4.10	4.65
S-1038	52 28	3.30	3.50	3.71	3.95	4.25	4.60	5.08
S-1030B	57.12	3.73	3.80	3.82	3.90	4.10	4.50	
S-1030A	59.88	3.84	3.88	3.92	4.10	4.45	4 95	
S-1072	66.40	3.40	3.50	3.70	4.10	4.61	5.27	6.00
S-1073	67.16	2.52	2 90	3.30	3.70	4.10	4.50	4.90
S-1076	69.92	2.97	3.13	3.37	3.70	4.04	4.49	4.95

In Table 2 the second and third columns present a series of values of average car weight and of train resistance at 5 miles per hour. Each pair of these values represents the results of

[1] Table 2 has been prepared from the original curves of the individual tests, only one of which is separately presented in Part I (see Fig. 1). It gives no information not obtainable from Fig. 2, but presents the information in more convenient form, since the number of curves drawn in the figure makes it confusing.

one of the 32 tests. Using these pairs of values as coordinates, a series of points has been plotted to form a new diagram, Fig. 3. For example, the point marked 21 in Fig. 3 is derived from the curve of test S-1021. The curve of resistance for this test (see Fig. 1 or Fig. 2) shows that at 5 miles per hour the mean resistance is 4.21 lb. per ton. During this test the average weight of the cars in the train was 46.16 tons. Table 2 also exhibits both of these values which, when plotted in Fig. 3, determine the point there marked 21. The other points of Fig. 3 were similarly determined. Each point represents the value of resistance at 5 miles per hour derived from a particular test train.

Although there is considerable variation among the points of Fig. 3, they indicate clearly a decrease in the resistance as the car weight increases. The curve drawn in Fig. 3 represents, for the trains tested, the mean relation which existed between resistance at 5 miles per hour and the average car weight[1]. For higher speeds this relation between resistance and car weight is shown by Fig. 4 to 9, which were derived by the same methods employed in producing Fig. 3.

The variation in resistance represented by the points in Fig. 3 to 9 is sufficient to warrant further discussion. Such discussion will, however, be postponed until later in the report. The conclusion reached is that these variations are largely caused by factors which are uncontrollable in ordinary train operation. If this be admitted, it is clear that the discussion of such variations may enter into the solution of tonnage rating problems only as an argument for reserve tractive effort in the locomotive. An estimate of the desirable amount of such reserve appears beyond.

The curves of Fig. 3 to 9 have been accepted as representing, for these tests, the mean relation which existed between train resistance and the average gross weight of the cars composing the trains. These curves exhibit this relation at seven different speeds, 5, 10, 15, 20, 25, 30 and 35 miles per hour. For convenience in use and to make comparison easier, these seven curves have been brought together in one diagram which is reproduced in Fig. 10.

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[1]As has been previously explained, the curve is drawn by finding the "centers of gravity" of several groups of points. These centers are defined in Fig. 3 to 9 by the crosses within circles. Points 34 and 74 were virtually ignored in drawing the curves of Fig. 6 and 7. The numbers at the points are the last two figures of the test numbers.

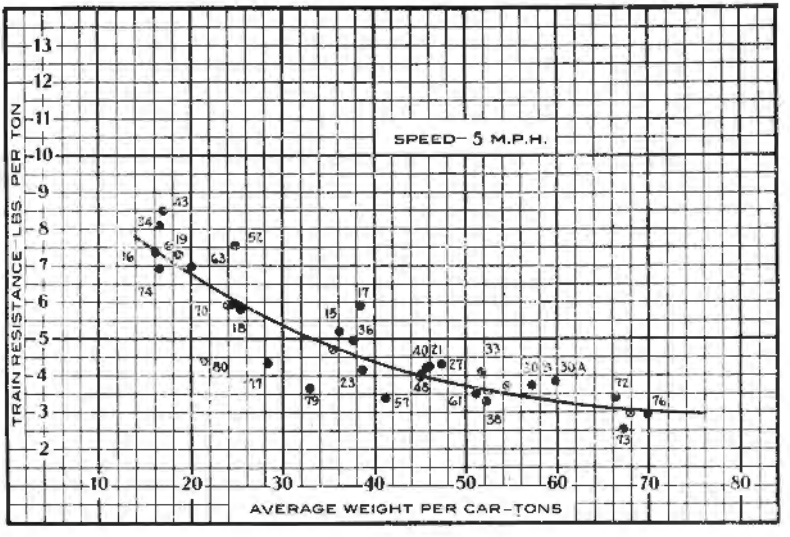

FIG. 3 THE RELATION BETWEEN RESISTANCE AND AVERAGE CAR WEIGHT, AT A SPEED OF 5 MILES PER HOUR

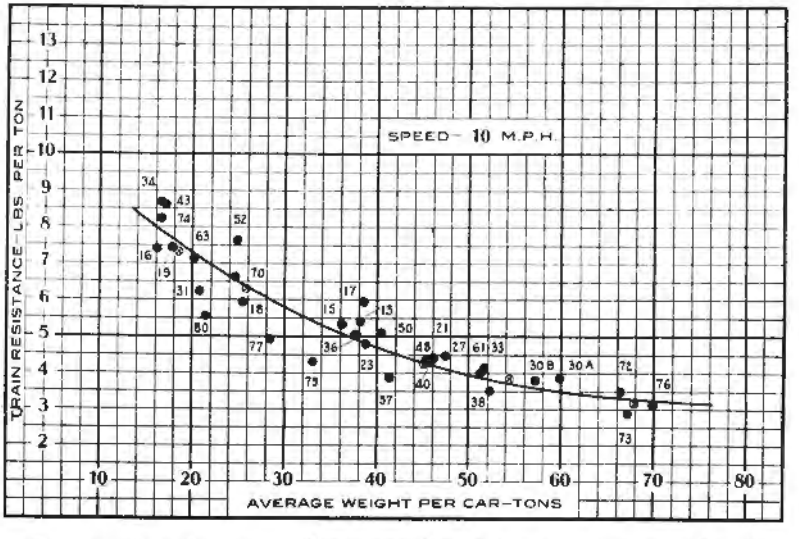

FIG. 4 THE RELATION BETWEEN RESISTANCE AND AVERAGE CAR WEIGHT, AT A SPEED OF 10 MILES PER HOUR

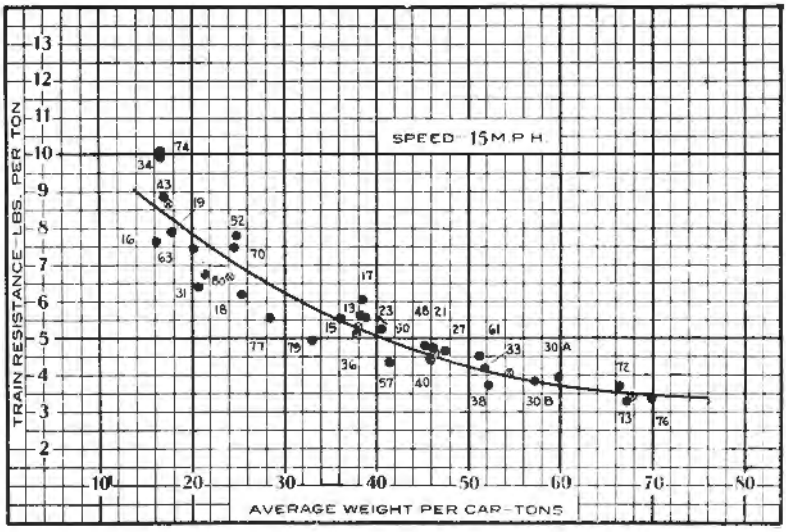

FIG. 5 THE RELATION BETWEEN RESISTANCE AND AVERAGE CAR WEIGHT, AT A SPEED OF 15 MILES PER HOUR

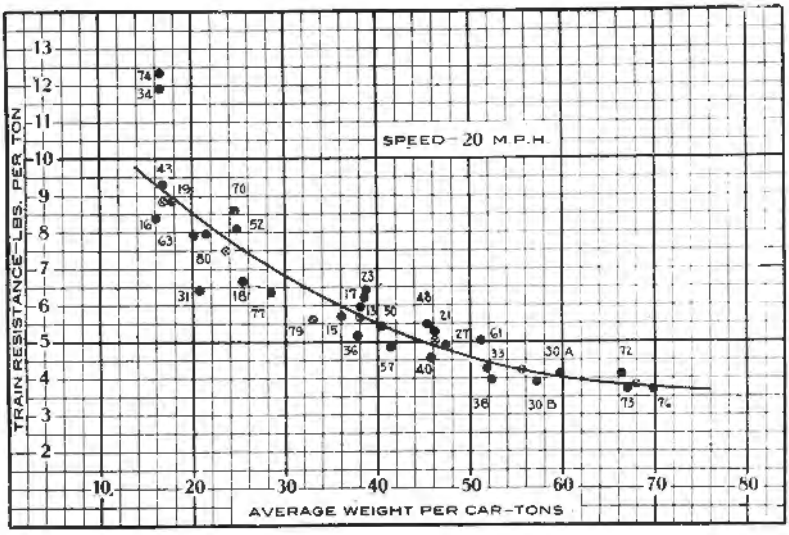

FIG. 6 THE RELATION BETWEEN RESISTANCE AND AVERAGE CAR WEIGHT, AT A SPEED OF 20 MILES PER HOUR

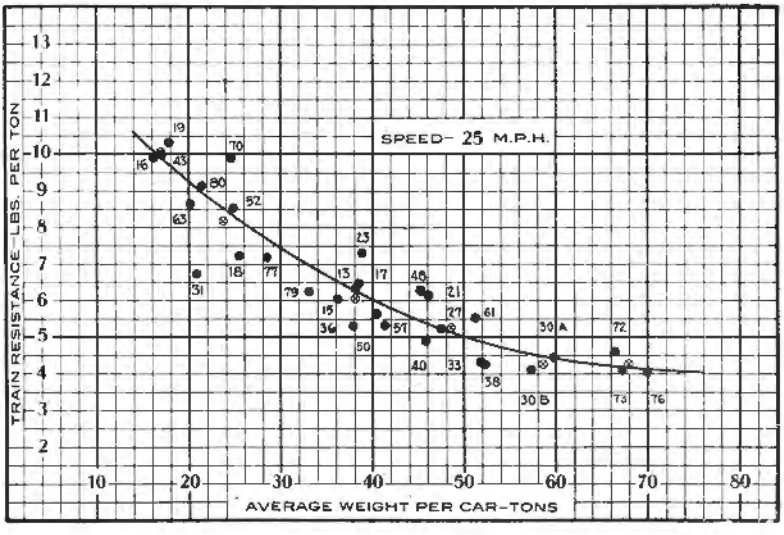

FIG. 7 THE RELATION BETWEEN RESISTANCE AND AVERAGE CAR WEIGHT, AT A SPEED OF 25 MILES PER HOUR

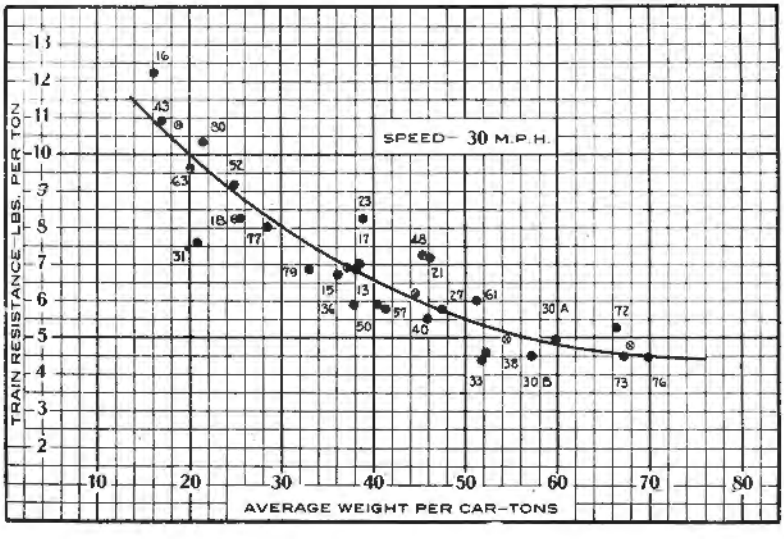

FIG. 8 THE RELATION BETWEEN RESISTANCE AND AVERAGE CAR WEIGHT, AT A SPEED OF 30 MILES PER HOUR

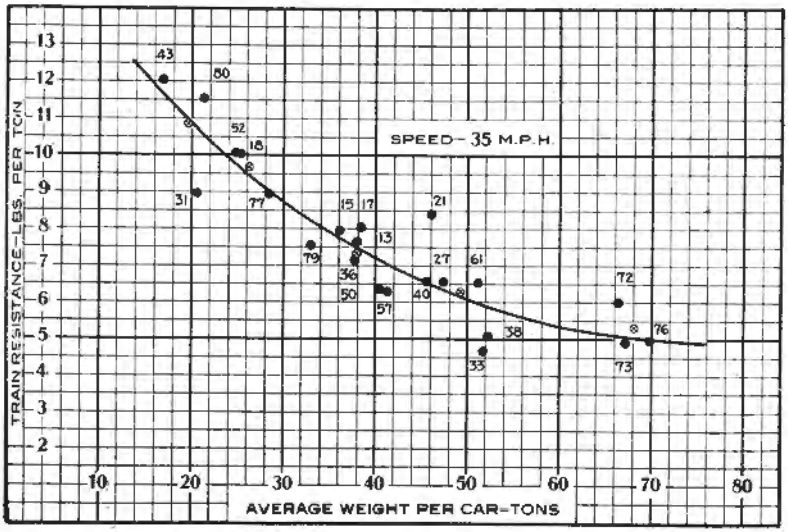

FIG 9 THE RELATION BETWEEN RESISTANCE AND AVERAGE CAR WEIGHT, AT A SPEED OF 35 MILES PER HOUR

Fig. 10 presents the final results of the whole research. Each of the curves there drawn shows the mean relation, which existed during the tests, between car weight and resistance at a definite speed.

It is believed that the curves of Fig. 10 are generally applicable to ordinary American freight trains, provided the conditions surrounding their operation are like those which prevailed during these tests. The curves of Fig. 10 enable one to determine the probable mean resistance of any such train, at speeds between 5 and 35 miles per hour, provided the average weight of the cars composing the train be known.

21. *The Results Expressed as Resistance-Speed Curves.*—While Fig. 10 presents the main results of the experiments, the form in which these results are there expressed is unusual. Ordinarily, train resistance is expressed either as a curve or equation which defines the relation between resistance and speed, instead of the relation between resistance and car weight as in Fig. 10. Obviously, to express the results of these experiments in the usual form, a single curve will not suffice, since the influence of car weight cannot be thereby made evident. A number of curves will

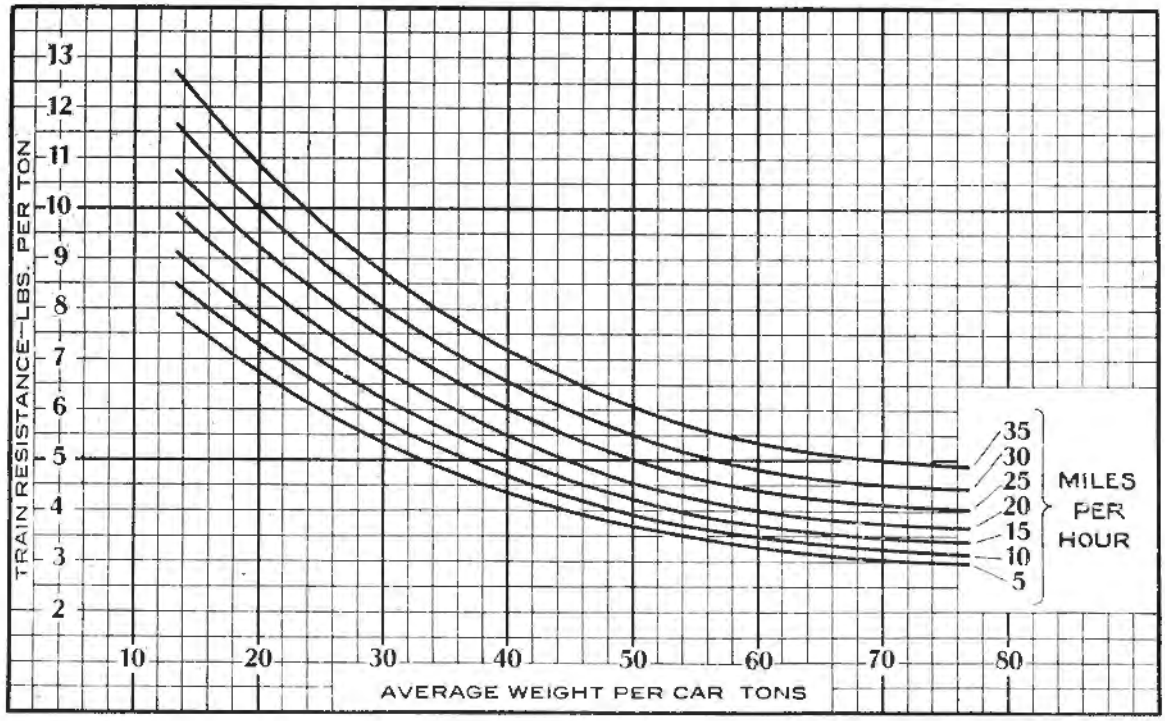

FIG. 10 THE RELATION BETWEEN RESISTANCE AND AVERAGE CAR WEIGHT, AT VARIOUS SPEEDS

be required for this purpose each of which will apply only to a definite average car weight. Fig. 11 presents such a group of resistance-speed curves, which have been derived directly from the curves of Fig. 10. Fig. 11 therefore exhibits in different form only such information as is obtainable from Fig. 10.

The relation between the two figures may be made clear by explaining the derivation of the upper curve in Fig. 11, the one applying to a car weight of 15 tons. In Fig. 10 the ordinate corresponding to an average car weight of 15 tons cuts the seven curves there drawn at 7 points, at which the mean resistance values are 7.62, 8.20, 8.81, 9.56, 10.37, 11.24 and 12.25 lb. per ton, corresponding to speeds of 5, 10, 15, 20, 25, 30 and 35 miles per hour, respectively. These values are the coordinates of 7 points on a resistance-speed curve applying to a car weight of 15 tons. These 7 points have been plotted in Fig. 11 and the upper curve there shown has been passed through them and extended to 40 miles per hour. The other curves of Fig. 11 were derived by a like process. In the original diagram three additional curves, corresponding to 55, 65, and 70 tons per car, were drawn. These three curves have been omitted from the figure to avoid confusion. Fig. 11 reproduces quite exactly the facts presented in Fig. 10[1]; and presents the final results of the experiments.

22. *The Results Expressed in Tabular Form.*—From each of the curves of Fig. 11 the values of resistance at various speeds have been determined and set down in Table 3. Table 3 also includes the coordinates of the resistance curves corresponding to 55, 65, and 70 tons per car, which are omitted from Fig. 11.

23. *The Results Expressed As Equations.*—The relation between resistance and speed shown by each of the curves of Fig. 11 may also be expressed in the form of an equation. Formulas 1 to 13 below are such equations, by means of which resistance may be calculated for any speed and for various car weights. In the formulas, R is the resistance expressed in pounds per ton, S is the speed expressed in miles per hour, and W is the average weight of the cars in the train expressed in tons. The formulas are purely empirical, and are simply equations of parabolas so

[1] The points derived from Fig. 10 have been omitted from the tracing from which Fig. 11 was reproduced. All such points lie very close to the curves drawn in Fig. 11, the maximum deviation amounting to but $\frac{3}{4}$ of one per cent of the corresponding curve ordinate. In Appendix 6 there are presented tables of coordinates, by means of which Fig. 10 and 11 may be exactly reproduced.

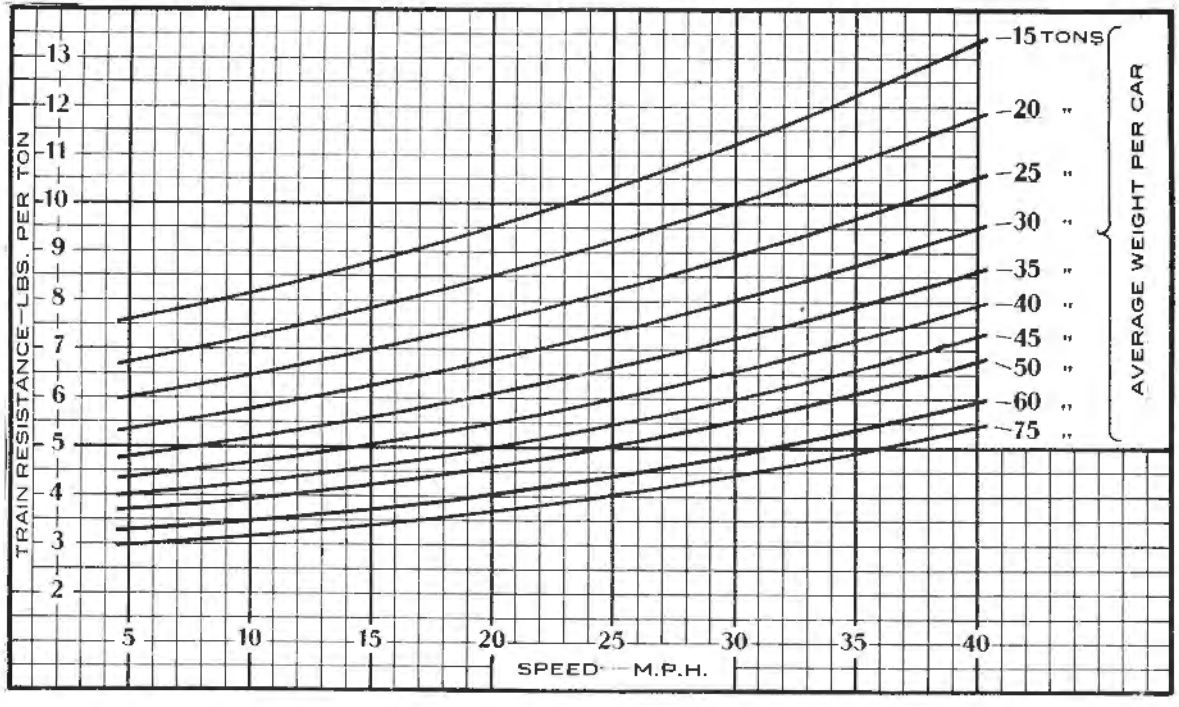

FIG. 11 THE RELATION BETWEEN RESISTANCE AND SPEED, FOR VARIOUS AVERAGE WEIGHTS PER CAR

selected as to correspond very closely with the curves of Fig. 11. The correspondence between the formulas and the curves is such that the maximum difference between any value of resistance obtained by the formulas and the corresponding value obtained from the curves of Fig. 11 is ½ of one per cent. Since these are empirical equations, their use should not be extended beyond the speed limits shown on Fig. 11.

TRAIN RESISTANCE FORMULAS.

When W = 15 tons; $R = 7.15 + 0.085\,S + 0.00175\,S^2$. (1)
When W = 20 tons; $R = 6.30 + 0.087\,S + 0.00126\,S^2$. (2)
When W = 25 tons; $R = 5.60 + 0.077\,S + 0.00115\,S^2$. (3)
When W = 30 tons; $R = 5.02 + 0.066\,S + 0.00116\,S^2$. (4)
When W = 35 tons; $R = 4.49 + 0.060\,S + 0.00108\,S^2$. (5)
When W = 40 tons; $R = 4.15 + 0.041\,S + 0.00134\,S^2$. (6)
When W = 45 tons; $R = 3.82 + 0.031\,S + 0.00140\,S^2$. (7)
When W = 50 tons; $R = 3.56 + 0.024\,S + 0.00140\,S^2$. (8)
When W = 55 tons; $R = 3.38 + 0.016\,S + 0.00142\,S^2$. (9)
When W = 60 tons; $R = 3.19 + 0.016\,S + 0.00132\,S^2$. (10)
When W = 65 tons; $R = 3.06 + 0.014\,S + 0.00130\,S^2$. (11)
When W = 70 tons; $R = 2.92 + 0.021\,S + 0.00111\,S^2$. (12)
When W = 75 tons; $R = 2.87 + 0.019\,S + 0.00113\,S^2$. (13)

The results of the tests may also be approximately expressed by the following single empirical equation in which R is expressed in terms of both S and W.

$$R = \frac{S + 39.6 - 0.031\ W}{4.08 + 0.152\ W} \qquad (14).$$

When compared with the results of the tests as shown in Figure 11, or in Table 69 in Appendix 6, this equation results in a maximum error of 9.5 per cent. This error occurs when $S = 21$ and $W = 55$. For all other values of S and W the error resulting from the use of the equation is 9.0 per cent or less.

24. *Final Results.*—The final results of the research are presented in Fig. 11, in Table 3, and in formulas 1 to 13. It is believed that by means of the figure, or the table or the formulas, the resistance of ordinary freight trains may be fairly accurately predicted; provided the conditions surrounding their operation are similar to those which prevailed during these tests. These conditions have been fully stated and are restated in the conclusions.

It is sufficient to repeat at this point that the results apply to trains running at uniform speed, on tangent and level track of good construction, during weather when the temperature is not lower than 30° F., and when the wind velocity does not exceed about 20 miles per hour.

TABLE 3

VALUES OF RESISTANCE AT VARIOUS SPEEDS AND FOR TRAINS OF DIFFERENT AVERAGE WEIGHTS PER CAR.

The values are derived directly from the curves of Fig. 11 and represent the final results of the tests.

Speed miles per hour	Train Resistance—Pounds per ton													Speed miles per hour
	Column Headings Indicate the Average Weights Per Car													
	15 tons	20 tons	25 tons	30 tons	35 tons	40 tons	45 tons	50 tons	55 tons	60 tons	65 tons	70 tons	75 tons	
5	7.6	6.8	6.0	5.4	4.8	4.4	4.0	3.7	3.5	3.3	3.2	3.1	3.0	5
6	7.7	6.9	6.1	5.5	4.9	4.4	4.1	3.8	3.5	3.3	3.2	3.1	3.0	6
7	7.8	7.0	6.2	5.5	5.0	4.5	4.1	3.8	3.6	3.4	3.2	3.1	3.1	7
8	8.0	7.1	6.3	5.6	5.0	4.6	4.2	3.9	3.6	3.4	3.3	3.2	3.1	8
9	8.1	7.2	6.4	5.7	5.1	4.6	4.2	3.9	3.6	3.4	3.3	3.2	3.1	9
10	8.2	7.3	6.5	5.8	5.2	4.7	4.3	4.0	3.7	3.5	3.3	3.2	3.2	10
11	8.3	7.4	6.6	5.9	5.3	4.8	4.3	4.0	3.7	3.5	3.4	3.3	3.2	11
12	8.4	7.5	6.7	6.0	5.4	4.8	4.4	4.0	3.8	3.6	3.4	3.3	3.3	12
13	8.6	7.6	6.8	6.1	5.5	4.9	4.5	4.1	3.8	3.6	3.5	3.4	3.3	13
14	8.7	7.8	6.9	6.2	5.5	5.0	4.5	4.2	3.9	3.7	3.5	3.4	3.4	14
15	8.8	7.9	7.0	6.3	5.6	5.1	4.6	4.2	3.9	3.7	3.6	3.5	3.4	15
16	9.0	8.0	7.1	6.4	5.7	5.1	4.7	4.3	4.0	3.8	3.6	3.5	3.5	16
17	9.1	8.1	7.2	6.5	5.8	5.2	4.8	4.4	4.1	3.9	3.7	3.6	3.5	17
18	9.3	8.3	7.4	6.6	5.9	5.3	4.8	4.5	4.1	3.9	3.7	3.7	3.6	18
19	9.4	8.4	7.5	6.7	6.0	5.4	4.9	4.5	4.2	4.0	3.8	3.7	3.6	19
20	9.6	8.5	7.6	6.8	6.1	5.5	5.0	4.6	4.3	4.0	3.9	3.8	3.7	20
21	9.7	8.7	7.7	6.9	6.2	5.6	5.1	4.7	4.3	4.1	3.9	3.9	3.8	21
22	9.9	8.8	7.9	7.0	6.3	5.7	5.2	4.8	4.4	4.2	4.0	3.9	3.8	22
23	10.0	9.0	8.0	7.1	6.4	5.8	5.3	4.9	4.5	4.3	4.1	4.0	3.9	23
24	10.2	9.1	8.1	7.3	6.6	5.9	5.4	4.9	4.6	4.3	4.2	4.1	4.0	24
25	10.4	9.3	8.3	7.4	6.7	6.0	5.5	5.0	4.7	4.4	4.2	4.1	4.0	25
26	10.5	9.4	8.4	7.5	6.8	6.1	5.6	5.1	4.8	4.5	4.3	4.2	4.1	26
27	10.7	9.6	8.5	7.7	6.9	6.2	5.7	5.2	4.8	4.6	4.4	4.3	4.2	27
28	10.9	9.7	8.7	7.8	7.0	6.3	5.8	5.3	4.9	4.7	4.5	4.4	4.3	28
29	11.1	9.9	8.8	7.9	7.1	6.5	5.9	5.4	5.0	4.8	4.6	4.5	4.4	29
30	11.3	10.0	9.0	8.0	7.3	6.6	6.0	5.5	5.1	4.9	4.7	4.5	4.5	30
31	11.4	10.2	9.1	8.2	7.4	6.7	6.1	5.6	5.2	5.0	4.8	4.6	4.5	31
32	11.6	10.4	9.3	8.3	7.5	6.8	6.2	5.8	5.3	5.0	4.9	4.7	4.6	32
33	11.8	10.5	9.4	8.5	7.6	7.0	6.3	5.9	5.4	5.2	5.0	4.8	4.7	33
34	12.0	10.7	9.6	8.6	7.8	7.1	6.5	6.0	5.5	5.3	5.1	4.9	4.8	34
35	12.3	10.9	9.7	8.8	7.9	7.2	6.6	6.1	5.7	5.4	5.2	5.0	4.9	35
36	12.5	11.1	9.9	8.9	8.0	7.4	6.7	6.2	5.8	5.5	5.3	5.1	5.0	36
37	12.7	11.2	10.0	9.0	8.2	7.5	6.9	6.4	5.9	5.6	5.4	5.2	5.1	37
38	12.9	11.4	10.2	9.2	8.3	7.6	7.0	6.5	6.0	5.7	5.5	5.3	5.2	38
39	13.1	11.6	10.4	9.4	8.5	7.8	7.1	6.6	6.2	5.8	5.6	5.4	5.3	39
40	13.4	11.8	10.6	9.5	8.6	7.9	7.3	6.8	6.3	6.0	5.7	5.6	5.5	40

VII. DISCUSSION OF THE RESULTS

25. *Variation in Resistance of Different Trains.*—Reference has been made to the variations among the points of Fig. 8 to 9. In

each figure about one half of the points lie above the curve there drawn, and their resistance values vary from those of the curve by different amounts. It should be borne in mind that, in these figures, each point represents the average resistance which prevailed throughout a particular test, and differences among the points represent, therefore, differences in the mean resistance of the different trains.

Among those trains which are regarded as normal there are two or three whose resistance at some speed varies from the mean, as expressed in the curves, by as much as 23 per cent. The great majority, however, vary from this mean by about 10 per cent or less. In Fig. 4, for example, there are 19 points which lie above the curve, among which the maximum deviation from the mean is 23 per cent, while the average of the deviations for all 19 points is 8 per cent. The following table presents similar average deviations above and below the mean for each of Fig. 3 to 9.

AVERAGE DEVIATION OF ALL POINTS IN FIG. 3 TO 9, FROM THE MEAN AS SHOWN BY THE CURVES THERE DRAWN.—EXPRESSED AS PERCENTAGES OF THE CURVE ORDINATES.

	Fig. 3 5 m. p. h.	Fig. 4 10 m. p. h.	Fig. 5 15 m. p. h.	Fig. 6 20 m. p. h.	Fig. 7 25 m. p. h.	Fig. 8 30 m. p. h.	Fig. 9 35 m. p. h.
Points above the curve	11	8	8	11	13	8	7
Points below the curve	13	10	9	8	9	9	9

The data present no satisfactory general explanation for these differences in the resistance of different trains of like average weight per car. They may be due to difference in external conditions or to difference in train condition and make-up. Whatever may be the explanation for these differences it is significant that about one-half of the trains experimented upon developed a resistance about 9 per cent in excess of the mean resistance which would be predicted by the use of Fig. 3 to 9 and Fig. 10 and 11. Obviously a similar excess may be expected with any train, and it is suggested therefore that, in determining the resistance of trains on *level tangent track* for the purpose of rating locomotives under operating conditions which demand conservative ratings, 9 per cent be added to the resistance values obtained from the curves, tables, and equations presented. Such considerations are

of little practical importance in rating locomotives for speeds above 15 miles per hour. In such cases an excess in resistance over that expected can result in nothing more serious than failure to realize the expected train speed.

It should be understood that this 9 per cent allowance is intended to cover probable variations in the resistance of different trains under normal operating conditions. It in no way takes the place of that additional reserve which must be allowed to cover unusual variations in resistance due to low temperatures or high winds, or of that reserve in tractive effort of the locomotive which is necessitated by operating conditions which reduce the efficiency of the locomotive itself.

26. *Tests Which Present Abnormal Resistance Values.*—There are four points in Fig. 3 to 9 whose deviation from the curves is so great as to demand special examination. These are the points corresponding to tests S–1034, S–1074, S–1080, and S–1031 (points 34, 74, 80, and 31). These tests show a persistent and great variation from the mean at various speeds. The trains of tests 1034, 1074, and 1080 were alike in having average car weights less than 23 tons and in containing a large proportion of empty gondolas, 99, 98, and 84 per cent, respectively. Any explanation based on the train composition is however nullified by the fact that the trains of tests No. 1016, 1043, and 1063, which show close correspondence with the curves, had similar average car weights and contained almost equally large proportions of empty gondolas. Weather and wind conditions likewise offer no explanation of the divergences presented by these three tests. Explanations are rendered more difficult by the fact that, while the trains of tests 1034 and 1074 show unusually high resistance, the resistance in test 1080 is exceptionally low. The abnormalities presented by these three trains have therefore been accepted as unexplained by the data at hand.

The resistance of the trains of the fourth test mentioned above (S-1031) is low at all speeds. This train had an average car weight of 20.7 tons, contained 94 per cent of box cars, and was only 1425 ft. long. Other test trains of similar average car weight differ from this in having generally less than 60 per cent of box cars and in being all 2400 ft. or more in length. Taking into consideration all the data, neither fact seems, however,

to offer an adequate explanation of the variations exhibited by this train.

27. *Car Weight as a Basis of Expression.*—Objection may be made to the form of expression adopted in Fig. 8 to 9 and 10, in which the resistance is expressed solely in terms of average car weight, to the apparent neglect of the influence of those elements of resistance, such as air resistance, which are independent of weight and which probably vary only with the number of cars in the train. The neglect is only apparent, however, for the process by which Fig. 10 was derived involves, although indirectly, the recognition of the influence of the number of cars. It is quite likely that, if Fig. 10 were applied to determine the total resistance of a single car, the result would be in error.

Whatever objection may be urged against the form of expression adopted, it remains true that Fig. 10 rests upon experimental results obtained with trains of usual length and that in practice one is not likely to encounter trains which present in this respect any extreme variation from the test data. The form of expression will not lead to error unless misapplied and it was chosen because it permits the results to be conveniently used in establishing tonnage ratings.

It might likewise have been more rational to express the resistance in terms of load per axle instead of load per car, since the latter can operate to cause variations in resistance only in so far as it affects the former. Since, however, all American freight cars have four axles, the expression in either form would be identical. Convenience in application warrants the choice made in this respect also.

28. *Effect of Variety in Car Weight upon Total Train Resistance.*—In Fig. 10 those portions of the curves which apply to average car weights below 20 tons were derived from trains which were quite homogeneous in their make-up as regards weight per car. These trains were necessarily composed almost exclusively of empty cars, since an average car weight of 20 tons or less cannot be obtained with cars of current design unless they are empty or nearly so, and being empty they will be uniform in weight. Similarly for average car weights above 55 or 60 tons, the test trains were necessarily uniform in make-up. For trains of average car weights below 20 and above 60 tons, the curves of Fig. 10 are ac-

cepted, therefore, as valid and applicable to any train to be met with in practice.

In Fig. 10, those portions of the curves corresponding to car weights of from 20 to 60 tons were, on the other hand, derived from trains which presented considerable diversity in make-up as regards weight per car. Some of these trains were composed almost entirely of loaded cars, others contained large proportions of both empty and loaded cars. In presenting the results in the form adopted in Fig. 10 (and Fig. 11) the assumption is that the curves there drawn will be used throughout their entire range of average car weight to determine the total resistance of both homogenous and mixed trains, and that, when so applied, they will lead to no material error. In view of the facts just stated it is pertinent to inquire whether this assumption is justifiable.

Assume two trains of equal tonnage, and of the same average weight per car. Assume further that one is composed of cars uniform in weight, and that the other is composed of cars of different individual weights. Now if such trains are to have equal total resistance, it can be shown that the variation in the resistance *per car* of the individual cars must be directly proportional to their weight. This implies that the curve showing the relation between *total car resistance* and car weight at a given speed must be a straight line, if homogeneous and mixed trains are to have equal total resistances at this speed. From Fig. 10 there have been derived curves showing this relation between car resistance and car weight. These curves (not shown in the report) correspond quite closely, but not exactly, with straight lines; and the correspondence is especially close for those portions of the curves which apply to car weights between 20 and 60 tons. From these facts we may conclude that the curves of Fig. 10 are not quite, but are nearly equally applicable to mixed and homogeneous trains, and that, if the curves are applied to both kinds of trains, we may expect a slight error in the resulting total train resistance. The amount of such error is indicated by the following examination of a specific case.

Assume two trains, A and B, the first homogeneous, the second mixed, as regards car weight. Train A is composed of 60 cars, each weighing 45 tons, and its total weight is 2700 tons. Train B is composed of 30 cars of 70 tons each, and 30 cars of 20

tons each; its total weight is 2700 tons and its average car weight is 45 tons. Train B presents about as great a diversity in car weight as may be encountered in current practice. Both trains have equal tonnage and the same average weight per car. Assume that the total resistance of these two trains at a speed of 5 miles per hour is to be determined. By the procedure, which it is intended shall usually be followed in using Fig. 10, the resistance for an average car weight of 45 tons, at 5 miles per hour, is found to be 4.0 lb. per ton; and the total resistance of either train A or train B is 2700 x 4.0 = 10 800 lb.

Train B, however, may be considered as made up of two shorter homogeneous trains of average car weights of 20 and 70 tons respectively and the resistance of each may be determined from those portions of the curves of Fig. 10, about whose validity no question is raised. From Fig. 10, the resistance at 5 miles per hour for a car weight of 20 tons is found to be 6.8 lb. per ton and for a car weight of 70 tons, 3.1 lb. per ton. By the use, therefore, of these portions of the curves of Fig. 10, the total resistance of train B is found to be 30 x 20 x 6.8 + 30 x 70 x 3.1 = 10 590 lb., which differs from the resistance previously found by 2 per cent. If a similar analysis be made for a speed of 40 miles per hour, the corresponding difference is found to be 4 per cent. If these differences be accepted as a measure of the maximum error likely to result from the indiscriminate application of the curves of Fig. 10 to mixed and homogeneous trains, we may conclude that for purposes of rating locomotives the results of the tests as expressed in Fig. 10 and 11 and Table 3 may be so applied without material error.

29. *The Influence of Speed on Resistance.*—Within the last two years the opinion has been expressed in some quarters that train resistance between speeds of 5 and 35 miles per hour is constant. It is proper to point out that there is nothing in the data here presented to support such a conclusion.

30. *The Influence of Wind Velocity on Resistance.*—The wind velocities prevailing during the tests were generally less than 20 miles per hour. The data do not permit the influence of such winds to be differentiated from the other elements affecting resistance; but they do warrant the conclusion that this influence is small. In the introduction, train resistance was defined as the

resistance in still air, whereas throughout the report the term is used to apply to the test results from which the influence of wind has not been eliminated. This inconsistency has been deliberately incurred to avoid unwieldy expression and is partially justified by the facts just stated.

31. *Comparison with Other Experiments.* -There is no point in comparing the results of these tests with formulas in which the influence of car weight is given no consideration, nor with those which are not derived from tests with American cars of recent design. The results obtained on the Chicago, Burlington and Quincy Railroad and on the Pennsylvania Railroad, and recently published by Mr. F. J. Cole,[1] take into consideration the influence of car weight and they apply to cars of recent design. They are therefore selected for comparison.

The results obtained on the Chicago, Burlington and Quincy road (curve No. 1, for temperatures above 30° F. and no wind) apply to a speed of 20 miles per hour. Compared with the curve for 20 miles per hour in Fig. 10, they show resistance values which are from 35 to 60 per cent lower than the corresponding results of these tests. The Pennsylvania Railroad results are claimed to be equally applicable at all speeds between 5 and 30 miles. When plotted on Fig. 10 of this report they show very close correspondence with the curve there drawn for 10 miles per hour, for car weights from 25 to 70 tons; while for car weights below 25 tons they indicate resistance values as much as 20 per cent in excess of the results obtained during these tests.

[1] Railway Age Gazette, August 27 to October 1, 1909.

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APPENDIX 1

APPENDIX 1

Railway Test Car No. 17

The dynamometer car by means of which these tests were made was built in 1900. Under the arrangements perfected at that time, the car was built and has since been maintained by the Illinois Central Railroad, while the University has supplied all apparatus, and has manned and operated the car. Both the car body and the apparatus were remodeled in 1907[1].

The car body was especially designed for its purpose. It is 40 ft. long over the end sills, and 8 ft. 4 in. wide inside. The central sills and the platforms are of steel, while the remainder of the construction is of wood. The general design of the car is shown in Fig. 12, and an interior view is shown in Fig. 13. The working space occupies about two thirds of the length of the car, and in it are placed the recording apparatus, the auxiliary instruments, the storage batteries, work-bench, etc.

During the tests, the test car apparatus made continuous autographic records of drawbar pull, speed, time, mile post positions, airbrake cylinder pressure, wind velocity with respect to the car, and wind direction with respect to the longitudinal axis of the car. These records are made upon a chart 36 in. wide, drawn across the table of the recording apparatus. This chart was driven by gearing from the axle of the central truck below the car, so that its travel was proportional to the travel of the car itself. In all tests a car travel of one mile produced a paper travel of 13.2 in. A view of the recording apparatus is shown in Fig. 14.

Fig. 15 is reproduced from a tracing of a portion of the chart made during test S-1057 of this series. The only lines there shown which do not appear on the original record are the profile and the transverse lines which mark the limits of one of the sections selected for calculation. These lines and some of the explanatory lettering have been added to the tracing, in order to make clearer the significance of the various records.

The total pull which comes upon the measuring drawbar of the car is transmitted to oil contained in the receiving cylinder, the design of which is shown in Fig. 16. This cylinder is hung

[1] A more detailed description of the present equipment is contained in an article by F. W. Marquis, in the Railway Age Gazette February 15, 1909.

