HIGHWAY RESEARCH BOARD

Research Report No. 9-A

TIME AND GASOLINE CONSUMPTION IN MOTOR TRUCK OPERATION AS AFFECTED BY THE WEIGHT AND POWER OF VEHICLES AND THE RISE AND FALL IN HIGHWAYS

REPORT OF COMMITTEE

PRESENTED AT THE
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AS AFFECTED BY THE WEIGHT AND POWER OF VEHICLES AND THE RISE AND FALL IN HIGHWAYS

REPORT OF COMMITTEE ON ECONOMICS OF MOTOR VEHICLE SIZE AND WEIGHT, DEPARTMENT OF ECONOMICS, FINANCE AND ADMINISTRATION

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HIGHWAY RESEARCH BOARD
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DEPARTMENT OF ECONOMICS, FINANCE AND ADMINISTRATION

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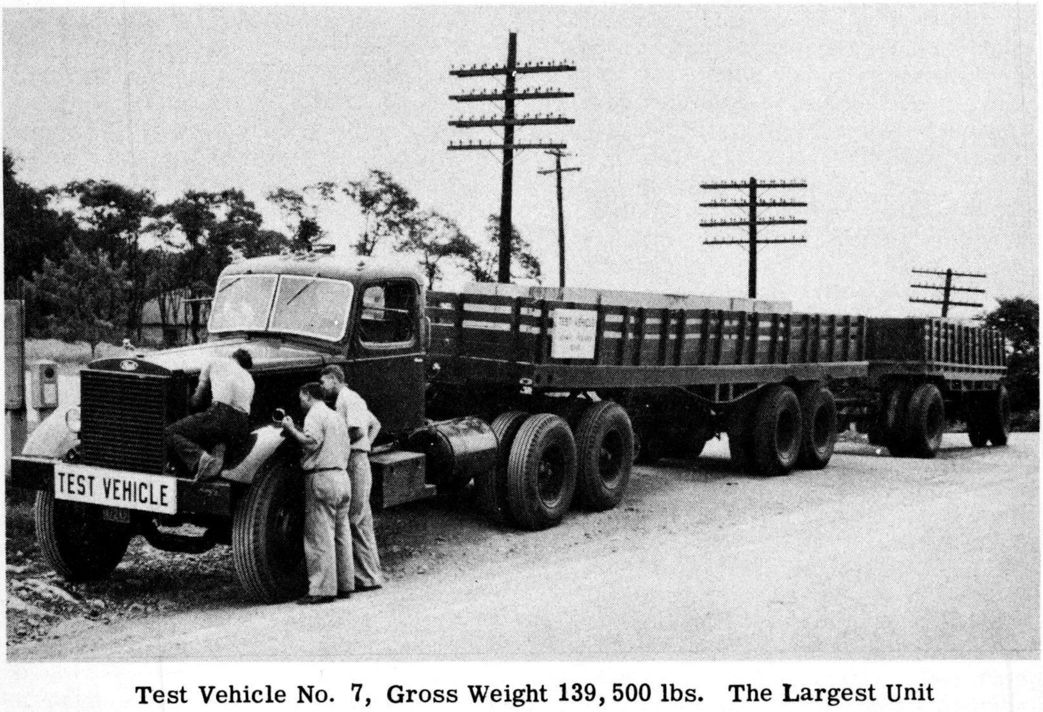

Test Vehicle No. 7, Gross Weight 139,500 lbs. The Largest Unit

TIME AND GASOLINE CONSUMPTION IN MOTOR TRUCK OPERATION AS AFFECTED BY THE WEIGHT AND POWER OF VEHICLES AND THE RISE AND FALL IN HIGHWAYS

The problem of the size and weight of commercial vehicles has been with us for some time and will continue to be with us until it is solved through the joint efforts of the entire highway transportation industry and the public officials who must deal with the problem. The steps to the solution are many, but an answer certainly exists that will serve best both the public and the industry. It was with this thought in mind that the Highway Research Board, through the Department of Economics, Finance, and Administration, established the Committee on the Economics of Motor Vehicle Size and Weight, with members carefully chosen from all the interests that make up the greatest transportation team in the world. It is the goal of this committee to compile the mass of factual information required and to translate it into a practical solution of the problem.

The first action of this committee, whose membership is listed on the preceding pages, was a survey of all existing basic information on the subject. Needless to say, certain information was found to be lacking. Among the missing were adequate data on the direct operating costs of commercial motor vehicles as related to the weight and power of the vehicle and the profile of the highway. To collect a part of the required information the Committee initiated in June 1948, in Pennsylvania, a large-scale research project which became popularly known as the Pennsylvania Pilot Study. In reality, the term "Pilot Study" was a misnomer, for the study was definitely not designed to plot the course of a similar but more comprehensive study to follow. It was the first of two distinctly but closely integrated studies planned by the Committee to obtain operating-cost data. Simply, it was a vehicle-performance study designed primarily to produce two segments of the direct operating costs, fuel and time, for heavy commercial vehicles of various types, powers, and gross weights. As such, it was a full-fledged study in its own right but, contrary to public opinion, as evidenced by many letters of inquiry, it was not in any sense expected to provide complete information with which to solve the problem confronting the committee. The data obtained constitute an important part of the total factual data which will be required.

COOPERATING AGENCIES

The results of the field tests which were completed in October 1948 have now been analyzed and are the subject of this report. This contribution of data toward the solution of a difficult problem is not the product of any one man or any one interest. It is the contribution of industry and Government for a joint solution of the size and weight problem. Each shared in the cost of the study and each furnished wholeheartedly the personnel required to plan, organize, and accomplish the research. Specifically, the Automobile Manufacturers Association provided the powered vehicles, mechanics, and insurance; the Truck-Trailer Manufacturers Association, the semitrailers and full trailers, the American Trucking Associations, Inc.; and the National Council of Private Motor Truck Owners, the truck drivers; the Department of the Army, a wrecker for loading the test vehicles; the Pennsylvania Department of Highways, the facilities of the two State highway garages for bases of operation and personnel for recording data; the Pennsylvania Turnpike Commission, the toll-free use of the Turnpike; the Bureau of Public Roads, the instrumentation and supervisory personnel; and eight major eastern petroleum companies, the gasoline and oil. This study was an exemplary demonstration of how industry and Government can work together toward the solution of a basic transportation problem.

PURPOSE OF REPORT

The purpose of this report is twofold, with the primary one being to relate the gasoline consumption and travel time observed on the tests with the weight and power of the vehicle and with the profile of the highway in such a manner that they can be practically applied to the problems at hand. The idea is to develop factors that will fit any given character of highway or vehicle in any part of the country. The secondary purpose is to show by a few examples how the factors developed can be applied to the problems of highway and vehicle economics.

It is impossible at this time to attempt to show which type and weight of vehicles are the most economical from the operating standpoint because only two segments of the overall cost are evaluated. The costs of tires, maintenance, depreciation, and overhead remain to be evaluated. Their evaluation is the purpose of another project being planned by the committee.

In addition to the observations of time and fuel, information was also collected on gear shifts, brake applications, and engine revolutions with the idea that this information would aid the committee in relating maintenance costs, to be derived from the projected study, to the highway. The analyses of these additional data are not yet complete and will necessarily be the subject of a future report. This report treats solely of fuel consumption and travel time.

BASIC TERMS DEFINED

Throughout the text and on the charts and tables certain terms are used which must be thoroughly understood to prevent misinterpretation of the results. A description of these terms follows:

1. *Total rise and fall* - The arithmetic sum of the vertical rise and fall in feet for any section of highway. For example, if a section of highway progressively rises 100 feet, falls 500 feet, rises 30 feet, and falls 10 feet, the total rise and fall will be 640 feet. The total rise and fall is the same regardless of the direction of travel. The rise in one direction of travel will become the fall in the opposite direction and vice versa.

2. *Rate of rise and fall* - The total rise and fall for any section of highway divided by the length of section in hundreds of feet. If the total rise and fall is 640 feet and the length of section is 20,000 feet, then the rate of rise and fall is 3.2 feet per hundred feet. It is not to be confused with the percent of grade. It is equivalent to the average percent of grade only when either the rise or fall is 100 percent of the total rise and fall.

3. *Gross horsepower* - The brake horsepower of the engine, operating without accessories such as fan, air compressor, generator, muffler, etc., that is available at the clutch or its equivalent.

4. *Net horsepower* - The brake horsepower of the engine, operating with all its normal accessories, that is available at the clutch or its equivalent. It is the gross horsepower minus the horsepower absorbed by fan, compressor, generator, etc., and is the one recommended for use in studying the performances of motor vehicles. However, until recently it has not been published by very many of the manufacturers. Therefore, it is usually necessary in studies involving the general traffic on the highways to use the gross horsepower and then convert to net horsepower. For all practical purposes net horsepower can be assumed to be 90 percent of the gross horsepower.

5. *Weight-power ratio* - The ratio of the gross weight of the vehicle or combination of vehicles to the gross or net horsepower of the powered unit. In this study, except for certain explanatory uses of the results, the weight-power ratio is determined by using the net horsepower.

6. *Gasoline consumption* - The gallons of gasoline consumed per mile of highway travel. Gallons per mile is used throughout this report as a measure of gasoline consumption, as it is more easily applied to the type of problems usually encountered. The conversion from gallons per miles to miles per gallon can be easily made since one is the reciprocal of the other.

7. *Travel time* - The minutes re-

quired to travel one mile of highway. Minutes per mile can be converted to miles per hour by dividing 60 by the minutes per mile.

8. *Composite gasoline consumption* - The total number of gallons of gasoline required by a vehicle of a given weight to travel in both directions on a section of highway, divided by twice the length of the section in miles. If a truck uses 14 gallons in one direction and 2 gallons in the other on a 4-mile section of highway, the composite gasoline consumption is 2 gallons per mile.

9. *Composite travel time* - The sum of the minutes required by a vehicle of a given weight-power ratio to travel in each direction on a section of highway, divided by twice the length of the section in miles. The composite travel time is 3 minutes per mile if 14 minutes is required in one direction and 10 minutes in the other direction, and the length of the section is 4 miles.

10. *Directional gasoline consumption* - The gallons of gasoline consumed by a vehicle in traveling in a single direction over a section of highway, divided by the length of the section in miles.

11. *Directional travel time* - The minutes required for a vehicle to travel in a single direction over a section of highway divided by the length of the section in miles.