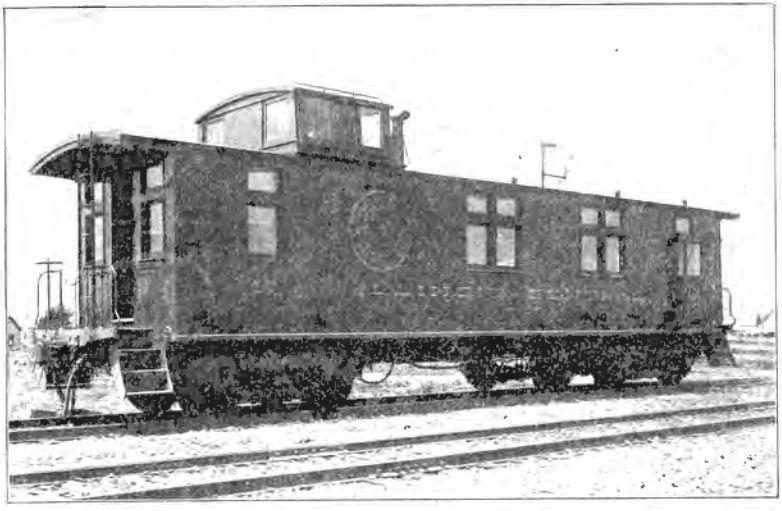

FIG. 12 RAILWAY TEST CAR NO. 17

FIG. 13 INTERIOR OF TEST CAR NO. 17

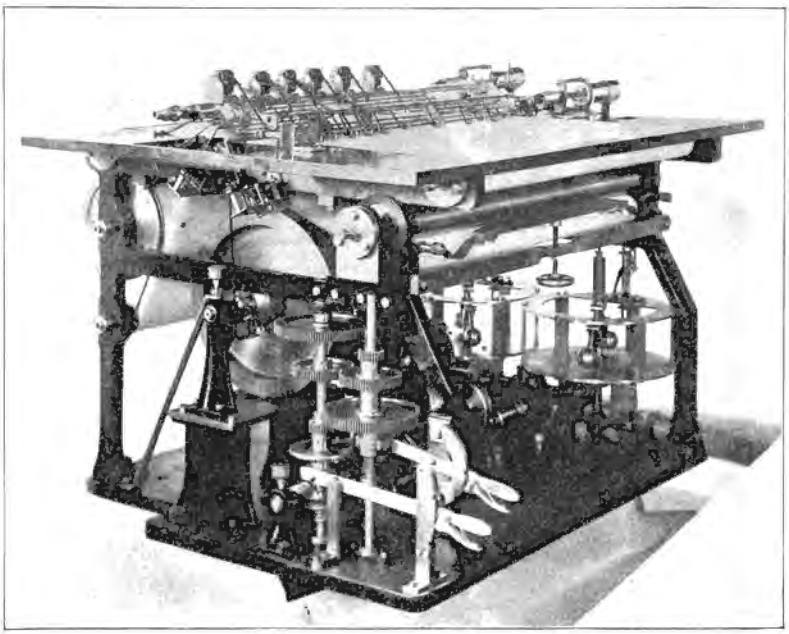

FIG. 14 THE RECORDING APPARATUS

from the center sills, immediately behind the drawbar yoke. Its inside diameter is 10 in., and its piston is 7½ in. long. Both cylinder and piston are carefully ground to an exact fit and no piston packing is used. The pull is transmitted from the drawbar yoke to the piston through a roller-borne yoke; and the whole device is practically frictionless. Such leakage of oil as takes place proceeds so slowly as to prove no inconvenience, even when operating under maximum pull. The cylinder may be refilled with oil by means of a pump within the car, and this is done while the car is in operation and without impairing the accuracy of the record. The pressure of the oil in this receiving cylinder is transmitted to the cylinder of an indicator located upon the table within the car. This indicator is identical, in its design, with one of the modern types of steam engine indicators, although it is larger and heavier throughout. During its ten years of service this type of dynamometer has demonstrated its reliability and accuracy.

Two speed records are shown on the chart, and both are used. The one is obtained from a speed recorder which resembles in design a "fly-ball" engine governor. This instrument is used in measuring speeds above 15 miles per hour. The second record is obtained from a chain-driven Boyer speed recorder, geared to run at a speed about three times as great as is usual with these instruments. This record is used for speeds up to 35 miles per hour. Within their respective ranges, both instruments produce accurate speed curves.

The air-brake cylinder of the test car is connected to the cylinder of an ordinary steam engine indicator, which is mounted upon the table and which draws a curve of air-brake cylinder pressure.

The velocity of the wind with respect to the car is obtained by means of a Robinson cup-anemometer of the standard United States Weather Bureau type, which is so mounted that the cups revolve 32 in. above the car roof. This instrument controls an electric circuit, which operates an electro-magnet connected to the recording pen. By means of this magnet offsets are made in the line drawn by the pen. During the time which elapses between two successive offsets, the travel of the air past the cups amounts to 0.2 of a mile.

The direction of the wind with respect to the longitudinal axis of the car is derived from a wind vane mounted 3 ft. above the car roof. The spindle of the vane extends downward to a point above the recording apparatus and terminates there in a crank, parallel to the vane. This crank is connected to the recording pen through a rod with a yoke end. The ordinate of the curve drawn by this pen is proportional to the sine of the angle made by the vane with the car axis. The offsets in the datum line for this curve, which appear in Fig. 15, indicate that the vane, at the moment, was pointed toward the front end of the car. While the vane points toward the rear end no offsets are made in the datum line.

Fig. 15 shows a record of "area under the curve of pull" which is made by means of a recording planimeter mounted on the table. This record is inaccurate and was not used in these calculations.

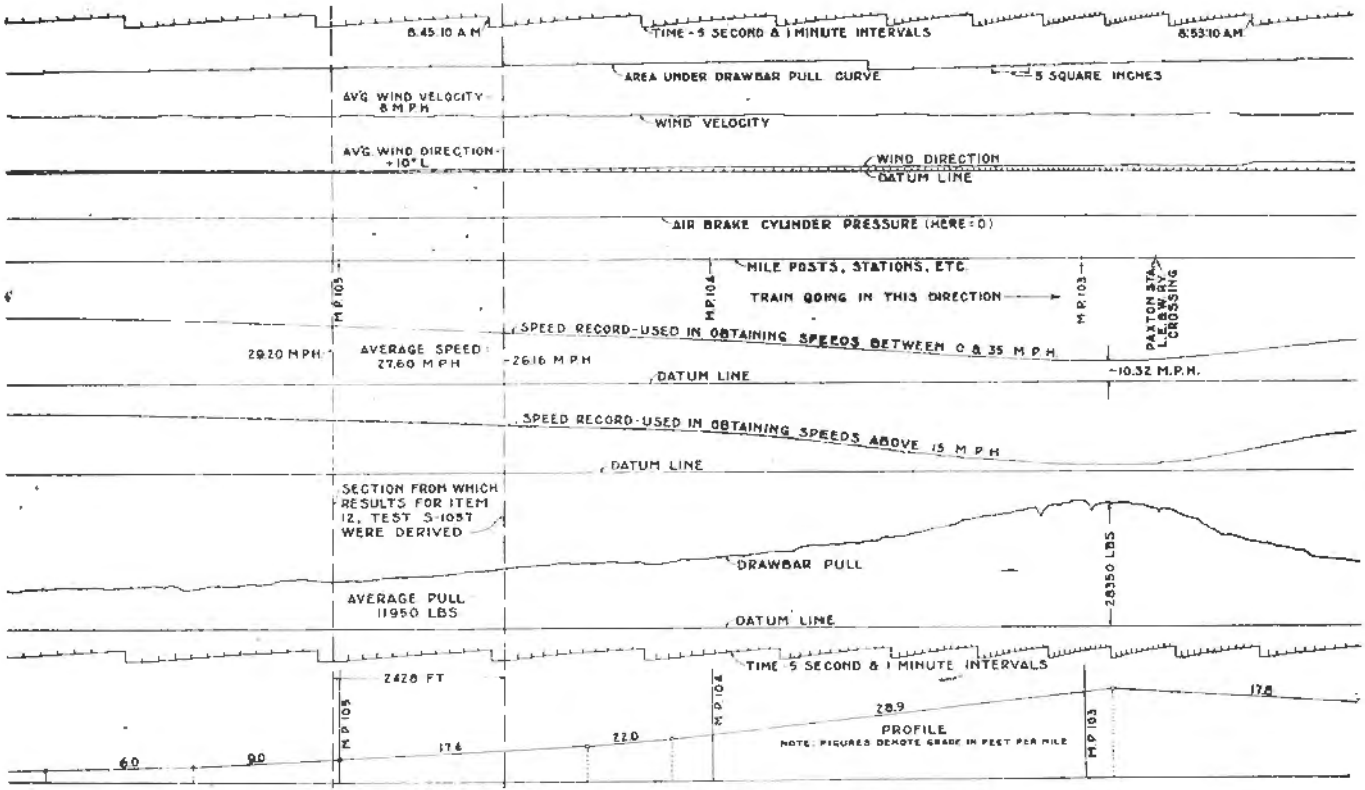

FIG. 15 A PORTION OF THE CHART FROM TEST S-1057

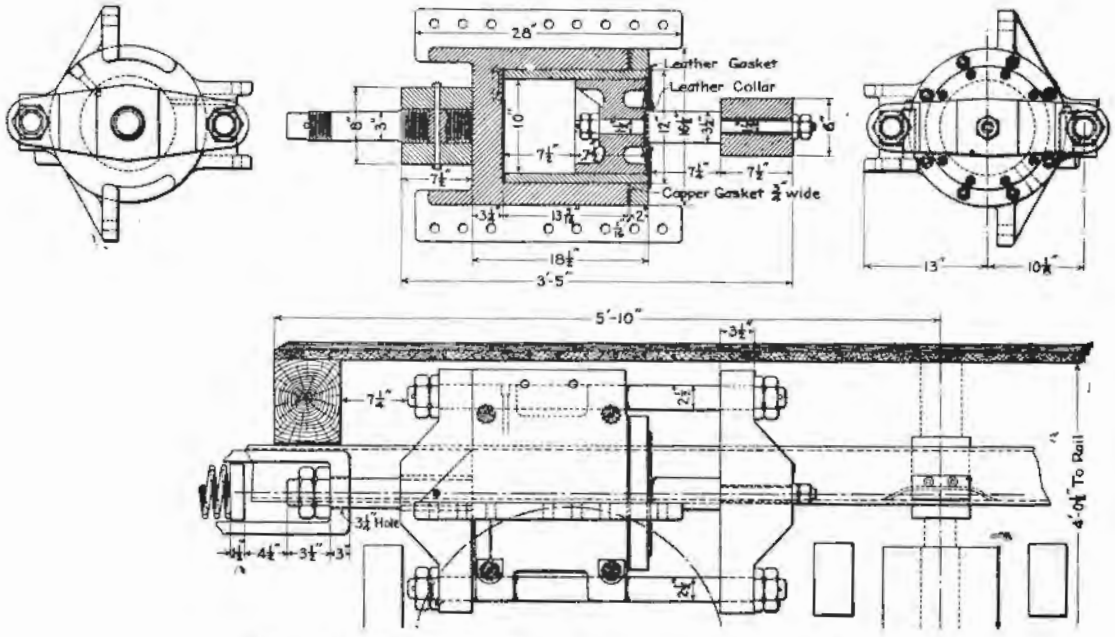

FIG. 16 THE RECEIVING CYLINDER OF THE DYNAMOMETER

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APPENDIX 2

APPENDIX 2

The Tonnage Records of The Trains

Tables 4 to 35 present the records of make-up and tonnage of the trains. The car numbers are arranged in the tables in the order in which the cars were placed in the train, beginning at the head end.

With the few exceptions cited in Part I, the weights given in the last column of the tables were obtained by weighing the train on the track scales. In all tests the dynamometer car was coupled immediately behind the locomotive tender. In the tonnage records for those tests in which the test car ran with its measuring drawbar pointed toward the rear of the train, the test car weight is excluded, since in such cases its own resistance is not included in the pull recorded on the chart.

TABLE 4 TONNAGE RECORD

Test No. S-1013

Kind of Car	Loaded or Empty	Car No.	Car Initial	Stenciled Light Weight	Capacity	Gross Weight
	L or E			pounds	pounds	pounds
Test Car	E			58 000		58 000
Gondola	L	82 386	I. C.	28 700	60 000	92 300
Refrigerator	E	6 641	N. C. L.		60 000	36 400
Box	L	48 857	I. C.	39 100	80 000	96 200
"	"	36 476	"	37 000	80 000	92 000
"	"	92 329	N. C. & St. L.	33 300	60 000	95 000
"	"	9 842	N. C. & St. L.	33 400	60 000	94 000
"	"	37 668	I. C.	34 600	80 000	107 000
"	"	14 301	"	29 200	60 000	72 700
Refrigerator	E	726	C. B. T.			38 200
Box	L	38 254	I. C.	34 000	80 000	58 700
Gondola	"	85 604	"	31 500	80 000	105 100
Box	"	39 840	"	38 900	80 000	82 400
"	"	9 337	L. & N.	34 500	65 000	69 300
"	"	94 116	"	35 400	65 000	64 700
"	"	3 135	"	34 000	65 000	89 600
Refrigerator	E	5 260	A. R. L.	36 500	50 000	38 100
Box	L	39 404	I. C.	38 300	60 000	122 000
Gondola	E	16 778	Erie	42 800	100 000	42 600
Box	L	38 711	I. C.	37 600	80 000	86 500
"	"	5 078	N. C. & St. L.	38 300	60 000	76 000
"	"	3 954	L. & N.	33 100	65 000	94 000
"	"	133 684	S. O.	33 200	60 000	68 000
Gondola	"	3 193	I. S.	40 200	100 000	147 800
Tank	"	704	B. T. R.			78 500
"	"	540	D. R. & U.			80 000
"	"	293	A. C. O.			88 100
Gondola	"	82 968	I. C.	28 400	60 000	83 700
Box	"	34 623	"	37 100	60 000	68 100
"	"	19 773	"	28 300	60 000	62 600
"	"	47 730	"	30 600	80 000	108 700
"	"	130 091	"	42 300	80 000	88 100
"	"	14 834	"	31 600	60 000	74 000
Refrigerator	"	5 223	M. R. T.			50 600
Box	"	48 273	I. C.	39 700	80 000	99 600
"	"	38 741	"	34 500	80 000	119 200
"	"	36 076	"	35 700	80 000	122 000
"	"	49 417	"	35 200	80 000	90 000
"	"	34 147	"	37 000	80 000	92 300
"	"	136 690	S. O.	34 300	60 000	87 800
"	"	32 645	"	31 800	60 000	36 600
"	"	17 853	I. C.	29 900	60 000	63 900
"	"	45 691	"	39 400	80 000	100 000
"	"	38 217	"	34 000	80 000	74 300
Gondola	"	93 582	"	30 400	80 000	115 600
Box	"	47 588	"	41 600	80 000	89 300
"	"	140 760	"	42 900	100 000	76 600
"	"	45 432	"	36 300	80 000	123 300
"	"	12 104	"	28 800	60 000	64 300
"	"	22 796	"	37 500	80 000	113 600
"	L	48 388	"	39 700	80 000	63 500
"	E	22 742	L. S. & M. S.	29 300	60 000	31 000
"	L	36 825	I. C.	33 900	80 000	72 000
Gondola	"	79 267	"	24 800	50 000	27 000
Box	"	12 784	"	28 300	80 000	63 000
Gondola	"	81 750	"	26 700	60 000	65 500
Refrigerator	E	275	B. T.	28 000	60 000	32 000
Box	"	11 972	W. C.	29 900	80 000	29 300
"	L	12 658	I. C.	37 400	80 000	63 000
"	E	45 051	"	36 000	60 000	67 000
"	L	20 070	"	28 500	60 000	84 000
"	"	17 783	"	29 800	60 000	63 000
"	"	141 980	"	43 700	100 000	74 000
"	"	15 026	"	30 000	60 000	70 000
Gondola	"	6 232	S. I.	28 500	60 000	80 000
Refrigerator	"	6 003	A. R. L.	34 800	50 000	45 100
Caboose	E	98 018	I. C.	34 000		34 000

TABLE 5 TONNAGE RECORD

Test No. S-1015

Kind of Car	Loaded or Empty	Car No.	Ca Initial	Stenciled Light Weight	Capacity	Gross Weight
	L or E			pounds	pounds	pounds
Gondola	L	89 299	I. C.	32 000	80 000	82 000
"	"	91 712	"	29 400	80 000	80 000
Box	"	130 646	"	42 300	80 000	92 000
Tank		500	Champ'n stock	32 100	60 000	86 000
Box	"	24 678	I. C.	36 000	80 000	67 000
"	"	23 251	"	25 200	80 000	92 300
"	"	140 501	"	42 700	100 000	81 500
"	"	141 254	"	43 500	100 000	96 300
Tank		185	A. P. L.			78 000
Box	"	8 457	I. C.	30 100	50 000	93 100
"	"	26 732	"	36 100	80 000	114 400
"	"	13 635	"	28 900	60 000	84 600
"	"	11 069	"	30 200	60 000	86 600
"	"	23 530	"	36 100	80 000	98 000
"	"	12 235	"	28 800	60 000	90 900
"	"	17 652	"	28 900	60 000	83 300
"	"	37 500	"	34 100	80 000	100 000
"	"	39 126	"	36 700	80 000	95 500
"	"	17 644	"	30 000	60 000	75 800
"	"	12 774	"	30 400	60 000	81 400
"	"	33 668	"	36 100	80 000	84 300
"	"	6 985	"	27 700	50 000	80 600
Gondola	"	86 493	"	30 800	60 000	102 000
Box	"	83 722	S. Pa.	33 900	80 000	123 000
"	"	5 000	A. R. L.	34 800	50 000	38 500
"	"	11 598	N. C. & St. L.	33 200	60 000	99 100
"	"	6 902	N. C. & St. L.	29 900	60 000	96 100
"	"	35 113	S. L. & S. F.	35 100	60 000	80 400
"	"	29 220	I. C.	38 100	60 000	53 500
Gondola	"	91 289	"	29 000	80 000	70 600
Flat	"	8 146	I. S.	33 200	100 000	115 500
Box	"	39 343	I. C.	36 600	80 000	95 000
"	"	141 804	"	43 500	100 000	84 500
"	"	141 686	"	43 500	100 000	103 500
"	E	25 376	M.St.P.&S.SM	33 500	60 000	33 600
"	L	140 755	I. C.	42 900	100 000	48 500
"	"	58 092	U. P.	25 800	50 000	72 800
"	"	15 503	I. C.	28 800	60 000	70 000
"	E	13 330	C. G. W.	30 000	60 000	29 700
Flat	L	10 638	V.	24 500	60 000	33 800
"	"	10 521	V.	21 200	60 000	31 700
Box	"	45 514	I. C.	39 100	80 000	78 600
"	"	142 175	"	42 800	100 000	81 300
"	"	22 064	"	37 800	80 000	76 000
"	"	46 450	"	37 600	80 000	78 000
"	"	58 576	"	33 800	80 000	85 000
Refrigerator	"	33 476	C. & N. W.	32 200	50 000	50 000
Box	"	12 530	I. C.	30 500	60 000	59 600
Tank	"	990	A. P. L.			82 300
Box	"	46 660	I. C.	38 000	80 000	67 400
"	"	49 154	"	35 200	80 000	70 300
Refrigerator	"	6 502	U. R. T. C.	30 860	100 000	47 700
Flat	"	65 228	I. C.	23 900	60 000	71 200
Box	"	140 108	"	42 900	100 000	125 600
Refrigerator	"	4 531	N. C. L.		50 000	41 600
Tank	"	150	A. T. L.			80 100
"	"	153	"			78 600
"	"	1 017	"			82 000
Box	"	140 161	I. C.	42 700	100 000	73 600
Tank	"	904	A. T. L.			81 100
Box	E	82 244	C. & N. W.	32 600	80 000	32 800
Flat	L	1 549	C. H. & D.	21 400	50 000	26 000
"	"	1 799	"	21 700	40 000	38 400
"	"	67 930	I. C.	26 800	80 000	35 700
"	"	878	G. & S. I.			54 700
"	E	30 237	C. & H. R.	27 000	80 000	27 100
"	"	16 056	P. M.	22 600	60 000	22 400
Flat	"	8 249	N.Y.N.H. & H.	28 900	80 000	28 800
Caboose	"	98 100	I. C.			40 000

TABLE 6 TONNAGE RECORD

Test No. S-1016

Kind of Car	Loaded or Empty	Car No.	Car Initial	Stenciled Light Weight	Capacity	Gross Weight
	L or E			pounds	pounds	pounds
Test	E	17				58 000
Gondola	"	93 191	I. C.	35 300	80 000	35 300
"	"	90 844	"	32 900	80 000	32 900
"	"	88 459	"	31 500	80 000	31 500
"	"	94 843	"	31 700	80 000	31 700
"	"	82 365	"	26 800	60 000	26 800
"	"	92 596	"	30 200	80 000	30 200
"	"	81 323	"	28 600	80 000	28 600
"	"	93 948	"	31 800	80 000	31 800
"	"	84 190	"	27 000	60 000	27 000
"	"	252	S. S. C.	25 500	50 000	25 500
"	"	616	E. F. D. & Co.	23 700	50 000	23 700
"	"	85 594	I. C.	31 400	80 000	31 400
"	"	84 200	"	27 400	80 000	27 400
"	"	95 241	"	30 100	80 000	30 100
"	"	3 252	I. S.	40 300	100 000	40 300
"	"	82 622	I. C.	27 800	80 000	27 800
"	"	106 404	"	40 300	100 000	40 300
"	"	93 494	"	29 600	80 000	29 600
"	"	86 663	"	31 100	80 000	31 100
"	"	96 262	"	31 800	80 000	31 800
"	"	95 707	"	30 800	80 000	30 800
"	"	83 544	"	28 200	60 000	28 200
"	"	93 960	"	31 300	80 000	31 300
"	"	87 697	"	33 500	80 000	33 500
"	"	96 082	"	31 400	80 000	31 400
"	"	76 634	"	25 700	50 000	25 700
"	"	91 067	"	30 200	80 000	30 200
"	"	91 424	"	30 000	80 000	30 000
"	"	89 402	"	32 000	80 000	32 000
"	"	115 127	"	42 600	100 000	42 600
"	"	106 777	"	40 300	100 000	40 300
"	"	104 930	"	40 600	100 000	40 600
"	"	95 782	"	31 500	80 000	31 500
"	"	104 131	"	40 600	100 000	40 600
"	"	92 338	"	30 800	80 000	30 800
"	"	81 653	"	26 400	60 000	26 400
"	"	96 137	"	31 000	80 000	31 000
"	"	88 950	"	31 800	80 000	31 800
"	"	115 043	"	43 200	100 000	43 200
"	"	80 128	"	28 900	60 000	28 900
"	"	94 357	"	30 900	80 000	30 900
"	"	96 123	"	31 200	80 000	31 200
"	"	91 024	"	31 000	80 000	31 000
"	"	84 272	"	27 500	60 000	27 500
"	"	85 516	"	29 400	80 000	29 400
"	"	88 283	"	31 600	80 000	31 600
"	"	87 090	"	30 900	80 000	30 900
"	"	83 604	"	27 300	60 000	27 300
"	"	80 933	"	27 500	60 000	27 500
"	"	83 243	"	28 000	60 000	28 000
"	"	85 694	"	30 800	80 000	30 800
"	"	75 812	"	26 000	50 000	26 000
"	"	85 649	"	30 700	80 000	30 700
"	"	88 925	"	31 900	80 000	31 900
"	"	93 575	"	31 100	80 000	31 100
"	"	104 318	"	40 800	100 000	40 800
"	"	86 327	"	30 400	80 000	30 400
"	"	94 273	"	30 100	80 000	30 100
"	"	80 921	"	28 200	60 000	28 200
"	"	82 167	"	26 900	60 000	26 900
"	"	101 116	"	38 500	100 000	38 500
"	"	86 515	"	30 400	80 000	30 400
"	"	88 352	"	31 200	80 000	31 200
"	"	104 944	"	40 200	100 000	40 200
"	"	105 533	"	40 500	100 000	40 500
"	"	262	S. S. C.	30 600	80 000	30 600
"	"	89 849	I. C.	32 000	80 000	32 000
"	"	95 296	"	30 000	80 000	30 000
"	"	93 197	"	31 400	80 000	31 400
"	"	106 428	"	40 300	100 000	40 300
Caboo se	"	98 172	"	40 000		40 000

TABLE 7 TONNAGE RECORD

Test No. S-1017

Kind of Car	Loaded or Empty	Car No.	Car Initial	Stenciled Light Weight	Capacity	Gross Weight
	L or E			pounds	pounds	pounds
Box	L	32 302	I. C.	32 500	60 000	96 500
Gondola	"	3 363	I. S.	40 300	100 000	140 800
Box	"	9 009	I. C.	27 700	50 000	74 000
"	"	48 654	"	38 500	80 000	96 100
"	"	12 968	"	29 200	60 000	65 100
"	"	150 887	"	30 000	40 000	73 700
"	"	17 772	"	29 400	60 000	80 800
"	"	10 673	"	31 700	60 000	96 800
"	"	130 783	"	42 300	80 000	130 600
"	"	150 961	"	30 500	40 000	75 900
"	"	11 350	"	29 700	60 000	69 300
Refrigerator	"	6 638	U. R. T.	34 800	40 000	52 000
Box	"	141 330	I. C.	43 700	100 000	76 000
"	"	141 589	"	43 600	100 000	114 000
"	"	24 682	"	35 800	80 000	80 000
"	"	22 896	"	37 000	80 000	86 000
"	"	24 158	"	35 500	80 000	72 000
"	"	22 041	"	37 800	80 000	86 000
"	E	107 946	C. & N. W.	36 600	80 000	37 000
"	L	47 421	I. C.	41 500	80 000	116 000
"	"	10 485	"	29 400	80 000	92 800
"	"	130 247	"	42 400	80 000	132 000
"	"	22 942	"	36 800	80 000	123 800
"	"	22 968	"	36 600	80 000	115 700
"	"	141 969	"	43 500	100 000	119 500
"	"	32 317	"	31 100	60 000	98 400
"	"	22 318	"	38 200	80 000	56 700
"	"	11 165	"	30 300	60 000	71 800
"	"	8 390	"	31 200	60 000	77 500
"	"	142 726	"	42 800	100 000	62 000
"	"	7 698	L. & N.	28 400	60 000	60 000
"	"	1 807	"	34 200	65 000	98 000
Refrigerator	E	4 056	M. R. T.	40 400	80 000	40 000
Box	"	53 873	C. R. I. & P.	32 400	60 000	32 000
"	"	56 432	C. M. & St. P.	29 900	60 000	29 000
"	L	35 199	I. C.	36 800	80 000	105 200
"	E	10 428	W. C.	29 400	60 000	29 700
"	"	2 786	A. & W. P.	35 000	65 000	33 200
Refrigerator	"	397	W. R. T.	34 700	40 000	35 000
Gondola	"	1 025	C. & I. W.	32 200	100 000	32 000
Box	L	49 236	I. C.	34 800	80 000	103 000
"	"	14 943	"	30 800	60 000	84 600
"	"	17 142	"	30 500	60 000	84 000
"	"	22 404	"	27 900	80 000	109 000
"	"	150 265	"	29 300	40 000	65 000
"	"	5 298	Ga.	31 800	60 000	73 100
"	"	14 010	I. C.	32 200	60 000	68 900
"	"	36 980	"	31 300	80 000	81 000
"	"	48 699	"	39 300	80 000	59 300
"	"	48 721	"	39 200	80 000	77 500
"	"	21 715	"	36 200	80 000	81 500
"	"	1 292	I. L. & M.	29 200	60 000	113 000
"	"	142 255	I. C.	42 900	100 000	97 500
"	"	45 525	"	39 300	80 000	75 700
Refrigerator	E	9 056	C. R. D.	34 600		34 600
Box	L	48 739	I. C.	39 100	80 000	74 100
"	"	45 762	"	40 300	80 000	78 700
"	E	38 636	"	34 100	80 000	35 300
"	L	22 995	"	35 100	80 000	94 300
Gondola	"	108 302	"	40 300	100 000	90 500
Box	E	72 344	C. M. & St. P.	30 400	60 000	29 000
"	L	19 840	I. C.	29 300	60 000	64 300
"	"	17 625	"	29 300	60 000	58 000
"	E	64 590	N. & W.	39 500	80 000	38 800
"	L	45 386	I. C.	38 700	80 000	79 800
Caboose	E	98 023	"			40 000

TABLE 8 TONNAGE RECORD

Test No. S-1018

Kind of Car	Loaded or Empty	Car No.	Car Initial	Stenciled Light Weight	Capacity	Gross Weight
	L or E			pounds	pounds	pounds
Test	E	17				58 000
Box	L	28 594	A. T. & S. F.	36 700	70 000	113 800
"	"	73 246	C. & N. W.	29 800	80 000	92 600
"	E	49 016	I. C.	39 300	60 000	44 200
"	L	18 179	"	29 700	80 000	38 400
Gondola	"	104 113	"	40 800	100 000	131 400
Box	E	46 485	"	37 800	80 000	43 400
"	L	24 331	S. A. L.	28 900	60 000	39 200
"	E	5 372	L. R. & M.	34 600	60 000	34 400
"	"	251	O. G. & N. E.	38 700	80 000	38 800
"	"	19 944	South	31 900	60 000	33 600
Gondola	"	180 614	"	40 100	100 000	37 200
Box	"	56 649	L. & N.	41 100	50 000	42 800
"	L	45 413	Big 4.	38 100	80 000	82 200
"	"	49 161	T. C.	35 800	80 000	59 400
"	E	68 250	C. & N. W.	30 000	60 000	39 200
"	L	39 546	"	33 500	80 000	51 000
Locomotive		423	I. C.			145 200
Flat	L	66 644	"	20 000	80 000	65 800
Tank	"	6 059	S. I.		8 000 Gal.	35 200
"	E	6 052	"		8 000 Gal.	41 600
"	"	6 239	"		8 000 Gal.	39 000
"	"	6 233	"		8 000 Gal.	39 400
"	"	6 054	"		8 000 Gal.	38 400
"	"	6 190	"		8 000 Gal.	39 800
"	"	600	I. T. Co.	30 000	80 000	39 200
Box	"	130 857	I. C.	41 000	80 000	80 800
Tank	L	680	S. C. O. Co.	48 100	12 500 Gal.	49 200
Gondola	"	3 175	I. S.	40 400	100 000	148 000
"	E	273	S. C. Co.	30 700	80 000	35 800
Locomotive		732	I. C.			223 600
Box	E	30 105	M. L. & T.	33 100	80 000	33 400
"	"	11 571	A. G. S.	34 700	60 000	34 400
"	"	2 004	D. & W.	36 900	60 000	36 200
"	"	14 533	L. & N.	33 300	65 000	34 800
"	L	558 937	Penn.	45 400	100 000	71 400
"	"	84 494	P. R. R.	30 800	60 000	55 600
"	E	9 230	N. C. & St. L.	33 300	60 000	34 000
"	L	9 264	"	30 200	60 000	34 600
"	E	6 316	"	29 100	60 000	29 800
"	"	135 068	South	33 500	60 000	33 500
"	"	13 161	"	33 800	60 000	33 800
"	"	13 761	St. L. & S. F.	34 000	60 000	34 000
"	"	32 482	South	35 600	60 000	34 000
Flat	"	1 276	G. S. I.	28 600	80 000	27 000
"	"	803	M. C.	28 500	80 000	28 500
"	"	621	"	28 500	80 000	28 500
"	"	413	G. S. F.	27 200	60 000	27 800
"	"	553	"	27 200	60 000	27 600
"	"	709	"	27 500	80 000	27 500
Caboose	"		I. C.			40 000

TABLE 9 TONNAGE RECORD

Test No. S-1019

Box	E	46 712	I. C.	38 100	80 000	38 100
"	"	38 898	"	36 700	80 000	38 600
"	"	14 965	"	30 100	60 000	30 400
"	"	35 160	"	36 900	80 000	36 900
Flat	L	500	A. T. L. Co.	41 720	60 000	103 000
Box	"	25 173	I. C.	37 100	80 000	70 000
"	"	19 287	S. A. L.	33 300	80 000	62 000
"	"	11 539	N. C. & St. L	33 800	60 000	4 300
"	"	997	P. M	34 400	50 000	50 100
"	"	1 853	D & M.	33 100	60 000	71 100
"	"	3 768	N. C. & St. L	37 100	60 000	62 600
"	"	57 378	C. M. & St. P	29 900	80 000	70 000
"	"	33 580	I. C.	36 000	80 000	74 000
"	E	55 968	L. & N.	41 400	55 000	42 000
"	"	46 836	I. C.	38 100	80 000	36 500
"	L	16 200	"	30 000	50 000	30 000

TABLE 9 TONNAGE RECORD—(*Continued*)

Kind of Car	Loaded or Empty	Car No.	Car Initial	Stenciled Light Weight	Capacity	Gross Weight
	L or E			pounds	pounds	pounds
Box	E	12 296	I. C.	29 400	60 000	89 000
"	"	12 302	"	29 700	60 000	90 000
"	"	37 189	"	34 500	80 000	35 000
"	"	24 525	"	36 400	80 000	36 400
"	"	37 157	"	33 600	80 000	34 500
Gondola	"	88 956	"	31 900	80 000	32 000
"	"	90 907	"	30 900	80 000	32 000
"	"	81 808	"	28 800	60 000	28 000
"	"	96 187	"	30 500	80 000	32 100
"	"	87 235	"	31 400	80 000	31 400
"	"	86 619	"	30 900	80 000	30 800
Box	"	30 249	T. R. E.	38 700	50 000	38 700
Refrigerator	"	19 529	C. F. X.	34 400	50 000	37 200
Tank	L	6 278	C. T. L.	47 000		95 200
Box	E	45 216	I. C.	37 400	80 000	37 200
"	"	142 342	"	42 700	100 000	42 700
"	E	141 780	"	43 600	100 000	43 100
"	L	7 613	"	27 100	50 000	27 100
Gondola	E	105 880	"	40 399	100 000	40 400
"	"	86 524	"	31 200	80 000	31 400
"	"	104 438	"	40 700	100 000	40 800
"	"	106 223	"	40 400	100 000	41 000
"	"	94 144	"	31 000	80 000	32 000
"	"	93 670	"	30 000	80 000	30 400
"	"	5 470	"	23 200	50 000	23 100
"	"	94 433	"	30 900	80 000	30 600
"	"	87 576	"	31 500	80 000	32 100
"	"	81 635	"	27 700	60 000	26 900
"	"	87 931	"	31 900	80 000	31 800
"	"	88 493	"	30 800	80 000	31 100
"	"	89 415	"	31 700	80 000	32 100
"	"	90 560	"	32 200	80 000	32 300
"	"	83 302	"	28 400	60 000	28 400
"	"	83 372	"	28 600	60 000	28 600
"	"	92 680	"	30 900	80 000	30 900
"	"	95 924	"	31 700	80 000	32 100
"	"	89 504	"	32 000	80 000	32 400
"	"	91 813	"	29 600	80 000	30 000
"	"	86 821	"	32 200	80 000	32 300
"	"	81 851	"	28 700	60 000	28 900
"	"	90 634	"	32 300	80 000	32 500
"	"	82 958	"	28 400	60 000	28 400
"	"	91 289	"	29 000	80 000	30 100
"	"	89 443	"	31 800	80 000	32 100
"	"	95 945	"	31 800	80 000	32 000
"	"	94 941	"	31 000	80 000	30 900
"	"	85 915	"	31 600	80 000	31 900
"	"	87 758	"	31 000	80 000	31 800
"	"	91 822	"	30 400	80 000	30 600
"	"	91 482	"	30 300	80 000	30 400
"	"	96 285	"	32 000	80 000	32 000
"	"	83 017	"	27 300	60 000	28 100
"	"	101 052	"	38 500	100 000	39 500
Box	"	82 279	"	28 100	60 000	28 200
"	"	31 042	I. S.	36 300	60 000	36 500
"	"	22 320	I. C.	31 000	60 000	31 500
Gondola	"	6 391	"	24 200	60 000	24 200
"	"	94 066	"	30 500	80 000	31 100
"	"	90 487	"	31 600	80 000	31 900
"	"	86 903	"	31 000	80 000	31 000
"	"	93 952	"	31 400	80 000	31 700
"	"	91 861	"	33 700	80 000	33 100
"	"	86 214	"	30 700	80 000	31 100
"	"	88 076	"	31 700	80 000	31 400
"	"	90 050	"	31 000	80 000	31 000
"	"	85 151	"	31 300	80 000	31 200
"	"	83 526	"	27 300	60 000	27 900
Flat	"	790	"	27 100	60 000	27 000
"	"	1 202	M. C.	28 100	80 000	28 100
"	"	590	C. S. I	27 400	80 000	27 400
"	"	272	C. S. I	24 400	60 000	29 400
"	"	825	M. C.	28 500	80 000	28 400
Caboose	"	98 800	I. C.			40 000

TABLE 10 TONNAGE RECORD

Test No. S-1021

K Car	Loaded or Empty	Car No.	Car Initial	Stenciled Light Weight	Capacity	Gross Weight
	L or E			pounds	pounds	pounds
Test	E	17				58 000
Gondola	L	97 430	I. C.	31 400	100 000	104 600
"	"	95 341	"	30 100	80 000	105 000
"	"	88 198	"	33 000	80 000	98 000
"	"	105 823	"	40 400	100 000	152 000
"	"	90 733	"	31 400	80 000	107 000
"	"	87 110	"	32 000	80 000	108 300
"	"	88 418	"	32 000	80 000	105 600
"	"	84 458	"	30 800	60 000	87 000
"	"	88 321	"	32 600	80 000	109 000
"	"	81 982	"	29 400	60 000	88 000
"	"	91 087	"	30 700	80 000	110 700
"	"	92 434	"	31 400	80 000	108 200
"	"	110 325	"	41 600	100 000	135 800
"	"	3 380	I. S.	40 400	100 000	144 000
"	"	83 881	I. C.	28 900	60 000	87 700
"	"	84 313	"	27 300	60 000	86 000
"	"	92 813	"	30 700	80 000	110 000
"	"	100 242	"	33 100	90 000	124 400
Box	"	47 936	"	39 000	80 000	104 000
"	"	17 469	"	29 000	60 000	70 600
Tank	E	6 355	C. T. L.			38 300
"	"	6 315	"			37 800
Box	L	22 469	I. C.	38 600	80 000	81 700
"	"	9 858	N. C. & St. L.	33 200	60 000	66 200
Gondola	"	104 238	I. C.	40 500	100 000	148 500
"	"	89 092	"	32 500	80 000	115 500
"	"	101 130	"	36 700	100 000	134 700
"	"	82 069	"	29 000	60 000	88 000
"	"	81 382	"	26 900	60 000	83 000
Box	"	130 860	"	42 300	80 000	98 000
"	"	82 292	S. P.	34 200	80 000	75 000
"	"	56 120	C. & N. W.	31 500	50 000	58 000
"	"	12 655	I. C.	29 000	60 000	58 000
Flat	"	66 686	"	28 000	80 000	105 000
"	"	131 191	"	39 500	80 000	95 000
Refrigerator	E	9 547	A. R. L.	38 700	50 000	40 000
Box	L	7 304	H. & T. C.	30 400	60 000	69 000
"	"	130 987	I. C.	42 300	80 000	78 000
Gondola	"	86 023	"	31 200	80 000	118 000
Refrigerator	E	2 130	C. R. D.			41 000
Box	"	74 674	C. & N. W.	34 000	80 000	34 000
Gondola	L	104 603	I. C.	40 500	100 000	149 000
"	"	104 872	"	40 000	100 000	146 000
"	"	105 603	"	40 200	100 000	143 800
Refrigerator	E	6 417	A. R. L.	31 300	50 000	35 800
"	"	50 504	I. C.	35 600	50 000	36 000
Flat	L	807	G. & S. I.	26 400	80 000	61 800
Box	"	39 641	I. C.	36 300	80 000	47 900
Refrigerator	E	3 031	P. B. C.	30 700	40 000	33 700
Box	L	11 344	H. & B.	42 000	100 000	111 200
Gondola	"	87 136	I. C.	31 700	80 000	112 400
"	"	83 896	"	26 600	60 000	86 000
"	"	90 589	"	33 300	80 000	112 000
"	"	87 685	"	31 800	80 000	109 400
"	"	93 498	"	31 000	80 000	107 800
"	"	95 054	"	30 200	80 000	108 000
"	"	100 041	"	34 400	90 000	123 000
"	"	97 555	"	31 800	80 000	99 000
"	"	220	S. L. B. & S.	28 000	80 000	89 000
"	"	95 342	I. C.	29 000	80 000	105 000
"	"	97 459	"	31 400	100 000	103 000
Caboose	E		"			34 000

TABLE 11 TONNAGE RECORD

Test No. S-1023

Kind of Car	Loaded or Empty	Car No.	Car Initial	Stenciled Light Weight	Capacity	Gross Weight
	L or E			pounds	pounds	pounds
Test	E	17				58 000
Box	L	141 953	I. C.	43 500	100 000	76 000
Gondola	"	104 462	"	40 700	100 000	110 000
"	"	95 110	"	30 000	80 000	83 000
"	"	110 088	"	41 000	100 000	100 000
"	"	95 949	"	30 900	80 000	79 000
Tank	"	59	R. O. R. Co.		80 000	58 000
Box	"	80 880	P. R. R.	33 500	80 000	74 000
"	"	10 951	N. C. & St. L.	32 700	60 000	88 000
"	E	133 684	Southern	33 200	80 000	33 000
Gondola	L	85 410	I. C.	33 300	80 000	93 000
"	"	80 355	"	27 100	60 000	80 000
"	"	90 035	"	29 500	80 000	112 000
Box	"	11 893	L. & N.	30 400	60 000	75 000
Gondola	"	85 248	I. C.	31 000	80 000	112 000
"	"	89 009	"	32 200	80 000	106 000
"	"	94 119	"	31 100	80 000	113 000
"	"	81 946	"	28 400	60 000	96 000
"	"	84 309	"	27 500	60 000	92 000
"	"	88 551	"	32 400	80 000	103 000
"	"	87 027	"	31 700	80 000	95 000
"	"	87 989	"	32 100	80 000	110 000
"	"	90 347	"	33 000	80 000	111 000
"	"	80 226	"	24 700	60 000	80 000
"	"	84 268	"	29 500	60 000	78 000
"	"	100 190	"	34 400	90 000	124 000
"	"	110 198	"	40 800	100 000	133 000
"	"	108 943	"	40 300	100 000	143 000
"	"	80 936	"	27 900	60 000	87 000
"	"	90 907	"	30 900	80 000	108 000
"	"	82 970	"	26 200	60 000	88 000
"	"	101 451	"	40 700	100 000	133 800
"	"	84 142	"	28 200	60 000	89 000
"	"	89 380	"	31 800	80 000	108 000
Box	"	39 074	"	38 300	80 000	94 000
"	"	141 730	"	43 700	100 000	105 000
Refrigerator	E	6 492	N.C. L. C.		60 000	43 000
Box	L	10 049	I. C.	30 800	60 000	36 900
Refrigerator	E	301	U. R. T. Co.	41 100	50 000	39 000
Box	"	155	S. H. C. Co.	40 800	80 000	40 000
"	"	2 056	G. B. & W.	31 400	80 000	31 000
"	"	108 260	Erie	40 100	80 000	38 900
"	L	7 220	I. C.	25 500	50 000	77 800
"	E	28 475	"	30 500	60 000	52 800
Tank	L	708	D. R. & U.			76 000
Box	E	48 782	I. C	39 100	80 000	55 000
Gondola	"	50 861	Erie	40 900	100 000	41 000
"	"	16 977	"	42 800	100 000	42 800
Box	L	141 005	I. C.	43 800	100 000	80 000
Gondola	"	57 131	B. & O.	28 200	60 000	87 000
Box	E	83 308	C. & N. W.	32 600	80 000	32 000
"	"	56 189	U. P.	28 000	50 000	28 000
"	"	78 219	C. & N. W.	34 450	80 000	34 000
"	"	48 596	"	28 300	40 000	28 400
"	"	86	S. H. C. Co.	40 800	80 000	39 000
"	L	13 803	I. C.	29 100	60 000	71 000
"	"	14 437	"	29 500	60 000	65 000
Caboose	E	98 026	"			40 000

TABLE 12 TONNAGE RECORD

Test No. S-1027

Kind of Car	Loaded or Empty	Car No.	Car Initial	Stenciled Light Weight	Capacity	Gross Weight
	L or E			pounds	pounds	pounds
Test	E	17				58 000
Gondola	L	104 866	I. C.	40 300	100 000	146 700
"	"	104 482	"	36 000	100 000	148 100
"	"	106 662	"	40 200	100 000	146 000
Box	"	15 035	"	29 200	60 000	52 000
"	"	17 391	"	30 000	60 000	59 800
Gondola	"	3 008	I. S.	40 200	100 000	135 400
"	"	609	C. C. & Co.	31 700	80 000	105 900
"	"	622	C. C. & Co.	31 700	80 000	106 500
"	"	92 361	I. C.	33 000	80 000	109 800
"	"	104 423	"	40 900	100 000	139 300
"	"	3 054	I. S.	40 100	100 000	142 400
"	"	105 824	I. C.	40 300	100 000	122 000
"	"	80 466	"	26 700	60 000	84 000
"	"	92 965	"	30 800	80 000	98 000
"	"	94 160	"	31 400	80 000	100 200
"	"	85 775	"	31 200	80 000	100 300
"	"	88 635	"	31 400	80 000	104 400
"	"	83 229	"	27 200	60 000	81 000
"	"	81 193	"	27 500	60 000	83 600
"	"	80 822	"	27 500	60 000	81 900
"	"	104 540	"	40 500	100 000	142 000
"	"	94 317	"	30 800	80 000	108 500
"	"	91 922	"	30 400	80 000	101 800
"	"	91 551	"	28 800	80 000	105 800
"	"	88 090	"	31 500	80 000	101 100
"	"	93 890	"	30 300	80 000	107 100
"	"	80 089	"	28 900	60 000	80 800
"	"	75 482	"	23 000	50 000	65 900
"	"	86 315	"	31 000	80 000	103 200
"	"	629	C. C. & Co.	31 700	80 000	106 500
"	"	76 275	I. C.	24 800	50 000	78 300
"	"	16 225	W. M.	39 100	80 000	117 300
"	"	87 491	I. C.	32 000	80 000	101 800
"	"	93 520	"	29 800	80 000	104 700
Box	"	10 931	T. & N. O.	30 700	60 000	84 100
"	"	21 957	I. C.	38 200	80 000	104 500
Gondola	"	85 133	"	31 500	80 000	62 700
Box	"	33 362	C. & N.	32 400	50 000	38 000
Gondola	"	88 516	I. C.	31 800	80 000	918 000
Box	"	1 614	C. & O.	37 700	80 000	90 100
"	"	7 542	I. C.	28 200	50 000	75 000
"	"	17 356	"	30 100	60 000	73 000
Flat	"	99 086	"	33 100	100 000	75 000
"	E	67 114	"	25 600	80 000	27 600
Caboose	"					38 000