DESCRIPTION OF TEST ROUTES

The performance tests were conducted over two routes in Pennsylvania which differ radically in geometric design. One was a major portion of the Pennsylvania Turnpike between Carlisle interchange and the New Stanton interchange, a distance of 148.7 miles. It is a 4-lane divided highway with 12-ft. lanes, a maximum gradient of 3 percent, and a maximum curvature of 6 degrees. It is paved with portland cement concrete for its entire length. The other was a section of U.S. 11 from Carlisle to Chambersburg and a section of U.S. 30 from Chambersburg to Greensburg, a total length of 149.4 miles. This latter route afforded a conglomerate of surface types, pavement widths, curvature, and gradient. Generally, it consists of two lanes varying in individual width from 9 to 12 ft. Only a small mileage has lanes wider than 10 ft. Narrow shoulders, sharp curves, and restricted sight distances are the rule. The greater portion of the route is paved with bituminous surface with high crown prevailing in many sections.

The greatest difference between the two routes, insofar as commercial-vehicle operation is concerned, is the gradient. Maximum grades as high as 12 percent are encountered on U. S. 30 in the mountainous area and continuous climbs for several miles averaging from 6 to 8 percent are common. The difference in gradient is vividly demonstrated by a comparison of the total rise and fall for the two routes which have about the same terminal elevations. The total rise and fall is 26,257 ft. for U.S. 30 and U.S. 11, and 11,327 ft. for the Pennsylvania Turnpike. Profiles and sketches of the two routes are shown on Figure 1. It is to be noticed that each of the routes is divided into test sections by control points located at definite changes in the character of the profile. Control points are indicated by numbers for the Turnpike and letters of the alphabet for U.S. 11 and U.S. 30. In effect, there resulted 37 test routes instead of two on which time and fuel data were observed.

A description of the test sections is given in Table 1. The sections are grouped according to the rate of rise and fall. These same groupings will be used later in the analyses of the data. The range in the rate of rise and fall is great, varying from 0.8 for section 15-16 to 7.9 for section O-P. This range covers practically every conceivable condition of rise and fall that may occur in the highways of this country, a condition which influenced the selection of the routes. It is to be noted that sections E-F and F-G have been combined to form section E-G.

The rise expressed as a percentage of the total rise and fall is listed by the direction of travel. It is an important consideration in the derivation of directional gasoline consumption and travel time. In the case of section 1-16, the

Turnpike as a whole, the rise approximates the fall, being 48 percent in the eastbound direction and 52 percent in the westbound direction. On the other hand, for section R-S, the rise is 0 percent in the eastbound direction and 100 percent in the westbound direction which indicates that travel on section R-S was either all downgrade or all upgrade. In the latter case the rate of rise and fall is identical with the average gradient expressed in percent.

DESCRIPTION OF TEST VEHICLES

Considerable thought was given to the selection of vehicles, for it was upon the data obtained for a relatively small number of vehicles that the committee hoped to base future determinations of operating economy. The characteristics of the test vehicles chosen are contained in Table 2. Seven test vehicles ranging from a 2-axle single-unit truck to a 7-axle tractor, semitrailer, full-trailer combination were included in the study. Gross weights ranged from 20,000 lb. for test vehicle No. 1 to 139,500 lb. for test vehicle No. 7. The range in pounds per net horsepower was from 177 to 534. The power developed by the engines varied from 112 net horsepower to 276 net horsepower, the most powerful gasoline engine in a truck that was available commercially.

Each vehicle was tested with three gross weights. The lightest weight was obtained with 14,000-lb. axle loads, the intermediate weight with 18,000-lb. axle loads, and the heaviest weight with 22,000-lb. axle loads. The use of these axle loads was only a practical means of obtaining three equally distributed gross weights for each vehicle. It is to be noted that with the exception of test vehicle No. 1 there is an overlapping of weights between vehicles. This was necessary in order to insure continuity of results from the lowest to the highest gross weight. The resulting gross weights cover a range inclusive of the practical possibilities of commercial-vehicle operation. The axle load distributions had no perceptible effect on the results of this phase of the study.

The powered units for test vehicles Nos. 3, 4, 5, 6, and 7 were selected with the basic requirement that there should be a weight-power ratio of 400 for the intermediate gross weight of each vehicle. A glance at the weight-power ratios contained in Table 2 will show that is was not possible exactly to fulfill this requirement. The practical side, the availability of powered units for the specific job, dictated the actual pounds per net horsepower. Test vehicles Nos. 1 and 2 were necessary exceptions to the rule of approximately 400 lb. per net horsepower, for it was not possible to obtain vehicles with a small enough power plant that also had axles, frame, and tires to carry the axle loads involved. Test vehicle No. 1 had about the same horsepower output as test vehicle No. 3 which is in accordance with present practice. Test vehicle No. 2 had the power output that is normally available in a 3-axle single-unit truck that is rated to carry the gross weights under investigation. The end result, with respect to the weight-power ratio, was a range that includes most of the weight-power ratios of commercial vehicles normally operating over the highways.

The requirement of 400 lb. per net horsepower for the intermediate weight is not to be construed as an endorsement by the committee of a minimum performance requirement of 400 lb. per net horsepower. The committee adopted it as a yardstick for the selection of vehicles, because it is fairly representative of the ratio between the manufacturers' gross train-weight rating and the engine horsepower.

The gear ratios for the transmissions and rear axles were recommended by the manufacturer for operation over the two contrasting routes. If operation had been limited to either route, undoubtedly different gear ratios would have been provided. Each manufacturer was furnished the profiles of each route, the maximum grades to be encountered, the legal top speeds for each route, and the conditions of the tests to assist in the selection of proper gear ratios.

DESCRIPTION OF TEST PROCEDURES

A motion picture depicting the procedures of test was prepared by the

Bureau of Public Roads and was shown at the 1948 meeting of the Highway Research Board as part of a progress report. Since that time it has been shown frequently to interested audiences throughout the country. For that reason test procedures will not be detailed in this report. However, a resume of the procedures with special emphasis on those items that could have a direct bearing on the final results will be given.

Each vehicle made three round trips on each test route with each gross weight. In one instance, after a major change had been made in the vehicle that might have had some effect on its performance, additional trips were made. The gasoline consumption or travel time used in the analyses for any test section is thus the average of the data recorded for three round trips over the section.

The tests were conducted in three series:

Series I - Test vehicle Nos. 1, 2, and 7.

Series II - Test vehicle Nos. 1, 4, and 6.

Series III - Test vehicle Nos. 1, 3, and 5.

It was not feasible to test all the vehicles at one time because of the lack of sufficient trained personnel, the large quantity of test weights required, and the inability to exercise the proper control over seven vehicles running at one time. To gain some measure of the effect of changing weather conditions during the period of test, particularly temperature, test vehicle No. 1 operated with its intermediate weight as a control vehicle after the first series of tests.

Tests were run on an around-the-clock basis starting at 8:00 a.m. on Monday morning and continuing until early Saturday morning. Most of Saturday was reserved for servicing vehicles and changing the loads. The first trip was started on July 19, 1948, and the last trip was completed on October 7, 1948. The data obtained are representative of day and night operation and of the variety of weather and traffic conditions that prevailed during the summer and autumn months. The tests continued regardless of weather conditions.

An observer rode in the test vehicle and recorded the following information as he passed the control points which are shown on Figure 1.

1. Time of day,
2. Fuel meter reading,
3. Temperature of metered fuel,
4. Weather and its probable effect on test,
5. Accumulated gear shifts and brake applications,
6. Accumulated engine revolutions for test vehicles Nos. 2 and 6,
7. Odometer reading.

Also recorded were the delays with the reason and location, the quantity and temperature of gasoline added to the tanks en route or at the end of the run, and the spot speeds of the vehicle at selected points along the route.

The time of passing each control point was read from a watch to the nearest minute. Each of the observers' watches was periodically checked to determine that it did not gain or lose more than 2 minutes in a complete trip. All delays for such items as eating, refueling, rests, and tire and mechanical failures were recorded and later subtracted from the travel time observed for the section in which the delay occurred.

The fuel consumption was determined with a positive displacement fuel meter that measured the volume of gasoline used to the nearest 0.05 of a gallon. The fuel meters were calibrated in the laboratory and were found to vary within 2 percent of the true volume passing through the meter. However, this accuracy was not experienced in the actual testing, for the variation between the gasoline consumed for a complete trip as indicated by the fuel meter and the quantity metered into the tank at refueling points was from -5 to +5 percent. The field calibration rather than the laboratory calibration was used to adjust the gasoline observed for the intermediate test sections.

In planning the tests it had been hoped to measure gasoline consumption for short sections of highway, obtaining a reading at each break in grade. This was not possible, since accurate fuel-meters that measured to at least the nearest 0.01 of a gallon were not available. Because of the inability to obtain more precise meters, the control points had to be spread over a greater distance.

The temperature of the gasoline metered through the fuelmeter or into the tanks was recorded, so that it would be possible to correct the volume of metered fuel to the standard condition of 60 F., if that were found to be desirable. A quantity of gasoline will change 0.0006 of its volume at 60 F. per degree of temperature change.

As previously explained in the introduction of this report, the information observed on gear shifts, brake applications, and engine revolutions will be used to help relate maintenance costs, to be determined by another study, to the rate of rise and fall. It will be the subject of a future report. The analyses of these data will follow the same procedure developed for travel time and gasoline consumption.

Several of the items were recorded solely for control purposes. The odometer reading was observed to have a check on the observer as to whether he recorded data at the proper point. Information on the weather helped to explain apparent discrepancies in the data for specific test sections. The spot speeds of the test vehicles were recorded by the observers and those of normal traffic were obtained with automatic speed recorders so that the speeds maintained by the drivers of the test vehicles could be compared with those of the normal traffic on various percentages of grade at the same locations.

TESTS CAREFULLY CONTROLLED

Every possible means was employed during the tests to obtain the best possible performance using operating procedures that approximated normal commercial-vehicle operation. It was not feasible to investigate in detail the effect of some of the related factors, such as grade of gasoline, seasonal changes, vehicle condition, driver behavior, and traffic volumes, on the fuel and time consumption. However, considerable effort was exercised to keep these factors constant throughout the period of the tests and, where this was not possible, to evaluate their probable effect on the final results.