TABLE 13 TONNAGE RECORD

Test No. S-1030A

Kind of Car	Loaded or Empty	Car No.	Car Initial	Stenciled Light Weight	Capacity	Gross Weight
	L or E			pounds	pounds	pounds
Test	E	17				58 000
Gondola	L	110 699	I. C.	41 100	100 000	130 900
"	"	111 182	"	40 700	100 000	129 400
"	"	87 386	"	30 700	80 000	109 300
"	"	3 264	I. S.	40 400	100 000	142 300
"	"	101 200	I. C.	38 100	100 000	145 000
"	"	106 217	"	40 400	100 000	144 500
"	"	25 601	"	31 300	80 000	105 800
"	"	101 180	"	40 200	100 000	145 000
"	"	105 667	"	40 300	100 000	142 600
"	"	101 052	"	38 500	100 000	143 600
"	"	96 213	"	31 900	80 000	106 200
"	"	106 868	"	40 200	100 000	145 200
"	"	81 275	"	29 700	60 000	88 400
"	"	82 959	"	27 900	60 000	87 600
"	"	89 028	"	33 600	80 000	109 600
"	"	81 296	"	28 800	60 000	86 600
"	"	111 248	"	40 800	100 000	133 000
"	"	3 375	I. S.	40 500	100 000	147 000
"	"	104 037	I. C.	40 900	100 000	147 000
"	"	86 480	"	32 000	80 000	119 000
"	"	104 386	"	40 400	100 000	154 800
"	"	92 183	"	31 000	80 000	116 900
"	"	94 862	"	32 600	80 000	117 400
"	"	94 539	"	32 100	80 000	119 200
"	"	104 877	"	40 300	100 000	154 000
"	"	93 341	"	30 700	80 000	118 600
"	"	86 032	"	29 800	80 000	111 500
"	"	89 076	"	31 900	80 000	113 400
"	"	88 556	"	32 200	80 000	110 500
"	"	96 704	"	32 000	100 000	113 000
"	"	88 577	"	32 400	80 000	111 200
"	"	100 243	"	32 800	90 000	125 500
Caboose	E	98 016	"			40 000

TABLE 14 TONNAGE RECORD Test No. S-1030B

Kind of Car	Loaded or Empty	Car No.	Car Initial	Stenciled Light Weight	Capacity	Gross Weight
	L or E			pounds	pounds	pounds
Test	E	17				58 000
Gondola	L	110 090	I. C.	41 100	100 000	130 900
"	"	111 182	"	40 700	100 000	129 400
"	"	87 386	"	30 700	80 000	109 300
"	"	3 264	I. S.	40 400	100 000	142 300
"	"	101 209	I. C.	38 100	100 000	145 000
"	"	106 217	"	40 400	100 000	144 500
"	"	25 601	"	31 300	80 000	105 800
"	"	101 160	"	40 200	100 000	145 000
"	"	105 067	"	40 300	100 000	142 800
"	"	101 052	"	38 500	100 000	143 600
"	"	96 213	"	31 900	80 000	106 200
"	"	108 868	"	40 200	100 000	145 200
"	"	81 275	"	29 700	60 000	88 400
"	"	82 959	"	27 900	60 000	87 600
"	"	89 028	"	33 600	80 000	109 600
"	"	81 296	"	28 800	60 000	86 600
"	"	111 248	"	40 800	100 000	133 000
"	"	3 375	I. S.	40 500	100 000	147 000
"	"	101 037	I. C.	40 900	100 000	147 000
"	"	86 480	"	32 000	80 000	119 000
"	"	104 566	"	40 400	100 000	154 800
"	"	92 183	"	31 000	80 000	116 900
"	"	94 862	"	32 600	80 000	117 400
"	"	94 539	"	32 100	80 000	119 200
"	"	104 877	"	40 300	100 000	154 000
"	"	93 341	"	30 700	80 000	118 600
"	"	86 032	"	29 800	80 000	111 500
"	"	89 078	"	31 900	80 000	113 400
"	"	88 556	"	32 900	80 000	110 500
"	"	96 794	"	52 000	100 000	113 000
"	"	88 577	"	32 400	80 000	111 200
"	"	100 243	"	32 800	90 000	125 500
Box	"	91 482	L. & N.	35 300	65 000	106 100
Gondola	"	68 107	"	37 200	80 000	102 920
Box	E	95 645	M. C.	39 800	60 000	40 000
"	L	13 470	S.	32 600	60 000	50 000
"	"	142 610	I. C.	42 900	100 000	151 900
"	"	14 474	C. N. O. & T. P.	34 800	60 000	71 700
"	"	11 845	L. & N.	30 400	60 000	88 600
Caboose	E	98 016	I. C.			40 000

TABLE 15 TONNAGE RECORD Test No. S-1031

Box	E	34 853	I. C.	37 300	80 000	37 300
"	"	37 120	"	34 300	80 000	34 300
"	"	33 101	"	37 800	80 000	37 900
"	"	11 771	"	29 500	60 000	29 500
"	"	24 386	"	36 500	80 000	36 500
"	"	45 812	"	39 000	80 000	39 000
"	"	35 859	"	36 300	80 000	36 300
"	"	49 227	"	35 600	80 000	35 700
"	"	37 430	"	35 000	80 000	35 100
"	"	48 723	"	39 100	80 000	39 200
"	"	15 256	"	29 500	60 000	29 500
"	"	18 389	"	28 900	60 000	28 800
"	"	46 321	"	37 100	80 000	37 100
"	"	26 699	"	36 300	80 000	36 200
"	"	38 079	"	33 700	80 000	33 700
"	"	49 040	"	38 000	80 000	38 100
"	"	25 514	"	35 500	80 000	35 500
"	"	34 974	"	36 500	80 000	36 600
"	"	24 617	"	35 800	80 000	35 600
"	"	47 800	"	37 700	80 000	37 700
"	"	141 461	"	43 600	100 000	43 600
"	"	140 995	"	42 800	100 000	42 800
"	"	49 435	"	33 800	80 000	33 800
"	"	36 259	"	38 400	80 000	36 400
"	"	16 183	"	30 000	60 000	30 000
"	L	49 414	"	35 300	80 000	59 050
"	"	22 932	"	37 400	80 000	72 900
"	"	19 896	"	29 100	60 000	73 800

TABLE 15—(*Continued*)

Kind of Car	Loaded or Empty	Car No.	Car Initial	Stenciled Light Weight	Capacity	Gross Weight
	L or E			pounds	pounds	pounds
"	"	20 289	"	28 600	60 000	74 300
"	"	15 490	"	29 900	60 000	73 500
"	"	49 183	"	35 500	80 000	74 100
"	E	6 909	L. & N.	30 900	60 000	30 700
Gondola	"	18 273	S.	40 100	100 000	40 300
Box	"	19 508	St. L. & S. W.	32 000	80 000	32 100
Flat	"	66 887	I. C.	27 600	80 000	27 300
Caboose	"	98 119	"			40 000

TABLE 16 TONNAGE RECORD Test No. S-1033

Test	E	17				58 000
Gondola	L	49 085	N. & W.	37 900	80 000	124 000
"	"	731	C. C. & Co.	31 700	80 000	110 000
"	"	708	"	31 600	80 000	104 600
"	"	619	"	31 700	80 000	104 000
"	"	742	"	31 700	80 000	108 300
"	"	748	"	31 700	80 000	104 300
"	"	101 775	I. C.	40 300	100 000	132 400
"	"	104 149	"	40 700	100 000	133 100
"	"	83 232	"	28 300	60 000	88 900
"	"	12 076	D	33 500	80 000	97 100
"	"	89 448	I. C.	31 800	80 000	109 000
"	"	89 505	"	32 500	80 000	108 400
"	"	47 043	N. & W.	32 000	85 000	99 000
"	"	79 189	I. C.	24 500	50 000	72 700
"	"	666	L. A. & W.	40 600	60 000	92 800
"	"	115 005	I. C.	45 000	100 000	122 300
"	"	85 906	"	34 600	80 000	113 000
"	"	83 928	"	26 500	60 000	77 000
"	"	106 446	"	39 600	100 000	133 100
"	"	104 846	"	40 200	100 000	142 000
"	"	86 763	"	32 100	80 000	104 000
"	"	97 319	"	32 900	100 000	98 000
"	"	97 061	"	31 900	100 000	101 000
"	"	81 966	"	26 400	60 000	88 100
"	"	707	C. C. Co.	34 700	80 000	107 000
"	"	94 140	I. C.	31 600	80 000	98 000
"	"	88 213	"	31 900	80 000	105 000
"	"	86 642	"	31 300	80 000	106 000
"	"	111 336	"	40 100	100 000	126 000
"	"	80 952	"	26 000	60 000	84 000
"	"	79 077	"	34 900	50 000	82 000
"	"	14 722	M. & O.	33 900	80 000	95 100
"	"	106 167	I. C.	40 300	100 000	136 000
"	"	90 535	"	32 700	80 000	102 000
"	"	93 442	"	29 500	80 000	104 600
"	"	16 738	Erie	42 800	100 000	102 800
"	"	85 379	I. C.	31 200	80 000	110 900
"	"	87 672	"	31 300	80 000	104 000
"	"	30 456	C. & B.	39 100	100 000	128 000
"	"	80 855	I. C.	28 300	60 000	86 100
"	"	85 959	"	31 000	80 000	103 100
"	"	644	C. C. Co.	31 700	80 000	106 100
Caboose	E	19 510	I. C.			40 000

TABLE 17 TONNAGE RECORD Test No. S-1034

Kind of Car	Loaded or Empty	Car No.	Car Initial	Stenciled Light Weight	Capacity	Gross Weight
	L or E			pounds	pounds	pounds
Gondola	E	80 223	I. C.	26 900	60 000	25 200
"	"	89 617	"	32 200	80 000	32 400
"	"	110 863	"	41 000	100 000	41 200
"	"	34 775	N. Y. C.	41 600	100 000	41 700
"	"	86 158	I. C.	31 300	80 000	31 100
"	"	80 338	"	24 500	60 000	23 900
"	"	87 806	"	31 500	80 000	31 500
"	"	96 249	"	30 900	80 000	30 500
"	"	9 038	T. & O. C.	26 700	60 000	24 500
"	"	79 089	I. C.	23 200	50 000	23 300
"	"	93 123	"	31 100	80 000	31 800
"	"	82 546	"	27 900	60 000	27 500
"	"	104 295	"	40 500	100 000	40 400
"	"	89 543	"	30 900	80 000	31 300
"	"	110 722	"	41 500	100 000	41 700
"	"	92 260	"	31 100	80 000	30 500
"	"	84 227	"	28 400	60 000	27 200
"	"	81 254	"	27 400	60 000	28 700
"	"	85 110	"	31 400	80 000	30 400
"	"	105 192	"	40 300	100 000	40 200
"	"	15 248	Van. Line	40 700	100 000	40 600
"	"	92 465	I. C.	31 200	80 000	30 200
"	"	90 716	"	31 400	80 000	30 700
"	"	800 312	Penn.	38 400	100 000	38 300
"	"	3 190	I. S.	40 600	100 000	40 400
"	"	47 608	N. & W.	32 600	85 000	34 000
"	"	93 502	I. C.	30 100	80 000	30 400
"	"	105 620	"	40 300	100 000	40 100
"	"	85 250	"	30 400	80 000	30 900
"	"	90 396	"	31 000	80 000	30 900
"	"	3 183	I. S.	40 400	100 000	40 600
"	"	96 492	I. C.	31 000	80 000	30 300
"	"	104 730	"	40 400	100 000	40 500
"	"	104 667	"	40 700	100 000	40 600
"	"	94 692	"	32 000	80 000	32 100
"	"	82 744	"	27 900	60 000	28 600
"	"	282 398	Penn.	45 000	100 000	40 400
"	"	94 128	I. C.	30 300	80 000	30 100
"	"	94 783	"	31 200	80 000	30 900
"	"	104 702	"	40 600	100 000	40 500
"	"	96 797	"	31 400	100 000	33 200
"	"	96 917	"	30 200	80 000	30 200
"	"	108 219	"	40 300	100 000	40 200
"	"	28 743	C. & O.	39 900	100 000	38 700
"	"	83 171	I. C.	28 400	60 000	27 200
"	"	96 089	"	31 000	80 000	31 000
"	"	49 415	N. & W.	38 300	100 000	37 100
"	"	93 048	I. C.	31 600	80 000	31 000
"	"	13 930	C. & O.	25 000	60 000	25 300
"	"	13 648	N. & W.	34 100	80 000	34 000
"	"	29 059	C. & O.	41 400	100 000	41 000
"	"	14 840	"	30 900	80 000	30 300
"	"	76 008	I. C.	24 300	50 000	23 000
"	"	86 763	"	32 100	80 000	30 700
"	"	83 909	"	26 200	80 000	27 200
"	"	88 028	"	30 400	80 000	31 400
"	"	89 502	"	31 800	80 000	31 500
"	"	800 908	"	40 200	100 000	40 100
"	"	68 608	L. & N.	35 400	80 000	35 500
"	"	81 422	I. C.	26 800	60 000	27 000
"	"	106 388	"	40 800	100 000	40 800
"	"	11 625	C. & E. I.	32 400	80 000	31 000
"	"	75 084	"	38 400	100 000	38 900
"	"	3 393	I. S.	40 100	100 000	40 000
"	"	105 811	I. C.	40 400	100 000	40 800
"	"	91 161	"	30 000	80 000	29 600
"	"	27 237	Big Four	22 500	50 000	24 600
"	"	33 336	L. & N.	28 400	66 000	28 500
"	"	91 941	I. C.	33 000	80 000	31 300
"	"	106 191	"	40 000	100 000	40 200
"	"	78 930	"	25 200	50 000	23 500
"	"	85 198	"	31 300	80 000	30 500
"	"	91 102	"	31 300	80 000	29 700
"	"	32 243	L. & N.	30 400	66 000	30 200
"	"	44 069	N. & W.	38 100	100 000	38 000
Caboose	"	98 465	I. C.			40 000

TABLE 18 TONNAGE RECORD

Test No. S-1036

Kind of Car	Loaded or Empty	Car No.	Car Initial	Stenciled Light Weight	Capacity	Gross Weight
	L. or E.			pounds	pounds	pounds
Test	E	17				58 000
Flat	L	65 913	I. C.	27 900	80 000	79 600
Gondola	"	81 595	"	27 500	60 000	90 000
"	"	97 920	"	31 100	80 000	98 000
"	"	95 885	"	31 000	80 000	105 000
"	"	87 632	"	31 700	80 000	108 400
"	"	96 914	"	31 800	100 000	105 000
"	"	76 735	"	25 200	50 000	78 000
"	"	84 272	"	37 500	80 000	76 000
"	"	91 429	"	33 000	80 000	106 000
"	"	89 678	"	32 400	80 000	110 100
Box	"	13 664	W. C.	29 000	60 000	32 100
Refrigerator	"	55 059	I. C.	36 900	60 000	38 400
Box	E	14 610	N. Y. C.	33 800	30 000	31 000
"	L	21 307	I. C.	37 500	80 000	56 300
"	E	41 633	P. M.	34 500	80 000	35 800
"	L	18 103	C. B. & Q.	25 200	40 000	64 000
"	"	131 327	I. C.	39 700	80 000	91 400
"	"	122 440	C. S. N. O. & P.	39 500	80 000	109 100
"	"	8 116	St. J. & G. I.	35 400	80 000	73 800
"	"	39 116	I. C.	36 300	80 000	111 600
"	"	141 137	"	43 100	100 000	64 300
"	"	12 971	"	30 200	60 000	46 000
"	"	7 198	Big Four	31 200	60 000	93 500
"	"	19 591	M. & O.	33 700	60 000	88 200
"	"	18 581	"	33 500	60 000	91 500
"	"	9 593	"	31 200	60 000	83 600
"	"	9 224	C. I. & L.	29 800	50 000	73 100
"	"	11 136	M. C. & St. L.	34 000	60 000	67 700
"	E	64 614	C. & N. W.	30 100	60 000	29 400
"	L	5 251	N. C. & St. L.	29 500	60 000	93 400
"	"	6 714	"	29 600	60 000	69 800
"	"	49 041	I. C.	39 100	80 000	106 800
Gondola	"	95 823	"	31 600	80 000	74 000
Refrigerator	E	5 773	Armour	38 700	50 000	39 600
Box	L	6 892	I. C.	26 800	50 000	72 000
"	"	6 609	T. St. L. & W.	38 100	80 000	82 100
"	"	28 434	N. Y. C.	35 800	80 000	81 000
"	"	14 257	Penn.	44 400	100 000	98 000
"	"	40 571	M. & O.	34 600	60 000	90 000
Gondola	"	85 836	I. C.	30 500	80 000	60 000
Box	"	11 615	"	29 800	60 000	111 000
"	"	13 534	Q. & C.	33 800	60 000	80 000
"	"	42 169	I. C.	33 400	60 000	76 100
"	E	27 093	L. S. & M. S.	29 300	60 000	23 000
"	L	10 859	I. C.	30 000	60 000	66 400
"	"	141 286	"	42 600	100 000	106 200
Gondola	"	3 218	I. S.	40 300	100 000	91 400
Box	"	13 675	I. C.	29 800	60 000	46 000
Gondola	"	93 300	"	31 900	80 000	74 100
Refrigerator	E	55 987	"	38 600	60 000	39 400
Caboose	"	98 040	"			40 000

TABLE 19 TONNAGE RECORD

Test No. S-1038

Kind of Car	Loaded or Empty	Car No.	Car Initial	Stenciled Light Weight	Capacity	Gross Weight
	L. or E.			pounds	pounds	pounds
Test	E	17				58 000
Gondola	L	91 059	I. C.	29 400	80 000	115 000
"	"	106 262	"	40 300	100 000	136 000
"	"	106 565	"	40 300	100 000	134 000
Box	"	142 548	"	42 900	100 000	91 800
Gondola	"	730	C. C. & Co.	30 900	80 000	103 300
"	"	84 047	I. C.	28 500	60 000	85 300
"	"	88 999	"	32 200	80 000	105 000
"	"	85 215	"	31 600	80 000	102 700
"	"	82 640	"	27 800	60 000	81 300
"	"	81 883	"	28 800	60 000	80 000
"	"	76 477	"	23 300	50 000	75 500
"	"	93 590	"	29 800	80 000	107 300
"	"	90 934	"	31 000	80 000	104 800
"	"	93 342	"	32 500	80 000	104 500
"	"	102 091	"	37 300	80 000	120 000
"	"	31 063	C. & O.	39 200	100 000	138 000
"	"	85 304	I. C.	31 500	80 000	111 500
"	"	26 505	C. & O.	38 100	100 000	130 200
"	"	110 803	I. C.	41 100	100 000	135 500
"	"	104 015	"	40 500	100 000	146 500
"	"	105 581	"	40 400	100 000	139 000
"	"	104 984	"	40 500	100 000	146 100
"	"	91 126	"	30 600	80 000	104 000
"	"	88 342	"	31 800	80 000	105 000
"	"	93 901	"	31 500	80 000	103 400
"	"	81 303	"	28 100	60 000	85 000
"	"	44 086	N. & W.	38 300	100 000	129 300
"	"	104 532	I. C.	40 600	100 000	142 300
"	"	15 820	M. & O.	34 100	80 000	104 600
"	"	106 646	I. C.	40 400	100 000	143 800
"	"	88 819	"	31 600	80 000	104 600
"	"	104 584	"	40 400	100 000	152 000
"	"	3 160	I. S.	40 300	100 000	154 000
Box	"	87 344	B. & O.	30 400		73 300
"	"	704	W. H. & D.		60 000	41 000
"	E	12 694	W. C.	29 100	60 000	28 900
"	L	19 705	I. C.	29 600	60 000	74 300
"	"	16 310	"	29 800	60 000	59 600
"	"	12 417	"	29 900	60 000	91 400
Caboose	E	98 090	"			40 000

TABLE 20 TONNAGE RECORD

Test No. S-1040

Kind of Car	Loaded or Empty	Car No.	Car Initial	Stenciled Light Weight	Capacity	Gross Weight
	L. or E.			pounds	pounds	pounds
Test	E	17				58 000
Box	L	98 633	C. B. & Q.	34 300	80 000	54 900
Gondola	"	106 306	I. C.	40 800	100 000	138 500
"	"	106 358	"	40 400	100 000	146 500
"	"	94 314	"	29 000	80 000	105 600
Box	"	39 814	"	37 100	80 000	121 000
Gondola	"	86 947	"	31 100	80 000	110 000
"	"	16 683	H. V. Y.	32 800	80 000	110 700
"	"	97 659	I. C.	30 200	80 000	99 300
Box	"	78 121	B. & O.	31 600	60 000	70 200
Gondola	"	90 363	I. C.	33 600	80 000	95 600
"	"	13 381	N. & W.	34 100	80 000	107 600
Box	"	35 061	St. L. & S. F.	35 100	60 000	82 200
"	"	17 339	I. C.	28 600	60 000	62 000
"	"	37 489	"	33 500	80 000	71 200
Tank	"	505	F. O. Co.		60 000	88 900
Box	"	25 394	V. S. & P	32 200	60 000	80 400
"	"	131 417	I. C.	39 900	80 000	64 500
"	"	39 626	"	36 200	80 000	79 000
Gondola	"	92 487	"	30 000	80 000	110 600
Box	"	91 157	L. & N.	33 200	65 000	86 500
Gondola	"	89 843	I. C.	30 900	80 000	86 600
Box	"	4 931	N. & S.	32 200	60 000	74 300
Gondola	"	5 642	K. & M.	32 500	80 000	91 600
"	"	93 209	I. C.	32 800	80 000	110 000
Box	"	34 736	"	36 400	80 000	56 300
"	"	101 264	C. B. & Q.	35 000	80 000	60 000
"	"	32 412	C. R. I. & P.	38 900	80 000	67 900
"	"	10 137	N. C. & St. L.	33 400	80 000	80 300
Gondola	"	94 256	I. C.	30 000	80 000	78 800
Box	"	3 467	L. E. & St. L.	34 300	60 000	101 000
"	"	11 122	S.	30 900	60 000	75 800
"	"	46 541	I. C.	38 000	80 000	67 100
Gondola	"	86 513	"	31 200	80 000	125 800
"	"	89 288	"	31 800	80 000	95 800
"	"	105 949	"	40 300	100 000	145 600
"	"	91 129	"	28 800	80 000	108 100
"	"	85 020	"	31 400	80 000	108 900
"	"	95 929	"	29 900	80 000	124 000
"	"	12 555	C. & O.	30 900	80 000	115 800
"	"	96 796	I. C.	31 900	100 000	114 300
"	"	84 200	"	27 400	60 000	80 000
"	"	27 738	H. V.	40 700	100 000	147 900
Box	"	30 778	S. P.	34 000	80 000	85 200
"	"	49 450	I. C.	35 300	80 000	67 700
"	"	17 968	"	31 200	80 000	52 300
Caboose	E		"			40 000

TABLE 21 TONNAGE RECORD

Test No. S-1043

Kind of Car	Loaded or Empty	Car No.	Car Initial	Stenciled Light Weight	Capacity	Gross Weight
	L. or E.			pounds	pounds	pounds
Gondola	E	95 986	I. C.	30 600	80 000	30 600
"	"	101 110	"	38 400	100 000	38 400
"	"	5 968	P. & L. E.	34 300	80 000	34 300
Box	"	37 982	I. C.	37 300	80 000	37 300
"	"	15 601	"	29 300	60 000	29 300
"	"	19 314	"	29 900	60 000	29 900
"	"	12 938	"	29 600	60 000	29 600
"	"	17 905	"	30 100	60 000	30 100
"	"	14 809	"	30 400	60 000	30 400
"	"	37 132	"	33 000	80 000	33 000
"	"	11 765	"	29 900	60 000	29 900
"	"	23 243	"	33 800	80 000	33 800
"	"	41 230	"	32 900	50 000	32 900
"	"	37 957	"	33 000	80 000	33 000
"	"	35 762	"	35 600	80 000	35 600
"	"	38 298	"	36 400	80 000	36 400
"	"	15 281	"	30 400	80 000	30 400
Tank	L	489	A. T. L.	38 000	65 000	102 900
Gondola	E	643	C. C. & C.	31 700	80 000	31 700
"	"	641	"	31 700	80 000	31 700
"	"	182 400	C. I. & S.	31 000	80 000	31 000
"	"	82 014	I. C.	26 500	80 000	26 500
"	"	638	C. C. & C.	31 700	80 000	31 700
"	"	19 570	C. & A.	37 200	100 000	37 200
"	"	89 865	I. C.	31 700	80 000	31 700
"	"	105 764	"	40 400	100 000	40 400
"	"	92 517	"	32 000	80 000	32 000
"	"	3 303	I. S.	40 200	100 000	40 200
"	"	97 056	I. C.	32 500	100 000	32 500
"	"	83 510	"	28 400	60 000	28 400
"	"	97 836	"	30 900	80 000	30 900
"	"	89 837	"	32 200	80 000	32 200
"	"	81 684	"	30 700	60 000	30 700
"	"	115 302	"	42 600	100 000	42 600
"	"	81 483	"	28 000	60 000	28 000
"	"	87 171	"	31 500	80 000	31 500
"	"	25 359	P. & R.	33 200	100 000	31 200
"	"	95 635	I. C.	30 200	80 000	30 200
"	"	92 911	"	31 200	80 000	31 200
"	"	88 752	"	32 000	80 000	32 000
"	"	25 900	H. V.	33 100	80 000	33 100
"	"	85 502	I. C.	31 500	80 000	31 500
"	"	89 559	"	31 900	80 000	31 200
"	"	93 107	"	31 800	80 000	31 800
"	"	81 999	"	28 300	60 000	28 700
"	"	104 780	"	40 300	100 000	40 300
"	"	93 305	"	31 200	80 000	31 200
"	"	110 801	"	41 100	100 000	41 100
"	"	97 203	"	30 300	100 000	30 200
"	"	93 068	"	31 200	80 000	31 200
"	"	91 183	"	30 900	80 000	30 000
"	"	86 323	"	30 100	80 000	30 100
"	"	85 904	"	31 600	80 000	31 600
"	"	95 984	"		80 000	32 100
"	"	93 093	"	32 000	80 000	32 000
"	"	89 480	"	30 800	80 000	30 800
"	"	111 066	"	41 100	100 000	41 100
"	"	111 012	"	41 200	100 000	41 900
"	"	97 889	"	31 400	80 000	31 400
"	"	98 577	"	32 400	100 000	32 400
"	"	97 927	"	32 000	80 000	32 000
"	"	90 488	"	30 600	80 000	30 600
"	"	9 548	T. & O. C.	26 300	60 000	26 300
"	"	111 311	I. C.	40 800	100 000	40 800
Box	"	6 498	N. C. & St. L.	29 200	60 000	29 200
Caboose	"	98 185	I. C.	40 000		40 000

TABLE 22 TONNAGE RECORD

Test No. S-1048

Kind of Car	Loaded or Empty	Car No.	Car Initial	Stenciled Light Weight	Capacity	Gross Weight
	L. or E.			pounds	pounds	pounds
Test	E	17				58 000
Box	L	98 252	N. Y. C.&H. R.	35 600	80 000	43 500
Gondola	"	106 449	I. C.	40 300	100 000	140 000
"	"	18 867	C. H. & D.	30 200	70 000	97 200
"	"	15 342	C. & O.	30 700	85 000	78 300
"	"	104 271	I. C.	40 600	100 000	146 500
"	"	68 282	L. & N.	36 800	80 000	120 000
"	"	10 579	I. C.	41 200	100 000	134 300
"	"	83 518	"	27 000	60 000	82 600
"	"	95 129	"	31 200	80 000	107 900
"	"	93 198	"	30 600	80 000	105 000
"	"	96 507	"	32 300	100 000	111 000
"	"	93 807	"	29 300	80 000	107 800
"	"	106 189	"	40 400	100 000	112 100
"	"	111 300	"	40 800	100 000	124 200
"	"	105 618	"	40 300	100 000	106 600
"	"	91 108	"	28 900	80 000	108 500
Box	"	2 050	C. P. T.	30 800	60 000	90 800
Gondola	"	84 458	I. C.	30 800	60 000	92 400
"	"	87 958	"	31 800	80 000	109 000
"	"	235 224	P.	40 800	100 000	125 400
"	"	28 318	C & O		100 000	144 200
"	"	82 790	I. C.	31 400	60 000	86 400
"	"	86 569	"	30 600	80 000	107 700
"	"	87 485	"	33 000	80 000	108 600
"	"	94 069	"	31 000	80 000	107 400
"	"	89 271	"	32 000	80 000	109 200
"	"	81 386	"	29 100	60 000	84 200
"	"	95 850	"	30 500	80 000	104 600
"	"	110 910	"	40 800	100 000	140 800
"	"	96 255	"	31 000	80 000	105 000
"	"	94 541	"	31 400	80 000	107 600
"	"	83 229	"	27 000	60 000	85 000
"	"	95 820	"	30 800	80 000	100 000
"	"	82 045	"	28 900	60 000	87 300
"	"	91 443	"	30 300	80 000	105 300
"	"	106 431	"	40 400	100 000	121 600
Box	"	16 038	"	30 800	60 000	80 400
"	E	6 672	A. R. L.	31 500	50 000	33 000
"	"	5 284	"	32 800	50 000	39 400
"	"	9 851	"	39 400	50 000	39 800
"	"	7 342	S.			39 500
"	"	10 458	A.	39 500	60 000	39 600
"	L	8 969	A. R. L.	34 000	50 000	42 100
"	E	352	U. R. T.	42 000	50 000	47 300
"	L	141 533	I. C.	43 700	100 000	96 600
"	"	60 182	C. & N. W.	30 000	60 000	85 300
"	"	28 208	I. C.	35 500	60 000	68 500
"	"	13 088	C. G. W.	30 000	60 000	58 700
"	"	16 008	C. B.	32 000	60 000	58 500
"	"	41 753	P. M.	36 700	60 000	64 300
"	"	13 494	I. C.	31 100	60 000	72 200
"	"	19 247	"	29 600	60 000	63 900
Caboose	E	98 008				40 000

TABLE 23 TONNAGE RECORD

Test No. S-1050

Kind of Car	Loaded or Empty	Car No.	Car Initial	Stenciled Light Weight	Capacity	Gross Weight
	L. or E.			pounds	pounds	pounds
Box	L	34 403	I. C.	36 800	80 000	124 900
"	"	13 317	"	30 100	60 000	81 000
"	"	11 385	"	29 200	60 000	91 800
"	"	140 166	"	42 800	100 000	139 500
"	"	42 477	"	34 400	60 000	84 200
"	"	36 731	"	33 700	80 000	100 900
"	"	39 317	"	37 500	80 000	125 200
"	"	25 435	"	36 600	80 000	119 500
"	E	31 909	T. R. E.	32 100	50 000	34 800
"	L	25 238	I. C.	36 900	80 000	119 300
"	"	45 799	"	41 400	80 000	105 200
"	E	12 043	O. N. & T. P.	33 550	60 000	33 500
"	L	36 163	I. C.	36 800	80 000	121 600
"	"	24 700	"	35 800	80 000	120 800
"	"	6 364	"	27 600	50 000	82 400
"	"	14 070	"	31 600	60 000	100 300
"	"	15 686	"	30 300	60 000	97 000
"	"	35 019	"	36 500	80 000	126 800
"	"	15 962	"	30 400	60 000	88 800
"	"	141 521	"	43 600	100 000	142 400
"	"	130 492	"	40 100	80 000	120 800
"	"	45 586	"	38 500	80 000	119 900
"	"	131 556	"	39 000	80 000	97 600
"	"	21 716	"	37 800	80 000	105 600
"	"	46 134	"	40 700	80 000	127 700
"	"	39 374	"	37 900	80 000	125 200
"	E	31 415	T. R. E.	32 400	50 000	32 400
"	"	31 968	"	32 100	50 000	33 000
"	"	31 395	"	34 100	50 000	34 800
Gondola	"	94 837	I. C.	32 800	80 000	32 800
"	"	110 177	"	41 200	100 000	41 200
"	"	3 170	I. S.	38 200	100 000	38 200
"	"	91 705	I. C.	29 700	80 000	29 700
"	"	90 082	"	30 700	80 000	30 700
"	"	86 138	"	30 100	80 000	30 100
"	"	104 284	"	40 700	100 000	40 700
"	"	104 495	"	40 700	100 000	40 700
"	"	107 359	"	39 600	100 000	39 600
"	"	110 117	"	41 700	100 000	41 700
Caboose	"	98 197	"			34 000

TABLE 24 TONNAGE RECORD

Test No. S-1052

Kind of Car	Loaded or Empty	Car No.	Car Initial	Stenciled Light Weight	Capacity	Gross Weight
	L. or E.			pounds	pounds	pounds
Gondola	E	91 308	I. C.	30 200	80 000	30 200
"	"	83 764	"	26 800	60 000	26 800
"	"	252	S. S. C.	25 500	50 000	25 800
"	"	89 137	I. C.	31 200	80 000	31 300
"	"	83 992	"	28 200	60 000	28 400
"	"	112 770	"	43 500	100 000	43 500
"	"	81 989	"	28 900	50 000	28 900
"	"	94 688	"	31 100	80 000	31 300
"	"	101 073	"	38 200	100 000	38 200
"	"	3 351	I. S.	40 700	100 000	40 800
"	"	106 100	I. C.	40 200	100 000	40 200
"	"	106 314	"	40 300	100 000	40 200
"	"	82 600	"	26 800	60 000	27 000
"	"	91 316	"	30 200	80 000	30 500
"	"	722	C. C. & Co.	31 700	80 000	31 200
"	"	91 162	I. C.	29 700	80 000	30 100
"	"	107 030	"	39 800	100 000	39 800
"	"	641	C. C. & Co.	31 700	80 000	31 500
"	"	80 993	I. C.	23 600	60 000	26 500
Box	"	11 116	F. G. E.	36 500	50 000	33 200
"	"	11 050	"	36 500	50 000	34 600
"	"	31 153	T. R. E.	32 300	50 000	34 000
"	"	31 286	"	31 500	50 000	34 200
"	"	11 243	N. C. & St. L.	33 600	60 000	33 500
"	"	15 945	Air Line	34 600	60 000	34 800
"	"	827	D. S. D.	35 500	50 000	37 800
"	"	133 280	S.	33 500	60 000	32 800
"	"	33 886	C. of N. J.	30 500	60 000	30 600
"	L	24 968	I. C.	36 000	80 000	119 500
"	"	39 671	"	36 300	80 000	118 100
"	"	21 633	"	38 400	80 000	122 500
"	"	131 151	"	38 900	80 000	129 600
"	"	13 782	"	29 800	60 000	92 300
"	"	45 456	"	38 800	80 000	98 000
"	"	47 105	"	40 100	80 000	100 100
"	"	20 336	"	28 600	60 000	89 000
"	"	13 831	"	29 900	60 000	89 000
"	E	25 361	V. S. & P.	31 800	60 000	31 800
"	"	31 199	T. R. E.	32 150	50 000	34 800
"	"	30 283	"	38 700	50 000	36 000
Gondola	L	92 708	I. C.	32 000	80 000	84 000
"	"	112 608	"	43 500	100 000	88 400
Box	"	580 498	U. L.	30 500	60 000	53 500
"	E	30 562	S.	35 600	60 000	35 400
Gondola	L	92 748	I. C.	30 400	80 000	74 000
Box	E	25 391	V. S. & P.	32 200	60 000	32 400
"	"	17 212	L. & N.	31 200	60 000	31 700
"	"	35 863	S.	35 900	60 000	35 800
"	"	37 798	S.	35 200	60 000	35 800
"	L	130 809	I. C.	40 200	80 000	97 800
Gondola	"	94 511	"	31 000	80 000	37 800
Box	"	141 249	"	43 500	100 000	82 800
"	"	39 219	"	36 300	80 000	79 000
"	E	25 618	A. C. L.	34 980	60 000	34 700
"	"	19 314	St. L. S. W.	32 700	60 000	32 800
"	"	85 683	S. P.	42 600	100 000	43 500
"	"	10 255	N. C. & St. L.	32 900	60 000	34 000
"	"	5 803	L. & N.	30 500	60 000	30 000
"	"	20 864	S.	32 800	60 000	35 100
Flat	"	10 016	N. O. & N. E.	27 200	80 000	27 000
Caboose	"	98 093	I. C.			34 000

TABLE 25 TONNAGE RECORD

Test No. S–1057

Kind of Car	Loaded or Empty	Car No.	Car Initial	Stenciled Light Weight	Capacity	Gross Weight
	L or E			pounds	pounds	pounds
Test	E	17				58 000
Box	L	12 269	C. N. O. & T. P.	33 800	60 000	89 300
Gondola	"	91 889	I. C.	29 500	80 000	107 400
"	"	83 859	"	27 200	60 000	87 800
"	"	83 709	"	28 000	60 000	88 200
"	"	94 023	"	30 600	80 000	102 200
"	"	97 927	"	32 000	80 000	106 600
Box	"	46 152	"	40 000	80 000	58 700
Gondola	"	93 980	"	30 700	80 000	105 400
"	"	91 254	"	29 400	80 000	110 800
Box	"	6 750	"	26 400	50 000	68 600
"	E	57 408	N. Y. C. & H. R.	31 000	60 000	38 100
"	L	108 212	Erie	39 900	80 000	69 700
Tank	"	628	D. R. & U.			68 200
Gondola	"	91 422	I. C.	30 000	80 800	105 600
Box	E	D27 572	L. S. & M. S.	28 800	80 000	33 400
"	L	15 891	I. C.	28 700	60 000	70 300
"	"	11 267	"	28 400	80 000	81 100
"	"	33 918	"	37 900	80 000	80 300
Gondola	"	106 527	"	40 200	100 000	142 800
"	"	104 823	"	40 300	100 000	145 100
"	"	91 474	"	29 900	80 000	112 800
"	"	82 786	"	26 900	80 000	86 700
"	"	607	C. C. & C.	31 700	80 000	107 800
"	"	106 577	I. C	40 300	100 000	144 400
"	"	106 447	"	40 400	100 000	142 900
Box	"	130 255	"	41 000	80 000	90 300
"	"	7 086	"	26 600	50 000	69 000
Flat	"	67 554	"	28 800	80 000	56 200
Box	"	39 223	"	37 500	80 000	72 800
"	"	21 181	"	37 500	80 000	85 800
"	E	515 733	P. F. W. C.	43 800	100 000	41 200
"	L	29 516	I. C.	39 800	60 000	73 000
Flat	"	2 202	G. C.	23 500	60 000	79 200
Gondola	"	105 859	I. C.	40 400	100 000	146 200
"	"	86 778	"	31 000	80 000	115 100
"	"	112 241	"	36 500	80 000	96 300
Box	"	15 982	"	30 400	60 000	80 000
Gondola	E	189	C. & I. W.	32 700	90 000	33 100
"	"	7 162	N. Y. C. & St. L.	31 700	80 000	31 000
"	L	91 371	I. C.	30 400	80 000	80 600
Flat	"	814	G. & S. I.	26 600	80 000	85 800
Box	"	15 282	I. C.	29 400	60 000	67 400
"	E	1 695	A. R.	28 200	50 000	31 200
"	L	15 427	I. C.	30 000	60 000	67 800
"	"	24 933	"	35 000	80 000	102 000
"	"	27 737	B.	29 500	60 000	61 200
"	"	40 712	M. & O.	34 500	66 000	72 800
Gondola	"	85 879	I. C.	30 500	80 000	79 600
Box	"	30 586	"	36 000	80 000	58 200
Caboose	E	98 585				34 000

TABLE 26 TONNAGE RECORD

Test No. S-1061

Kind of Car	Loaded or Empty	Car No.	Car Initial	Stenciled Light Weight	Capacity	Gross Weight
	L or E			pounds	pounds	pounds
Test	E	17				58 000
Gondola	L	88 518	I. C.	32 200	80 000	107 400
"	"	106 156	"	38 400	100 000	146 000
"	"	106 707	"	40 500	100 000	144 600
"	"	94 475	"	31 100	80 000	109 200
"	"	81 333	"	27 300	60 000	82 300
"	"	86 360	"	31 900	80 000	104 300
"	"	95 040	"	30 400	80 000	106 600
"	"	101 029	"	37 500	100 000	138 600
"	"	112 734	"	43 500	100 000	112 600
"	"	81 632	"	26 200	60 000	85 200
"	"	87 626	"	31 700	80 000	103 700
"	"	80 610	"	27 200	60 000	82 400
"	"	94 976	"	31 400	80 000	119 000
"	"	88 425	"	31 400	80 000	118 000
"	"	95 299	"	30 500	80 000	101 200
"	"	628	C. C. & Co.	31 700	80 000	110 400
"	"	95 250	I. C.	30 300	80 000	112 000
"	"	88 750	"	31 900	80 000	112 200
"	"	276	S. C. Co.	30 700	80 000	112 000
"	"	205	S. S. C. Co.	26 500	60 000	82 700
"	"	254	"	26 500	50 000	80 000
"	"	208	"	24 500	60 000	81 300
"	"	256	"	25 500	50 000	80 000
"	"	88 256	I. C.	32 000	80 000	107 700
"	"	104 074	"	40 600	100 000	138 400
"	"	93 754	"	29 600	80 000	104 400
"	"	92 486	"	30 500	80 000	102 000
"	"	106 300	"	40 200	100 000	147 300
"	"	104 742	"	40 300	100 000	146 000
"	"	108 846	"	40 500	100 000	141 000
"	"	11 247	"	40 900	100 000	134 900
"	"	111 175	"	40 700	100 000	138 900
"	"	84 467	"	30 400	60 000	96 200
"	"	90 399	"	31 000	80 000	108 600
"	"	82 953	"	28 000	60 000	91 200
"	"	86 147	"	31 200	80 000	103 500
"	"	107 646	"	39 500	100 000	137 900
Flat	"	6 708	"	27 900	60 000	81 800
"	E	3 736	A. C. L.	31 700	40 000	31 700
"	L	6 719	"	27 900	60 000	74 400
"	"	6 455	"	26 400	60 000	66 400
"	E	8 494	H. & H.	28 800	80 000	30 300
Caboose	"	98 155	I. C.			34 000