The gasoline used in the test vehicles was "regular" grade since most operators use that quality. Also, it was furnished by one supplier. To determine whether the quality varied during the period of tests, test samples were taken of each tank load delivered to the terminals and of the gasoline added at an intermediate point. Refueling en route was not necessary on the Turnpike, and it was always done at the same station when necessary on U. S. 11 and U. S. 30. These samples were sent to the National Bureau of Standards for test. The results are contained in Table 3. It is very evident that the quality of the gasoline remained constant throughout the period of study. The A. S. T. M. octane number 78 is slightly higher than the average for regular grade gasolines now being produced.

It would have been desirable from the standpoint of the possible effect of seasonal changes on performance to test all seven test vehicles during the same period. Since this was not feasible, test vehicle No. 1 was run continuously during each series of tests to determine if there was any appreciable change in performance that could be charged to changes in weather conditions between mid-July and the first part of October. The fuel and time consumption observed for test vehicle No. 1, operating with its intermediate load of 24,000 lb. during the series I, II, and III tests, varied little from the first to the last trip. The average gasoline and travel time for three round trips of test vehicle No. 1 during series I and III tests are in Table A.

Since there is so little difference in the results for the two series of tests, it is concluded that seasonal changes during the test period did not appreciably affect the final results.

Each test vehicle was a 1948 model and was maintained in excellent condition throughout the tests by mechanics furnished by the manufacturers. It was thoroughly "broken in" prior to the start of the series of tests. Preventive maintenance before each trip was strictly enforced and vehicles were complete-

Table A.

Route	Gasoline - Gallons Series I	Gasoline - Gallons Series III	Time - Hours Series I	Time - Hours Series III
Turnpike	22.8	22.3	3.37	3.25
U.S. 11 and U.S. 30	29.7	29.0	5.25	5.20

ly serviced at the end of each week, after approximately 2,000 miles of driving. The drivers reported any mechanical defect at the end of each trip and, if serious, it was fixed on the spot. The performance of the test vehicles in terms of fuel and time as related to vehicle condition represent the optimum in presentday operation.

The drivers were all skilled professional drivers supplied by private trucking companies. Two West Coast drivers were obtained to drive test vehicles Nos. 7 and 6 in series I and II. They alternated on each of these vehicles. Four drivers from the Middle West and East Coast operated the other vehicles in series I and II, and six drivers from the Middle West and East Coast operated the test vehicles in series III. With the exception of the West Coast drivers, the drivers were rotated from one vehicle to another to minimize the driver element. Each driver was thoroughly familiarized with the test routes prior to the test runs and was instructed to operate the vehicle at all times in keeping with the speed limits in effect on the test routes and under full control on downgrades.

The general speed limits in effect for vehicles corresponding to test vehicles were 50 mph on the Turnpike and 30 mph on U. S. 11 and U. S. 30. There has been some criticism that by adhering to those limits the performance was biased on the low side. Actually this was not the case, for the behavior of the test drivers compared closely with that of the regular commercial driver using the same routes. This is clearly indicated by the comparison made in Table 4 between average spot speeds obtained for the test vehicles and for normal commercial traffic at the same locations. The speeds observed for vehicles operating down a 3-percent grade on the Turnpike are more indicative of the driver's desire, since weight, power, and grade are not the limiting factors. The average speed of 54 miles per hour for the test vehicles down a 3-percent grade compares closely with that observed for normal commercial traffic on the same downgrade. On the level, both for the Turnpike and U. S. 30, the test vehicles averaged from 4 to 5 miles per hour more than the normal traffic. The average speed of 46 miles per hour on a level section of U. S. 30 indicates how the test driver obeyed the speed limit of 30 miles per hour. It can be safely concluded that the fuel and time consumption observed are representative of normal operations insofar as driver behavior is concerned.

The average daily traffic volumes on the test sections of the Turnpike and U. S. 30 and U. S. 11 are tabulated in Table 5. The volumes prevailing on the Turnpike and on U. S. 30 and U. S. 11, except for sections A-B and S-T, are such that unreasonable delay or restriction to the driver's freedom to maneuver because of other traffic did not occur. The volumes shown for sections A-B and S-T actually only occurred for relatively short lengths of each section. Also comparisons of fuel and time consumption for sections A-B and S-T with that for other sections of lesser traffic volume but with approximately the same rate of rise and fall show that traffic volume could not have been a significant factor. The results obtained over the two test routes will be representative of operation over any highway on which the practical capacity is not exceeded.

METHODS OF ANALYSIS

The temperature of the gasoline metered by the fuelmeter into the carburetor and by calibrated pumps into the tanks was observed with the idea of correcting the volumes of gasoline measured to a standard temperature of 60 F. However, after considering the uses to be made of the results and the temperatures involved, it was decided that the data as observed would be more representative of actual operations. For that reason corrections for temperatures have not been made. If a temperature correction had been computed, the gasoline consumption shown in this report would be reduced on the average about 2 percent.

The gasoline consumption in gallons and the travel time in minutes were observed for each direction of 37 highway sections and for 21 gross vehicle weights.[1] The problem was how to relate in a practical manner the fuel consumption or travel time with the weights and powers of the seven test vehicles and the various highway profiles as represented by 37 sections of different lengths, each of which was composed of several different grades.

The first step in the analysis was to convert the gasoline consumption in gallons to gallons per mile for each section and the travel time in minutes to minutes per mile. This was done on a composite basis and on a directional basis. The next step was to find a measure for the grade characteristics of each section. It was soon found that the only possible measure, since fuel and time were not observed on individual grades, was the rate of total rise and fall. Each section was then rated in terms of the total rise and fall in feet per 100 ft. of length. The sections in order of the magnitude of the rate of total rise and fall are listed in Table 1.