TABLE 27 TONNAGE RECORD

Test No. S-1063

Kind of Car	Loaded or Empty	Car No.	Car Initial	Stenciled Light Weight	Capacity	Gross Weight
	L or E			pounds	pounds	pounds
Box	L	22 195	I. C.	37 800	80 000	115 400
"	"	46 472	"	36 500	80 000	127 300
"	"	17 530	"	28 600	60 000	95 200
"	"	49 063	"	37 200	80 000	125 300
Gondola	E	112 486	"	43 400	100 000	43 400
"	"	112 463	"	43 700	100 000	43 700
"	"	112 300	"	36 500	80 000	36 500
"	"	112 527	"	43 400	100 000	43 400
"	"	112 515	"	43 500	100 000	43 500
"	"	112 428	"	43 300	100 000	43 300
"	"	112 407	"	43 600	100 000	43 600
"	"	112 679	"	43 300	100 000	43 300
"	"	112 403	"	43 500	100 000	43 500
"	"	112 775	"	43 600	100 000	43 600
"	"	112 585	"	43 400	100 000	43 400
"	"	92 756	"	36 500	80 000	36 500
"	"	88 647	"	31 500	80 000	31 500
"	"	82 152	"	26 600	60 000	26 600
"	"	112 633	"	43 500	100 000	43 500
"	"	112 578	"	43 400	100 000	43 400
"	"	112 596	"	43 700	100 000	43 700
"	"	112 685	"	43 600	100 000	43 600
"	"	112 549	"	43 400	100 000	43 400
"	"	112 502	"	43 400	100 000	43 400
"	"	112 724	"	43 500	100 000	43 500
"	"	112 481	"	43 200	100 000	43 200
"	"	112 709	"	43 400	100 000	43 400
"	"	112 491	"	43 800	100 000	43 800
"	"	112 684	"	43 600	100 000	43 600
"	"	106 653	"	40 300	100 000	40 300
"	"	87 789	"	31 300	80 000	31 300
"	"	82 875	"	28 400	60 000	28 400
"	"	95 097	"	30 200	80 000	30 200
"	"	92 650	"	30 000	80 000	30 000
"	"	93 464	"	30 000	80 000	30 000
"	"	89 101	"	31 800	80 000	31 800
"	"	90 256	"	31 400	80 000	31 400
"	"	86 615	"	30 500	80 000	30 500
"	"	96 487	"	30 600	80 000	30 600
"	"	110 780	"	41 000	100 000	41 000
"	"	86 267	"	31 200	80 000	31 200
"	"	111 294	"	41 100	100 000	41 100
"	"	95 713	"	32 700	80 000	32 700
"	"	88 462	"	32 200	80 000	32 200
"	"	88 685	"	30 800	80 000	30 800
"	"	81 090	"	27 200	60 000	27 200
"	"	81 497	"	29 100	60 000	29 100
"	"	107 342	"	39 500	100 000	39 500
"	"	90 418	"	31 200	80 000	31 200
"	"	80 286	"	26 200	60 000	26 200
"	"	75 883	"	27 600	50 000	27 600
"	"	87 257	"	26 700	60 000	26 700
"	"	104 716	"	39 500	100 000	39 500
"	"	80 903	"	28 200	60 000	28 200
"	"	88 848	"	32 300	80 000	32 300
"	"	95 991	"	30 500	80 000	30 500
"	"	112 072	"	35 900	80 000	35 900
"	"	89 296	"	32 800	80 000	32 800
"	"	87 877	"	31 000	80 000	31 000
"	"	90 809	"	30 000	80 000	30 000
"	"	91 004	"	30 500	80 000	30 500
"	"	96 718	"	31 600	100 000	31 600
"	"	95 836	"	32 000	80 000	32 000
"	"	87 904	"	32 000	80 000	32 000
"	"	95 513	"	30 800	80 000	30 800
"	"	108 236	"	40 400	100 000	40 400
"	"	97 033	"	33 500	100 000	33 500
"	"	110 743	"	41 100	100 000	41 100
"	"	112 512	"	43 400	100 000	43 400
"	"	110 531	"	40 600	100 000	40 600
"	"	88 994	"	31 300	80 000	31 300
"	"	85 921	"	31 800	80 000	31 800
"	"	70 984	"	23 300	40 000	23 300
Caboose	"	98 068	"			34 000

TABLE 28 TONNAGE RECORD

Test No. S-1070

Kind of Car	Loaded or Empty	Car No.	Car Initial	Stenciled Light Weight	Capacity	Gross Weight
	L or E			pounds	pounds	pounds
Test	E	17				58 000
Box	L	10 826	I. C.	31 300	60 000	96 800
"	"	131 644	"	39 600	80 000	127 100
"	E	25 703	V. S. & P.	32 000	60 000	32 000
"	L	7 628	I. C.	27 200	50 000	91 000
"	"	12 951	"	29 700		99 800
"	"	33 524	"	36 500	80 000	120 100
"	"	22 113	"	40 200	80 000	93 900
Gondola	"	97 293	"	31 500	100 000	78 500
"	"	96 803	"	34 400	100 000	74 900
Stock	E	151 427	"		40 000	29 300
"	"	150 457	"		40 000	28 100
"	"	32 589	"	31 200	60 000	31 200
"	"	32 738	"	31 000	60 000	31 000
"	"	150 986	"	30 000	40 000	30 000
"	"	4 206	S. W. S. C. L.	29 300	40 000	29 300
"	"	32 714	I. C.	33 200	60 000	33 200
"	"	151 275	"	29 600	40 000	29 800
"	"	32 663	"	32 600	60 000	32 600
"	"	31 168	"	29 000	50 000	29 700
"	"	150 874	"	32 800	60 000	32 600
"	"	32 176	"	32 800	60 000	32 800
"	"	151 497	"	31 100	40 000	31 100
"	"	151 023	"	30 300	40 000	30 300
"	"	32 411	"	35 000	60 000	35 000
Box	L	142 729	"	42 900	100 000	65 200
"	"	39 777	"	37 400	80 000	61 100
"	"	19 989	"	28 300	60 000	60 900
"	E	95 571	L. & N.	34 500	65 000	34 500
"	L	140 687	I. C.	42 700	100 000	137 600
"	"	45 487	"	38 400	80 000	119 600
"	"	142 979	"	42 800	100 000	136 900
"	"	142 275	"	42 700	100 000	135 000
"	E	30 047	T. R. E.	34 800	50 000	34 800
"	"	31 974	"	32 100	50 000	32 100
Gondola	"	95 202	I. C.	30 400	80 000	31 400
"	"	96 724	"	32 000	100 000	32 000
"	"	108 393	"	40 400	100 000	40 400
"	"	87 275	"	32 200	80 000	33 200
Box	L	15 680	"	29 900	60 000	91 200
Gondola	E	96 130	"	32 000	80 000	32 000
Box	"	55 803	"	37 700	60 000	37 700
"	"	21 244	F. G. E.	36 500	50 000	36 500
Gondola	"	82 806	I. C.	27 500	60 000	27 500
"	"	82 709	"	28 800	60 000	28 800
Box	L	135 028	S.	33 700	60 000	68 700
Gondola	E	88 465	I. C.	32 600	80 000	32 600
"	"	91 623	"	30 700	80 000	30 700
"	"	106 662	"	40 000	100 000	40 000
"	"	86 231	"	31 700	80 000	31 700
"	"	80 430	"	26 500	60 000	26 500
"	"	93 350	"	31 300	80 000	31 300
"	"	94 475	"	31 100	80 000	31 100
"	"	93 620	"	30 400	80 000	30 400
"	"	96 757	"	31 800	100 000	31 800
"	"	89 088	"	30 200	80 000	30 200
"	"	82 367	"	26 800	60 000	26 800
"	"	94 594	"	30 300	80 000	30 300
"	"	92 570	"	31 000	80 000	31 000
"	"	115 109	"	43 000	100 000	43 000
"	"	81 281	"	29 000	80 000	29 000
"	"	84 172	"	28 400	80 000	28 400
"	"	83 919	"	28 200	80 000	28 200
"	"	714	C. C.C. & Co.	31 800	80 000	31 800
"	"	92 158	I. C.	30 400	80 000	30 400
Caboose	"	98 130	"			34 000

TABLE 29 TONNAGE RECORD

Test No. S-1072

Kind of Car	Loaded or Empty	Car No.	Car Initial	Stenciled Light Weight	Capacity	Gross Weight
	L or E			pounds	pounds	pounds
Gondola	L	106 825	L. C.	40 400	100 000	134 700
"	"	104 661	"	40 300	100 000	146 700
"	"	106 529	"	40 200	100 000	144 900
"	"	104 968	"	39 200	100 000	144 700
"	"	115 250	"	42 700	100 000	141 900
"	"	111 111	"	40 900	100 000	148 300
"	"	89 762	"	31 600	80 000	114 200
"	"	110 559	"	40 800	100 000	147 600
"	"	86 636	"	31 200	80 000	114 100
"	"	107 020	"	39 800	100 000	144 300
"	"	91 917	"	30 800	80 000	114 000
"	"	87 078	"	31 800	80 000	117 900
"	"	110 980	"	41 600	100 000	144 000
"	"	110 318	"	40 900	100 000	137 800
"	"	106 382	"	40 400	100 000	136 900
"	"	107 436	"	39 700	100 000	147 600
"	"	91 606	"	30 400	80 000	114 100
"	"	101 156	"			159 100
"	"	101 075	"		100 000	120 100
"	"	108 878	"	40 200	100 000	144 900
"	"	102 054	"	38 000	80 000	117 000
"	"	110 951	"	41 800	100 000	131 000
"	"	105 689	"	40 200	100 000	139 200
"	"	3 345	I. S.	40 100	100 000	147 700
"	"	105 713	I. C.	39 800	100 000	143 900
"	"	106 829	"	40 300	100 000	142 100
"	"	106 121	"	40 400	100 000	144 100
Caboose	E	98 155	"			35 100

TABLE 30 TONNAGE RECORD

Test No. S-1073

Kind of Car	Loaded or Empty	Car No.	Car Initial	Stenciled Light Weight	Capacity	Gross Weight
	L or E			pounds	pounds	pounds
Gondola	L	104 181	L. C.	40 800	100 000	139 300
"	"	110 059	"	42 300	100 000	135 800
"	"	110 679	"	42 000	100 000	135 700
"	"	111 062	"	41 000	100 000	134 500
"	"	111 336	"	40 100	100 000	134 300
"	"	112 464	"	43 400	100 000	118 600
"	"	112 431	"	43 300	100 000	118 700
"	"	106 038	"	38 800	100 000	133 700
"	"	107 581	"	40 100	100 000	130 200
"	"	3 012	I. S.	40 100	100 000	145 200
"	"	115 335	I. C.	43 000	100 000	141 600
"	"	106 459	"	40 000	100 000	138 800
"	"	3 400	I. S.	40 400	100 000	141 700
"	"	106 818	I. C.	40 500	100 000	141 200
"	"	106 087	"	41 200	100 000	141 900
"	"	3 131	I. S.	40 200	100 000	141 400
"	"	104 817	I. C.	40 400	100 000	141 800
"	"	107 217	"	39 700	100 000	141 300
"	"	107 599	"	39 600	100 000	142 000
"	"	106 101	"	40 300	100 000	141 900
"	"	106 598	"	40 200	100 000	142 500
"	"	106 197	"	40 400	100 000	138 600
"	"	104 390	"	40 700	100 000	140 400
"	"	105 651	"	40 300	100 000	140 600
"	"	106 551	"	40 000	100 000	143 100
"	"	107 124	"	39 600	100 000	140 500
"	"	106 722	"	40 300	100 000	141 300
Caboose	E					34 000

TABLE 31 TONNAGE RECORD

Test No. S-1074

Kind of Car	Loaded or Empty	Car No.	Car Initial	Stenciled Light Weight	Capacity	Gross Weight
	L or E			pounds	pounds	pounds
Test	E	17				58 000
Gondola	"	92 451	I. C.	30 100	80 000	30 500
"	"	93 288	"	30 800	80 000	31 500
"	"	705	C. C. C. & Co.	31 300	80 000	31 200
"	"	91 779	I. C.	29 900	80 000	29 400
"	"	83 029	"	28 000	80 000	27 400
"	"	86 841	"	31 000	80 000	31 300
"	"	267	St. L. B. & S.	25 700	60 000	24 800
"	"	83 597	I. C.	27 100	60 000	27 200
"	"	82 261	"	28 300	60 000	27 700
"	"	86 473	"	31 400	80 000	31 000
"	"	94 563	"	30 600	80 000	30 700
"	"	85 327	"	30 400	80 000	32 000
"	"	92 664	"	31 200	80 000	30 500
"	"	87 201	"	32 000	80 000	32 000
"	"	95 260	"	29 800	80 000	29 400
"	"	105 612	"	40 400	100 000	40 400
"	"	93 048	"	31 500	80 000	31 200
"	"	295	St. L. B. & S.	24 000	60 000	24 500
"	"	82 249	I. C.	27 000	60 000	27 000
"	"	86 327	"	30 400	80 000	30 600
"	"	85 482	"	31 500	80 000	31 000
"	"	80 882	"	27 600	60 000	27 600
"	"	106 064	"	40 300	100 000	40 400
"	"	105 983	"	40 400	100 000	40 800
"	"	86 779	"	31 000	80 000	33 900
"	"	93 956	"	30 100	80 000	30 400
"	"	104 389	"	40 800	100 000	40 400
"	"	86 183	"	31 000	80 000	30 700
"	"	81 190	"	27 200	60 000	26 800
"	"	82 470	"	30 600	80 000	30 200
"	"	95 912	"	32 000	80 000	30 800
"	"	91 788	"	30 500	80 000	30 300
"	"	86 132	"	29 500	80 000	30 700
"	"	95 167	"	30 500	80 000	31 500
"	"	107 604	"	39 600	100 000	40 000
"	"	87 657	"	32 000	80 000	32 300
"	"	87 590	"	32 300	80 000	35 200
"	"	89 683	"	31 400	80 000	31 200
"	"	7 555	"	23 400	50 000	23 200
"	"	107 148	"	39 800	100 000	40 300
"	"	104 379	"	40 400	100 000	40 400
"	"	88 351	"	31 500	80 000	31 600
"	"	87 468	"	31 900	80 000	31 500
"	"	101 229	"	38 400	100 000	37 800
"	"	88 120	"	32 000	80 000	31 600
"	"	94 808	"	31 500	80 000	31 500
"	"	95 480	"	31 900	80 000	32 000
"	"	87 780	"	32 100	80 000	31 600
"	"	93 494	"	29 700	80 000	30 000
"	"	90 671	"	30 800	80 000	30 800
"	"	106 167	"	40 300	100 000	40 100
"	"	89 097	"	32 000	80 000	31 600
"	"	96 072	"	31 800	80 000	31 200
"	"	88 688	"	31 500	80 000	31 700
"	"	94 133	"	31 900	80 000	30 600
"	"	93 394	"	30 600	80 000	31 300
"	"	106 088	"	40 400	100 000	40 200
"	"	89 272	"	30 600	80 000	30 800
"	"	94 599	"	30 800	80 000	30 800
"	"	87 595	"	32 100	80 000	31 500
"	"	91 988	"	30 500	80 000	30 000
"	"	92 035	"	31 300	80 000	31 200

TABLE 31 TONNAGE RECORD *(Continued)*

Test No. S-1076

Kind of Car	Loaded or Empty	Car No.	Car Initial	Stenciled Light Weight	Capacity	Gross Weight
	L or E			pounds	pounds	pounds
Gondola	E	93 848	I. C.	29 500	80 000	29 700
"	"	106 911	"	40 200	100 000	40 200
"	"	105 727	"	40 400	100 000	40 900
"	"	80 466	"	26 700	60 000	26 100
"	"	110 363	"	41 500	100 000	40 800
"	"	80 324	"	25 600	60 000	30 300
"	"	95 278	"	31 000	80 000	30 000
"	"	82 246	"	28 500	60 000	28 200
"	"	106 288	"	39 800	100 000	40 000
"	"	105 836	"	40 300	100 000	40 200
"	"	104 811	"	40 300	100 000	40 200
"	"	3 207	I. S.	40 300	100 000	39 800
"	"	91 420	I. C.	29 200	80 000	29 600
"	"	112 413	"	43 400	100 000	43 200
"	"	90 452	"	29 600	80 000	31 600
"	"	104 047	"	40 800	100 000	40 400
"	"	115 181	"	41 800	100 000	42 300
Caboose	"	98 005	"			32 000

TABLE 32 TONNAGE RECORD

Test No. S-1076

Kind of Car	Loaded or Empty	Car No.	Car Initial	Stenciled Light Weight	Capacity	Gross Weight
	L or E			pounds	pounds	pounds
Gondola	L	104 098	I. C.	41 000	100 000	149 000
"	"	104 679	"	39 200	100 000	146 000
"	"	105 091	"	40 400	100 000	148 600
"	"	105 690	"	40 300	100 000	143 400
"	"	3 344	I. S.	40 000	100 000	143 300
"	"	110 982	I. C.	41 100	100 000	137 000
"	"	104 698	"	40 600	100 000	138 500
"	"	104 023	"	40 600	100 000	142 500
"	"	107 109	"	39 700	100 000	144 000
"	"	104 361	"	40 200	100 000	148 000
"	"	107 310	"	39 700	100 000	146 000
"	"	106 268	"	40 300	100 000	147 000
"	"	104 087	"	40 900	100 000	152 000
"	"	106 161	"	40 600	100 000	146 500
"	"	107 133	"	39 700	100 000	144 900
"	"	106 144	"	40 400	100 000	150 000
"	"	111 280	"	41 800	100 000	139 000
"	"	111 229	"	40 800	100 000	135 300
"	"	110 525	"	41 300	100 000	139 300
"	"	106 713	"	40 500	100 000	143 300
"	"	110 736	"	40 700	100 000	142 000
"	"	110 421	"	43 500	100 000	148 000
"	"	110 843	"	41 200	100 000	142 400
"	"	111 061	"	41 200	100 000	141 000
"	"	107 126	"	39 700	100 000	143 000
Caboose	E	98 320	"			36 100

TABLE 33 TONNAGE RECORD

Test No. S-1077

Kind of Car	Loaded or Empty	Car No.	Car Initial	Stenciled Light Weight	Capacity	Gross Weight
	L. or E.			pounds	pounds	pounds
Test	E	17				58 000
Gondola	L	2 186	L. E. A. & W.	36 200	80 000	120 200
"	"	107 315	I. C.	39 700	100 000	138 800
"	"	106 426	"	40 500	100 000	151 800
"	"	104 103	"	37 600	100 000	153 600
"	"	88 740	"	32 000	80 000	104 600
Box	"	82 474	B. & O.	33 600	60 000	83 600
"	E	33 880	S. P.	42 700	100 000	41 900
"	"	11 238	H. & T. C.	40 200	100 000	42 800
"	L	11 150	D. S. S. & A.	32 400	80 000	73 600
"	E	10 846	N. C. & St. L.	35 400	60 000	35 000
"	E	337	G. & F.	32 500	60 000	31 700
"	"	34 552	I. C.	37 700	80 000	37 060
"	"	140 487	"	41 900	100 000	42 000
"	"	142 394	"	42 900	100 000	42 000
"	"	49 498	"	34 400	80 000	34 500
"	"	131 662	"	39 500	80 000	40 000
"	"	38 755	"	38 600	80 000	38 600
"	"	15 853	N. O. & N. E.	30 600	60 000	30 600
"	"	9 644	L. & N.	40 800	60 000	40 700
"	"	11 712	"	30 900	60 000	30 700
"	L	15 492	I. C.	30 200	60 000	90 000
"	"	141 573	"	43 500	100 000	63 800
"	"	140 563	"	42 200	100 000	64 500
"	E	10 381	L. & N.	29 800	60 000	29 800
"	"	11 364	S.P.L.A.&S.L	43 500	100 000	43 100
"	"	11 893	N. C. & St. L.	33 400	60 000	33 300
"	"	65 969	S. P.	29 600	60 000	30 300
"	"	93 651	L. & N.	36 500	65 000	35 200
"	"	94 824	"	34 800	65 000	34 000
"	"	13 705	"	30 700	60 000	30 700
"	"	9 312	N. C. & St. L.	32 550	60 000	32 700
"	L	98 561	N. Y. C.& H.R.	35 700	80 000	78 200
"	E	12 887	C. N. O. & T. P.	34 500	60 000	33 400
"	"	4 886	N. & S.	33 600	60 000	32 000
"	"	12 027	N. & M.	37 000	80 000	30 200
"	L	131 675	I. C.	38 900	80 000	110 400
"	"	14 554	"	32 000	60 000	75 500
"	"	10 060	"	31 000	60 000	70 000
"	"	12 724	"	29 300	60 000	76 500
"	"	13 276	St. L. S. W.	32 000	60 000	79 900
"	"	26 615	I. C.	35 800	80 000	90 800
"	"	141 284	"	43 500	00 000	105 900
Gondola	E	618	E. F. D. & Co.	24 200		24 800
"	"	744	C. C. & Co.	31 800	80 000	30 600
"	"	106 729	I. C.	40 400	100 000	40 100
"	"	94 503	"	30 600	80 000	35 800
"	"	112 570	"	43 500	100 000	43 100
"	"	112 153	"	37 200	80 000	39 500
"	"	107 346	"	39 700	100 000	39 900
"	"	105 529	"	40 200	100 000	40 600
"	"	104 361	"	40 200	100 000	40 000
Caboose	"	98 370	"			35 900

TABLE 34 TONNAGE RECORD .

Test No. S-1079

Kind of Car	Loaded or Empty	Car No.	Car Initial	Stenciled Light Weight	Capacity	Gross Weight
	L or E			pounds	pounds	pounds
Box	E	11 050	H. & T. C.	42 100	100 000	36 200
"	"	43 031	M. C.	30 700	60 000	30 400
"	"	41 654	C. & N. W.	27 100	40 000	27 700
"	L	31 105	C. R. I. & P.	36 300	80 000	80 800
"	"	15 746	I. C.	29 600	60 000	69 000
"	"	22 691	S. P.	26 600	50 000	70 000
Refrigerator	E	6 696	A. R. L.	35 600	50 000	34 000
Box	L	14 053	I. C.	30 500	60 000	70 400
"	"	33 125	"	36 200	80 000	89 600
"	"	39 747	"	36 200	80 000	72 500
"	"	46 477	"	37 200	80 000	76 000
"	"	30 352	R. I. A. & L.	36 400	80 000	74 000
"	"	131 445	I. C.	39 800	80 000	80 000
"	"	19 385	M. P.	32 000	60 000	62 000
"	"	70 716	B. & O.	30 800	60 000	67 600
"	"	31 563	C. R. I. & P.	38 700	80 000	93 500
"	"	700	H. E. & W. T.	31 700	60 000	80 000
"	"	12 116	Mex. Cent.	30 600	27 500K	86 700
Gondola	"	87 708	I. C.	31 600	80 000	66 400
Box	"	46 057	"	39 400	80 000	80 400
"	"	12 562	"	30 300	60 000	69 600
"	"	131 611	"	39 000	80 000	63 600
"	"	142 973	"	41 000	100 000	80 000
"	"	50 174	C. & G. W.	38 400	60 000	79 000
"	"	34 506	I. C.	37 500	80 000	62 700
Gondola	"	82 347	"	27 300		85 600
Box	"	37 578	"	33 000	80 000	85 000
Refrigerator	E	6 459	M. & Co. R. L.			36 700
Gondola	L	97 161	I. C.	32 700	100 000	86 500
Box	"	14 550	"	29 800	60 000	65 300
Gondola	"	91 822	"	31 000	80 000	97 000
Box	"	15 713	"	29 900	60 000	72 500
Refrigerator	E	4 068	M. F. T. Co.	40 500	60 000	40 400
"	"	5 886	A. R. L.	31 900	50 000	34 000
Box	L	112 042	I. C.	42 900	100 000	83 000
Refrigerator	E	307	U. R. T. Co.	38 000	40 000	39 000
Box	L	131 734	I. C.	39 300	80 000	88 700
Refrigerator	E	3 831	U. R. T. Co.		40 000	36 500
Box	"	74 936	Erie	32 200	60 000	32 400
Refrigerator	"	20 018	F. G. E.	38 700	50 000	33 800
"	"	6 115	A. R. L.	36 500	50 000	37 700
Box	L	85 137	U. P.	39 700	80 000	89 000
Gondola	"	111 101	I. C.	40 500	100 000	78 600
Refrigerator	E	1 840	M. R. D.	37 500	60 000	38 500
Box	L	72 907	Penn.	30 900	60 000	91 000
"	"	25 346	C. B. & Q.	27 400	60 000	70 200
"	"	60 245	S. P.	35 200	60 000	88 500
"	"	64 733	"	29 600	60 000	75 500
"	"	11 771	I. C.	29 500	60 000	65 500
"	"	13 983	K. C. S.	31 600	60 000	82 300
Caboose	E	98 260	I. C.			35 400

TABLE 35 TONNAGE RECORD

Test No. S-1080

Kind of Car	Loaded or Empty	Car No.	Car Initial	Stenciled Light Weight	Capacity	Gross Weight
	L or E			pounds	pounds	pounds
Test	E	17				58 000
Box	L	10 315	I. C.	30 400	80 000	91 200
"	"	141 744	"	43 600	100 000	147 100
"	"	141 622	"	43 600	100 000	135 200
"	"	21 385	"	36 600	80 000	124 200
"	E	31 478	T. R. E.	32 200	50 000	33 400
"	L	38 140	I. C.	34 400	80 000	125 000
"	"	48 223	"	39 800	80 000	89 300
Gondola	E	104 852	"	40 000	100 000	39 400
"	"	105 936	"	40 000	100 000	40 000
"	"	88 440	"	31 600	80 000	31 800
Box	"	12 000	M. L. & T.	32 000	60 000	31 800
Gondola	"	90 647	I. C.	31 500	80 000	31 600
"	"	82 853	"	28 400	60 000	27 900
"	"	107 065	"	39 900	100 000	39 900
"	"	100 701	"	40 600	100 000	40 400
"	"	106 321	"	40 400	100 000	40 200
"	"	3 354	I. S.	40 400	100 000	40 100
"	"	104 969	I. C.	40 000	100 000	40 000
"	"	106 793	"	40 200	100 000	40 100
"	"	101 154	"	37 800	100 000	37 800
"	"	100 021	"	32 700	90 000	33 000
"	"	107 624	"	39 600	100 000	40 000
"	"	107 217	"	39 700	100 000	39 900
"	"	106 305	"	39 400	100 000	40 100
"	"	104 027	"	40 400	100 000	40 500
"	"	94 971	"	33 200	80 000	31 900
"	"	94 209	"	30 800	80 000	30 800
"	"	87 979	"	32 000	80 000	31 600
"	"	76 795	"	30 000	50 000	29 900
"	"	110 818	"	41 600	100 000	41 400
"	"	107 532	"	39 500	100 000	40 200
"	"	92 400	"	31 600	80 000	31 500
"	"	88 001	"	31 200	80 000	31 100
"	"	3 009	I. S.	40 300	100 000	40 300
"	"	89 391	I. C.	30 700	80 000	30 500
"	"	94 566	"	30 900	80 000	30 700
"	"	104 167	"	40 800	100 000	40 700
"	"	91 513	"	30 200	80 000	30 200
"	"	91 485	"	30 400	80 000	30 400
"	"	86 008	"	34 300	80 000	31 600
"	"	85 444	"	31 000	80 000	30 900
"	"	87 389	"	31 400	80 000	31 400
"	"	91 106	"	31 400	80 000	31 300
"	"	111 131	"	40 800	100 000	30 700
"	"	90 929	"	31 700	80 000	31 600
"	"	100 071	"	32 900	80 000	32 900
"	"	89 481	"	31 800	80 000	31 400
"	"	104 746	"	40 400	100 000	40 400
"	"	87 877	"	31 000	80 000	30 600
"	"	92 494	"	26 800	80 000	30 100
"	"	101 177	"	37 700	100 000	37 800
"	"	86 841	"	31 000	80 000	31 200
"	"	85 409	"	31 800	80 000	31 600
"	"	89 100	"	32 600	80 000	31 000
"	"	83 948	"	27 600	60 000	27 900
"	"	94 065	"	30 900	80 000	30 800
"	"	82 328	"	28 400	60 000	27 900
"	"	87 302	"	30 600	80 000	38 800
"	"	102 002	"	38 000	80 000	37 800
"	"	88 051	"	31 300	80 000	31 600
"	"	91 268	"	30 500	80 000	30 500
Caboose	"	98 413	"			34 800

APPENDIX 3

APPENDIX 3

THE TRACK

All tests, except No. S-1030A, were made over the 91 miles of Illinois Central main line track lying between Gilman (mile 81.12) and Mattoon (mile 172.38), Illinois.

Roadbed.—This track, formerly a part of one of the oldest single track lines in the State, was converted about ten years ago into a double track road; and the roadbed is now well settled and in good condition. In construction the roadbed has been made to conform as closely as practicable to the standard Illinois Central section for class A double track. This section has a 34-ft. crown with a slope of 1½ to 1 for embankments, and a 46½-ft. base with slopes of 1 to 1 or 1½ to 1 for cuts. The drainage of the track is, in general, excellent.

Ballast and Ties.—Except on a few short stretches through station grounds where screenings are used for ballast, both tracks are ballasted with broken limestone throughout this distance. There is not less than 12 in. of ballast beneath the ties, and the ballast shoulder extends 12 in. beyond the ties whence it runs off to the sub grade on a slope of 1¾ to 1. The cross ties are of either untreated white oak or treated red oak, and are 6 in. by 8 in. by 8 ft. long. They are spaced about 20 in. from center to center.

Rail.—The south-bound or west track between mile 161+3500 ft. and mile 171 is laid with rail weighing 75 lb. per yard. The remainder of the west track and all of the east track are laid with rail weighing 85 lb. per yard. The 75-lb. rail is of the standard American Society of Civil Engineers' section, rolled by the Illinois Steel Company, and is further designated as Illinois Steel Company's section No. 7506. All 85-lb. rail is of standard A. S. C. E. section, and Illinois Steel Company's section No. 8504.

Rail Joints and Fastenings.—All rails are laid with square joints, supported on three ties. The 75 lb. rails are joined with Illinois Central Standard 40-in. angle-bar splices, weighing 76 lb. per pair; and the 85-lb. rails are joined with similar splices weighing 80-lb. per pair. In each joint six track bolts are used, which are ¾ by 4½ in. for the 75-lb. rails, and ¾ by 4½ in. for the 85-lb. rails. Four $\frac{9}{16}$ by 5½ in. track spikes are used in each cross tie. No tie plates or rail braces are used, except through switches.

Maintenance.—During eight months of the year there is employed in maintaining this portion of the road a force of men averaging one man per mile of track; during the remaining four months this force is reduced to one man for each two miles.

APPENDIX 4

APPENDIX 4

Methods Employed in Calculating the Results

This appendix presents a detailed explanation of the processes used throughout this investigation in deriving the results of the tests. Two methods of calculation have been employed. By one method resistance was determined at a point on the road; by the other, the average resistance was determined for the period during which the test car passed over a certain track section. The former is termed Method 1, the latter, Method 2. A general statement and comparison of the two methods and an explanation of the general limitations imposed upon the selection of points and sections have been given in Part I. Whatever is said under "Methods Employed in Calculating the Results" in Part I is to be considered as supplementary to the contents of this Appendix.

The Elements of Gross Resistance

The various elements which make up gross train resistance are:

1. Net resistance on straight, level track, at uniform speed, in still air.
2. Resistance due to wind, (as distinguished from still air resistance).
3. Resistance due to grade.
4. Resistance due to acceleration.
5. Resistance due to track curvature.

Item 1 is always in operation to retard a moving train. One or more (or none) of the others may also be acting with item 1 to form gross resistance.

The dynamometer car records directly the gross resistance or drawbar pull as here defined. The purpose of the calculations has been to determine net resistance (item 1); or more strictly speaking, the purpose, by force of circumstances, has been to determine the sum of net resistance (item 1), and wind resistance (item 2), since it has been impossible to differentiate the latter from the other elements. Curve resistance has been entirely eliminated from consideration by selecting for calculation only those points and sections where the train was on tangent track. Grade resistance and acceleration resistance may always be determined by

calculation; and in order to find the net resistance, it is necessary only to subtract these two items (3 and 4) from the gross resistance recorded on the test car chart.

Since the process employed implies the ability to calculate the grade and acceleration resistances, their determination will be explained before proceeding with the explanation of the two methods by which net resistance was derived.

The following general notation is used throughout. Other special notation needed in the development of the analysis is given as the necessity arises.

NOTATION:

P = Total gross resistance=drawbar pull.—pounds.

R = Net resistance on tangent, level track, at uniform speed. pounds per ton.

R_g = Resistance due to grade.—pounds per ton.

R_a = Resistance due to acceleration.—pounds per ton.

W = Total train weight.—tons.

V, V_1, etc. = Train speed.—miles per hour.

G = Grade.—feet per mile.

A = Acceleration of the train speed.—miles per hour per second.

a = Acceleration of the train speed.—feet per second per second.

E_1 and E_2 = Elevations of the center of mass of the train.—feet.

S = Length of track section used in Method 2.—feet.

N = Number of cars in the train.

GRADE RESISTANCE

If the train be on a uniform grade of G feet per mile, the grade resistance in pounds per ton is at the moment:

$$R_g = 0.379 \times G \ldots\ldots\ldots\ldots\ldots\ldots (15).$$

If it be desired to find the average grade resistance during the period in which the test car passes a certain section of track, we must determine the elevations of the center of mass of the train at the moments the car enters and leaves the section. If we call these elevations E_1 and E_2 respectively, and the length of the section S (in feet), then the average grade in feet per mile is:

$$G = (E_2 - E_1) \times \frac{5280}{S}$$

and

$$R_g = 0.379 \times (E_2 - E_1) \times \frac{5280}{S} = \frac{2001\ (E_2 - E_1)}{S} \quad \ldots\ldots (16).$$

G and $(E_2 - E_1)$ in these equations may be found directly from the profile; and S may be calculated from the profile or from the dynamometer chart. To give correct results, the entire train must be on uniform grade at the moments for which G, E_1 and E_2 are determined.

Acceleration Resistance

The total force needed to produce acceleration is made up of two parts. The first is the force needed to produce acceleration in the motion of translation of the train as a whole; and the second is the force needed to produce acceleration in the rotation of the wheels and axles. This total force is the total acceleration resistance R_a.

Let

R_a = Acceleration resistance due to both translation and rotation. —pounds per ton.

F = Total drawbar pull needed to produce the acceleration.- pounds.

T = Drawbar pull needed to produce acceleration in the translation of the whole train.—pounds.

f = Drawbar pull needed to produce acceleration in the rotation of all wheels and axles. - pounds.

Then

$$R_a = \frac{F}{W}$$

and

$$F = T + f$$

therefore

$$R_a = \frac{T + f}{W} \quad \ldots\ldots (17).$$

T and f in this equation are found as follows:

$$T = \text{mass} \times \text{acceleration} = \frac{W \times 2000}{32.2} \times a$$

but

$$a = A \times \frac{5280}{60 \times 60} = 1.466\ A$$

hence

$$T = \frac{W \times 2000 \times 1.466\ A}{32.2} = 91.05\ A\ W \quad \ldots\ldots (18).$$

To find f:

Let

p = Drawbar pull required to produce the acceleration in the rotation of one pair of wheels and their axle.—pounds. This is to be considered as a force applied at the wheel rim.

p_1 = Force which, applied at the end of the "radius of gyration", would produce the acceleration in rotation produced by p.

r = Wheel radius.—any unit.

k = Radius of gyration of one pair of wheels and axle.—same unit as r.

w = Weight of one pair of wheels and their axle. — pounds.

a = Acceleration in the linear velocity of a point on the wheel rim.—feet per second per second. This equals the acceleration of the train.

b = Acceleration in the linear velocity of a point at the end of the radius of gyration.—feet per second per second.

w is taken as equal to 1950 lb[1], which is the approximate mean between the weight of a 4½ by 8 axle and its wheels and the weight of a 5 x 9 axle and its wheels. $\frac{k}{r}$ is found to be about 0.64 for various axles and wheels[1].

Since cars have 4 axles, we have:

$$f = 4\,N \times p$$

$$p = \frac{k}{r} \times p_1$$

$$p_1 = \frac{w}{32.2} \times b = \frac{1950}{32.2} \times b = 60.56\,b$$

$$b = a\,\frac{k}{r} = 1.466\,A \times \frac{k}{r}$$

$$p_1 = 60.56 \times 1.466\,A \times \frac{k}{r} = 88.82\,A \times \frac{k}{r}$$

$$p = 88.82\,A \times \frac{k^2}{r^2} = 88.82 \times (0.64)^2 \times A = 36.38\,A,$$

and

$$f = 4 \times N \times 36.38\,A = 145.5\,A\,N \qquad (19)$$

[1]The maximum error in Ra which may result from possible variations in w and $\frac{k}{r}$ under current standards of car design is 1.1 per cent. Ra in the calculations seldom exceeds R, and the maximum probable error in R due to such variations is therefore about one per cent. It would occur with a train of *empty* gondolas equipped with 5¾ x 10 journals and wheels weighing 725 lb. each.

From equations 17, 18, and 19

$$R_a = \frac{T}{W} \div \frac{f}{W}$$

Hence

$$R_a = (91.05 + 145.5 \frac{N}{W}) \times A \ldots\ldots\ldots\ldots\ldots (20).$$

Formula 20 may be applied to find the momentary acceleration resistance at a point on the road, or to determine its average value while the train passes a certain section. In the former case A denotes the momentary acceleration, and in the latter case A denotes the average acceleration over the section. N and W are derived from the train data. In either case A may be found as explained below.

The determination of acceleration.—In determining the net resistance by Method 1—at a point on the road—the momentary value of A in formula 20 has been determined as follows. In this discussion it should be remembered that all curves on the dynamometer chart are drawn on a distance base, i. e., to some scale their abscissas represent distances, in feet.

On the speed curve in Fig. 17, let B represent the point on the road which is under consideration. At B draw the tangent CD to this curve, and select on this tangent the points C and D *equidistant* from B. This tangent may be considered as a speed curve which at B represents the same acceleration as the actual speed curve. By direct measurement the ordinates of the tangent at C and D are determined as v_1 and v_2, respectively. Similarly the distance S may be determined. The speed at B is called v. The acceleration A at the point B is then determined thus:

Let

v, v_1, v_2 = Speed.—feet per second.

V_1, V_2 = Speed.—miles per hour.

t = Time.—seconds.

l = Distance.—feet.

a = Acceleration.— feet per second per second.

Then

$$a = \frac{d\,v}{d\,t}$$

and

$$d\,t = \frac{d\,l}{v}.$$

hence

$$a = \frac{v dv}{dl}$$

The equation of the tangent referred to the axes Ov and Ol is:

$$v = ml$$

$$m = \frac{v_2 - v_1}{S}$$

$$v = \frac{v_2 - v_1}{S} \times l$$

whence

$$d\,v = \frac{v_2 - v_1}{S}\, d\,l$$

and

$$\frac{d\,v}{dl} = \frac{v_2 - v_1}{S}$$

also, since v is the mean between v_1 and v_2,

$$v = \frac{v_2 + v_1}{2}$$

therefore

$$a = \frac{v dv}{d\,l} = \frac{v_2 + v_1}{2} \times \frac{v_2 - v_1}{S} = \frac{v_2^2 - v_1^2}{2\,S}$$

but

$$a = 1.466\ A$$

and

$$v = 1.466\ V,$$

hence

$$A = \frac{(1.466)^2 \times (V_2^2 - V_1^2)}{1.466 \times 2\ S} = 0.733 \frac{V_2^2 - V_1^2}{S} \quad \ldots\ldots\ldots\ldots (21).$$

Formula 21 is used to determine the momentary acceleration at a point B on the speed curve. V_1 and V_2 are ordinates at the two points, C and D, located on the tangent drawn at B and equidistant from B. To draw this tangent with sufficient accuracy, the speed curve must be nearly a straight line for a small distance on either side of B.

In determining the net resistance by Method 2—while the test car passes a certain track section—the average value of A in formula 20 has been determined as follows. The conditions are represented in Fig. 18.

Let a = the *uniform* acceleration which, acting during the passage of the car through the section, would have caused a speed change the same as that actually produced.—feet per second per second.

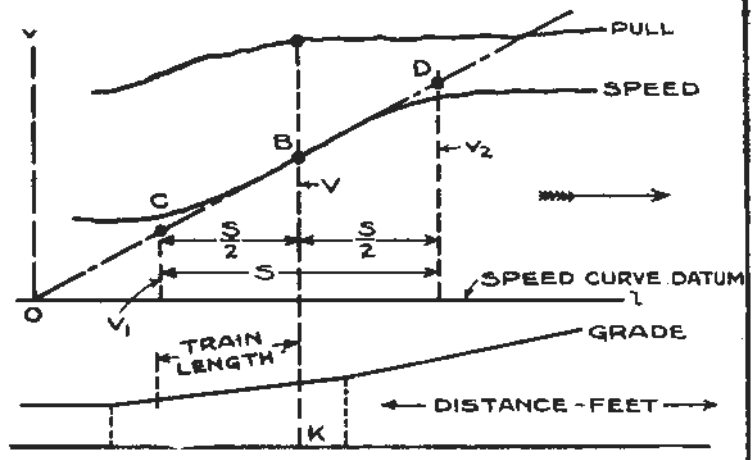

FIGURE 17

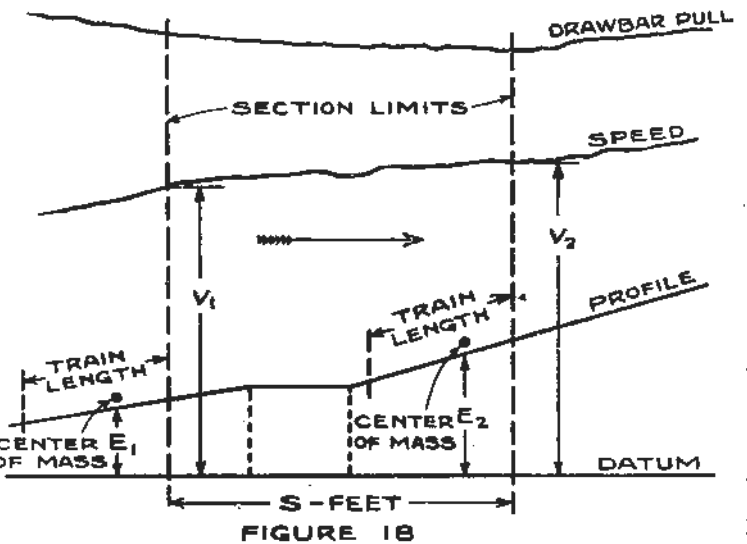

FIGURE 18

FIG. 17 DIAGRAM USED IN THE EXPLANATION OF METHOD I
FIG. 18. DIAGRAM USED IN THE EXPLANATION OF METHOD II

A = The same, expressed in miles per hour per second.
v_1 and v_2 = Speeds at entrance and exit.—feet per second.
V_1 and V_2 = Speeds at entrance and exit.—miles per hour.
S = The length of the section.—feet.
t = The time elapsed in transit over the section.—seconds.
Then

$$v_2 = v_1 + a\,t$$

and

$$S = v_1\,t + \frac{a\,t^2}{2}$$

whence, by the elimination of t,

$$a = \frac{v_2^2 - v_1^2}{2\,S}$$

and, since

$$a = 1.466\,A$$

and

$$v = 1.466\,V,$$

$$A = 0.733\,\frac{V_2^2 - V_1^2}{S} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (22)$$

This equation is identical in form with equation 21. It is used to determine the average acceleration over a given track section. In it A is to be understood as that hypothetical uniform acceleration which, acting during transit over the section, would have caused the absorption of the same energy as was actually expended to produce acceleration under the prevailing speed changes. V_1 is the speed at the moment the head of the train enters the section. V_2 is the speed at the moment the head of the train leaves the section. S is the length of the section.

Formula 22 is correct for all cases, regardless of the shape or variations of the speed curve. However, for reasons which are entirely unrelated to the accuracy of the acceleration determination and which have been explained in Part I, the sections were so chosen that V_1 and V_2 varied but slightly, and that the speed curve between the section limits presented no great speed variations.

The Determination of Net Resistance

Net resistance on straight, level track, at uniform speed is termed R, and is expressed in pounds per ton. In both methods of calculation its value was derived from the equation:

$$R = \frac{P}{W} - R_g - R_a \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (23).$$

In which P is determined from the test car chart, W from train data, and R_g and R_a as previously explained.

Method No. 1.—To determine R at a point on the track, equations 23, 15, and 20 may be used; these when combined give us:

$$R = \frac{P}{W} - 0.379G - (91.05 + 145.5\,\frac{N}{W}) \times A \ldots\ldots\ldots\ldots (24).$$

If the train is on a down grade the sign of the second term should be changed to plus. The value of A should be found by means of equation 21, and, as there explained, by drawing a tangent to the speed curve. The other quantities in the equation,—W, N, P, S, and G, may be found directly from the train data, or the dynamometer chart, or the profile. Fig. 17 represents the conditions which prevailed at points chosen for the calculations by this method. In Fig. 17 the line $K\,B$ represents the point on the road which is under consideration. All values of momentary resistance included in this report have been found by means of formula 24.

In the selection of points for the application of Method 1, the following precautions must be and have been observed:

1. The entire train must be on tangent track and on a uniform grade.
2. The speed curve must be nearly straight for a certain distance either side of the point chosen, in order to permit the tangent to be accurately drawn.
3. The acceleration should preferably be low. The maximum acceleration at any point chosen for the calculation of values included in this report was 0.106 miles per hour per second.

Method No. 2. To determine the mean value of R over a certain track section, equations 23, 16, and 20 may be used; these when combined give:

$$R = \frac{P}{W} - \frac{2001 \times (E_2 - E_1)}{S} - (91.05 + 145.5\,\frac{N}{W}) \times A \ldots\ldots (25).$$

In this case the value of A should be found by means of equation 22. The quantities to be determined in order to use formula 25 are W, N, P, S, V_1, V_2 and $(E_2 - E_1)$. W and N are derived from

the train data. P is the mean drawbar pull over the section, and is found by determining by the use of a planimeter the mean height of the pull curve between the section limits. S is the section length and may be found directly from the dynamometer chart. V_1 is the speed as the train enters the section. V_2 is the speed as the train leaves the section. V_1 and V_2 are determined directly from the dynamometer chart. E_1 is the elevation of the center of mass of the train at the moment its head end enters the section. E_2 is the corresponding elevation at the moment the head end of the train leaves the section. The quantity $(E_2 - E_1)$ is found from the profile. R in this case corresponds to the mean speed over the section. This mean speed is determined by means of the records of time and distance. Fig. 18 represents the conditions which prevailed at sections chosen for the calculations by this method. In Fig. 15, Appendix 1, is represented the section from which the results for item 12 of test S-1057 were derived. All values of mean resistance included in this report have been found by formula 25.

In the selection of points for the application of Method 2, the following precautions must be and have been observed:

1. The track must be straight over the section and also for a distance (equal to the train length) before the entrance to the section.
2. The entire train must be on a uniform grade at the moment its head end enters the section, and again at the moment it leaves the section. These grades need not, however, be alike.
3. For reasons which have been explained in Part I, the speed curve between the section limits should not present great speed variations nor should the difference between V_1 and V_2 be greater than ten or twelve miles per hour.

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APPENDIX 5

APPENDIX 5

The Results of the Individual Tests

Appendix 5 exhibits for each test a table showing the main results of the calculations. Where both methods of calculation have been employed, the tables show two groups of items. The one group displays the results obtained by Method 1, and the other shows those obtained by Method 2. The notation following the column headings is the same as that used in Appendix 4. The final values of net resistance on tangent, level track, at uniform speed are given in column 13, and the corresponding values of speed are given in column 12.

Following the table of results for each test is a figure which shows the relation between speed and resistance for the same test. The coordinates of the points plotted in these diagrams are the values of speed and resistance given in columns 12 and 13 of the corresponding table. The points represented in the diagrams by circles are plotted from values of momentary speed and momentary resistance obtained by Method 1. The points represented by circular black spots are plotted from values of average speed and average resistance obtained by Method 2. The numbers shown at the points are the corresponding item numbers given in column 2 in the table.

The curves represent for each test the mean relation between resistance and speed. In order to draw these curves, the plotted points were assumed to be arranged in a number of groups for each of which the "center of gravity" was determined and plotted on the diagram. The curve was then drawn by confining attention to the few points thus determined. The groups of points were arbitrarily selected so that the resulting "centers of gravity" were almost equidistantly distributed throughout the speed range.

TABLE 36 TEST NO. S-1013

From Champaign to Gilman, April 27, 1908. Weather: Intermittent rain. Temperature: 42° F. at start, 44° F. at end of test. Total weight behind measuring drawbar = 2549 tons, including the test car. Train length = 2784 ft. Center of mass 1425 ft. back of measuring drawbar. 67 cars: 10 empty, 57 loaded. Kind of cars: 53 box, 9 gondola, 3 tank, 1 test, 1 caboose. Average weight per car = 38.04 tons.

1	2	3	4	5	6	7	8	9	10	11	12	13
Method of Calculation	Item No.	Location on Road Milepost No.	Length of Section feet	Total Drawbar Pull pounds	Acceleration miles per hour per second	Speeds		Grade + Up − Down feet per mile	Wind		Speed m. p. h.	Net Train Resistance pounds per ton
						At Entrance to Section m. p. h.	At Exit from Section m. p. h.		Approximate Direction	Approximate Velocity m. p. h.		
				P	A	V_1	V_2	G			V	R
Point Columns 5, 6, and 9 to 13 show Momentary Values	2	116.67		16400	0			+1.48	+50°L	18	18.20	5.86
	3	112.23		13750	0			−2.78	90°L	19	24.30	6.45
	4	110.46		20600	0			+16.50	90°L	19	11.50	5.34
	5	108.80		11900	0			−4.82	+40°L	25	24.60	6.50
	7	105.86		9850	0			−10.00	+50°L	32	32.70	7.05
	8	100.51		23000	0			+8.52	+90°L	17	12.70	5.79
	9	99.29		12750	0			−5.74	+35°L	21	27.50	7.18
	10	91.00		12500	0			−2.59	+55°L	15	26.30	5.89
	11	90.08		12550	+0.0280			−9.32	+55°L	27	27.50	5.81
	12	87.00		13100	0			−2.23	+45°L	17	24.10	5.99
	13	86.15		15300	0			0.00	90°L	17	20.70	6.00
	14	84.46		16400	−0.0200			+6.20	90°L	14	18.40	6.00
	15	83.24		12250	0			−5.00	90°L	21	25.10	6.71
	16	81.86		13000	0			−1.67	90°L	15	16.00	5.73
Section Columns 5, 6, and 9 to 13 show Average Values	4	116.25—117.00	3960	16400		18.20	18.20	+2.00	+50°L	18	18.20	5.68
	5	110.46—111.00	2870	30000		11.60	11.60	+19.32	+90°L	19	11.60	4.45
	6	100.82—101.55	3880	23700		12.60	12.60	+10.60	+90°L	17	12.60	5.29

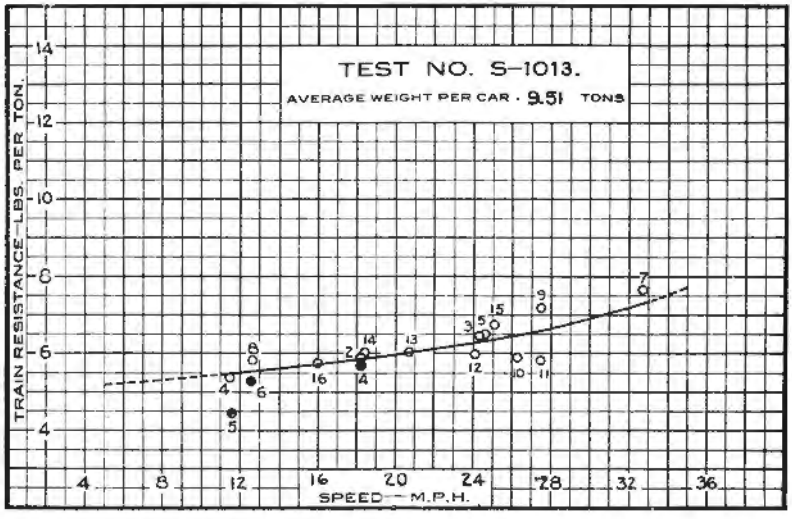


FIG. 19 TO 50 CURVES SHOWING THE RELATION BETWEEN RESISTANCE AND SPEED FOR EACH OF THE 32 TESTS

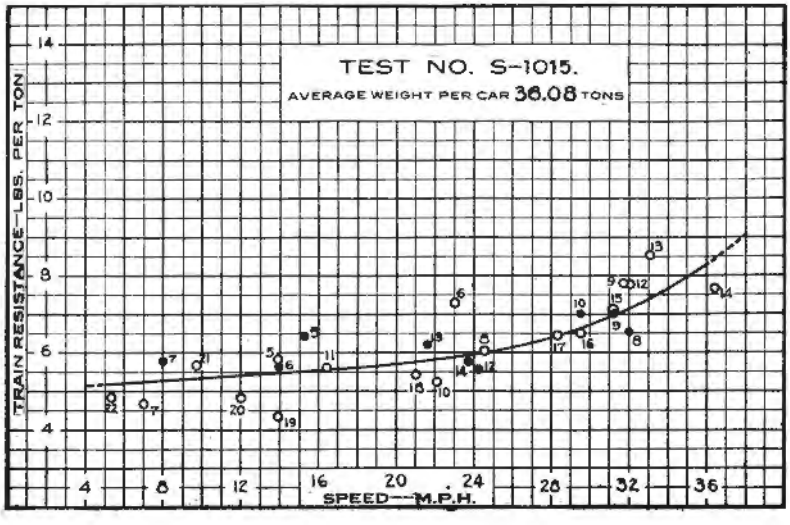


FIG. 20

TABLE 37 TEST NO. S-1015*

From Champaign to Gilman, April 29, 1908. Weather: Fair. Temperature: 40° F. at start, 48° F. at end of test. Total weight behind measuring drawbar = 2489 tons, excluding the test car. Train length = 2520 ft. Center of mass 1200 ft. back of measuring drawbar. 69 cars: 8 empty, 61 loaded. Kind of cars: 46 box, 4 gondola, 11 flat, 7 tank, 1 caboose. Average weight per car = 36.08 tons.

1	2	3	4	5	6	7	8	9	10	11	12	13
Method	Item	Mile Post	Section Length	Pull P'	Accel. A	Speed V_1	Speed V_2	Grade G	Direction	Velocity	Speed V	Resistance R
Point Columns 5, 6, and 9 to 13 Show Momentary Values	5	114.35		21800	0			+ 7.98	+80°L	6	13.90	5.84
	6	112.27		14800	0			− 3.56	+50°L	10	23.00	7.30
	7	110.64		31000	0			+20.50	+65°L	7	7.00	4.68
	8	108.67		13900	−0.0220			+ 4.39	+60°L	9	24.50	6.02
	9	105.95		10500	+0.0220			−15.04	+40°L	15	31.77	7.80
	10	101.76		11600	0			− 1.47	+30°L	12	22.10	5.23
	11	100.49		18500	0			+ 4.82	+55°L	6	16.40	5.61
	12	96.94		3750	0			−16.55	+35°L	15	32.10	7.79
	13	96.00		5500	+0.0021			−27.00	+45°L	15	33.10	8.51
	14	95.48		3500	+0.0300			−24.00	+55°L	11	36.40	7.65
	15	94.00		5250	0			−13.20	+30°L	16	31.25	7.11
	16	92.00		5500	0			−11.30	+60°L	7	29.50	6.50
	17	90.00		7750	0			− 8.80	+80°L	12	28.25	6.44
	18	86.00		12500	0			− 1.05	−80°L	10	21.00	5.42
	19	103.44		25800	−0.0587			+30.60	+35°L	10	13.90	4.35
	20	103.35		28800	−0.0537			+31.60	+25°L	8	12.00	4.84
	21	103.25		31600	−0.0567			+33.00	+25°L	6	9.70	5.69
	22	103.02		36750	−0.0140			+29.70	+65°L	2	5.28	4.95
Section Columns 5, 6, and 9 to 13 Show Average Values	6	114.81—114.18	3310	22200		13.90	13.90	+ 8.62	+80°L	6	13.90	5.66
	7	111.22—110.58	3380	31500		9.00	7.00	+19.82	+65°L	7	8.00	5.80
	8	97.16— 96.19	5160	5250		31.40	31.70	−12.38	+55°L	11	32.00	6.51
	9	94.18— 93.54	3420	5250		31.20	31.20	−12.96	+30°L	16	31.20	7.03
	12	88.14— 87.12	5380	10000		24.20	24.20	− 4.12	+40°L	10	24.20	5.58
	13	86.31— 85.41	4650	12500		21.50	21.70	− 3.52	−80°L	10	21.60	6.21
	14	83.80— 82.79	5380	11200		22.80	24.70	− 6.48	+80°L	12	23.70	5.79

* For complete table heading see Table 36, p. 99.

TABLE 38 TEST NO. S-1016*

From Gilman to Champaign, April 30, 1908. Weather: Fair. Temperature: 44° F. at start, 48° F. at end of test. Total weight behind measuring drawbar = 1161 tons, including the test car. Train length = 3030 ft. Center of mass 1515 ft. back of measuring drawbar. 72 cars: 72 empty, 0 loaded. Kind of cars: 70 gondolas, 1 test, 1 caboose. Average weight per car = 16 12 tons.

1	2	3	4	5	6	7	8	9	10	11	12	13
Method	Item	Mile Post	Section Length	Pull P	Accel. A	Speed V_1	Speed V_2	Grade G	Direction	Velocity	Speed A	Resistance R
Point Columns 5, 6, and 9 to 13 show Momentary Values	9	94.57		14400	0			+12.21	+55°R	14	11.20	7.77
	10	95.55		10450	0			+ 5.06	+60°R	10	16.30	7.08
	11	96.61		20250	0			+25.80	+55°R	10	9.50	7.06
	12	98.67		21500	0			+28.80	+55°R	6	8.30	7.60
	15	105.66		6250	−0.0118			− 8.20	+30°R	12	21.10	9.74
	16	106.27		9250	−0.0300			− 4.44	+35°R	11	22.90	9 29
	17	106.91		13600	−0.0117			+13.25	+35°R	7	17.10	7.85
	18	107.39		14750	−0.0117			+17.40	+30°R	10	16.60	7.27
	19	107.75		14700	−0.0117			+16.20	+25°R	9	15.00	7.67
	21	115.89		7500	0			− 7.32	+20°R	9	23.60	9.23
	22	117.65		8000	0			− 1.57	+20°R	9	21.30	7.48
	23	109.22		9900	0			− 1.92	+30°R	11	20.10	9.26
	24	99.70		8750	0			− 4.87	+20°R	15	18.90	9.38
Section Columns 5, 6, and 9 to 13 show Average Values	5	98.23— 98.85	3280	21000		9.25	7.40	+29.90	+55°R	6	8.75	7.43
	6	104.37—104.88	2675	6000		25.00	25.00	−16.78	+40°R	10	25.00	11.52
	7	105.17—105.66	2596	8200		25.85	24.53	−11.30	+40°R	11	25.30	11.15
	8	105.66—106.27	3208	8400		24.28	22.90	− 8.62	+30°R	12	24.00	10.10
	9	106.91—107.37	2430	14000		18.20	16.60	+14.13	+35°R	7	17.40	7.56
	10	107.37—107.75	2030	14300		16.60	14.90	+16.05	+30°R	10	15.70	7.96
	11	115.65—116.15	2640	7400		23.30	23.30	− 0.40	+20°R	9	23.40	8.79
	12	116.68—117.65	5120	7750		22.50	21.40	− 2.68	+20°R	9	21.95	7.77
	13	118.17—120.37	11570	10250		22.00	23.30	− 0.14	+15°R	11	22.65	8.51
	14	120.33—121.64	6950	10000		23.30	24.20	− 2.58	+35°R	8	23 75	9.13
	15	123.20—125.07	9880	10200		22.20	22.30	− 0.27	+35°R	9	22.30	8.90
	16	111.45—111.79	1752	6600		24.16	26.15	−22.90			25.15	10.18
	17	111.79—112.28	2604	6500		26.15	29.10	−29.65			27.65	12.26
	18	112.28—112.62	600	3500		29.17	29.42	−28.20			29.20	11.87

* For complete table heading see Table 36, p. 99.

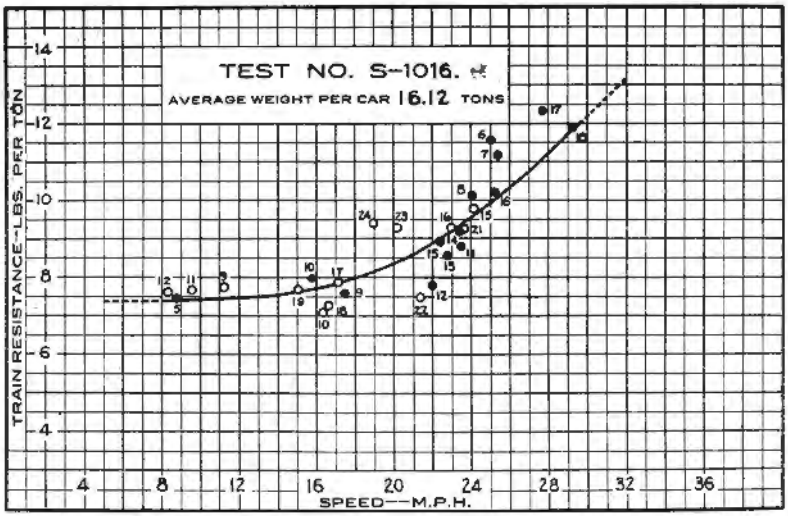

TEST NO. S-1016.
AVERAGE WEIGHT PER CAR 16.12 TONS
TRAIN RESISTANCE-LBS. PER TON
SPEED—M.P.H.

FIG. 21

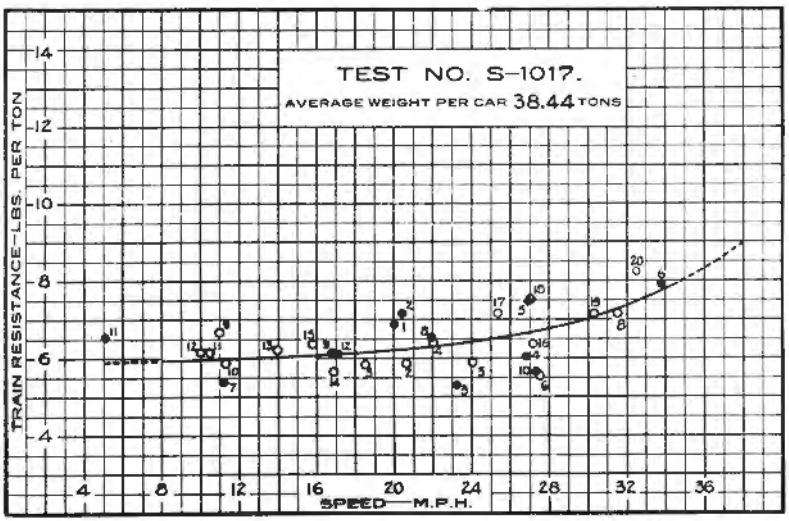

TEST NO. S-1017.
AVERAGE WEIGHT PER CAR 38.44 TONS
TRAIN RESISTANCE-LBS. PER TON
SPEED—M.P.H.

FIG. 22

TABLE 39 TEST NO. S-1017*

From Champaign to Gilman, May 1, 1908. Weather: Intermittent rain. Temperature: 48° F. at start, 54° F. at end of test. Total weight behind measuring drawbar = 2532 tons, excluding the test car. Train length = 2670 ft. Center of mass 1200 ft. back of measuring drawbar. 66 cars: 13 empty, 53 loaded. Kind of cars: 62 box, 3 gondola, 1 caboose. Average weight per car = 38.44 tons.

1	2	3	4	5	6	7	8	9	10	11	12	13
Method	Item	Mile Post	Section Length	Pull P	Accel. A	Speed V_1	Speed V_2	Grade G	Direction	Velocity	Speed V	Resistance R
Point Columns 5, 6, and 9 to 13 shown Momentary Values	2	85.23		11250	0			− 3.71	+75°L	18	20.60	5.86
	3	86.16		14700	0			− 0.00	+70°L	16	18.50	5.81
	4	88.12		10000	0			− 6.45	+65°L	19	22.00	6.40
	5	90.00		6500	0			− 8.47	+50°L	37	24.00	5.88
	6	91.25		5750	0			− 8.54	+65°L	20	27.50	5.51
	8	95.82		5850	+0.0465			−24.35	+85°L	13	31.50	7.14
	9	100.71		25300	0			+ 8.90	+60°L	22	11.00	6.62
	10	101.48		21900	−0.0101			+10.20	+90°L	14	11.35	5.84
	11	103.69		29000	−0.0500			+27.80	+70°L	14	10.50	6.14
	12	103.60		30100	−0.0545			+28.90	+75°L	13	10.00	6.11
	13	103.89		25500	−0.0500			+22.60	+70°L	16	14.00	6.20
	14	104.53		19900	−0.0388			+15.50	−85°L	16	16.90	5.66
	15	104.41		21850	−0.0388			+15.64	−85°L	12	15.80	6.38
	16	105.71		12250	0			− 4.05	+85°L	10	27.20	6.37
	17	106.30		14250	+0.0325			−12.10	+85°L	9	25.30	7.14
	18	106.00		12750	+0.0325			−14.72	+60°L	12	27.00	7.53
	19	98.00		5350	+0.0550			−27.05	+80°L	11	30.30	7.14
	20	95.65		3500	+0.0425			−28.70	+80°L	17	32.50	8.25
Section Columns 5, 6, and 9 to 13 show Average Values	1	82.41− 82.00	2152	17300		20.10	19.40	+ 2.20	+45°L	9	20.00	6.80
	2	87.58− 86.80	4318	16100		22.10	21.32	− 0.66	+85°L	12	20.40	7.15
	3	89.10− 88.59	2372	9000		23.40	22.70	− 1.90	+50°L	21	23.20	5.22
	4	92.00− 91.25	3970	6500		28.30	27.20	−11.43	+85°L	20	26.80	6.02
	5	94.13− 93.63	2624	6600		27.15	27.33	−13.55	+80°L	21	26.90	7.49
	6	95.30− 95.10	988	3400		33.55	33.95	−20.80	+60°L	14	33.75	7.90
	7	101.50−101.00	2620	24000		11.60	10.70	+12.23	+90°L	14	11.20	5.38
	8	105.74−105.34	2028	19150		21.90	21.90	+ 2.79	+70°L	16	21.90	6.51
	9	104.40−104.10	1580	24500		16.30	16.30	+13.35	−85°L	15	16.80	6.13
	10	105.72−105.42	1640	12500		27.30	26.50	+ 2.90	−85°L	10	27.30	5.63
	11	111.16−110.86	1600	35800		5.10	5.10	+19.80	−80°L	13	5.10	6.60
	12	116.00−115.50	2240	17200		17.10	17.00	+ 2.24	−85°L	13	17.10	6.08

* For complete table heading see Table 36, p. 99.

TABLE 40 TEST No. S-1018*

From Gilman to Champaign, May 2, 1908. Weather: Fair. Temperature: 40° F. at start, 45° F. at end of test. Total weight behind measuring drawbar = 1353 tons, including the test car. Train length = 2130 ft. Center of mass 1000 ft. back of measuring drawbar. 49 cars: 34 empty, 15 loaded. Kind of cars: 28 box, 3 gondola, 8 flat, 8 tank, 1 test, 1 caboose, and 2 I. C. locomotives, No. 423 and No. 732 with tenders. Average weight per car = 25.40 tons.

1	2	3	4	5	6	7	8	9	10	11	12	13
Method	Item	Mile Post	Section Length	Pull P	Accel. A	Speed V_1	Speed V_2	Grade G	Direction	Velocity	Speed V	Resistance R
Point Columns 5, 6, and 9 to 13 show Momentary Values	5	93.94		13300	0			+ 8.92	+85°R	15	16.00	6.47
	6	94.59		14800	0			+10.90	+70°R	12	14.70	6.67
	7	96.34		20600	−0.0018			+26.50	+55°R	7	10.60	5.32
	8	97.29		14750	−0.0042			+ 9.30	+45°R	13	17.05	7.78
	9	98.68		22000	−0.0048			+28.80	+60°R	8	9.45	5.82
	10	100.15		18500	−0.0025			+22.00	+85°R	14	13.10	5.57
	11	102.00		9470	+0.0159			− 8.90	+75°R	13	24.80	8.83
	12	104.43		4750	−0.0263			−20.10	+10°R	23	30.20	8.59
	13	105.34		5000	−0.0046			−10.15	+65°R	14	29.30	8.00
	14	106.25		7000	−0.0419			+ 7.44	+45°R	12	26.30	6.40
	15	106.40		8300	−0.0645			+13.90	+50°R	11	25.70	7.12
	16	106.53		8550	−0.0644			+15.40	+55°R	10	21.20	6.72
	17	106.64		9350	−0.0596			+15.60	+60°R	11	23.15	6.77
	18	106.71		10250	−0.0419			+14.37	+60°R	10	22.50	6.18
	19	106.90		10000	−0.0419			+12.15	+45°R	11	21.00	6.85
	20	107.07		11000	−0.0419			+14.38	+45°R	9	19.70	6.74
	21	107.47		12000	−0.0419			+17.10	+45°R	8	17.00	6.44
	22	108.23		16000	0			+16.10	+45°R	7	13.80	5.72
	23	109.17		8750	0			− 2.72	+45°R	10	21.50	7.50
	26	115.94		9200	0			− 5.70	+35°R	12	23.20	7.00
Section Columns 5, 6, and 9 to 13 show Average Values	3	92.00— 92.51	2675	12800		16.20	15.20	+11.20	+80°R	13	15.80	6.00
	4	96.22— 96.74	2770	21250		11.30	11.30	+25.50	+55°R	7	11.40	6.02
	5	104.43—105.34	4800	5100		29.70	29.20	−14.30	+65°R	14	29.50	9.62
	8	126.00—126.45	2400	9600		18.20	17.70	+ 3.08	+60°R	12	17.68	6.46
	11	96.55— 98.85	1588	22000		10.35	10.12	+25.70	+6°0R	8	9.40	6.72
	12	101.70—102.00	1584	10100		23.41	24.77	−11.00	+75°R	13	24.00	8.74
	13	108.08—108.41	1748	15000		14.20	14.00	+16.30	+45°R	7	14.20	5.21
	14	108.00—107.30	6940	9300		28.05	18.23	+12.50			22.80	6.82
	15	106.00—106.53	2750	7500		28.05	24.32	+ 7.88			26.60	7.59
	16	106.53—107.30	4096	10500		24.32	28.23	+15.10			20.90	6.52

* For complete table heading see Table 36, p. 99.

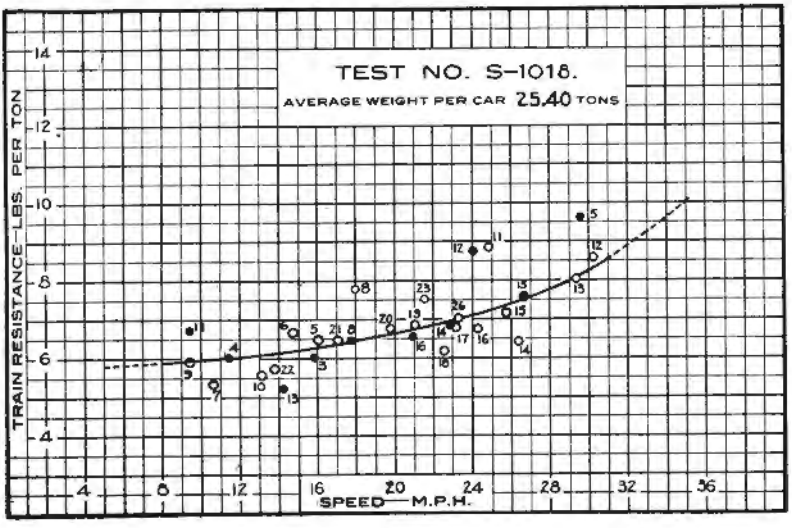

TEST NO. S-1018.
AVERAGE WEIGHT PER CAR 25.40 TONS
TRAIN RESISTANCE—LBS. PER TON
SPEED—M.P.H.

FIG. 23

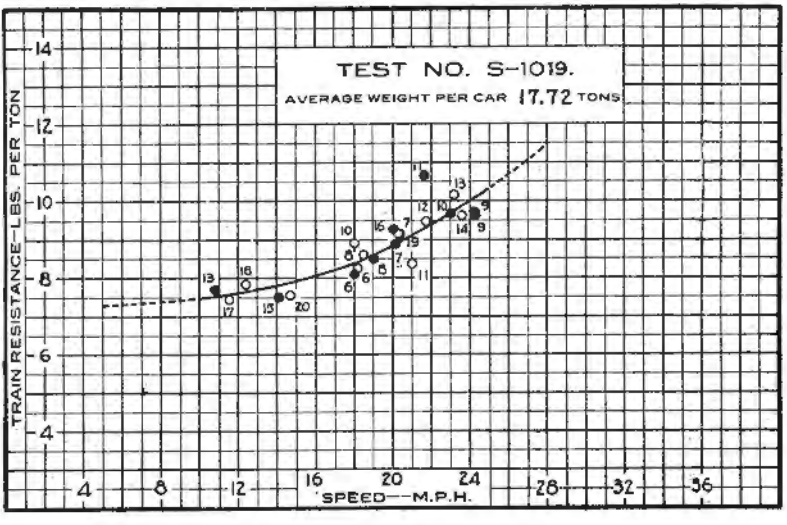

TEST NO. S-1019.
AVERAGE WEIGHT PER CAR 17.72 TONS
TRAIN RESISTANCE—LBS. PER TON
SPEED—M.P.H.

FIG. 24

TABLE 41 TEST No. S-1019*

From Champaign to Mattoon, May 9, 1908. Weather: Fair. Temperature: 44° F. at start, 62° F. at end of test. Total weight behind measuring drawbar = 1572 tons, excluding the test car. Train length = 3480 ft. Center of mass 1600 ft. back of measuring drawbar. 89 cars: 75 empty, 14 loaded. Kind of cars: 29 box, 52 gondola, 6 flat, 1 tank, 1 caboose. Average weight per car = 17.72 tons.

1	2	3	4	5	6	7	8	9	10	11	12	13
Method	Item	Mile Post	Section Length	Pull P	Accel. A	Speed V_1	Speed V_2	Grade G	Direction	Velocity	Speed V	Resistance R
Point Columns 5, 6, and 9 to 13 show Momentary Values	6	141.18		10700	0			− 3.75	+30° R	21	18.20	8.23
	7	143.80		9000	0			− 9.03	+25° R	27	20.25	9.14
	8	144.90		11000	0			− 4.16	+30° R	21	18.50	8.58
	9	147.30		7500	0			−12.70	+20° R	30	24.30	9.61
	10	149.80		11800	0			− 3.64	+30° R	21	18.00	8.89
	11	145.98		9000	+0.0289			−14.52	+20° R	31	21.00	8.36
	12	146.19		8700	+0.0289			−17.95	+20° R	31	21.75	9.46
	13	146.38		8050	+0.0210			−19.50	+35° R	21	23.20	10.14
	14	146.54		7400	+0.0289			−20.50	+20° R	31	23.60	9.62
	17	157.13		16000	0			+ 7.21	+25° R	18	11.58	7.44
	18	159.82		15400	0			+ 5.22	+25° R	18	12.45	7.82
	19	161.44		9800	0			− 7.66	+20° R	32	20.30	9.13
	20	165.93		13250	0			+ 2.39	+45° R	15	14.70	7.51
Section Columns 5, 6, and 9 to 13 show Average Values	6	141.18—141.56	2370	10900		17.90	17.90	− 3.03	+30° R	21	18.00	8.09
	7	143.80—144.27	2450	9200		20.20	20.00	− 7.33	+25° R	27	20.10	8.86
	8	144.89—145.44	2890	10200		18.50	19.50	− 7.80	+30° R	21	19.00	8.49
	9	146.98—144.47	2568	7000		24.25	24.25	−13.76	+20° R	30	24.25	9.67
	10	146.19—146.54	1856	8250		21.54	23.86	− 7.90	+20° R	31	23.00	9.67
	11	145.99—146.38	2064	8850		20.85	23.18	− 8.90	+20° R	31	21.65	10.06
	13	155.83—156.33	2640	18000		10.78	10.78	+ 9.90	+35° R	19	10.78	7.70
	15	165.66—166.16	2640	12950		14.00	14.00	+ 2.00	+30° R	21	14.10	7.48
	16	161.21—161.61	2112	10100		19.83	19.97	− 3.30	+30° R	32	20.00	9.26

For complete table heading see Table 36, p. 99.

TABLE 42 TEST NO. S-1021*

From Rantoul to Paxton, May 13, 1908. Weather: Continuous Rain. Temperature: 66° F. at start, 70° F. at end of test. Total weight behind measuring drawbar = 2908 tons, including the test car. Train length = 2400 ft. Center of mass 1200 ft. back of measuring drawbar. 63 cars: 10 empty, 53 loaded. Kind of cars: 18 box, 38 gondola, 3 flat, 2 tank, 1 test, 1 caboose. Average weight per car = 46.16 tons.

1	2	3	4	5	6	7	8	9	10	11	12	13
Method	Item	Mile Post	Section Length	Pull P	Accel. A	Speed V_1	Speed V_2	Grade G	Direction	Velocity	Speed V	Resistance R
Point Columns 5, 6, and 9 to 13 show Momentary Values	7	106.79		10500	+0.0362			−16.70	+75°R	13	26.60	6.55
	8	105.82		10800	−0.0056			− 6.60	+80°R	15	29.90	6.74
	9	105.74		12050	−0.0172			− 3.96	+80°R	15	29.60	7.26
	10	104.65		18650	−0.0490			+15.80	+65°R	16	23.25	5.02
	11	104.59		19000	−0.0490			+16.05	+70°R	15	22.80	5.06
	12	104.53		20850	−0.0490			+16.30	+70°R	16	22.25	5.61
	13	104.41		21300	−0.0425			+15.20	+70°R	15	21.35	5.57
	14	104.32		21100	−0.0425			+14.10	+70°R	17	20.75	5.92
	15	104.21		21300	−0.0425			+14.08	+80°R	18	19.85	5.99
	16	104.10		21800	−0.0425			+16.90	+70°R	20	19.00	5.08
	17	103.62		28900	−0.0540			+28.60	+75°R	19	13.00	4.30
	18	103.50		30750	−0.0530			+29.50	+60°R	18	10.40	4.24
	19	103.72		27750	−0.0583			+27.90	+65°R	22	14.70	5.46
	20	105.40		12200	−0.0490			+ 5.94	+80°R	15	28.50	6.55
	21	104.82		17250	−0.0490			+11.90	+80°R	18	24.50	5.94
	22	106.84		10750	+0.0362			−17.40			26.40	6.90
	23	105.95		11500	+0.0150			−13.00			29.80	7.41
Section Columns 5, 6, and 9 to 13 show Average Values	7	107.04—106.73	1596	10850		25.44	26.92	−14.00	+75°R	12	26.20	7.03
	8	106.30—106.00	1588	11200		28.75	29.75	−13.20	+75°R	15	29.50	7.63
	9	106.00—105.70	1588	11150		29.75	29.75	− 6.60	+80°R	15	29.80	6.99
	10	105.70—105.40	1584	11650		29.75	28.40	+ 2.40	+80°R	15	29.00	6.29
	11	105.40—105.10	1592	13700		28.40	26.43	+ 6.07	+80°R	15	27.40	6.50
	12	105.10—104.80	1584	16500		26.43	24.32	+ 7.70	+80°R	18	25.40	6.66
	13	104.80—104.49	1588	18500		24.32	22.07	+13.30	+70°R	16	23.20	4.60
	14	104.49—104.19	1580	21350		22.07	19.80	+11.10	+70°R	16	20.80	6.16
	15	104.19—103.89	1576	22300		19.08	17.00	+13.50	+70°R	20	18.40	5.69
	16	103.89—103.59	1600	26900		17.00	12.95	+27.75	+65°R	22	15.00	5.87
	17	103.50—103.33	868	32500		11.52	8.45	+30.00			10.00	4.69
	18	103.33—103.21	648	35250		8.45	6.41	+30.00			7.40	3.99
	19	103.21—103.12	464	36750		6.41	4.50	+30.00			5.50	4.38
	20	103.12—103.03	512	37800		4.50	1.64	+30.00			3.00	3.94

* For complete table heading see Table 36, p. 99.

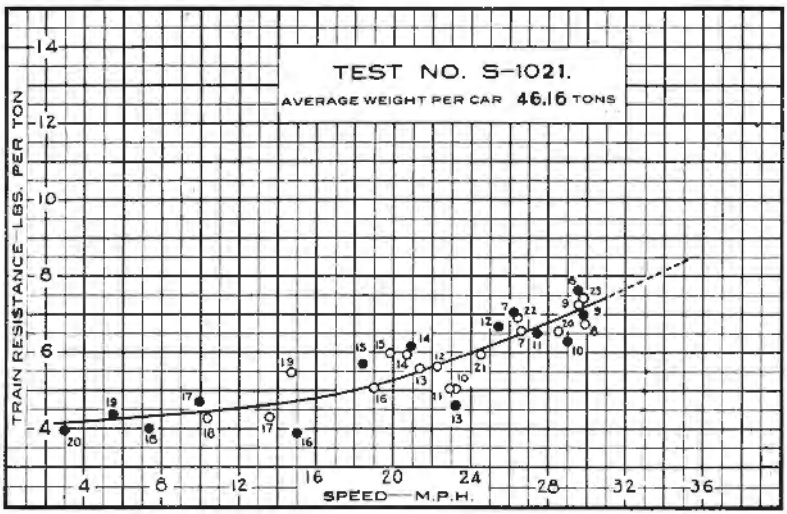

TEST NO. S-1021.
AVERAGE WEIGHT PER CAR 46.16 TONS
TRAIN RESISTANCE—LBS. PER TON
SPEED—M.P.H.

FIG. 25

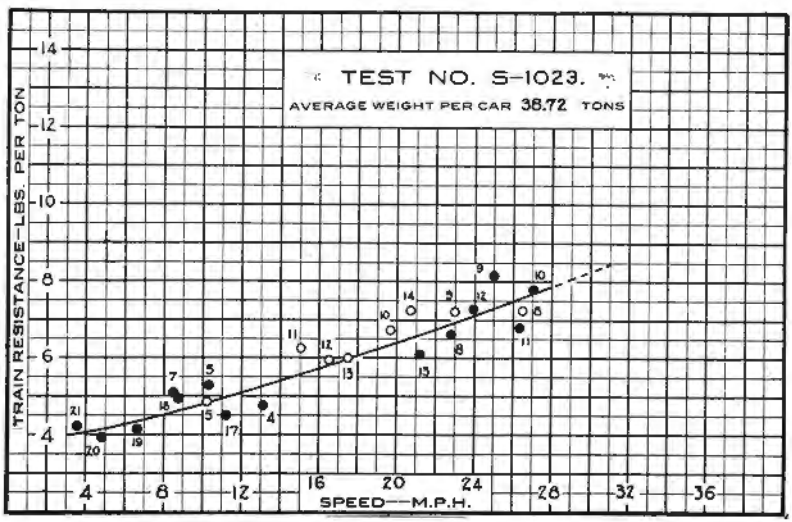

TEST NO. S-1023.
AVERAGE WEIGHT PER CAR 38.72 TONS
TRAIN RESISTANCE—LBS. PER TON
SPEED—M.P.H.

FIG. 26

TABLE 43 TEST NO. S-1023*

From Champaign to Paxton, May 23, 1908. Weather: Fair. Temperature: 62° F. at start, 74° F. at end of test. Total weight behind measuring drawbar = 2243 tons, including the test car. Train length = 2320 ft. Center of mass 1020 ft. back of measuring drawbar. 58 cars: 17 empty, 41 loaded. Kind of cars: 24 box, 30 gondola, 2 tank, 1 test, 1 caboose. Average weight per car = 38.72 tons.

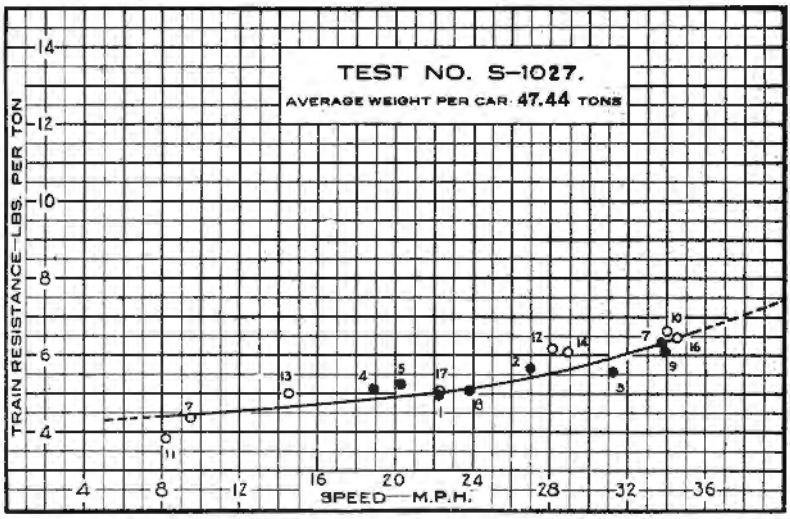
1	2	3	4	5	6	7	8	9	10	11	12	13
Method	Item	Mile Post	Section Length	Pull P	Accel. A	Speed V_1	Speed V_2	Grade G	Direction	Velocity	Speed V	Resistance R
Point Columns 5, 6, and 9 to 13 show Momentary Values	5	114.00		18400	0			+ 8.88	+85° R	15	10.20	4.84
	8	106.71		10300	+0.0360			−16.00	+80° R	18	26.50	7.24
	9	104.91		12500	−0.0600			+10.70	+85° R	17	23.00	7.19
	10	104.48		17000	−0.0500			+16.03	−80° R	17	19.65	6.71
	11	103.98		20600	−0.0500			+20.30	+75° R	19	15.00	6.22
	12	104.04		19200	−0.0400			+17.80	−90° R	18	18.50	5.94
	13	104.12		18500	−0.0400			+16.00	−85° R	20	17.50	5.97
	14	104.67		14850	−0.0675			+15.28	+90° R	17	20.68	7.23
Section Columns 5, 6, and 9 to 13 show Average Values	4	116.50—116.00	2640	14700		13.10	13.10	+ 4.81	90° R	13	13.10	4.73
	5	114.71—114.21	2640	18800		10.30	10.30	+ 7.92	+85° R	15	10.30	5.30
	7	110.88—110.38	2240	29000		8.50	8.50	+20.70	+80° R	15	8.50	5.10
	8	108.95—108.56	2104	9700		23.86	21.45	+ 3.38	90° R	17	22.80	6.64
	9	107.21—106.71	2644	11250		23.60	26.43	−18.15	+80° R	18	25.05	8.18
	10	106.71—106.21	2616	10550		26.43	28.05	−14.30	+80° R	18	27.00	7.78
	11	105.47—105.17	1584	10850		27.27	25.10	+ 8.00	+85° R	25	26.30	6.78
	12	105.17—104.87	1580	12050		25.10	22.60	+ 9.01	+85° R	17	23.90	7.18
	13	104.87—104.57	1584	14450		22.60	19.65	+15.30	+85° R	17	21.20	6.07
	17	103.81—103.64	920	25650		11.86	9.28	+29.30			11.20	4.48
	18	103.64—103.50	716	28150		9.28	7.24	+28.75			8.72	4.92
	19	103.50—103.40	546	30000		7.24	5.46	+31.90			6.66	4.17
	20	103.40—103.32	394	31850		5.46	3.82	+34.20			4.80	3.93
	21	103.32—103.27	292	33200		3.82	2.59	+32.90			3.56	4.21

* For complete table heading see Table 36, p. 90.

TABLE 44 TEST NO. S-1027

From Champaign to Gilman, July 2, 1908. Weather: Intermittent rain. Temperature: 64° F. at start, 80° F. at end of test. Total weight behind measuring drawbar = 2185 tons, including the test car. Train length = 1710 ft. Center of mass 800 ft. back of measuring drawbar. 46 cars: 3 empty, 43 loaded. Kind of cars: 8 box, 35 gondola, 1 flat, 1 test, 1 caboose. Average weight per car = 47.44 tons.