Gasoline consumption for a particular section was discovered to be definitely related to the gross vehicle weight, and travel time to be definitely related to the weight-power ratio. There was absolutely no relation between gasoline consumption and the weight-power ratio or between travel time and the gross vehicle weight. The fact that gasoline consumption was relative to gross vehicle weight substantiates the findings of the Oregon State Highway Commission reported in their Highway Department Technical Bulletin No. 5, 1937. The variation of time with the weight-power ratio was expected since the speed of a motor vehicle in minutes per mile is directly proportional to the ratio of weight to engine horsepower.

After plotting the composite fuel consumption against gross vehicle weight and composite travel time against pounds per net horsepower for each of the 37 sections, it became evident that results for sections with the same rate of rise and fall were practically identical. This was true regardless of pavement surface type, alignment, or length. This is clearly shown for the composite gasoline consumption by Figures 2 and 3, and for the composite travel time by Figures 4 and 5.

In Figure 2 the composite rates of gasoline consumption obtained for sections 1-16 and T-U, both with a rate of rise and fall of 1.4, are compared. Section 1-16 is a 148.7 mile section of the Pennsylvania Turnpike, and section T-U is a 14.8-mile section of U. S. 11. The same type of comparison is made in Figure 3 for sections 7-8 and I-J, which have a common rate of rise and fall of 2.5. Section 7-8 is a 6.8-mile continuous grade on the east slope of Allegheny Mt. on the Turnpike, whereas section I-J is a 27.0-mile section of U. S. 30 that is moderately rolling with a variety of grades ranging from 0 to 6 percent. Similar comparisons of travel time are shown in Figures 4 and 5 for the same sections.

It is to be noted that there is a curvilinear relation between gasoline consumption and gross vehicle weight and a straight-line relation between travel time and the weight-power ratio. The method of least squares was used to fit a variety of general equations to the basic data for individual sections. The following general equations were found to satisfy best the observed data:

1. Gasoline consumption

$$\text{g.p.m.} = aW^b$$

[1]Average basic data for each test vehicle are tabulated in Appendices A to G.

Where g. p. m. = gallons per mile, and W = gross vehicle weight in thousands of pounds.

2. Travel time

m. p. m. = a + b R

Where m. p. m. = minutes per mile, and R = weight-power ratio in pounds per net horsepower.

The method of least squares and the above general equations were used throughout the analysis to establish relations for composite and directional gasoline consumption and travel time.

COMPOSITE GASOLINE CONSUMPTION

The composite gasoline consumption in gallons per mile was determined for a particular section by dividing the total of the gasoline used in both directions by twice the length of the section in miles. A comparison of the composite gasoline consumption plotted against gross weight for each of 37 sections indicated that the data for sections with about the same rate of rise and fall could be averaged together to simplify the analyses. The sections naturally fell into the seven groups shown in Table 1. The groups consist of 13, 7, 2, 2, 5, 4, and 3 sections with average rates of rise and fall of 1.3, 2.3, 3.2, 4.0, 5.0, 6.4, and 7.4, respectively.

Table 6 shows the composite gasoline consumption for the 13 sections with an average rate of rise and fall of 1.3 for each of the 21 gross weights. A similar tabulation was made for each group of sections. The average values of gasoline consumption shown in Table 6 were plotted against gross weight in Figure 6. The curve shown was fitted to the average data by the method of least squares. For each group of sections the curves fitted the average data with a high degree of accuracy up to a gross weight of 90,000 lb. Above that weight there was a greater dispersion but a definite continuation of the trend.

The relations derived for the average rates of rise and fall for each of the seven groups of sections are shown in Figure 7. The equations derived for each curve are in Table B.

The values of gasoline consumption, determined from these equations, are shown in Figure 8 in a form that permits a practical application of the results. In Figure 8 gasoline consumption is related to the rate of rise and fall for 14 gross vehicle weights ranging from 10,000 lb. to 140,000 lb. The family of curves on Figure 8 is the final answer for composite gasoline consumption. If the total rise and fall in a highway section and the gross vehicle weight or weights are known, it is very simple to determine the gasoline consumption. The total rise and fall can be obtained from the construction profile, or it can easily be obtained on the ground with an altimeter. Examples of how the data in Figure 8 can be applied to the economics of highway grade and vehicle operation will be presented later in the report. The significant feature of these results and the results to follow is that they can be applied to a section of highway in any part of the country.

DIRECTIONAL GASOLINE CONSUMPTION

The composite gasoline consumption shown by Figure 8 will help solve many problems which confront the transportation economist. However, their use is limited to problems where commercial vehicles have the same weight characteristics in each direction of travel over a section, or considering individual vehicles where the same weight is hauled in each direction. This is not always the case for some highway sections. For instance, on access roads to heavy industry or mining operations, vehicles on the average are often loaded heavier in one direction than in the other. Also, when considering a given vehicle, the vehicle may be loaded in one direction and empty in the other. When such unequal conditions of weight exist, the composite gasoline consumption cannot be used. It is important to remember that the composite consumption is the average rate of consumption for a round trip over a section with a given gross vehicle weight.