1	2	3	4	5	6	7	8	9	10	11	12	13
Method of Calculation	Item No.	Location on Road Milepost No.	Length of Section feet	Total Drawbar Pull pounds	Acceleration miles per hour per second	Speeds: At Entrance to Section m. p. h.	Speeds: At Exit from Section m. p. h.	Grade + Up − Down feet per mile	Wind: Approximate Direction	Wind: Approximate Velocity m. p. h.	Speed m. p. h.	Net Train Resistance pounds per ton
				P	A	V_1	V_2	G			V	R
Point Columns 5, 6, and 9 to 13 show Momentary Values	7	110.51		25900	0			+19.72	−50°R	9	9.50	4.37
	10	105.91		6900	0			− 9.16	90°R	13	34.00	6.63
	11	103.00		29700	−0.005 a			+27.20	−55°R	5	8.20	3.81
	12	101.91		8100	0			− 6.54	90°R	17	28.10	6.16
	13	100.57		14400	0			+ 1.11	−70°R	15	14.50	5.00
	14	99.49		5300	0			− 9.56	−85°R	11	28.90	6.08
	16	97.10		3750	+0.040			−22.90	−85°R	16	31.50	6.46
	17	86.03		10000	0			− 1.32	−70°R	22	22.30	5.06
Section Columns 5, 6, and 9 to 13 show Average Values	1	85.40— 86.30	2430	9900		22.30	22.30	− 1.09	−70°R	22	22.25	4.94
	2	87.85— 88.45	3215	6600		27.10	27.10	− 6.94	−75°R	15	27.00	5.85
	3	89.81— 90.56	3955	4500		31.25	31.25	+ 9.22	−80°R	15	31.25	5.54
	4	115.56—116.17	3280	12800		19.00	19.00	+ 1.98	−60°R	12	18.90	5.11
	5	117.10—117.93	4440	11650		20.20	20.20	+ 0.27	−60°R	12	20.30	5.22
	7	106.11—105.51	3220	9400		33.40	32.85	+ 4.09	90°R	13	33.75	6.33
	8	98.88—98.29	3080	9050		22.90	21.70	+ 7.55	+70°R	10	23.80	5.08
	9	97.61—96.72	4720	4200		31.90	34.25	−17.00	+85°R	16	33.87	6.09


TEST NO. S-1027.
AVERAGE WEIGHT PER CAR 47.44 TONS
TRAIN RESISTANCE-LBS. PER TON
SPEED—M.P.H.
14
12
10
8
6
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16
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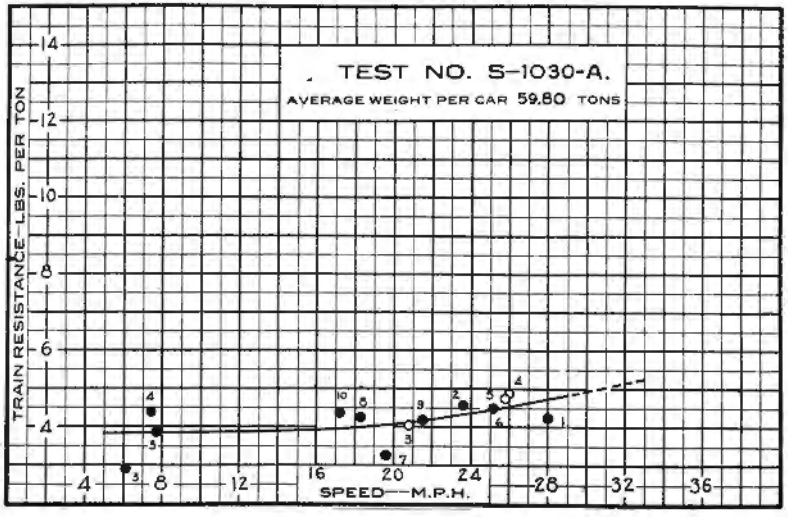
24
28
32
36

FIG. 27


TEST NO. S-1030-A.
AVERAGE WEIGHT PER CAR 59.80 TONS
TRAIN RESISTANCE-LBS. PER TON
SPEED—M.P.H.
14
12
10
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6
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4
8
12
16
20
24
28
32
36

FIG. 28

TABLE 45 TEST NO. S-1030A

From Effingham to Mattoon, July 8, 1908. Weather: Fair. Temperature: 60° F. at start, 68° F. at end of the test. Total weight behind measuring drawbar = 2036 tons, including the test car. Train length = 1380 ft. Center of mass 690 ft. back of measuring drawbar. 34 cars: 2 empty, 32 loaded. Kind of cars: 32 gondola, 1 test, 1 caboose. Average weight per car = 59.88 tons.

1	2	3	4	5	6	7	8	9	10	11	12	13
Method of Calculation	Item No.	Location on Road Milepost No.	Length of Section feet	Total Drawbar Pull pounds	Acceleration miles per hour per second	Speeds: At Entrance to Section m. p. h.	Speeds: At Exit from Section m. p. h.	Grade Up +, Down − feet per mile	Wind: Approximate Direction	Wind: Approximate Velocity m. p. h.	Speed m. p. h.	Net Train Resistance pounds per ton
				P	A	V_1	V_2	G			V	R
Point Columns 5, 6, and 9 to 13 show Momentary Values	3	190.35		13200	−0.0690			+33.40	+50°R	8	20.80	4.04
	4	193.16		9050	−0.1350			+32.10	+55°R	9	26.03	4.90
	5	193.61		11000	+0.1390			−32.40	+60°R	5	25.80	4.77
Section Columns 5, 6, and 9 to 13 show Average Values	1	174.50—173.88	3280	160		26.20	30.00	−22.70	+20°R	6	28.00	4.23
	2	175.00—174.50	2600	5620		20.71	26.20	−22.70	+20°R	6	23.60	4.57
	3	176.97—176.70	3500	30050		6.54	6.00	+31.50	+20°R	3	6.12	2.91
	4	177.58—176.97	3212	30650		10.22	6.54	+31.50	+20°R	3	7.44	4.39
	5	178.00—176.70	8956	28800		16.15	6.00	+31.50	+20°R	3	7.65	3.87
	6	181.50—180.37	5144	12050		23.92	26.10	0	+50°R	7	25.20	4.46
	7	190.01—189.36	3452	12000		19.20	20.05	+ 5.10	+55°R	9	19.60	3.29
	8	191.72—191.44	1576	15000		17.18	19.14	0	+55°R	8	18.30	4.25
	9	193.16—192.71	2360	11550		26.03	17.58	+32.10	+60°R	5	21.50	4.20
	10	196.19—195.81	2140	14900		17.30	17.18	+ 7.70	+65°R	6	17.20	4.39

TABLE 46 TEST NO. S-1030B*

From Mattoon to Champaign, July 8, 1908. Weather: Fair. Temperature: 68° F. at start, 72° F. at end of test. Total weight behind measuring drawbar = 2342 tons, including the test car. Train length = 1650 ft. Center of mass 900 ft. back of measuring drawbar. 41 cars: 3 empty, 38 loaded. Kind of cars: 6 box, 33 gondola, 1 test, 1 caboose. Average weight per car = 57.12 tons.

1	2	3	4	5	6	7	8	9	10	11	12	13
Method	Item	Mile Post	Section Length	Pull P	Accel. A	Speed V_1	Speed V_2	Grade G	Direction	Velocity	Speed V	Resistance R
Point Columns 5, 6, and 9 to 13 show Momentary Values	3	167.46		7200	0			−1 .92			26.60	3.80
	5	165.52		8500	0			−3 .20			28.90	3.97
	6	164.45		8080	0			−2 .88	20°R	12	28.40	4.53
	9	159.74		13900	0			+5 .12	20°R	7	15.25	4.00
	10	157.80		18100	+0.0356			+5 .12	25°R	6	12.30	4.23
	11	157.75		17000	+0.0356			+1 .12	25°R	6	13.00	3.50
	12	157.57		16200	+0.0356			−0 .54	35°R	6	14.20	3.93
	13	158.06		23600	+0.0457			+5 .60	65°R	3	8.30	3.70
	14	157.94		21500	+0.0457			+2 .56	30°R	5	10.70	3.96
	21	164.15		7200	+0.0700			−21.10	30°R	9	28.50	4.48
Section Columns 5, 6 and 9 to 13 show Average Values	1	166.62—167.06	2315	8000		25.80	25.80	−2.12			25.50	4.22
	2	164.45—164.95	3164	7350		27.40	27.00	−0.84	20°R	12	27.15	3.93
	3	158.72—159.25	2815	2500		17.30	17.30	−7.82	65°R	4	16.90	4.02
	4	155.44—154.81	3300	7550		27.10	28.90	−8.96	20°R	12	28.10	4.52
	5	152.25—152.88	3270	14200		17.50	17.50	+6.14			17.00	3.73
	6	149.04—148.20	4396	11800		21.40	23.00	−0.66			22.20	4.18
	7	143.32—143.92	3150	14000		16.30	16.30	+5.48			16.60	3.91
	8	140.49—141.23	3912	11950		19.63	19.25	+3.77			19.75	3.89
	9	132.65—131.68	5084	8500		26.75	25.26	0			26.05	4.68
	10	145.06—144.48	3068	16950		12.48	13.63	+7.65			13.10	3.65
	11	158.06—157.80	1400	20850		8.46	12.55	+3.40	65°R	3	10.60	3.41
	12	157.80—157.57	1200	17500		12.55	14.58	+0.86	25°R	6	13.70	4.08
	13	162.33—161.87	2416	8730		23.70	24.40	−4.36	20°R	9	23.50	3.59
	14	149.65—148.97	3280	12400		21.53	21.30	+4.90			21.30	3.87

* For complete table heading see Table 36, p. 99.

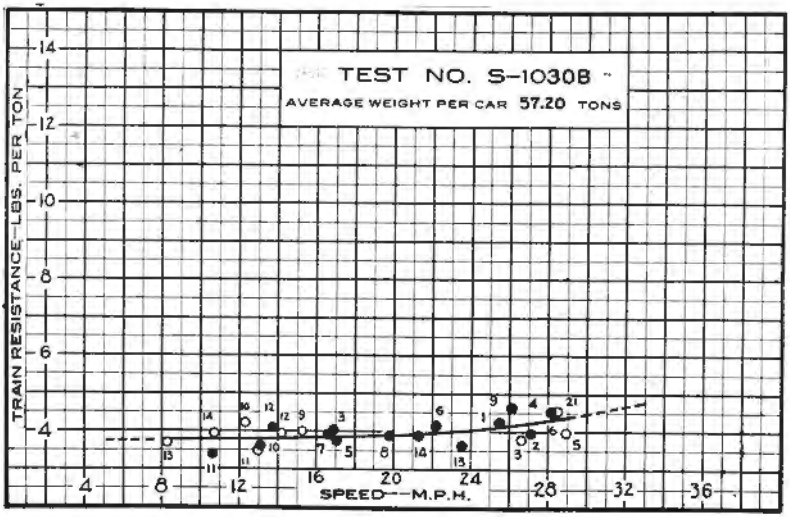
TEST NO. S-10308
AVERAGE WEIGHT PER CAR 57.20 TONS
TRAIN RESISTANCE—LBS. PER TON
SPEED—M.P.H.

FIG. 29

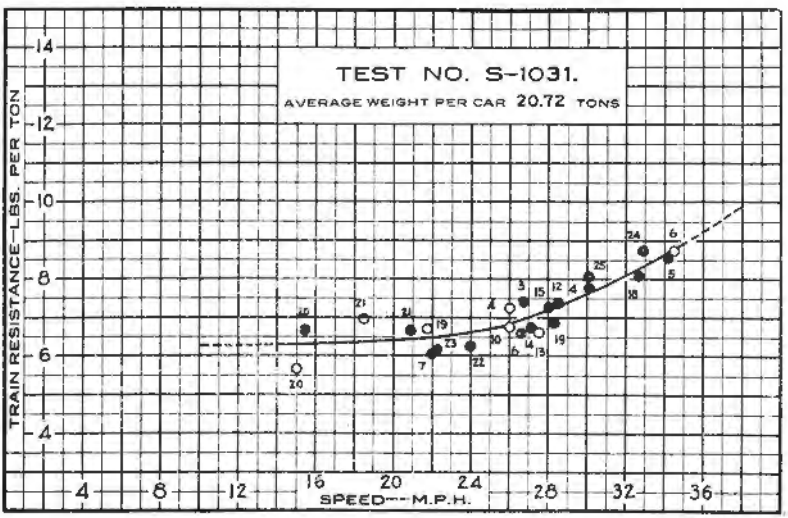
TEST NO. S-1031.
AVERAGE WEIGHT PER CAR 20.72 TONS
TRAIN RESISTANCE—LBS. PER TON
SPEED—M.P.H.

FIG. 30

TABLE 47 TEST NO. S-1031*

From Champaign to Dorans, July 22, 1908. Weather: Fair. Temperature: 70° F. at start, 82° F. at end of test. Total weight behind measuring drawbar = 747 tons, excluding the test car. Train length = 1425 ft. Center of mass 1000 ft. back of measuring drawbar. 36 cars: 30 empty, 6 loaded. Kind of cars: 33 box, 1 gondola, 1 flat, 1 caboose. Average weight per car = 20.72 tons.

1	2	3	4	5	6	7	8	9	10	11	12	13
Method	Item	Mile Post	Section Length	Pull P	Accel. A	Speed V_1	Speed V_2	Grade G	Direction	Velocity	Speed V	Resistance R
Point Columns 5, 6, and 9 to 13 show Momentary Values	4	142.06		4700	−0.0204			− 1.50	+ 0°	5	26.00	7.25
	6	147.10		2000	0			−13.84	+ 0°	7	34.50	8.73
	10	159.81		4200	0			− 3.01	+ 0°	6	26.00	6.76
	13	163.00		4400	0			− 1.89	+ 0°	7	27.50	6.60
	19	166.83		7900	0			+10.20	+ 0°	2	21.75	6.70
	20	164.40		12400	+0.0275			+21.80	+40°L	4	15.00	5.68
	21	164.75		9650	+0.0550			+ 1.50	+40°L	4	18.50	6.95
Section Columns 5, 6, and 9 to 13 show Average Values	3	139.57—140.30	4180	4350		26.70	26.70	− 4.13	+ 0°	5	26.70	7.40
	4	143.90—144.25	4460	3900		29.75	29.75	− 6.81	+ 0°	5	30.10	7.76
	5	146.68—147.51	4405	2500		33.90	33.90	−13.65	+ 0°	7	34.20	8.53
	6	151.94—152.77	4390	4950		26.60	26.60	+ 0.18	+ 0°	4	26.60	6.56
	7	155.70—156.45	4016	7100		22.00	22.00	+ 9.60	+ 0°	4	22.00	6.01
	12	149.00—149.53	2760	4650		28.36	27.77	− 0.77	+ 0°	7	28.50	7.36
	14	153.88—154.74	4588	4380		27.61	25.62	+ 2.14	+ 0°	5	27.10	6.72
	15	160.31—160.78	2468	4450		25.95	28.94	−16.15	+ 0°	7	28.00	7.24
	18	147.51—148.35	4412	2900		33.53	31.36	− 5.04	+ 0°	7	32.70	8.07
	19	153.20—153.87	3528	4470		28.30	28.30	− 2.25	+ 0°	5	28.30	6.85
	20	164.40—164.74	1812	11800		15.00	18.00	+13.70	+ 0°	1	15.40	6.69
	21	164.74—165.50	3980	7700		18.00	22.75	+ 0.40	+ 0°	1	20.90	6.65
	22	159.63—159.16	2464	5500		24.80	23.65	+ 7.30	+ 0°	5	24.00	6.22
	23	157.40—158.36	5064	5450		22.60	23.85	+ 0.91	+ 0°	5	22.30	6.11
	24	146.17—146.68	2652	3000		31.90	33.50	−19.90	+ 0°	7	32.90	8.74
	25	161.24—161.62	2014	4100		30.50	30.50	− 6.81	+ 0°	6	30.50	8.09

* For complete table heading see Table 36, p. 99.

TABLE 48 TEST NO. S-1033*

From Champaign to Gilman, Sept. 26, 1908. Weather: Fair. Temperature: 66° F. at start, 82° F. at end of test. Total weight behind measuring drawbar = 2275 tons, including the test car. Train length = 1710 ft. Center of mass 850 ft. back of measuring drawbar. 44 cars: 2 empty, 42 loaded. Kind of cars: 42 gondola, 1 test, 1 caboose. Average weight per car = 51.70 tons.

1	2	3	4	5	6	7	8	9	10	11	12	13
Method	Item	Mile Post	Section Length	Pull P	Accel. A	Speed V_1	Speed V_2	Grade G	Direction	Velocity	Speed V	Resistance R
Point Columns 5, 6, and 9 to 13 show Momentary Values	9	111.08		20050	0			+20.20	+0°	5	8.15	3.79
	10	110.72		25150	0			+19.45	+0°	5	9.75	3.68
	12	104.13		23900	0			+16.98	+5° R	7	12.00	4.07
	13	98.18		9000	+0.1066			−31.50	+5° L	12	29.35	4.26
	17	93.63		2700	0			−9.88	+5° R	12	40.00	4.93
	18	90.42		3850	0			−10.49	+5° L	17	39.40	5.67
	20	85.88		6450	0			− 4.02	+0°	16	31.75	4.35
	21	83.40		6800	0			− 3.40	+5° L	15	31.75	4.28
Section Columns 5, 6, and 9 to 13 show Average Values	2	118.27—117.19	5688	11300		23.60	24.10	+ 0.28	+15° R	7	24.25	4.57
	3	111.30—110.60	3681	25900		8.98	8.98	+20.29	+ 0°	5	8.98	3.72
	4	104.91—103.91	5260	24000		11.21	11.21	+16.30	+ 5° R	7	11.21	4.37
	5	101.66—100.97	3660	12400		22.85	18.75	+10.96	+10° R	15	20.79	4.50
	6	98.19— 97.14	5512	5000		29.20	37.25	−25.87	+ 5° L	14	34.17	5.33
	7	94.07— 93.24	4400	3200		40.00	40.00	− 9.24	+ 5° R	12	40.00	4.91
	8	93.25— 92.58	3556	3200		37.85	42.10	−28.80	+ 5° L	22	40.40	5.78
	9	90.66— 90.00	3492	4150		38.95	39.85	−10.43	+ 5° L	17	39.68	4.38
	10	89.24— 88.76	2504	4950		38.30	37.40	− 1.90	+ 5° L	10	37.91	4.77
	11	83.80— 83.40	2096	6900		31.25	31.58	− 5.04	+ 5° R	14	31.75	4.19
	12	116.00—115.36	3400	11800		23.00	22.40	+ 3.90	+ 5° R	7	23.20	4.23
	13	114.67—114.27	2108	14800		19.50	18.85	+ 8.55	+ 5° R	7	19.20	4.07
	14	103.91—103.41	2600	29000		10.72	5.81	+20.20	+ 5° R	7	6.33	1.20
	15	97.14— 96.25	4700	4200		37.50	38.00	−10.80	+ 5° L	22	37.70	5.40
	16	83.80— 83.05	3930	2900		32.05	31.10	− 5.78	+ 0°	15	31.50	4.53
	17	88.77— 88.00	4076	5200		37.53	37.05	− 5.12	+ 5° L	17	37.20	4.84

* For complete table heading, see Table 36, p. 99.

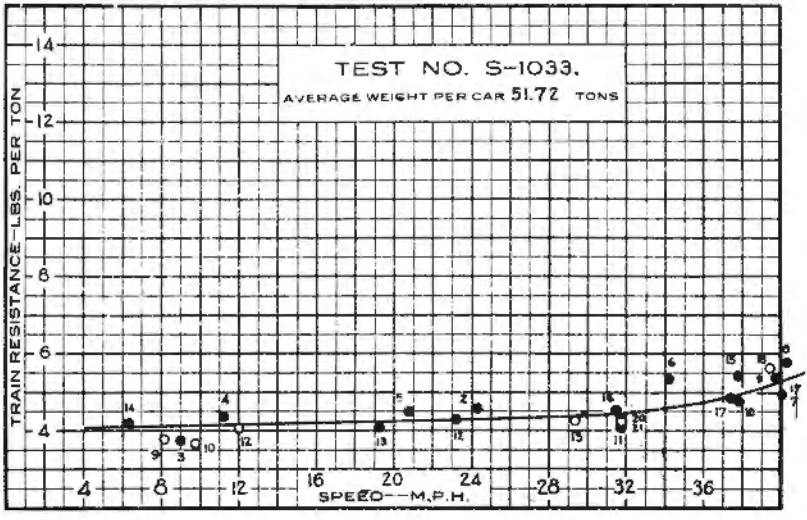
TEST NO. S-1033.
AVERAGE WEIGHT PER CAR 51.72 TONS
TRAIN RESISTANCE-LBS. PER TON
SPEED—M.P.H.

FIG. 31

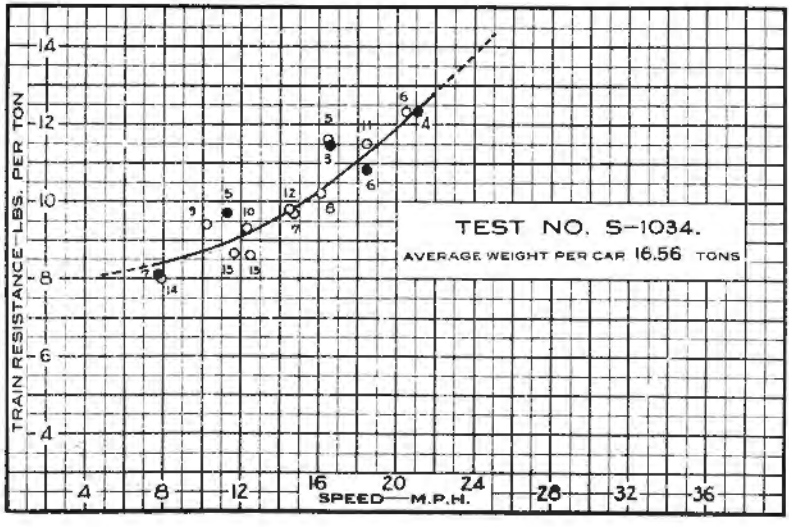
TEST NO. S-1034.
AVERAGE WEIGHT PER CAR 16.56 TONS
TRAIN RESISTANCE-LBS. PER TON
SPEED—M.P.H.

FIG. 32

TABLE 49 TEST NO. S-1034

From Champaign to Mattoon, October 3, 1908. Weather: Fair. Temperature: 42° F. at start, 60° F. at end of test. Total weight behind measuring drawbar = 1259 tons, excluding the test car. Train length = 3015 ft. Center of mass 1500 ft. back of measuring drawbar. 76 cars: 76 empty, 0 loaded. Kind of cars: 75 gondola, 1 caboose. Average weight per car =16.56 tons.

1	2	3	4	5	6	7	8	9	10	11	12	13
Method of Calculation	Item No.	Location on Road / Milepost No.	Length of Section feet	Total Drawbar Pull pounds	Acceleration miles per hour per second	Speeds: At Entrance to Section m. p. h.	Speeds: At Exit from Section m. p. h.	Grade Up + | Down − feet per mile	Wind: Approximate Direction	Wind: Approximate Velocity m. p. h.	Speed m. p. h.	Net Train Resistance pounds per ton
				P	A	V_1	V_2	G			V	R
Point Columns 5, 6, and 9 to 13 show Momentary Values	5	143.80		10000	0			− 9.64	—55°L	5	16.50	11.50
	6	146.89		7900	0			−15.94	—80°L	5	20.50	12.28
	7	149.30		11800	0			− 0.84	—55°L	4	14.70	9.70
	8	153.44		10300	0			− 5.25	—80°L	2	16.10	10.17
	9	156.22		16440	0			+ 9.52	—30°L	3	10.25	9.45
	10	159.72		14400	0			+ 5.52	+85°L	1	12.25	9.35
	11	161.05		9150	0			−12.30	− 0°	1	18.25	11.49
	12	165.81		13000	0			+ 1.40	—50°L	5	14.50	9.79
	13	166.80		15550	0			+ 9.81	—75°L	3	12.25	8.62
	14	168.45		17600	0			+15.75	—60°L	4	7.90	8.00
	15	167.93		12500	0			+ 3.41	90°L	5	11.60	8.65
Section Columns 5, 6, and 9 to 13 show Average Values	3	142.97—143.80	4373	10700		15.60	16.50	− 9.48	—55°L	5	16.56	11.45
	4	146.40—147.54	6027	7800		21.00	21.00	−16.12	—80°L	5	21.10	12.31
	5	154.78—155.70	4878	16000		11.25	11.25	+ 7.96	—45°L	5	11.27	9.69
	6	160.77—161.55	4058	9100		17.50	17.50	− 9.37	+85°L	4	18.44	10.78
	7	168.22—168.74	2744	18000		7.25	7.90	+15.57	—60°L	4	7.80	8.12

TABLE 50 TEST NO. S-1036*

From Champaign to Gilman, October 10, 1908. Weather: Fair. Temperature: 40° F. at start, 62° F. at end of test. Total weight behind measuring drawbar — 1961 tons, including the test car. Train length = 2010 ft. Center of mass 966 ft. back of measuring drawbar. 52 cars: 8 empty, 44 loaded. Kind of cars: 36 box, 13 gondola, 1 flat, 1 test, 1 caboose. Average weight per car = 37.72 tons.

1	2	3	4	5	6	7	8	9	10	11	12	13
Method	Item	Mile Post	Section Length	Pull P	Accel. A	Speed V_1	Speed V_2	Grade G	Direction	Velocity	Speed V	Resistance R
Point Columns 5, 6, and 9 to 13 show Momentary Values.	6	111.03		24350	0			+20.30	−15°R	5	9.14	4.71
	7	103.06		30450	0			+30.10	−45°R	3	5.73	4.12
	8	95.32		3300	0			−17.90	+70°R	11	36.65	8.35
	9	93.75		3200	0			−11.55	+75°R	8	31.50	6.01
	10	92.16		1800	0			−11.80	+80°R	7	29.15	5.39
	11	90.02		5500	0			− 8.90	+55°R	7	29.50	6.17
	12	86.10		8750	0			− 0.50	+25°R	3	21.60	4.65
	13	83.51		7400	0			− 4.70	+15°R	5	24.75	5.55
	14	81.38		5800	0			− 5.00	+35°R	4	22.50	4.85
	15	104.14		14800	−0.0440			+16.03	−65°R	5	18.14	5.65
	16	103.67		20150	−0.0620			+28.90	−40°R	9	12.90	5.20
	19	111.20		23900	−0.0260			+24.06	−15°R	4	9.90	5.19
	21	117.18		11800	0			+ 0.79	−50°R	4	16.23	6.32
	23	114.26		15100	−0.0070			+ 8.93	−60°R	5	12.54	4.99
	26	103.62		23450	−0.0440			+20.16	−35°R	10	10.90	5.07
Section Columns 5, 6, and 9 to 13 show Average Values	3	118.27—117.73	2888	11850		16.41	16.41	+ 0.18	−50°R	4	16.41	5.98
	4	117.73—117.18	2904	11750		16.50	16.50	+ 0.38	−50°R	4	16.50	5.86
	5	111.20—110.68	2768	23900		9.44	9.44	+18.70	−15°R	4	9.44	5.09
	6	101.46—101.01	2372	17350		14.45	12.82	+12.91	−75°R	5	13.48	5.26
	7	96.30— 95.71	3100	4600		30.40	34.50	−28.45	+80°R	8	32.50	7.19
	8	94.14— 93.40	3924	3300		30.95	31.25	−11.70	+75°R	7	31.48	5.78
	9	90.51— 90.02	2572	5850		28.80	29.50	− 9.96	+70°R	6	29.25	5.64
	10	89.18— 88.72	2412	6200		27.75	28.95	− 1.97	+65°R	5	27.42	5.18
	11	83.72— 82.99	3856	7250		24.50	25.75	− 5.89	+25°R	6	25.03	4.80
	12	81.19— 81.64	2348	6200		22.86	22.86	− 4.72	+35°R	4	22.86	4.95
	13	104.61—103.13	3884	14700		21.53	14.85	+17.00	+65°R	5	18.25	5.30
	14	109.85—109.10	3972	11600		15.17	23.90	−17.22	+70°R	1	19.30	6.17

* For complete table heading see Table 38, p. 99.

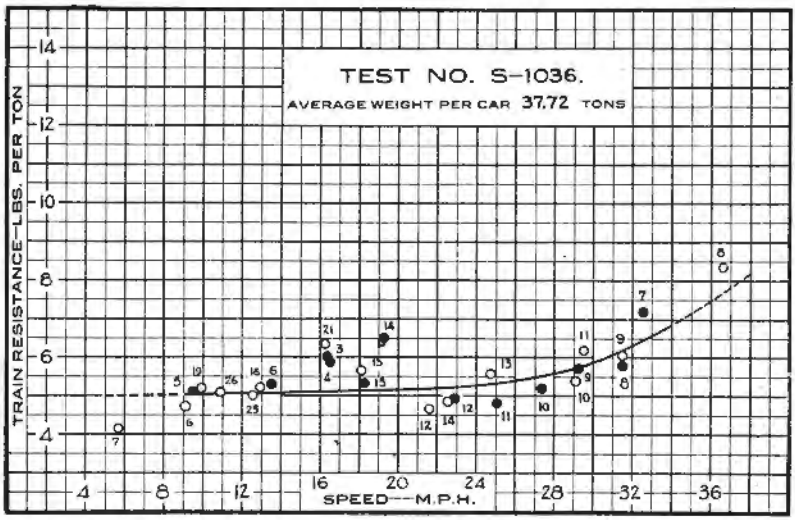
TEST NO. S-1036.
AVERAGE WEIGHT PER CAR 37.72 TONS
TRAIN RESISTANCE—LBS. PER TON
SPEED—M.P.H.
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FIG. 33

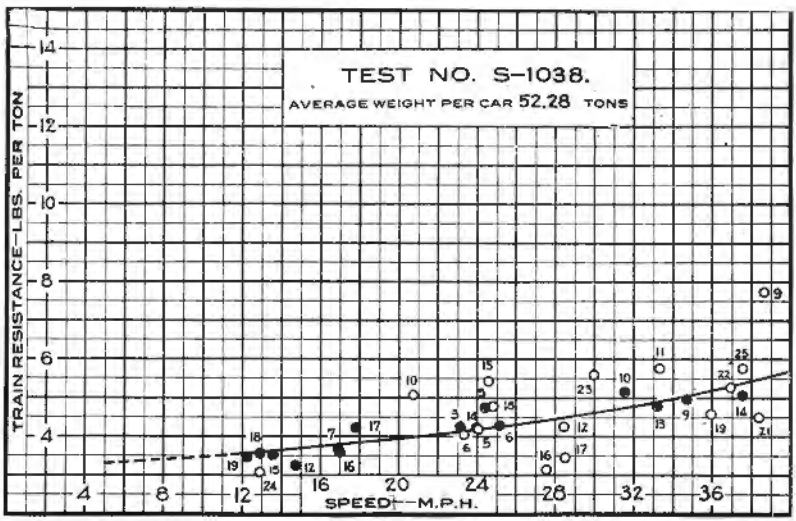
TEST NO. S-1038.
AVERAGE WEIGHT PER CAR 52.28 TONS
TRAIN RESISTANCE—LBS. PER TON
SPEED—M.P.H.
14
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FIG. 34

TABLE 51 TEST NO. S-1038*

From Champaign to Gilman, October 15, 1908. Weather: Fair. Temperature: 58° F. at start, 72° F. at end of test. Total weight behind measuring drawbar = 2144 tons, including the test car. Train length = 1650 ft. Center of mass 825 ft. back of measuring drawbar. 41 cars: 3 empty, 38 loaded. Kind of cars: 7 box, 32 gondola, 1 test, 1 caboose. Average weight per car = 52.28 tons.

1	2	3	4	5	6	7	8	9	10	11	12	13
Method	Item	Mile Post	Section Length	Pull P	Accel. A	Speed V_1	Speed V_2	Grade G	Direction	Velocity	Speed V	Resistance R
Point Columns 3, 6, and 9 to 13 show Momentary Values	5	117.32		9800	0			+ 0.96	+15°L	16	24.00	4.21
	6	115.84		10400	0			+ 2.08	+15°L	16	23.15	4.06
	7	113.84		14350	0			+ 8.01	+15°L	13	16.90	3.65
	9	106.00		5500	0			−13.00	+20°L	20	38.60	7.72
	10	100.53		13200	0			+ 2.85	+15°L	15	20.75	5.07
	11	99.29		8150	0			+ 5.18	+20°L	19	33.30	5.76
	12	93.18		8300	0			− 0.96	+ 5°L	18	28.40	4.24
	14	89.55		10200	0			+ 1.44	+20°L	17	24.00	4.21
	15	88.74		10100	0			− 1.85	+20°L	17	24.00	5.41
	16	87.71		9000	0			+ 2.78	+15°L	19	27.50	3.14
	17	87.04		8450	0			+ 1.28	+ 5°L	20	28.50	3.45
	18	86.42		10750	0			+ 0.64	+10°L	16	24.80	4.77
	19	97.86		6800	+0.0684			−28.15	+20°L	17	35.92	4.60
	21	97.54		3350	+0.0699			−24.95	+15°L	19	38.35	4.46
	22	97.76		6200	+0.0690			−28.15	+20°L	18	36.90	5.29
	23	98.90		9050	−0.0802			+ 16.30	+25°L	16	29.95	5.57
	24	103.05		22800	−0.0370			+29.10	+ 5°L	9	12.85	3.09
	25	105.90		5500	0.			− 8.42	+20°L	18	37.55	5.76
Section Columns 5, 6, and 9 to 13 show Average Values	3	117.06—118.18	5935	10000		23.65	24.15	+ 0.43	+15°L	16	23.12	4.23
	5	88.74— 89.55	4260	10250		24.20	24.75	− 0.95	+20°L	17	24.20	4.71
	6	85.84— 86.36	2768	10250		25.10	25.90	− 1.33	+10°L	16	25.15	4.28
	9	98.24— 97.76	2544	7100		31.95	36.90	−28.65	+20°L	16	34.69	4.97
	10	99.29— 98.90	2080	8100		32.80	29.95	+11.92	+20°L	17	31.51	5.14
	12	103.44—103.05	2050	19200		18.75	12.85	+31.70	+ 5°L	11	14.70	3.22
	13	105.18—104.58	3168	6850		35.10	30.60	+12.66	+15°L	17	33.20	4.78
	14	106.26—105.48	4120	6050		36.40	36.40	− 5.92	+20°L	18	37.50	5.06
	15	111.10—110.65	2384	20150		14.75	13.55	+18.04	+20°L	11	13.53	3.54
	16	110.24—109.82	2236	17050		15.00	19.75	− 1.89	+15°L	15	16.91	3.61
	17	114.74—114.24	2608	13750		18.70	17.80	+ 8.10	+15°L	13	17.80	4.22
	18	111.10—110.24	4536	20650		14.30	14.30	+15.95			12.85	3.59
	19	110.65—110.25	2152	21400		12.80	14.30	+13.73			12.22	3.48

*For complete table heading see Table 36, p. 99.

TABLE 52 TEST No. S-1040

From Champaign to Gilman, October 24, 1908. Weather: Intermittent rain. Temperature: 57° F. at start, 53° F. at end of test. Total weight behind measuring drawbar = 2152 tons, including the test car. Train length = 1830 ft. Center of mass 900 ft. back of measuring drawbar. 47 cars: 2 empty, 45 loaded. Kind of cars: 21 box, 23 gondola, 1 tank, 1 test, 1 caboose. Average weight per car = 45.76 tons.

1	2	3	4	5	6	7	8	9	10	11	12	13
Method	Item	Mile Post	Section Length	Pull P	Accel. A	Speed V_1	Speed V_2	Grade G	Direction	Velocity	Speed V	Resistance R
Point Columns 5, 6, and 9 to 13 show Momentary Values	6	114.68		16500	0			+ 7.72	+40° R	8	10.77	4.75
	10	102.99		28400	0			+27.10	+20° R	8	3.82	2.92
	12	100.64		15100	0			+ 7.22	+35° R	10	12.45	4.28
	15	88.71		8900	0			− 1.53	+20° R	13	28.20	4.71
	16	86.32		9850	0			− 0.26	+15° R	11	24.82	4.67
	20	101.55		8900	−0.0441			+ 9.53	+35° R	13	18.72	4.66
	23	100.85		13600	−0.0194			+10.97	+30° R	10	13.25	3.99
	24	103.48		23000	−0.0511			+30.00	+40° R	10	11.40	4.13
	25	108.45		13200	−0.0255			+ 9.81	+35° R	11	17.05	4.82
Section Columns 5 and 9 to 13 show Average Values	9	90.52— 90.03	2584	8500		28.70	29.62	− 9.61	+25° R	13	29.36	6.14
	10	89.29— 88.52	3768	8750		28.80	28.20	− 1.64	+20° R	13	28.54	5.33
	11	86.32— 95.91	2180	10150		24.62	24.62	− 0.70	+15° R	11	24.77	4 98
	12	83.83— 83.16	3548	7000		26.70	27.10	− 4.99	+15° R	12	26.88	4.72
	13	93.64— 93.20	2200	4000		22.37	21.74	− 5.04	+26° R	12	23.10	4.64
	14	83.83— 83.00	4360	7250		26.70	27.80	− 5.82	+15° R	12	27.00	4.64
	15	106.10—105.70	1988	7450		29.20	29.85	− 8.78	+25° R	13	30.10	5.45
	16	103.87—104.64	4056	15100		22.75	16.70	+17.20	+20° R	9	19.75	4.56

* For complete table heading see Table 38, p. 99.

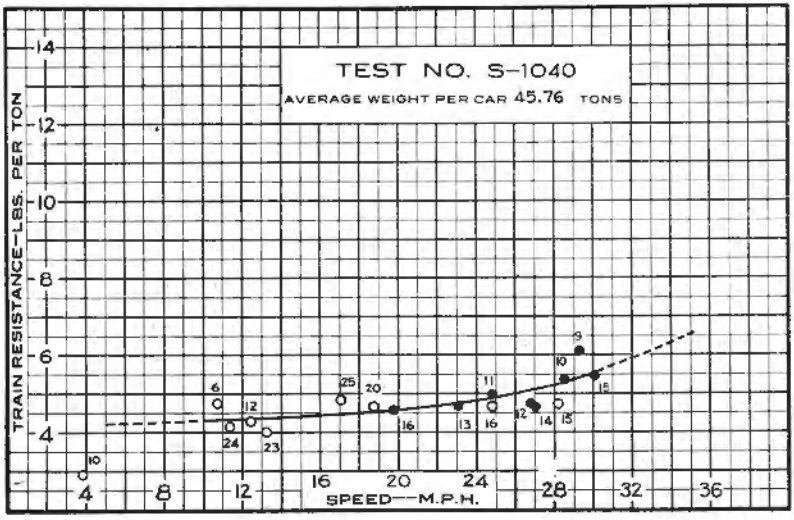
TEST NO. S-1040
AVERAGE WEIGHT PER CAR 45.76 TONS
TRAIN RESISTANCE—LBS. PER TON
SPEED—M.P.H.
14
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FIG. 35

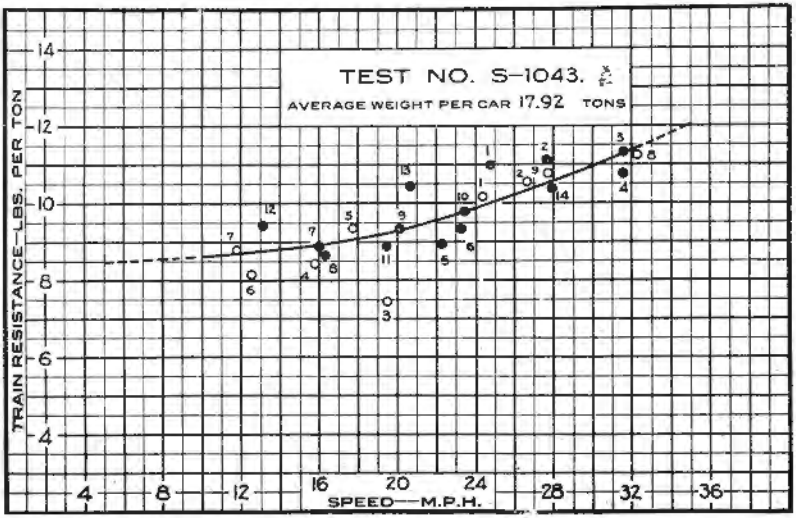
TEST NO. S-1043.
AVERAGE WEIGHT PER CAR 17.92 TONS
TRAIN RESISTANCE—LBS. PER TON
SPEED—M.P.H.
14
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FIG. 36

TABLE 53 TEST NO. S-1043*

From Champaign to Mattoon, November 7, 1908. Weather: Clear. Temperature: 38° F. at start, 53° F. at end of test. Total weight behind measuring drawbar = 1118 tons, excluding the test car. Train length = 2580 ft. Center of mass 1300 ft. back of measuring drawbar. 66 cars: 65 empty, 1 loaded. Kind of cars: 15 box, 49 gondola, 1 tank, 1 caboose. Average weight per car = 16.92 tons.

1	2	3	4	5	6	7	8	9	10	11	12	13
Method	Item	Mile Post	Section Length	Pull P	Accel. A	Speed V_1	Speed V_2	Grade G	Direction	Velocity	Speed V	Resistance R
Point Columns 5, 6, and 9 to 13 show Momentary Values	1	142.05		11300	0			− 0.14	↑25° R	8	24.35	10.15
	2	143.25		9400	+0.0124			− 8.80	↑20° R	11	26.70	10.51
	3	150.77		11000	+0.0165			+ 2.00	↑25° R	7	19.50	7.43
	4	156.10		13300	0			+ 9.21	↑20° R	6	15.80	8.41
	5	157.78		11700	0			+ 2.97	↑5° R	7	17.75	9.33
	6	168.23		15100	0			+14.13	↑65° R	4	12.55	8.14
	7	168.78		17000	+0.0106			+11.21	↑55° R	4	11.80	8.76
	8	147.29		7400	0			−12.11	↑15° R	13	32.30	11.21
	9	143.90		8650	0			− 7.06	↑10° R	11	27.75	10.75
Section Columns 5 and 9 to 13 show Average Values	1	139.25—140.49	6540	10500		24.70	25.50	− 3.97	↑30° R	8	24.76	10.97
	2	143.70—144.40	3652	8800		27.98	26.87	− 5.12	↑15° R	11	27.67	11.01
	3	146.20—147.52	6960	7500		29.43	32.10	−16.61	↑ 5° R	13	31.60	11.29
	4	147.52—148.31	4172	7600		32.10	30.42	− 5.50	↑ 5° R	13	31.60	10.72
	5	151.00—152.47	7832	11100		20.00	22.50	− 0.03	↑15° R	9	22.25	8.93
	6	152.47—153.45	5112	9450		22.50	23.90	− 4.70	↑25° R	10	23.24	9.31
	7	155.27—156.20	4952	13350		16.33	15.75	+ 9.02	↑20° R	6	16.07	8.79
	8	156.20—157.16	5028	13850		15.75	17.00	+ 8.34	↑20° R	6	16.32	8.63
	9	159.65—166.66	5316	10620		18.60	22.75	− 5.94	↑15° R	8	20.13	9.41
	10	160.66—162.22	8248	8500		22.75	20.90	− 3.84	↑15° R	8	23.43	9.76
	11	165.74—166.74	5276	11600		20.25	18.02	+ 7.01	↑50° R	7	19.45	8.88
	12	168.43—169.53	5792	15400		12.40	16.27	+ 8.20	↑55° R	4	13.16	9.40
	13	169.53—170.72	6272	11400		16.27	22.15	− 7.87	↑15° R	9	20.70	10.41
	14	145.58—146.20	3276	9150		26.90	29.40	−13.96	↑ 5° R	11	27.94	10.35

*For complete table heading see Table 38, p. 99.

TABLE 54 TEST NO. S-1048*

From Champaign to Ludlow, November 28, 1908. Weather: Fair. Temperature: 36° F. at start, 39° F. at end of test.
Total weight behind measuring drawbar = (*a*)-2443 tons, (*b*)-2355 tons, including the test car. Train length = (*a*)-2175 ft. (*b*)-2100 ft.
Center of mass 925 ft. back of measuring drawbar (*a*)-54 cars, (*b*)-52 cars, 8 empty, (*a*)-46 loaded. (*b*)-44 loaded. Kind of cars: 18 box (*a*)-34 gondola, (*b*)-32 gondola, 1 test, 1 caboose. Average weight per car = 45 24 tons. (*a*)—Champaign to Rantoul. (*b*)—Rantoul to Ludlow.

1	2	3	4	5	6	7	8	9	10	11	12	13
Method	Item	Mile Post	Section Length	Pull *P*	Accel. *A*	Speed *V*1	Speed *V*2	Grade *G*	Direction	Velocity	Speed *V*	Resistance *R*
Point Columns 5, 6, and 9 to 13 show Momentary Values	1	110.74		26750	0			+18.86	+ 5° L	5	9.35	4.21
	2	111.17		30150	0			+24.13	+ 5° L	5	7.78	3.65
	3	114.44		18200	0			+ 8.28	+25° L	6	14.00	4.33
	4	115.79		14200	0			+ 1.94	+30° L	6	18.36	5.08
	5	116.48		13550	0			+ 0.73	+25° L	7	19.36	5.27
	6	117.61		12800	0			0	+30° L	5	19.45	5.24
	7	118 43		13850	0			− 0.49	+ 5° L	6	19.73	5.74
	10	115.34		14800	−0.0229			+ 7.28	+30° L	6	17.36	5.46
	11	114.71		17800	−0.0053			+ 9.47	+25° L	6	14.27	4.20
	14	110.53		29350	0			+20.10	+ 5° L	5	8.73	4.84
	15	110.16		20950	+0.0388			+ 0.25	+10° L	6	11.73	5.16
	16	111.01		29850	+0.0123			+20.10	+ 5° L	5	8.28	3.89
	17	111.80		17800	−0.0900			+28.15	+15° L	5	16.45	5.37
	18	111.59		21950	−0 0652			+20.91	+15° L	5	12.00	4.15
	19	111.40		28550	−0.0352			+29.16	+15° L	5	9.10	4.39
	20	109.83		17400	+0.0805			− 4.78	+10° L	8	15.00	5.38
	21	111.51		25500	−0.0511			+20.91	+15° L	5	10.64	4.31
	22	109.09		9900	+0.0476			−19.35	+ 0°	9	21.20	7.05
	23	108.69		11000	−0 0405			+ 6.54	+ 5° R	9	23.91	6.01
	24	108.31		12200	−0.0493			+10.30	+ 5° R	9	21.30	5.92
	25	108.49		11200	−0.0511			+ 9.05	+ 5° R	9	23.00	6.15
Section Columns 5 and 9 to 13 show Average Values	5	118.42—117.61	4306	13400		19.73	19.45	0	+30° L	5	19.58	5.66
	6	115.94—115.34	3172	14650		18.27	17.36	+ 4.49	+30° L	6	18.02	5.00
	7	114.71—114.24	2476	18100		14.27	13.82	+ 8.11	+25° L	6	14.06	4.69
	9	111.40—110.61	4176	29000		9.10	9.10	+21.40	+ 5° L	5	8.50	4.19
	10	108.69—108.31	2008	11000		23.90	21 30	+ 9.21	+ 5° L	9	22.80	5.20
	11	112.06—111.40	3488	20000		20.82	9.10	+28.30	+15° L	5	13.98	4.72

* For complete table heading see Table 36, p. 99.