The development of gasoline consumption on a directional basis was a complicated problem to say the least. It was difficult because gasoline and time were only measured for relative-

Table B.

Rate of rise and fall	Equation[a]
1.3	g. p. m. = .0208 $W^{.618}$
2.3	g. p. m. = .0156 $W^{.736}$
3.2	g. p. m. = .0162 $W^{.775}$
4.0	g. p. m. = .0162 $W^{.793}$
5.0	g. p. m. = .0144 $W^{.881}$
6.4	g. p. m. = .0177 $W^{.907}$
7.4	g. p. m. = .199 $W^{.916}$

[a]These equations and those that subsequently will be shown for travel time have been developed to satisfy best the observed data within the range of the weight and power characteristics of the test vehicles. The equations listed in this report should not be applied to gross weights of less than 10,000 lb. and more than 140,000 lb. and to weight-power ratios of less than 100 and more than 600. They are not intended to indicate a precise relation between the factors involved, and there probably is no precise relation because of the multitude of conditions that may effect gasoline consumption and travel time.

ly long sections of highway composed generally of a number of up and downgrades of varying steepness. It was finally seen that there was a definite relation between directional gasoline consumption and the rate of rise and fall, gross vehicle weight, and the rise in the direction of travel expressed as a percentage of the total rise and fall. The first step in the analysis was the distribution of the sections by directions of travel into groups in accordance with the percentage that the rise was of the total rise and fall.

The groupings of test sections used in the analysis of directional gasoline consumption are shown in Table 7. There are eleven percentage groups ranging from those sections on which the rise in the direction of travel is 95 to 100 percent of the total rise and fall to those on which the rise in the direction of travel is 0 to 4 percent of the total rise and fall. The two above-mentioned groups contain the same sections, for if a section is 100-percent rise in one direction, it will be 0-percent rise in the opposite direction. Similarly, sections in the 75 to 84 percent group will also be in the 15 to 24 percent group. A section of 100-percent rise would be an ascending grade for its entire length while one of 0-percent rise would be a descending grade for its entire length. On the other hand, a section of 50-percent rise would contain at least one upgrade and one downgrade in the direction of travel. It could also be composed of any number of ascending and descending grades so long as the rise was equal to the fall. For instance, section 1-16, the Pennsylvania Turnpike, is 52-percent rise westbound and 48-percent rise eastbound. Both directions of travel are thus in the 45 to 54 percent group.

The directional gasoline consumption for those sections that have a rise of 95 to 100 percent of the total rise and fall is summarized in Table 8. An average rate of consumption is determined for average rates of rise and fall of 2.2, 5.0, 6.4, and 7.4. Similar tabulations were made for each of the eleven groups. The method of least squares was used to fit the general equation for gasoline consumption to the average values for each rate of rise and fall. The results for the average values contained in Table 8 are shown by Figure 9.

After similar relations had been derived for each of the eleven groups, a graph similar to that shown in Figure 10 was developed for each of 14 gross vehicle weights ranging from 10,000 lb. to 140,000 lb. Figure 10, used as an example, is for the 40,000-lb. weight, and shows the directional gasoline consumption related to the rate of rise and fall for each of the eleven percentage groups. The family of curves for each weight was developed by using the data illustrated by Figure 9. For example, from Figure 9, the directional gasoline consumption for 40,000 lb. is .38, .69, .92, and 1.10 gallons per mile for rates of rise and fall of 2.2, 5.0, 6.4, ahd 7.4 respectively. These values were plotted on Figure 10 and a smooth curve was drawn through the four points. The resulting curve is the one labeled 95 to 100 percent. The same procedure was followed to develop the curves for the other percentage groups.

On Figure 10, it will be noticed that all the curves converge to a point for a rate of rise and fall of zero which represents a level section. The point to which they converge is equivalent to the composite gasoline consumption incicated on Figure 8 for a weight of 40,000 lb. and a rate of rise and fall of zero. The directional consumption must be equal to the composite consumption for operation on the level. The solid lines on Figure 10 are based on observed data. Except for the 0 to 4 percent curve and the 95 to 100 percent curve, data were available only for rates of rise and fall less than 5. The dashed lines indicate an estimated projection of the curves beyond the limits of the data.

A very significant discovery was that the curve for the 45 to 54 percent group was always practically identical with the composite curve for the same weight. In other words, the curve for the 45 to 54 percent group on Figure 10 is identical with the composite curve for 40,000 lb. shown on Figure 8. It was also important that it was almost the exact average of the gasoline consumption for the 95 to 100 percent and 0 to 4 percent group for any given rate of rise and fall. This definitely proved that a consistent relation existed between directional gasoline consumption and the rise in percentage of the total rise and fall. It meant that there was a straight-line relation between gasoline consumption and rise in percentage of the total rise and fall for a given rate of rise and fall. This made it easy to adjust the intermediate curves when there were irregularities in the observed data, to interpolate curves for the 65 to 74 and 25 to 34 percent groups, and to project the curves beyond the limits of the observed data.