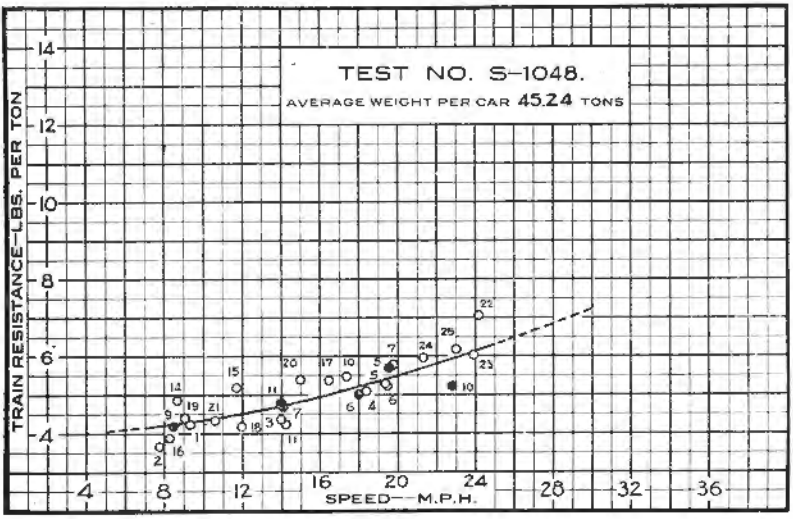

TEST NO. S-1048.
AVERAGE WEIGHT PER CAR 45.24 TONS
TRAIN RESISTANCE—LBS. PER TON
SPEED—M.P.H.

FIG. 37

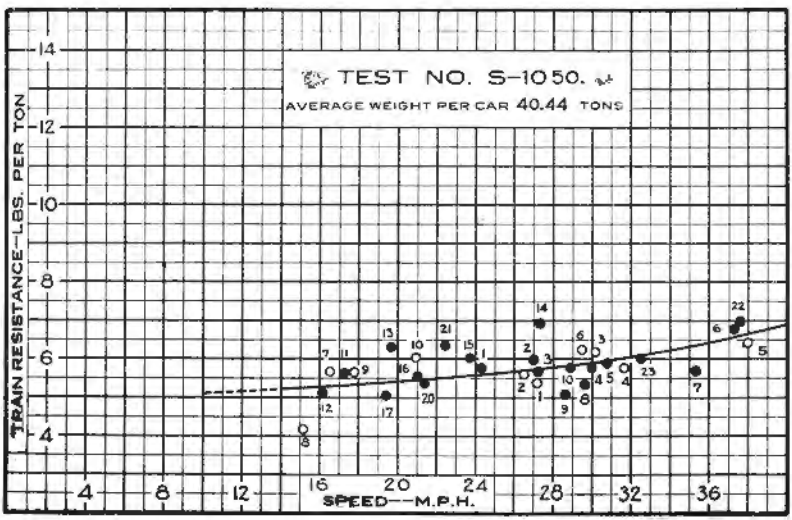

TEST NO. S-1050.
AVERAGE WEIGHT PER CAR 40.44 TONS
TRAIN RESISTANCE—LBS. PER TON
SPEED—M.P.H.

FIG. 38

TABLE 55 TEST NO. S-1050*

From Champaign to Mattoon, January 23, 1909. Weather: Fair. Temperature: 53° F. at start, 66° F. at end of test. Total weight behind measuring drawbar = 1618 tons, excluding the test car. Train length = 1620 ft. Center of mass 660 ft. back of measuring drawbar. 40 cars: 16 empty, 24 loaded. Kind of cars: 20 box, 10 gondola, 1 caboose. Average weight per car = 40.44 tons.

1	2	3	4	5	6	7	8	9	10	11	12	13
Method	Item	Mile Post	Section Length	Pull P	Accel. A	Speed V_1	Speed V_2	Grade θ	Direction	Velocity	Speed V	Resistance R
Point Columns 5, 6, and 9 to 13 show Momentary values	1	141.33		7800	0			− 1.50	+ 0°	4	27.20	5.39
	2	142.12		7800	0			− 1.83	+11° R	5	26.55	5.57
	3	144.65		7500	0			− 4.04	+ 0°	7	30.20	6.17
	4	145.56		6050	0			− 5.25	+ 0°	6	31.70	5.73
	5	147.33		4550	0			− 9.46	+ 0°	6	38.00	6.40
	6	153.18		5900	0			− 6.81	+65° R	6	29.46	6.23
	7	155.97		14900	0			+ 9.32	−60° R	8	16.55	5.68
	8	157.87		7250	0			+ 0.88	−45° R	6	15.18	4.15
	9	156.97		14100	0			+ 8.15	−60° R	11	17.77	5.62
	10	158.87		10400	0			+ 1.08	−60° R	14	20.95	6.02
Section Columns 5 and 9 to 13 show Average Values	1	139.00—140.21	6420	9100		23.14	25.72	− 3.91	+40° R	3	24.31	5.75
	2	140.21—141.56	7116	8200		25.72	27.50	− 4.82	+ 0°	4	26.95	5.97
	3	141.56—142.93	7188	7800		27.50	29.10	− 4.55	+10° R	5	27.23	5.67
	4	142.93—143.80	4616	7100		29.00	31.22	− 8.92	+ 0°	7	30.00	5.76
	5	143.80—145.16	7220	6950		31.22	31.20	− 4.17	+ 0°	7	30.78	5.99
	6	146.25—147.49	6560	4950		35.30	37.90	−15.13	+ 0°	6	37.30	6.79
	7	148.22—148.91	3632	4950		36.25	33.82	+ 1.67	+15° R	6	35.36	5.68
	8	150.79—151.78	5216	6950		30.20	29.10	− 0.40	+35° R	4	29.63	5.32
	9	151.78—152.57	4196	7400		29.10	28.55	+ 0.06	+60° R	5	28.60	5.08
	10	152.57—153.18	3176	7500		28.55	29.46	− 5.94	+65° R	6	28.87	5.74
	11	156.11—156.97	4552	14800		16.90	17.77	+ 8.15	−60° R	11	17.25	5.60
	12	157.48—158.25	4016	8850		17.23	17.23	+ 1.01	−45° R	6	16.11	5.09
	13	159.30—159.87	3032	13550		19.77	19.77	+ 5.48	−60° R	14	19.70	6.29
	14	160.80—161.79	5212	7750		26.64	26.64	− 5.68	−60° R	14	27.35	6.94
	15	162.59—163.28	3644	9200		22.90	24.37	− 4.35	−55° R	12	23.86	6.01
	16	164.96—165.66	3696	10550		20.37	21.73	− 0.16	−30° R	9	21.00	5.51
	17	166.19—166.84	3412	11800		20.55	18.60	+10.13	−25° R	8	19.40	5.01
	20	165.66—166.19	2828	10000		21.73	20.55	+ 5.45	−30° R	7	21.41	5.34
	21	159.87—160.62	3956	10400		19.77	25.55	−11.88	−60° R	13	22.46	6.34
	22	147.49—148.22	3860	4700		37.80	38.25	− 5.27	+10° R	7	37.60	6.96
	23	145.16—146.25	5716	6600		31.20	35.30	−13.76	+ 0°	6	32.50	5.99

* For complete table heading see Table 36, p. 99.

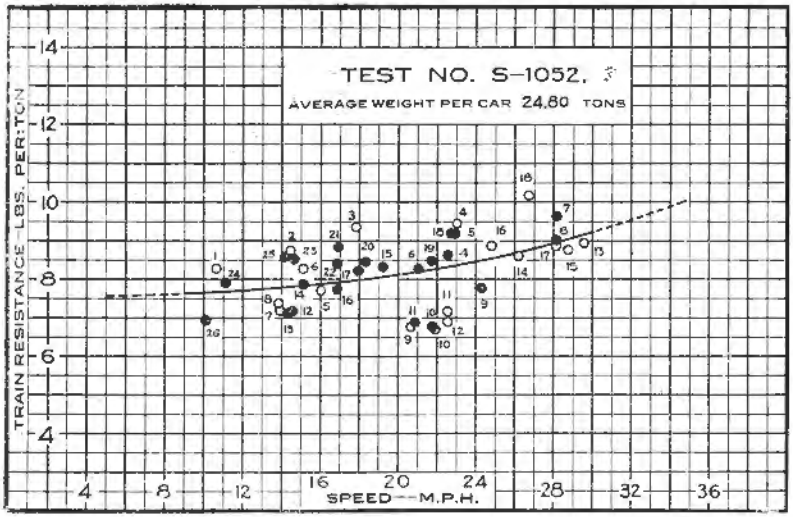

TEST NO. S-1052.
AVERAGE WEIGHT PER CAR 24.80 TONS
TRAIN RESISTANCE-LBS. PER TON
SPEED--M.P.H.

FIG. 39

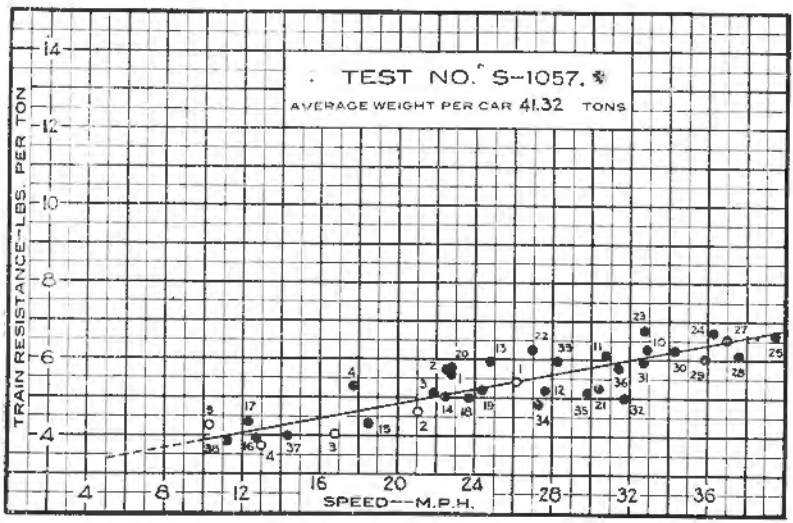

TEST NO. S-1057.
AVERAGE WEIGHT PER CAR 41.32 TONS
TRAIN RESISTANCE-LBS. PER TON
SPEED--M.P.H.

FIG. 40

TABLE 56 TEST No. S-1052

From Champaign to Mattoon, January 28, 1909. Weather: Continuous rain. Temperature: 36° F. at start, 40° F. at end of test. Total weight behind measuring drawbar = 1514 tons, excluding the test car. Train length = 2430 ft. Center of mass 1316 ft. back of measuring drawbar. 61 cars: 44 empty, 17 loaded. Kind of cars: 36 box, 23 gondola, 1 flat, 1 caboose. Average weight per car = 24.80 tons.

1	2	3	4	5	6	7	8	9	10	11	12	13
Method of Calculation	Item No.	Location on Road Milepost No.	Length of Section feet	Total Drawbar Pull pounds	Acceleration Miles per hour per second	Speeds		Grade + Up − Down feet per mile	Wind		Speed m. p. h.	Net Train Resistance pounds per ton
						At Entrance to Section m. p. h.	At Exit from Section m. p. h.		Approximate Direction	Approximate Velocity m. p. h.		
				P	A	V_1	V_2	G			V	R
Point Columns 5, 6, and 9 to 13 show Momentary Values	1	168.75		20850	0			+14.52	−45° L	14	10.64	8.37
	2	167.12		18050	0			+ 4.99	−50° L	19	14.45	8.71
	3	165.72		14400	0			+ 0.43	−60° L	18	17.32	9.35
	4	161.23		9550	0			− 8.25	−70° L	12	23.00	9.43
	5	159.84		13800	0			+ 3.75	−50° L	14	16.00	7.70
	6	157.37		16750	0			+ 7.38	−55° L	10	15.10	8.28
	7	155.97		16400	0			+ 9.06	−50° L	11	13.90	7.18
	8	155.11		15800	0			+ 8.10	−50° L	11	13.86	7.37
	9	152.52		9900	0			− 0.54	−80° L	6	20.64	6.75
	10	151.34		9750	0			− 0.65	90° L	7	21.90	6.69
	11	153.50		8650	0			− 3.77	−85° L	6	22.55	7.15
	12	149.60		9550	0			− 1.52	+70° L	6	22.46	6.89
	13	147.20		5800	0			−13.44	+85° L	10	29.47	8.92
	14	148.29		6900	−0.0368			− 0.74	+85° L	8	26.20	8.60
	15	147.44		5800	−0.0166			− 8.73	90° L	9	28.80	8.75
	16	148.57		9200	−0.0352			+ 1.71	+80° L	7	24.82	8.84
	17	146.59		8500	+0.0401			−18.85	+85° L	10	28.10	8.87
	18	146.33		8900	+0.0458			− 22.88	+85° L	11	26.73	10.17

Section Columns 5, and 9 to 13 show Average Values											
4	142.87—143.62	3972	9600		21.64	23.15	— 9.18	—80° L	10	22.55	8.61
5	143.62—144.38	4032	8850		23.15	21.61	— 5.70	—65° L	13	22.92	9.19
6	144.38—145.20	4312	10000		21.64	21.55	— 4.14	—66° L	10	21.00	8.24
7	146.22—147.15	4956	8000		25.91	29.29	—18.46	+85° L	10	28.16	9.61
8	147.15—148.29	5980	6200		29.29	26.20	— 7.56	90° L	9	28.13	9.00
9	148.29—149.09	4268	8450		26.20	23.00	+ 1.17	+80° L	7	21.26	7.76
10	151.12—151.85	3828	9400		22.10	21.28	— 0.26	90° L	7	21.74	6.77
11	151.85—152.55	3676	9800		21.28	20.64	+ 0.32	—80° L	6	20.90	6.88
12	156.01—156.74	3840	16850		14.10	15.00	+ 9.22	—54° L	11	14.54	7.16
13	155.29—156.01	3780	16000		14.18	14.10	+ 9.22	—50° L	11	14.31	7.12
14	156.74—157.37	3332	16100		15.00	15.10	+ 7.29	—55° L	10	15.15	7.82
15	158.23—159.24	5344	11200		18.00	18.00	— 2.37	—55° L	12	19.20	8.30
16	159.24—159.80	2964	13300		18.00	15.90	+ 7.31	—45° L	13	16.84	7.73
17	159.80—160.69	4732	12500		15.90	21.36	— 7.92	—50° L	14	17.92	8.21
18	160.69—161.45	3996	9600		21.36	22.82	—10.47	—70° L	12	22.70	9.16
19	161.45—162.17	3816	9550		22.82	18.91	+ 2.31	—60° L	14	21.68	8.46
20	162.17—163.08	4828	13400		18.91	19.50	+ 0.23	—55° L	13	18.29	8.44
21	164.85—165.69	4460	15200		15.82	17.82	+ 0.35	—60° L	18	16.90	8.84
22	165.69—166.67	5172	14600		17.82	15.18	+ 6.48	—60° L	16	16.80	8.39
23	166.67—167.26	3116	16100		15.18	13.86	+ 7.88	—50° L	19	14.66	8.52
24	168.57—169.13	2928	20400		10.91	12.64	+12.10	—45° L	14	11.09	7.90
25	169.13—169.60	2492	17000		12.64	15.40	+ 1.25	—50° L	13	14.15	8.56
26	171.44—171.72	1484	22600		12.32	8.50	+31.20	—50° L	14	10.12	6.91

TABLE 57 TEST No. S-1057

From Champaign to Gilman, March 6, 1909. Weather: Fair. Temperature: 34° F. at start, 40° F. at end of test. Total weight behind measuring drawbar = 2107 tons, including the test car. Train length = 1830 ft. Center of mass 860 ft. back of measuring drawbar. 51 cars: 8 empty, 43 loaded. Kind of cars: 23 box, 22 gondola, 3 flat, 1 tank, 1 test, 1 caboose. Average weight per car = 41.32 tons.

1	2	3	4	5	6	7	8	9	10	11	12	13
Method of Calculation	Item No.	Location on Road Milepost No.	Length of Section feet	Total Drawbar Pull pounds	Acceleration miles per hour per second	Speeds		Grade Up + | − Down feet per mile	Wind		Speed m. p. h.	Net Train Resistance pounds per ton
						At Entrance to Section m. p. h.	At Exit from Section m. p. h.		Approximate Direction	Approximate Velocity m. p. h.		
				P	A	V_1	V_2	G			V	R
Point Columns 5, 6, and 9 to 13 show Momentary Values	1	104.55		13600	−0.0561			+16.76	+10°L	8	26.16	5.41
	2	103.87		16800	−0.0723			+26.88	+ 5°L	13	21.02	4.63
	3	103.57		19550	−0.0638			+29.78	"	13	16.80	4.04
	4	103.29		24950	−0.0440			+32.38	"	13	13.00	3.73
	5	102.93		28350	0			+21.28	+10°L	6	10.32	4.26

Section
Columns 5 and 9 to 13 show Average Values

1	117.94—117.18	4004	12800		22.57	23.05	+ 0.20	+20° R	6	22.75	5.62
2	117.18—115.94	6596	13150		23.05	22.16	+ 2.41	+15° R	7	22.50	5.75
3	115.94—115.36	3044	12950		22.16	21.42	+ 4.58	+20° R	6	21.85	5.14
4	114.69—114.22	2472	17000		18.20	17.98	+ 7.90	+15° R	6	17.75	5.30
10	106.08—105.53	2892	9150		32.35	32.08	— 4.02	+10° L	7	32.86	6.28
11	105.53—105.02	2704	10050		32.08	29.20	+ 8.40	+10° L	8	30.74	6.11
12	105.02—104.56	2428	11950		29.20	26.16	+13.92	+10° L	8	27.60	5.90
13	104.56—104.25	1636	14600		26.16	24.10	+14.20	+10° L	8	24.79	5.93
14	104.25—103.87	1976	15700		24.10	21.02	+19.24	+ 5° L	13	22.45	5.03
15	103.87—103.57	1624	18350		21.02	16.80	+29.60	+ 5° L	13	18.45	4.32
16	103.57—103.05	2704	24000		16.80	10.58	+31.25	+ 5° L	13	12.72	3.92
17	103.05—102.40	3436	24000		10.58	18.88	+ 5.53	+10° L	6	12.33	4.37
18	102.40—101.65	3988	12800		18.88	25.76	—11.25	+25° L	9	25.65	5.00
19	101.65—101.24	2144	12800		25.76	23.50	+11.82	+25° L	9	24.38	5.20
20	101.24— 99.79	7680	13500		23.50	28.72	— 4.88	+25° L	8	22.77	5.80
21	99.79— 98.95	4452	6350		28.72	28.25	— 4.03	+25° L	8	30.38	5.25
22	98.95— 98.05	4744	8100		28.25	30.32	—11.02	+20° L	9	26.95	6.26
23	98.05— 97.50	2884	5800		30.32	34.54	—28.02	—35° L	11	32.76	6.78
24	97.50— 96.05	7704	5400		34.70	37.55	—15.83	—35° L	11	36.24	6.71
25	96.05— 95.38	3476	4950		37.55	41.10	—25.98	+35° L	12	39.50	6.64
26	95.38— 94.60	4144	4450		41.10	37.90	— 1.02	+35° L	12	40.38	6.73
27	94.60— 93.93	3528	6600		37.90	37.25	— 6.44	+35° L	12	37.00	6.53
28	93.93— 93.31	3308	6100		37.25	37.25	— 8.46	+35° L	12	37.60	6.11
29	90.09— 89.50	3156	5900		36.21	35.25	— 4.52	+35° L	11	35.86	6.02
30	89.50— 88.92	3016	6900		35.25	33.55	— 0.70	+35° L	11	34.28	6.23
31	88.92— 88.02	4792	7550		33.55	32.45	— 3.42	+35° L	11	32.68	5.93
32	88.02— 86.79	5500	7600		32.45	30.62	— 0.41	+35° L	7	31.66	4.99
33	86.79— 86.20	3108	8850		30.62	27.60	+ 5.78	+40° L	9	28.25	5.93
34	86.20— 85.74	2396	9250		27.60	27.80	— 1.98	+40° L	9	27.23	4.82
35	83.88— 83.38	2616	9800		29.21	30.02	— 4.64	+40° L	9	29.75	5.14
36	83.38— 82.16	6444	8750		30.02	31.40	— 6.72	+40° L	9	31.40	5.79
37	103.57—103.29	1472	22100		16.80	13.00	+31.20	+ 5, L	13	14.34	4.00
38	103.29—103.05	1232	26400		13.00	10.58	+31.30	+ 5° L	13	11.20	3.88

TABLE 58 TEST NO.S-1061*

From Champaign to Gilman, March 13, 1909. Weather: Fair. Temperature: 41° F. at start, 38° F. at end of test. Total weight behind measuring drawbar = 2252 tons, including the test car. Train length = 1785 ft. Center of mass 850 ft. back of measuring drawbar. 44 cars: 3 empty, 41 loaded. Kind of cars: 37 Gondola, 5 flat, 1 test, 1 caboose. Average weight per car = 51.20 tons.

1	2	3	4	5	6	7	8	9	10	11	12	13
Method	Item	Mile Post	Section Length	Pull P	Accel. A	Speed V_1	Speed V_2	Grade G	Direction	Velocity	Speed V	Resistance R
Section Columns 5 and 9 to 13 show Average Values	1	117.14—115.91	6496	11550		18.20	16.41	+ 2.40	+70° L	5	17.05	4.87
	2	115.91—115.34	3000	12000		16.41	14.95	+ 5.02	+70° L	5	15.73	4.48
	3	111.66—110.98	3724	21900		18.13	10.25	+25.70	90° L	5	12.10	4.10
	4	110.98—109.84	5888	22400		10.25	17.05	+ 9.43	+75° L	10	11.47	4.21
	5	109.84—109.22	3304	14000		17.05	25.00	—17.44	—85° L	7	20.50	5.87
	6	109.22—108.31	4792	9850		25.00	23.00	— 0.33	+75° L	6	25.15	5.88
	7	108.86—108.12	3904	7850		29.81	32.20	—14.50	+70° L	7	31.30	6.38
	8	108.12—105.58	2872	7150		32.20	31.91	— 5.70	+70° L	7	32.65	5.79
	9	105.58—104.96	3304	9250		31.91	28.20	+ 7.90	+65° L	7	30.00	5.77
	10	104.96—104.26	3676	12100		28.20	22.57	+14.75	+85° L	7	25.05	5.13
	11	104.26—103.65	3224	17150		22.57	15.49	+21.90	+80° L	7	19.10	5.06
	12	103.65—103.31	1800	22450		15.49	9.70	+30.00	+80° L	9	12.27	4.15
	13	103.31—103.04	1464	27050		9.70	5.15	+31.00	+65° L	4	6.88	3.43
	14	103.31—103.18	720	26200		9.70	7.37	+32.30	+65° L	4	8.18	3.18
	15	103.18—103.04	744	28000		7.37	5.15	+29.90	+65° L	4	5.90	3.67
	16	98.14— 97.61	2776	7650		24.23	29.57	—27.40	+65° L	8	27.03	6.67
	17	97.61— 95.76	9800	6000		29.57	30.17	—18.75	+60° L	8	32.80	6.73
	18	95.76— 95.29	2472	4450		30.10	37.68	—23.50	+50° L	10	37.40	7.64
	19	95.29— 94.58	3772	4450		37.68	34.10	+ 2.03	+50° L	10	38.75	5.91
	20	94.58— 93.79	4136	5600		34.09	33.60	— 7.68	+45° L	10	33.16	5.95
	21	93.79— 93.24	2956	5200		33.60	32.91	— 7.15	+45° L	10	33.55	6.09
	22	86.71— 85.77	4960	11000		20.06	19.10	+ 1.28	90° L	9	19.00	4.91
	23	83.67— 82.97	3728	8250		22.70	24.03	— 6.00	+60° L	7	23.10	4.78
	25	81.65— 81.30	1868	8300		16.98	17.52	— 5.10	+80° L	8	16.97	4.93

* For complete table heading see Table 36, p. 99.

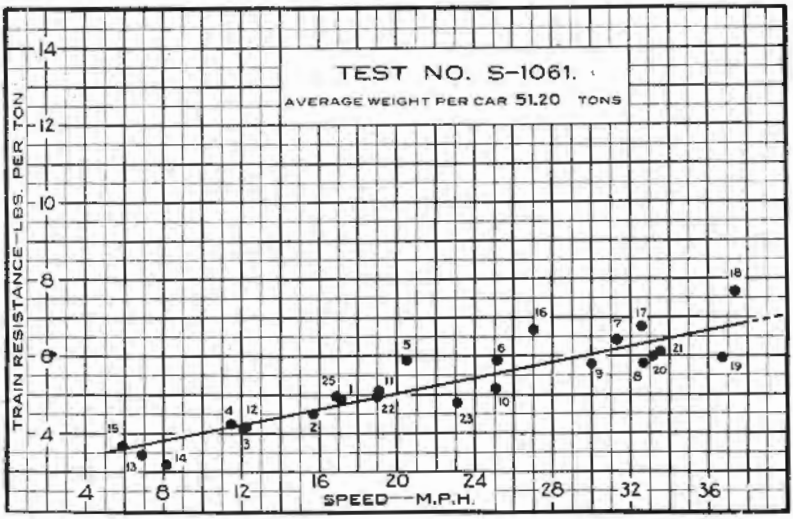

TEST NO. S-1061.
AVERAGE WEIGHT PER CAR 51.20 TONS
TRAIN RESISTANCE—LBS. PER TON
SPEED—M.P.H.

FIG. 41

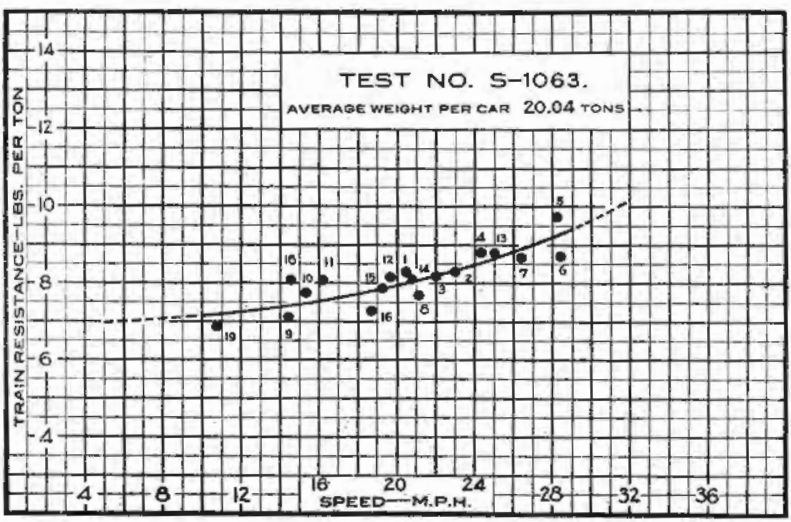

TEST NO. S-1063.
AVERAGE WEIGHT PER CAR 20.04 TONS
TRAIN RESISTANCE—LBS. PER TON
SPEED—M.P.H.

FIG. 42

TABLE 59 TEST NO. S–1063*

From Champaign to Mattoon, March 19, 1909. Weather: Intermittent rain. Temperature: 39° F. at start, 40° F. at end of test. Total weight behind measuring drawbar = 1484 tons, excluding the test car. Train length = 3060 ft. Center of mass 1200 ft. back of measuring drawbar. 74 cars: 70 empty, 4 loaded. Kind of cars: 4 box, 69 gondola, 1 caboose. Average weight per car = 20.04 tons.

1	2	3	4	5	6	7	8	9	10	11	12	13
Method	Item	Mile Post	Section Length	Pull P	Accel. A	Speed V_1	Speed V_2	Grade G	Direction	Velocity	Speed V	Resistance R
Section Columns 5 and 9 to 13 show Average Values	1	141.71—142.84	6000	10800		20.74	21.61	— 3.74	+35° R	13	20.45	8.26
	2	143.53—144.45	4900	8450		22.91	22.10	— 5.40	+35° R	14	23.00	8.29
	3	144.45—145.34	4672	9800		22.10	22.71	— 5.20	+35° R	14	22.00	8.15
	4	145.34—146.42	5700	8850		22.71	27.21	—14.90	+40° R	15	24.30	8.77
	5	146.42—147.20	4144	6900		27.21	28.61	—18.95	+40° R	15	28.25	9.70
	6	147.20—147.83	3336	6700		28.61	28.00	— 9.01	+40° R	15	28.40	8.69
	7	147.83—148.60	4064	7200		28.00	21.91	— 2.34	+40° R	15	26.40	8.64
	8	152.50—153.52	5416	10100		20.35	22.14	— 4.90	+30° R	13	21.10	7.66
	9	155.78—156.82	5484	16050		14.30	15.10	+ 8.95	+20° R	10	14.40	7.10
	10	156.82—157.37	2912	16000		15.10	15.24	+ 7.80	+20° R	10	15.30	7.71
	11	157.37—158.16	4156	15600		15.24	17.73	+ 2.80	+20° R	10	16.20	8.03
	12	158.16—159.35	6338	12450		17.73	19.09	— 0.84	+30° R	10	19.65	8.14
	13	161.21—161.48	1472	9200		25.00	25.10	— 7.50	+30° R	13	25.00	8.79
	14	162.17—163.12	5028	12000		21.60	21.61	+ 0.10	+30° R	12	20.75	8.09
	15	165.07—165.77	3720	13200		18.11	19.61	— 0.14	+35° R	12	19.25	7.85
	16	165.77—166.85	5680	13050		19.60	16.56	+ 7.80	+35° R	12	18.70	7.94
	18	169.38—169.66	1492	14950		13.95	14.93	+ 1.77	+40° R	9	14.55	8.08
	19	171.55—171.71	870	22200		11.96	9.86	+31.50	+25° R	8	10.78	6.84

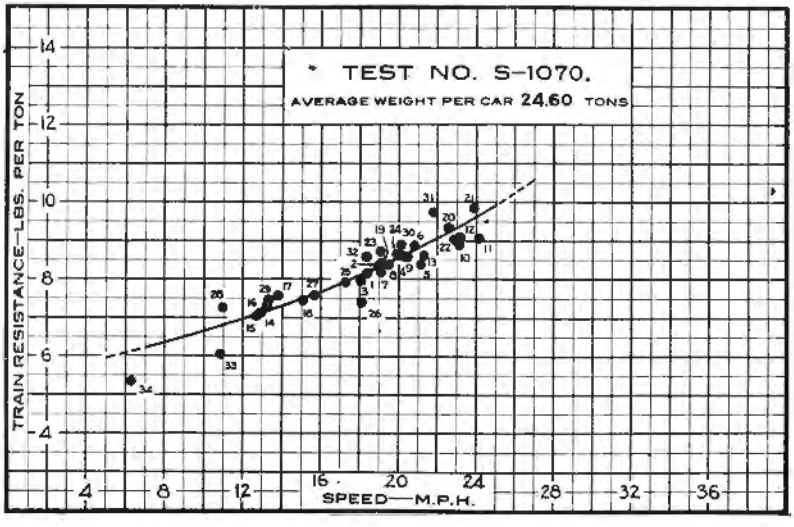
* For complete table heading see Table 36, p. 99.

TABLE 60 TEST NO. S-1070

From Champaign to Mattoon, April 17, 1909. Weather: Fair. Temperature: 58° F. at start, 71° F. at end of test. Total weight behind measuring drawbar = 1622 tons, including the test car. Train length = 2400 ft. Center of mass 1091 ft. back of measuring drawbar. 66 cars: 49 empty, 17 loaded. Kind of cars: 21 box, 28 gondola, 15 stock, 1 test, 1 caboose. Average weight per car = 24.60 tons.

1	2	3	4	5	6	7	8	9	10	11	12	13
Method	Item	Mile Post	Section Length	Pull P	Accel. A	Speed V_1	Speed V_2	Grade G	Direction	Velocity	Speed V	Resistance R
Section Columns 5 and 9 to 13 show Average Values	1	140.20—140.89	3636	11150		17.90	19.53	— 6.55	+ 0°	1	18.35	8.16
	2	140.89—141.70	4304	10800		19.53	18.65	— 2.94	+ 0°	1	18.90	8.31
	3	141.70—142.70	5308	11850		18.65	19.61	— 2.98	+ 0°	1	18.10	7.94
	4	142.70—143.38	3572	10150		19.61	21.19	— 9.47	+ 0°	1	20.25	8.57
	5	143.38—143.79	2164	9200		21.19	21.75	— 9.25	+ 0°	1	21.10	8.38
	6	143.79—144.37	3056	9150		21.75	20.13	— 4.33	+ 0°	1	20.80	8.86
	7	144.37—145.03	3496	10400		20.13	19.40	— 3.32	+ 0°	1	19.05	8.26
	8	145.03—145.38	1856	9900		19.40	19.98	— 8.26	+ 0°	1	19.45	8.36
	9	145.38—146.15	4040	9050		19.98	22.57	—13.00	+ 0°	1	20.40	8.57
	10	146.15—146.47	1692	5000		22.57	23.97	—22.50	+ 0°	1	23.10	8.88
	11	146.47—147.21	3892	5650		23.97	24.71	—16.40	+ 0°	1	24.10	9.04
	12	147.21—147.82	3236	5800		24.71	22.70	— 9.00	+ 0°	1	23.20	9.08
	13	147.82—148.32	2660	7700		22.70	20.61	— 3.77	+ 0°	1	21.30	8.60
	14	155.43—155.95	2740	16800		13.52	12.85	+ 9.80	+60° L	7	12.90	7.10
	15	155.94—156.41	2432	17500		12.85	13.10	+ 9.35	+60° L	7	12.75	7.06
	16	156.41—156.87	2424	17750		13.10	13.96	+ 7.83	+60° L	7	13.21	7.30
	17	156.87—157.36	2632	17600		13.96	14.30	+ 8.04	+60° L	7	13.80	7.54
	18	157.36—158.10	3864	16900		14.30	17.12	+ 3.14	+60° L	4	15.05	7.42
	19	158.10—159.29	6284	13950		17.12	18.87	— 1.35	+60° L	4	19.05	8.40
	20	160.55—160.80	1324	12650		21.90	25.63	—15.20	—75° L	3	22.60	9.32
	21	160.80—161.36	2980	11600		23.53	24.45	— 9.57	—75° L	3	23.90	9.84
	22	161.36—162.19	4368	11300		24.45	20.43	+ 2.30	—75° L	3	22.90	9.02
	23	162.19—162.77	3072	14100		20.43	19.53	+ 5.15	—75° L	3	19.02	8.70
	24	162.77—163.16	2040	13400		19.53	20.43	— 4.27	—75° L	3	19.90	8.63
	25	164.94—165.73	4188	14700		16.30	18.40	— 0.19	90° L	9	17.30	7.90
	26	165.73—166.16	2248	13800		18.40	17.74	+ 1.70	90° L	9	18.05	7.36
	27	166.16—166.85	3660	15050		17.74	14.62	+ 9.72	90° L	9	15.60	7.56
	28	168.36—168.69	1692	20750		11.40	10.98	+15.00	90° L	12	11.00	7.28
	29	168.69—169.63	4984	18650		10.98	16.45	+ 5.10	90° L	12	13.32	7.43
	30	169.63—170.56	4876	13600		16.45	22.70	—10.70	—65° L	6	20.10	8.87
	31	170.56—170.83	1440	12700		22.70	21.77	+ 0.37	—65° L	6	21.80	9.73
	32	170.83—171.42	3084	13550		21.77	14.30	+15.75	—65° L	6	18.30	8.58
	33	171.42—171.75	1752	20950		14.30	8.75	+31.90	+80° L	4	10.85	6.02
	34	171.86—172.10	1308	27050		7.60	6.00	+33.10	+80° L	4	6.38	5.32

or complete table heading see Table 36, p. 99.


TEST NO. S-1070.
AVERAGE WEIGHT PER CAR 24.60 TONS
TRAIN RESISTANCE—LBS. PER TON
SPEED—M.P.H.
14
12
10
8
6
4
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24
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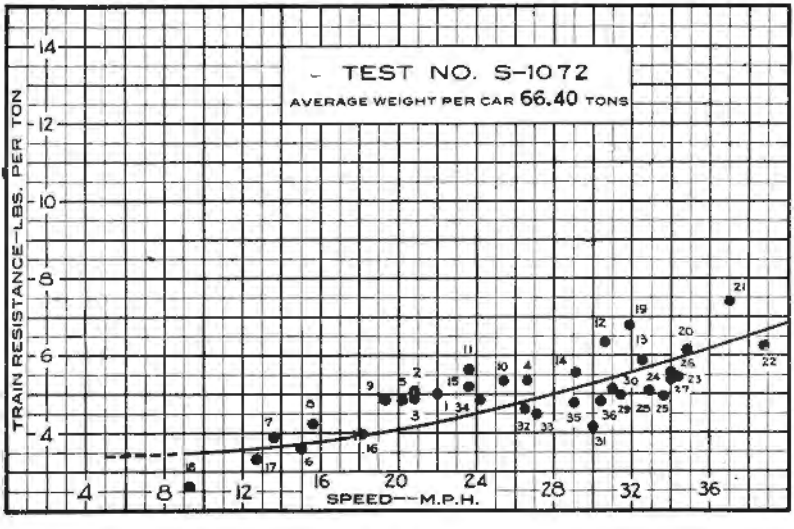
32
36

FIG. 43


TEST NO. S-1072
AVERAGE WEIGHT PER CAR 66.40 TONS
TRAIN RESISTANCE—LBS. PER TON
SPEED—M.P.H.
14
12
10
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12
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FIG. 44

TABLE 61 TEST NO. S-1072*

From Champaign to Gilman, May 1, 1909. Weather: Fair. Temperature: 35° F. at start, 37° F. at end of test. Total weight behind measuring drawbar = 1859 tons, excluding the test car. Train length = 1200 ft. Center of mass 600 ft. back of measuring drawbar. 28 cars: 1 empty, 27 loaded. Kind of cars: 27 gondola, 1 caboose. Average weight per car = 66.40 tons.

1	2	3	4	5	6	7	8	9	10	11	12	13
Method	Item	Mile Post	Section Length	Pull P	Accel. A	Speed V_1	Speed V_2	Grade G	Direction	Velocity	Speed V	Resistance R
Section Columns 5 and 9 to 13 show Average Values	1	118.31—117.62	3456	8800		22.30	21.82	+ 0.15	+75° L	22	22.00	4.08
	2	117.62—116.09	8212	10000		21.82	20.27	+ 2.25	+75° L	22	20.80	5.07
	3	116.09—115.37	3816	12350		20.27	20.75	+ 3.74	+75° L	22	20.80	4.88
	4	112.20—111.87	1752	11750		28.85	24.78	+25.00	90° L	21	26.90	5.34
	5	111.87—111.36	2668	14100		24.78	16.80	+39.70	90° L	21	20.20	4.83
	6	111.36—110.80	2968	17800		16.80	14.55	+20.11	+80° L	19	15.00	3.58
	7	110.80—110.35	2400	19000		14.55	14.55	+16.72	+80° L	19	13.60	3.88
	8	110.35—109.95	2164	10200		14.55	16.25	− 0.98	+80° L	19	15.60	4.21
	9	109.95—109.25	3686	8550		16.25	24.16	−16.19	90° L	19	19.34	4.82
	10	109.25—108.75	2608	7400		24.16	25.30	− 7.49	90° L	19	25.40	5.34
	11	108.75—108.36	2072	8200		25.30	22.30	+ 9.42	90° L	19	23.60	5.61
	12	107.10—106.29	4260	6200		28.74	31.48	−14.87	+85° L	20	30.60	6.33
	13	106.29—105.66	3336	5400		31.48	31.62	− 8.23	+85° L	20	32.50	5.85
	14	105.66—104.98	3624	6300		31.62	27.02	+ 7.72	+85° L	20	29.10	5.54
	15	104.98—104.42	2944	7700		27.02	20.95	+15.06	+80° L	14	23.60	5.18
	16	104.42—103.87	2912	11800		20.95	15.35	+18.85	+80° L	14	18.10	3.97
	17	103.87—103.45	2340	20700		15.35	11.24	+29.48	+80° L	14	12.70	3.30
	18	103.45—103.04	2184	24040		11.24	8.70	+31.42	+80° L	14	9.30	2.61
	19	98.05— 97.21	4448	5550		28.20	34.43	−25.77	+75° L	18	31.90	6.76
	20	97.21— 96.29	4856	4950		34.43	35.72	−11.31	+75° L	18	34.80	6.13
	21	96.29— 95.72	2984	3350		35.30	38.50	−29.03	+75° L	18	37.00	7.40
	22	95.72— 94.76	5120	1900		38.50	36.10	− 7.53	+70° L	17	36.80	6.26
	23	94.76— 93.95	4284	2900		36.10	34.30	− 4.93	+70° L	17	34.40	5.45
	24	93.95— 93.24	3736	3500		34.32	33.25	− 7.21	+70° L	17	34.00	5.39
	25	92.48— 91.88	3200	4950		32.70	34.28	−11.88	+75° L	17	33.60	4.93
	26	90.90— 90.29	3232	5050		34.02	34.32	− 8.08	+75° L	17	34.00	5.57
	27	90.29— 89.53	4020	4850		34.32	33.55	− 5.12	+75° L	17	34.30	5.44
	28	89.53— 88.99	2888	5300		33.55	32.29	− 0.73	+75° L	17	32.90	5.09
	29	88.99— 88.29	3684	5450		32.29	31.00	− 1.43	+85° L	13	31.40	4.98
	30	88.29— 87.65	3404	5100		31.00	30.37	− 4.19	+85° L	13	31.00	5.11
	31	87.65— 86.78	4612	5600		30.37	28.62	+ 1.03	+85° L	13	30.00	4.15
	32	86.78— 85.86	4848	7100		28.62	26.00	+ 2.07	+85° L	13	26.50	4.61
	33	85.86— 84.77	5760	8850		26.00	25.23	+ 2.93	90° L	10	27.10	4.49
	34	84.77— 84.36	2136	12500		25.23	25.93	+ 1.98	90° L	10	24.20	4.84
	35	84.36— 83.55	4272	7400		25.93	30.13	−11.98	90° L	10	28.00	4.76
	36	83.55— 83.05	2672	6400		30.13	30.80	− 6.32	90° L	10	30.40	4.80

For complete table heading see Table 36. p. 90.

TABLE 62 TEST NO. S-1073*

From Champaign to Gilman. May 4, 1909. Weather: Fair. Temperature: 53° F. at start, 63° F. at end of test. Total weight behind measuring draw-bar = 1880 tons excluding the test car. Train length = 1200 ft. Center of mass 600 ft. back of measuring draw-bar. 28 cars: 1 empty, 27 loaded. Kind of cars: 27 gondola, 1 caboose. Average weight per car = 67.16 tons.

1	2	3	4	5	6	7	8	9	10	11	12	13
Method	Item	Mile Post	Section Length	Pull P	Accel. A_1	Speed V_1	Speed V_2	Grade G	Direction	Veldcity	Speed V	Resistance R
Section Columns 5 and 9 to 13 show Average Values	1	115.97—115.36	3232	10700		29.80	29.10	+ 5.06	+40° R	12	29.40	4.64
	2	114.71—114.21	2648	11000		26.85	25.70	+ 8.18	+50° R	11	25.80	4.31
	3	113.13—112.53	3176	9100		28.05	32.90	—15.60	+45° R	14	30.80	5.13
	4	112.53—111.82	3752	7500		32.90	28.86	+12.52	+45° R	14	32.00	3.78
	5	111.82—111.43	2056	10300		28.86	23.12	+30.80	+45° R	14	25.50	3.79
	6	111.43—111.03	2108	14150		23.12	19.40	+23.30	+55° R	8	20.50	3.82
	7	111.03—110.57	2300	15800		19.39	17.11	+19.80	+55° R	8	18.15	3.27
	8	110.57—109.94	3352	16000		17.11	21.32	+ 3.31	+55° R	8	18.50	3.97
	9	109.94—109.21	3888	11250		21.33	30.13	—16.82	+50° R	12	25.30	4.40
	10	109.21—108.30	4776	8050		30.13	29.68	+ 1.99	+50° R	12	31.00	4.23
	11	107.85—107.44	2160	8350		31.33	34.04	—14.90	+50° R	12	32.70	4.49
	12	108.68—106.08	3188	8200		37.70	40.10	—13.74	+50° R	19	39.50	5.57
	13	106.08—105.45	3292	7250		40.10	39.50	— 1.80	+50° R	19	40.80	5.46
	14	105.45—104.62	4436	7350		39.50	34.62	+11.50	+50° R	19	37.80	5.11
	15	104.62—103.81	4264	8500		35.90	29.20	+18.94	+55° R	14	32.30	4.33
	16	103.81—103.27	2856	10650		29.20	30.60	+ 3.09	+55° R	14	24.30	4.19
	17	96.30— 95.69	3212	2600		37.05	41.25	—28.00	+40° R	17	39.80	5.32
	19	94.74— 94.31	2304	3000		39.65	37.90	+ 3.73	+35° R	12	39.30	4.57
	20	90.56— 89.99	3012	800		10.34	12.76	— 9.80	70° R	6	11.42	2.87
	21	89.99— 89.48	2688	750		12.76	9.85	— 1.77	+70° R	6	11.46	2.74
	22	89.48— 88.74	3900	3350		9.85	8.57	— 1.62	+50° R	2	8.32	2.80
	23	88.74— 88.08	3520	4500		8.57	11.15	— 3.45	+ 0°	3	8.01	2.70
	24	87.35— 86.95	2124	1850		10.63	9.70	— 3.33	+25° L	3	11.15	3.00
	25	86.95— 86.32	3308	12200		9.70	10.33	+ 8.51	+ 0°	0	7.65	2.99
	26	86.32— 85.78	2876	11600		10.33	16.04	— 1.74	+ 0°	3	13.07	3.26
	27	85.78— 85.20	3060	8400		16.04	19.96	— 5.87	+15° R	7	18.17	3.53
	28	85.20— 84.75	2416	11200		19.96	16.48	+16.40	+ 5° R	5	18.20	3.32
	29	84.75— 84.30	2372	15500		16.48	21.34	— 3.12	+ 5° R	5	17.20	4.14
	30	84.30— 83.75	2896	10600		21.34	27.34	—12.95	+15° R	7	24.70	3.66
	31	83.75— 83.13	3284	9500		27.50	29.70	— 5.62	+45° R	10	28.00	4.33
	32	83.13— 82.66	2480	8800		29.70	32.45	—12.13	+15° R	12	30.70	4.58
	33	90.94— 90.56	2036	4000		7.05	10.35	— 6.48	+70° R	6	7.71	2.66
	34	97.22— 96.30	4892	3450		35.90	37.05	— 11.34	+20° R	12	37.10	4.96
	35	97.80— 97.22	3060	3800		31.15	35.90	—24.15	+35° R	11	34.80	4.90

*For complete table heading see Table 36 p. 99.

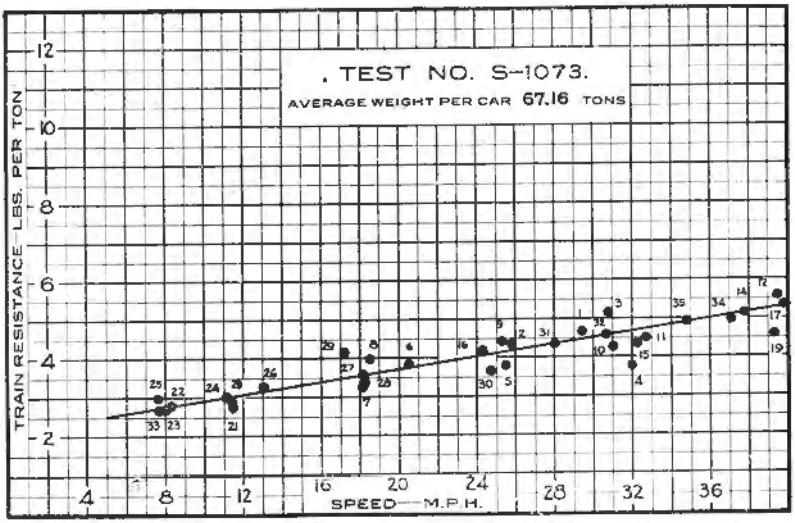
TEST NO. S-1073.
AVERAGE WEIGHT PER CAR 67.16 TONS
TRAIN RESISTANCE—LBS. PER TON
SPEED—M.P.H.

FIG. 45

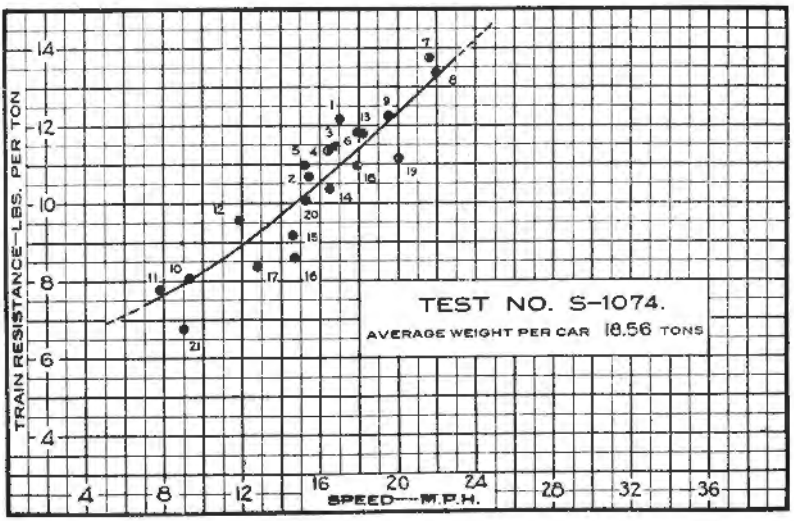
TEST NO. S-1074.
AVERAGE WEIGHT PER CAR 18.56 TONS
TRAIN RESISTANCE—LBS. PER TON
SPEED—M.P.H.

FIG. 46

TABLE 63 TEST NO. S-1074*

From Champaign to Mattoon, May 7, 1909. Weather: Fair. Temperature: 45° F. at start, 60° F. at end of test. Total weight behind measuring drawbar = 1340 tons, including the test car. Train length = 3180 ft. Center of mass 1600 ft. back of measuring drawbar. 81 cars: 81 empty, 0 loaded. Kind of cars: 79 gondolas, 1 test, 1 caboose. Average weight per car = 16.56 tons.

1	2	3	4	5	6	7	8	9	10	11	12	13
Method	Item	Mile Post	Section Length	Pull P	Accel. A	Speed V_1	Speed V_2	Grade G	Direction	Velocity	Speed V	Resistance R
Section Columns 5 and 9 to 13 Show Average Values	1	140.88—141.71	4380	13400		17.43	16.35	— 4.10	—80° L	11	17.00	12.16
	2	141.71—142.84	6025	12950		16.35	16.50	— 2.88	—80° L	11	15.40	10.69
	3	142.84—143.77	4930	11000		16.50	17.12	— 9.43	—80° L	11	16.80	11.47
	4	143.77—144.73	5190	11050		17.12	15.46	— 5.41	—85° L	12	16.40	11.34
	5	144.43—145.35	4825	13200		15.46	16.72	— 4.00	—85° L	12	15.20	10.98
	6	145.35—146.21	4600	12600		16.72	20.18	—11 71	—85° L	12	17.50	11.81
	7	146.21—147.02	4280	10550		20.18	22.35	—19.62	—80° L	10	21.60	13 74
	8	147.02—147.81	4170	11350		22.35	21.54	—10.64	—80° L	10	21.90	13.37
	9	147.81—148.74	4895	12050		21.54	17.82	— 2.81	—80° L	10	19.50	12.25
	10	151.75—152.07	1640	7500		10.90	7.82	+ 0.32	90° L	12	9.30	8.01
	11	152.46—152.86	2076	10000		8.13	8.13	— 0.76	—85° L	9	7.80	7.75
	12	153.50—153.88	2010	10450		12.50	11.40	— 2.10	—85° L	13	11.90	9.56
	13	160.63—161.44	4305	10650		17.43	18.28	—11.53	90° L	10	18.20	11.80
	14	161.44—162.20	4016	11300		18.28	14.30	+ 1.18	90° L	10	16.50	10.35
	15	165.08—165.76	3658	14000		13.25	15.55	— 0.14	+65° L	9	14.60	9.18
	16	165.76—166.50	3100	13050		15.55	13.50	+ 5.96	+65° L	9	14.70	8.60
	17	166.50—166.91	2164	15000		13.50	12.68	+ 9.52	+65° L	9	12.84	8.33
	18	169.66—170.41	3936	13500		15.48	20.43	—11.00	+75° L	7	17.90	10.96
	19	170.41—170.82	2200	11250		20.43	19.45	— 3.84	+75° L	7	20.00	11.15
	20	170.82—171.60	4136	15100		19.46	11.07	+15.20	+75° L	7	15.23	10.04
	21	171.60—172.02	2256	23050		11.07	7.01	+32.78	+75° L	7	9.09	6.75

*For complete table heading see Table 36, p. 99.

TABLE 64 TEST NO. S-1076*

From Champaign to Gilman, May 11, 1909. Weather: Fair. Temperature 51° F. at start, 67° F. at end of test. Total weight behind measuring drawbar-1818 tons, excluding the test car. Train length-1120 ft. Center of mass 500 ft. back of measuring drawbar. 26 cars: 1 empty, 25 loaded. Kind of cars: 25 gondola 1 caboose. Average weight per car-69.92 tons.

1	2	3	4	5	6	7	8	9	10	11	12	13
Method	Item	Mile Post	Section Length	Pull P	Accel. A	Speed V_1	Speed V_2	Grade G	Direction	Velocity	Speed V	Resistance R
Section Columns 5 and 9 to 13 Show Average Values	1	117.91—117.15	3976	8450		28.52	28.80	+ 0.40	+ 55° R	19	28.60	4.23
	2	117.15—116.10	5588	8700		28.80	27.82	+ 3.02	+ 55° R	19	28.20	4.32
	3	116.10—115.38	3820	8900		27.82	27.10	+ 3.87	+ 55° R	19	27.40	4.13
	4	114.77—114.28	2620	11000		24.78	23.70	+ 7.86	+ 60° R	18	23.80	4.44
	5	113.24—112.56	3590	8900		25.95	31.60	—15.60	+ 55° R	21	28.90	4.63
	6	112.56—112.04	2795	7550		31.60	30.02	+ 5.48	+ 55° R	21	31.80	4.45
	7	112.04—111'16	4710	11050		30.02	18.27	+27.70	+ 60° R	17	22.90	3.79
	8	111.16—110.64	2670	14250		18.27	15.09	+18.60	+ 65° R	13	16.50	3.50
	9	110.64—110.34	1575	16000		15.09	15.25	+13.40	+ 65° R	13	14.30	3.51
	10	110.34—109.94	2130	13650		15.25	19.25	+ 0.99	+ 65° R	13	17.10	3.49
	11	119.94—109.56	2015	11650		19.25	24.12	—12.83	+ 60° R	17	21.10	4.13
	12	109.56—109.20	1940	9000		24.12	28.75	—21.76	+ 60° R	17	26.40	4.60
	13	109.20—108.30	4700	7950		28.75	27.92	+ 2.70	+ 60° R	17	29.20	4.03
	14	108.93—106.26	3550	7700		35.26	38.38	—14.55	+ 75° R	16	37.10	5.35
	15	106.26—105.34	4855	6250		38.38	37.40	— 2.61	+ 75° R	16	39.00	5.47
	16	105.34—104.25	5780	7050		37.40	50.45	+12.90	+ 75° R	16	34.40	4.53
	17	104.25—103.05	3180	8200		30.98	23.57	+25.08	+ 75° R	16	27.10	3.69
	18	103.65—103.16	2580	12250		23.57	14.80	+30.90	+ 75° R	16	18.50	3 93
	19	98.06— 97.43	3340	2200		30.20	34.75	—26.70	+ 60° R	28	32.50	5.28
	20	97.43— 96.79	3404	1300		34.75	35.75	—11.40	+ 60° R	28	35.60	4.77
	21	90.42— 89.63	4204	650		24.65	23.12	— 6.28	+ 50° R	16	23.90	3.93
	22	87.62— 87.40	1180	7250		4.13	6 93	— 2.24	+ 45° R	5	4.73	3.05
	23	87 40— 86.94	2405	2150		6.93	5.73	— 3.07	+ 45° R	5	8.42	2.77
	24	86.46— 85.84	3288	4950		7.53	8.90	— 1.60	+ 40° R	6	7.88	2.86
	25	85.84— 85.21	3344	2700		8.90	10.33	— 5.53	+ 40° R	6	10.36	3.02
	26	83 88— 83.09	4170	7800		23.00	25.03	— 5.82	+ 60° R	21	25.70	4.90
	27	83.09— 82.40	3652	6100		25.03	27.21	— 9.11	+ 60° R	21	26.20	4.69

*For complete table heading see Table 36, p. 99.

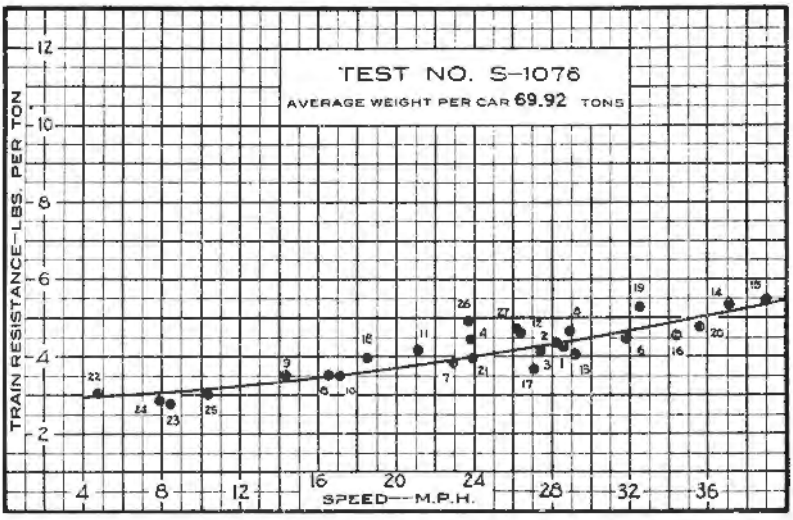
TEST NO. S-1076
AVERAGE WEIGHT PER CAR 69.92 TONS
TRAIN RESISTANCE—LBS. PER TON
SPEED—M.P.H.

FIG. 47

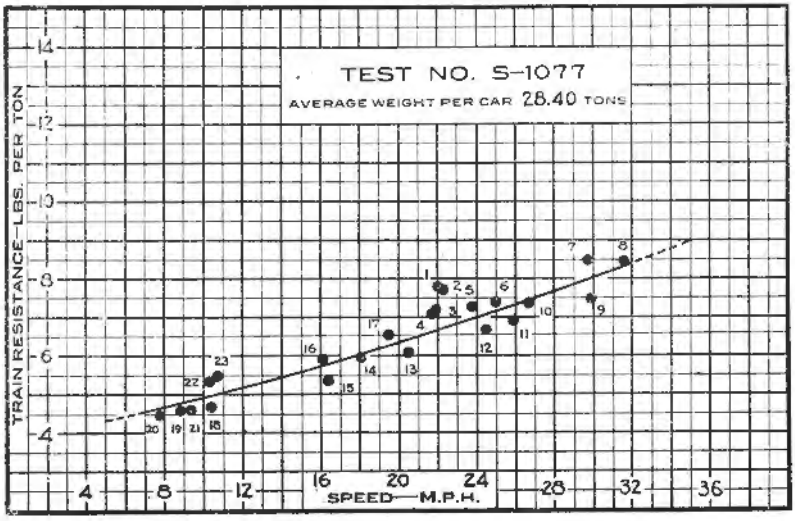
TEST NO. S-1077
AVERAGE WEIGHT PER CAR 28.40 TONS
TRAIN RESISTANCE—LBS. PER TON
SPEED—M.P.H.

FIG. 48

TABLE 65 TEST NO. S-1077*

From Champaign to Mattoon, May 14, 1909. Weather: Fair. Temperature: 64° F. at start, 70° F. at end of test. Total weight behind measuring drawbar = 1505 tons, including the test car. Train length = 2145 ft. Center of mass 930 ft. back of measuring drawbar. 53 cars: 35 empty, 18 loaded. Kind of cars: 37 box, 14 gondola, 1 test, 1 caboose. Average weight per car = 28.40 tons.

1	2	3	4	5	6	7	8	9	10	11	12	13
Method	Item	Mile Post	Section Length	Pull P	Accel. A	Speed V_1	Speed V_2	Grade G	Direction	Velocity	Speed V	Resistance R
Section Columns 5 and 9 to 13 show Average Values	1	139.56—140.29	3885	8900		22.56	22.18	— 4.10	—65° R	14	22.00	7.77
	2	140.29—141.04	3930	8650		22.18	23.05	— 7.00	—65° R	14	22.30	7.70
	3	141.04—142.03	5785	9000		23.05	21.33	— 0.70	—65° R	14	21.90	7.18
	4	142.13—142.85	3820	8850		21.33	23.20	— 7.20	—65° R	13	21.70	7.08
	5	142.85—143.65	4195	8050		23.20	25.15	— 9.20	—65° R	13	23.80	7.26
	6	143.65—144.07	2200	7700		25.15	25.40	— 7.00	—65° R	13	25.00	7.37
	7	146.08—147.07	5235	7000		27.31	31.55	—18.90	—75° R	19	29.75	8.47
	8	147.07—148.03	5555	7350		31.55	31.20	— 8.60	—75° R	19	31.60	8.42
	9	148.13—148.62	2630	7350		31.20	29.27	+ 1.40	—75° R	19	29.90	7.47
	10	149.09—149.53	2350	8350		27.76	26.72	— 0.20	—75° R	13	26.70	7.33
	11	150.11—150.98	4565	8100		27.09	25.35	— 0.30	—75° R	13	25.90	6.90
	12	150.98—151.79	4310	8750		25.35	25.45	— 0.30	—75° R	13	24.50	6.65
	13	154.82—155.50	3620	10300		22.45	19.70	+ 7.90	—55° R	12	20.50	6.09
	14	155.50—156.11	3190	11400		19.70	17.25	+ 9.80	—55° R	12	18.10	5.94
	15	156.11—156.65	2900	12450		17.25	16.42	+ 9.50	—55° R	12	16.40	5.35
	16	156.65—157.79	2840	12650		16.42	16.19	+ 7.10	—55° R	12	16.10	5.90
	17	158.01—158.66	3440	11000		18.27	21.52	— 4.90	—65° R	12	19.50	6.53
	18	164.89—165.17	1484	6050		10.90	10.18	—15.20	—30° R	8	10.40	4.86
	19	165.17—165.63	2456	4950		10.18	7.98	— 0.40	—30° R	8	8.80	4.59
	20	165.63—166.01	2036	7600		7.98	7.22	— 2.80	—30° R	8	7.80	4.46
	21	166.21—166.53	1664	15000		8.57	10.17	+10.80	—25° R	10	9.40	4.00
	22	166.53—166.87	1812	13500		10.17	10.33	+ 9.30	—25° R	10	10.30	5.31
	23	166.87—167.23	1878	12050		10.33	11.55	+ 5.10	—25° R	10	10.70	5.48

*For complete table heading see Table 36, p. 99.

TABLE 66 TEST NO. S-1079*

From Champaign to Gilman, May 18, 1909. Weather: Fair. Temperature: 65° F. at start, 68° F. at end of test. Total weight behind measuring drawbar = 1685 tons, excluding the test car. Train length = 2070 ft. Center of mass 1015 ft. back of measuring drawbar. 51 cars: 14 empty, 37 loaded. Kind of cars: 45 box, 5 gondola, 1 caboose Average weight per car = 33.04 tons.

1	2	3	4	5	6	7	8	9	10	11	12	13
Method	Item	Mile Post	Section Length	Pull P	Accel. A	Speed V_1	Speed V_2	Grade G	Direction	Velocity	Speed V	Resistance R
Section Columns 5 and 9 to 13 show Average Values	1	118.04—117.31	3850	10050		22.44	22.04	+ 0.14	+85° R	20	21.80	6.23
	2	117.31—115.99	7035	9700		22.04	19.24	+ 2.56	+85° R	20	20.00	5.93
	3	115.99—115.34	3440	12500		19.24	19.96	+ 3.60	+85° R	20	19.50	5.48
	4	115.92—112.48	2305	10550		25.00	28.27	—14.00	+70° R	21	26.20	6.63
	5	112.48—111.82	3490	8950		28.27	23.62	+ 9.40	+70° R	21	26.50	6.57
	6	111.82—111.37	2380	14200		23.62	16.10	+29.70	+70° R	21	19.10	5.94
	7	111.37—110.79	3070	18550		16.10	13.45	+21.80	+70° R	21	13.50	4.51
	8	110.79—110.16	3310	19750		13.45	15.63	+14.00	+80° R	19	13.25	5 07
	9	110.16—109.83	1760	15000		15.63	18.65	— 1.70	+80° R	19	17.15	5.45
	10	109.83—109.21	3310	9500		18.65	24.92	—16.90	+80° R	19	21.50	6.29
	11	109.21—108.30	4800	6450		24.92	22.30	— 1.00	+80° R	19	24.20	6.01
	12	108.81—106.20	3250	7040		28.98	30.73	—14.30	+80° R	20	29.60	7.36
	13	106.20—105.56	3375	5150		30.73	30.10	— 7.50	+80° R	20	30.70	6.70
	14	105.56—104.96	3180	7750		30.10	25.82	+ 7.80	+80° R	20	27.20	6.89
	15	104.96—104.44	2740	11750		25.82	22.20	+14.60	+80° R	20	23.40	5.85
	16	104.44—103.87	3050	13500		22.20	17.98	+16.80	+65° R	15	19.80	5.52
	17	103.87—103.48	2053	17900		17.98	12.94	+28.00	+65° R	15	14.75	5.31
	18	103.48—103.06	2240	22250		12.94	9.54	+32.10	+65° R	15	10.55	3.40
	19	102.29—101.55	3905	11650		22.10	26.60	— 8.50	+75° R	23	25.40	6.21
	20	101.55—100.48	5685	12650		26.60	22.70	+10.30	+75° R	23	23.50	5.97
	21	100.48— 99.73	3980	12400		22.70	31.34	—19.50	+75° R	23	25.90	6.56
	22	99.73— 98.87	4530	9350		31.34	31.53	— 2.60	+65° R	23	32.60	6.36
	23	98.87— 98.00	4614	11050		31.53	35.70	—12.60	+65° R	23	31.50	7.00
	24	98.00— 97.31	3616	8650		35.60	40.45	—26.30	+65° R	23	37.90	8.00
	25	94.59— 93.65	4970	2700		34.60	32.90	— 7.40	+65° R	16	33.30	6.02
	26	88.97— 88.11	4506	4850		10.10	10.10	— 2.30	—85° R	9	9.17	3.75
	27	88.11— 87.22	4748	3700		10.10	10.10	— 3.30	—85° R	9	9.80	3.45
	28	87.22— 86.76	2428	3100		10.10	5.00	+ 2.60	—85° R	9	8.70	3.06
	29	86.32— 85.81	2645	6450		6.00	8.42	— 1.40	90° R	8	6.95	3.44
	30	84.17— 83.39	4150	10550		20.12	25.95	— 9 70	+75° R	16	23.50	5.42
	31	85.39— 82.46	4920	8600		25.95	28.75	— 9.20	+75° R	16	26.90	6.42

*For complete table heading see Table 36, p. 99.

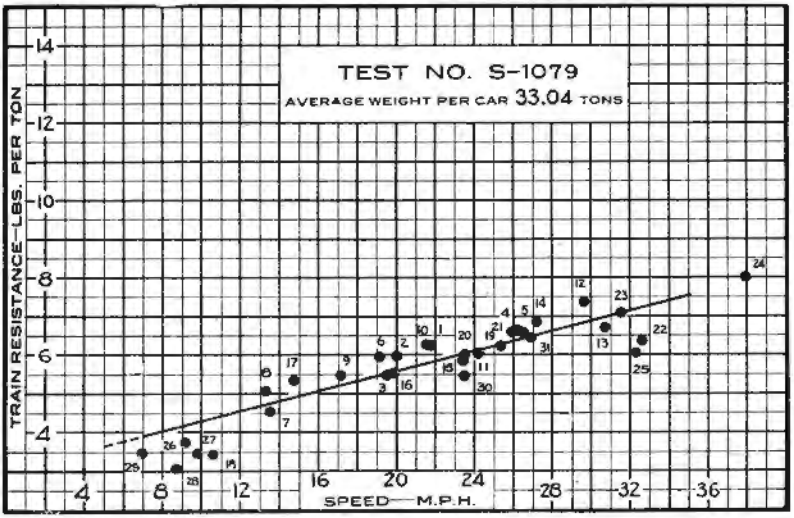
TEST NO. S-1079
AVERAGE WEIGHT PER CAR 33.04 TONS
TRAIN RESISTANCE—LBS. PER TON
SPEED—M.P.H.

FIG. 49

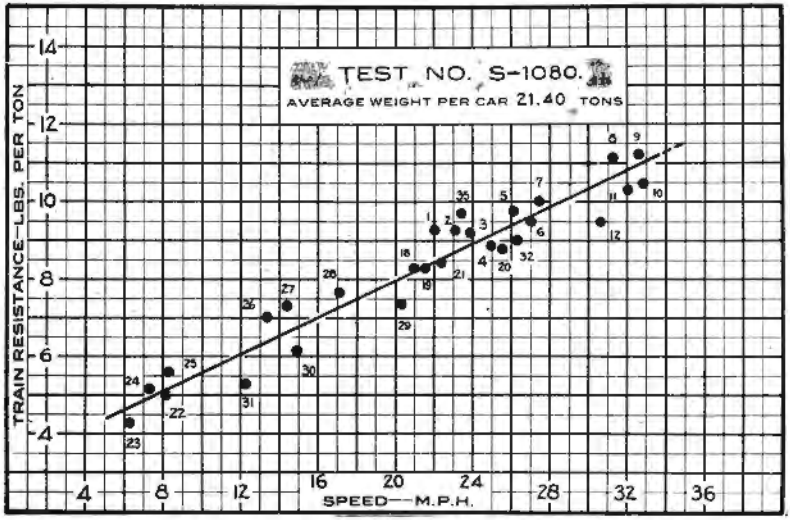
TEST NO. S-1080.
AVERAGE WEIGHT PER CAR 21.40 TONS
TRAIN RESISTANCE—LBS. PER TON
SPEED—M.P.H.

FIG. 50

TABLE 67 TEST NO. S-1080*

From Champaign to Mattoon, May 21, 1909. Weather: Fair. Temperature: 50° F. at start, 70° F. at end of test. Total weight behind measuring drawbar = 1347 tons, including the test car. Train length = 2550 ft. Center of mass 920 ft. back of measuring drawbar. 63 cars: 57 empty, 6 loaded. Kind of cars: 8 box, 53 gondola, 1 test, 1 caboose. Average weight per car = 21.40 tons.

1	2	3	4	5	6	7	8	9	10	11	12	13
Method	Item	Mile Post	Section Length	Pull P	Accel. A	Speed $V1$	Speed $V2$	Grade G	Direction	Velocity	Speed V	Resistance R
Section Columns 5 and 9 to 13 show Average Values	1	139.61—140.34	3872	11150		22.02	22.70	— 4.09	+30° L	12	22.00	9.27
	2	140.34—140.92	3044	11100		22.70	24.23	— 7.12	+30° L	12	23.07	9.25
	3	140.92—141 71	4192	10700		24.23	23.82	— 2.39	+30° L	12	23.82	9.20
	4	142.67—143.09	2196	10700		24.50	26.10	— 9.38	+25° L	11	24.95	8.86
	5	143.09—143.52	2300	10500		26.10	27.08	— 9.42	+25° L	11	26.14	9.75
	6	143.52—144.42	4752	10050		27.08	26.97	— 5.11	+25° L	11	27.00	9.49
	7	145.29—146.21	4828	10100		26.97	30.13	—13.87	+25° L	11	27.42	10.00
	8	146.21—146.73	2748	9850		30.13	32.35	—19.81	+25° L	11	31.23	11.13
	9	146.73—147.27	2868	9400		32.35	33.25	—15.10	+25° L	11	32.60	11.22
	10	147.27—147.81	2888	9450		33.25	33.03	— 8.23	+ 0°	12	32.81	10.49
	11	147.81—148.35	2820	9650		33.03	31.90	— 3 37	+13° L	10	32.05	10.31
	12	148.35—148.73	2020	10300		31.90	30.62	+ 2.61	+13° L	10	30.60	9.50
	18	159.23—159.58	1844	12250		21.90	20.75	+ 7.16	+45° L	11	20.96	8.39
	19	159.58—160.56	5200	12100		20.75	25.16	— 5.48	+45° L	11	21.50	8.38
	20	161.33—162.18	4500	9100		27.22	23.56	+ 2.46	+40° L	11	25.56	8.79
	21	162.18—163.25	5244	10800		23.56	23.42	— 0.81	+40° L	11	22.35	8.42
	22	164.97—165.65	3580	6050		8.82	7.22	0.00	+15° L	12	8.14	5.00
	23	165.81—166.23	2212	9000		6.12	5.82	+ 6.68	+15° L	12	6.28	4.27
	24	166.41—166.90	2584	11850		7.52	7.52	+ 9.61	+15° L	12	7.34	5.16
	25	166.90—167.31	2192	10750		7.52	9.20	+ 3.85	+15° L	12	8.30	5.60
	26	168.26—168.71	2348	16850		13.95	13.28	+15.97	+20° L	12	13.34	7.01
	27	168.71—169.29	3060	16050		13.28	16.50	+ 6.21	+20° L	12	14.40	7.30
	28	169.29—169.60	1628	13650		16.50	17.90	+ 0.97	+20° L	12	17.08	7.64
	29	170.83—171.48	3424	12100		23.55	17.20	+18.65	+15° L	11	20.30	7.33
	30	171.48—171.75	1420	17600		17.20	13.70	+32.72	+15° L	11	14.90	6.12
	31	171.75—171.95	1080	20000		13.70	11.80	+33.74	+15° L	11	12.27	5.28
	32	160.56—161.33	4044	9100		25.16	27.22	—10.96	+40° L	11	26.27	9.00
	35	142.28—142.67	2060	12000		25.28	24.50	— 7.44	+25° L	11	23.41	9.71

* For complete table heading see Table 36, p. 99.

APPENDIX 6

APPENDIX 6

Exact Coordinates for the Curves of Fig. 10 and 11.

The original drawings from which Fig. 10 and 11 have been reproduced were drawn to a scale about twice as great as that of the cuts shown in the report. From these original drawings, the values of the coordinates of the various curves of both figures have been determined as accurately as possible; and these values are presented in Tables 68 and 69.

The curves of Fig. 10 (and of Fig. 3 to 9) may be accurately reproduced by the use of Table 68; the curves of Fig. 11 may be reproduced from the values given in Table 69. The tables are presented merely to permit the accurate reproduction, to any scale, of the curves of the report; they are not intended for use in determining values of resistance. For the latter purpose Table 3 is more convenient and sufficiently accurate.

TABLE 68

VALUES OF RESISTANCE FOR TRAINS OF VARIOUS AVERAGE CAR WEIGHTS AND FOR DIFFERENT SPEEDS

This table presents the co-ordinates of the original curves from which Figures 3 to 9 and Figure 10 were reproduced.

Average Weight Per Car tons		Train Resistance—Pounds Per Ton Column Headings Indicate the Various Speeds 5 m. p. h	10 m. p. h.	15 m. p. h.	20 m. p. h.	25 m. p. h.	30 m. p. h.	35 m. p. h.	Average Weight Per Car tons	
15		7.62	8.20	8.81	9.56	10.37	11.24	12.25		15
	16	7.44	8.00	8.61	9.34	10.13	10.98	11.95	16	
	18	7.10	7.63	8.22	8.92	9.68	10.47	11.39	18	
	20	6.77	7.30	7.85	8.53	9.26	10.00	10.89	20	
	22	6.45	6.97	7.49	8.16	8.84	9.56	10.41	22	
	24	6.16	6.64	7.14	7.79	8.46	9.16	9.94	24	
25		6.02	6.50	6.98	7.62	8.28	8.95	9.72		25
	26	5.88	6.35	6.81	7.44	8.10	8.77	9.52	26	
	28	5.61	6.07	6.51	7.11	7.76	8.40	9.12	28	
	30	5.38	5.80	6.23	6.80	7.43	8.05	8.75	30	
	32	5.13	5.54	5.98	6.51	7.12	7.72	8.40	32	
	34	4.92	5.31	5.72	6.24	6.82	7.40	8.06	34	
35		4.82	5.20	5.61	6.11	6.68	7.26	7.91		35
	36	4.72	5.10	5.50	5.99	6.55	7.11	7.77	36	
	38	4.55	4.90	5.28	5.74	6.29	6.83	7.48	38	
	40	4.38	4.70	5.06	5.50	6.03	6.57	7.20	40	
	42	4.22	4.52	4.88	5.29	5.80	6.32	6.95	42	
	44	4.08	4.38	4.70	5.09	5.59	6.10	6.71	44	
45		4.01	4.30	4.61	4.99	5.49	6.00	6.60		45
	46	3.95	4.21	4.52	4.90	5.38	5.90	6.49	46	
	48	3.82	4.08	4.38	4.71	5.20	5.71	6.28	48	
	50	3.72	3.96	4.24	4.56	5.03	5.52	6.10	50	
	52	3.61	3.85	4.11	4.42	4.88	5.36	5.91	52	
	54	3.52	3.75	3.90	4.30	4.74	5.20	5.74	54	
55		3.48	3.71	3.94	4.25	4.68	5.12	5.67		55
	56	3.43	3.67	3.90	4.20	4.62	5.05	5.60	56	
	58	3.37	3.58	3.81	4.10	4.50	4.93	5.47	58	
	60	3.30	3.50	3.73	4.02	4.42	4.83	5.36	60	
	62	3.23	3.44	3.67	3.97	4.34	4.74	5.27	62	
	64	3.18	3.39	3.60	3.90	4.29	4.68	5.18	64	
65		3.15	3.36	3.58	3.88	4.25	4.64	5.14		65
	66	3.12	3.32	3.55	3.85	4.22	4.61	5.11	66	
	68	3.09	3.30	3.50	3.80	4.18	4.57	5.06	68	
	70	3.05	3.26	3.47	3.76	4.13	4.52	5.01	70	
	72	3.02	3.22	3.44	3.73	4.10	4.49	4.98	72	
	74	3.01	3.19	3.42	3.71	4.08	4.48	4.93	74	
75		3.00	3.18	3.41	3.70	4.07	4.47	4.91		75

TABLE 69

Values of Resistance at Various Speeds and for Trains of Different Average Weights Per Car

This table presents the co-ordinates of the original curves from which Fig. 11 is reproduced

Speed miles per hour	Train Resistance—Pounds Per Ton													Speed miles per hour
	Column Headings Indicate the Average Weights Per Car													
	15 tons	20 tons	25 tons	30 tons	35 tons	40 tons	45 tons	50 tons	55 tons	60 tons	65 tons	70 tons	75 tons	
5	7.62	6.77	6.02	5.38	4.82	4.39	4.01	3.72	3.49	3.30	3.16	3.05	3.00	5
6	7.73	6.86	6.12	5.46	4.90	4.43	4.07	3.77	3.52	3.33	3.19	3.08	3.03	6
7	7.83	6.97	6.21	5.53	4.98	4.50	4.12	3.81	3.56	3.37	3.23	3.12	3.07	7
8	7.96	7.06	6.31	5.62	5.04	4.57	4.18	3.86	3.60	3.40	3.26	3.16	3.10	8
9	8.07	7.18	6.40	5.71	5.11	4.62	4.22	3.90	3.64	3.44	3.30	3.20	3.13	9
10	8.19	7.29	6.50	5.80	5.20	4.69	4.28	3.96	3.69	3.49	3.34	3.24	3.18	10
11	8.30	7.40	6.60	5.90	5.29	4.76	4.33	4.00	3.73	3.52	3.38	3.29	3.21	11
12	8.42	7.51	6.71	5.98	5.37	4.83	4.40	4.04	3.78	3.58	3.42	3.33	3.26	12
13	8.56	7.63	6.81	6.08	5.46	4.90	4.47	4.11	3.83	3.62	3.47	3.38	3.31	13
14	8.70	7.76	6.92	6.18	5.53	4.98	4.53	4.18	3.89	3.68	3.52	3.43	3.36	14
15	8.82	7.88	7.01	6.28	5.64	5.06	4.60	4.24	3.94	3 73	3.57	3.48	3,41	15
16	8.98	8.00	7.12	6.39	5.73	5.13	4.68	4.31	4.00	3.80	3.62	3.53	3.47	16
17	9.10	8.13	7.24	6.49	5.82	5.23	4.75	4.38	4.05	3.86	3.68	3.60	3.52	17
18	9.25	8.27	7.37	6.60	5.92	5.32	4.83	4.45	4.12	3.92	3.74	3.66	3.58	18
19	9.40	8.40	7.49	6.71	6.01	5.41	4.91	4.52	4.19	3.98	3.81	3.72	3.64	19
20	9.58	8.53	7.60	6.82	6.11	5.50	5.00	4.60	4.27	4.04	3.88	3.79	3.71	20
21	9.71	8.69	7.72	6.93	6.22	5.60	5.08	4.69	4.32	4.11	3.94	3.85	3.78	21
22	9.88	8.82	7.86	7.03	6.33	5.70	5.17	4.78	4.41	4.18	4.00	3.92	3.84	22
23	10.02	8.97	7.99	7.14	6.44	5.80	5.27	4.86	4.49	4.25	4.07	3.99	3.92	23
24	10.20	9.11	8.11	7.27	6.55	5.90	5.37	4.94	4.58	4.33	4.15	4.06	3.98	24
25	10.37	9.26	8.25	7.40	6.67	6.01	5.46	5.03	4.66	4.41	4.23	4.13	4.04	25
26	10.52	9.42	8.38	7.52	6.79	6.11	5.57	5.12	4.75	4.50	4.31	4.21	4.12	26
27	10.71	9.57	8.51	7.65	6.91	6.21	5.67	5.22	4.83	4.58	4.40	4.29	4.20	27
28	10.89	9.72	8.67	7.78	7.01	6.33	5.78	5.32	4.92	4.67	4.48	4.38	4.29	28
29	11.06	9.89	8.81	7.91	7.12	6.45	5.88	5.43	5.01	4.76	4.57	4.46	4.36	29
30	11.25	10.03	8.96	8.04	7.26	6.58	5.99	5.53	5.11	4.86	4.66	4.53	4.45	30
31	11.43	10.20	9.10	8.18	7.39	6.71	6 10	5.64	5.21	4,95	4.75	4.63	4.53	31
32	11.63	10.37	9.26	8.31	7.51	6.83	6.21	5.76	5.32	5.04	4.85	4.73	4.62	32
33	11.84	10.53	9.41	8.46	7.63	6.96	6.33	5.87	5.43	5.15	4.95	4.83	4.72	33
34	12.04	10.71	9.57	8.60	7.78	7.08	6.47	5.99	5.54	5.26	5.05	4.92	4.82	34
35	12.25	10.89	9.72	8.75	7.91	7.20	6.60	6.10	5.67	5.36	5.16	5.01	4.92	35
36	12.47	11.07	9.89	8.90	8.04	7.35	6.73	6.23	5.78	5.48	5.27	5.12	5.01	36
37	12.69	11.23	10.04	9.04	8.19	7.49	6.87	6.36	5.90	5.59	5.38	5.22	5.12	37
38	12.91	11.42	10.21	9.20	8.33	7.64	7.00	6.49	6.02	5.71	5.48	5.33	5.22	38
39	13.12	11.61	10.39	9.36	8.48	7.79	7.13	6.63	6.15	5.83	5.60	5.44	5.33	39
40	13.35	11.80	10.55	9.51	8.62	7.93	7.29	6.78	6.28	5.95	5.72	5.55	5.45	40

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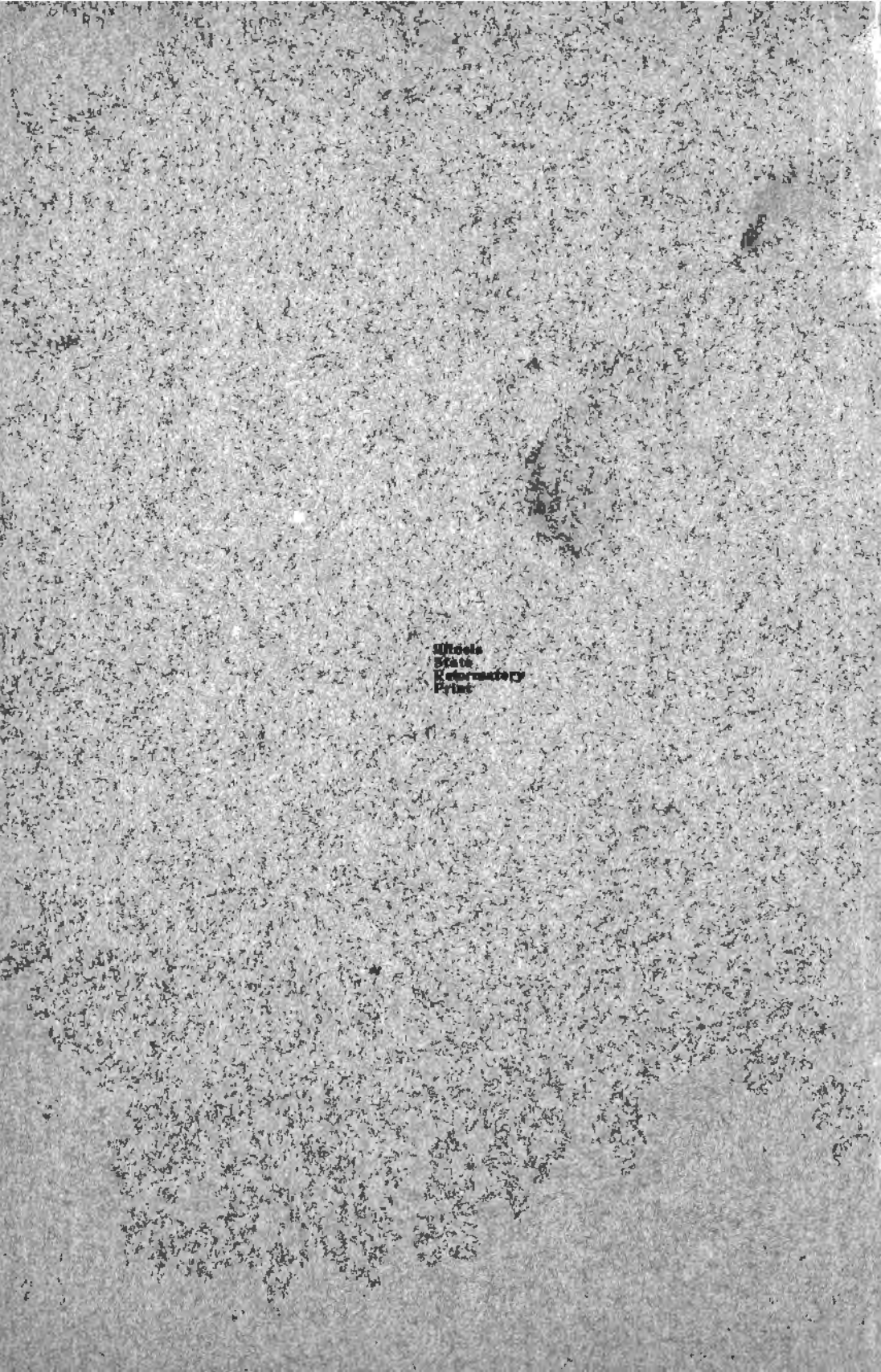
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