The final products of the analyses of directional gasoline consumption are represented by Figures 11 to 20, inclusive. They show the relation between directional gasoline consumption, rate of rise and fall, and gross vehicle weight for each percentage group, excepting the 45 to 54 percent group. The composite consumption shown in Figure 8 is to be used for this group. The 14 charts, similar to Figure 10, for each gross vehicle weight have been transformed into eleven charts. Instead of 14 charts with 11 curves, a curve for each percentage group, there are now 11 charts with 14 curves, a curve for each gross vehicle weight. For an illustration of how the transformation was made, the curve for the 95 to 100 percent group on Figure 10 is the same as the 40,000-lb. curve on Figure 11.

The directional gasoline consumption for each gross vehicle weight increases in most instances with an increase in the rate of rise and fall. Exceptions are when the rise in the direction of travel is a small percentage of the total rise and fall, in other words, when the operation is essentially downgrade. The curves in Figures 19 and 20 demonstrate the exceptions. When the rise is 5 to 14 percent of the total rise and fall, Figure 19, the curves indicate a decreasing gasoline consumption for rates of rise and fall from 0 to about 3. For rates of rise and fall greater than about 3, the gasoline consumption increases with the rate of rise and fall. The same condition that is evident on Figure 19 is present to a lesser degree on Figures 17 and 18. When the travel is entirely downgrade as evidenced in Figure 20, the gasoline consumption decreases for rates of rise and fall from 0 to about 4, and then remains practically constant. The dips in these curves appear as a curious phenomena, but actually result from a combination of road and vehicle characteristics.

The path to the final result for directional gasoline consumption was complicated, but the use of the data is very simple. For instance, if it is desired to compute the gallons of gasoline required for a vehicle to make a round trip over a section of highway under the following conditions:

A parabolic relation gave almost exactly the same standard error of estimate as the straight line relation. The latter was used because it simplified the analyses.

The composite travel time related to the rate of rise and fall for lbs. per net horsepower, ranging from 100 to 600 by increments of 50, is shown in Figure 23. This is the final answer for composite travel time just as Figure 8 is the final answer for composite gasoline consumption. Figures 8 and 23 are to be remembered for they are required to solve problems that involve composite gasoline consumption and travel time. Their application to typical problems will be demonstrated later in the report.

1. Gross vehicle weight in pounds . . . eastbound . . . 80,000
   westbound . . . 30,000
2. Rate of rise and fall 4.0
3. Rise in direction of travel . . . . . eastbound . . . 72%
   . . . . . westbound . . . 28%
4. Length of section . . . . 20 miles

The directional gasoline consumption for the 80,000-lb. weight is read from Figure 14 and for the 30,000-lb. weight from Figure 17. The consumption is .72 and .17 gallons per mile, respectively. The gasoline in gallons is then .72 x 20 plus .17 x 20, or 17.8 gallons.

COMPOSITE TRAVEL TIME

The composite travel time was analyzed in exactly the same manner as the composite gasoline consumption. The only difference is that composite travel time is related to lb. of gross weight per net horsepower, whereas gasoline consumption was related to gross vehicle weight. For illustrative purposes the composite travel time for the seven sections, the second group in Table 1, is summarized in Table 9. The average rate of rise and fall is 2.3. The averages for the seven sections are plotted against lb. per net horsepower in Figure 21. The relation between travel time and lb. per net horsepower is a straight line. The straight line fitted the plotted points with as high a degree of accuracy as any other relation. Similar relations were derived for other groups of rate of rise and fall.

The average composite travel time for each of the seven average rates of rise and fall is shown related to lbs. per net horsepower in Figure 22. The straight line marked 2.3 is the same one that is shown on Figure 21. The equations for each of the relations shown in Figure 22 are in Table C.

It is interesting to note that on Figure 23 the curves converge to a travel time of about 1.2 minutes per mile for a zero rate of rise and fall. This is equivalent to an average speed of 50 miles per hour on the level for any weight-power ratio. This compares very closely with the average spot speeds observed for the test vehicles on the two level sections shown in Table 4. The family of curves shown in Figure 23 are represented by the equations shown in Table D.

DIRECTIONAL TRAVEL TIME

The step-by-step analyses for directional travel time was exactly the same as that for directional gasoline consumption. The derivation of the average travel time for those sections that have a rise of 95 to 100 percent of the total rise and fall in the direction of travel is demonstrated in Table 10. The resulting straight-line relations for the averages for the four rates of rise and fall are shown on Figure 24. Similar relations were developed for each of the percentage groups listed in Table 7.

Table C.

Rate of rise and fall	Equation
1.3	m.p.m. = 1.054 + .0011R
2.3	m.p.m. = 1.073 + .0025R
3.2	m.p.m. = .942 + .0042R
4.0	m.p.m. = .896 + .0051R
5.0	m.p.m. = .912 + .0074R
6.4	m.p.m. = .544 + .0128R
7.4	m.p.m. = .617 + .0147R

where; m.p.m. = travel time in minutes per mile, and
R = weight-power ratio in pounds per net horsepower.

Table D.

Weight-Power Ratio	Equation
100	m.p.m. = $1.124 + .032E + .013E^2$
150	m.p.m. = $1.137 + .056E + .023E^2$
200	m.p.m. = $1.131 + .088E + .033E^2$
250	m.p.m. = $1.146 + .112E + .043E^2$
300	m.p.m. = $1.139 + .143E + .053E^2$
350	m.p.m. = $1.151 + .168E + .063E^2$
400	m.p.m. = $1.147 + .198E + .073E^2$
450	m.p.m. = $1.160 + .273E + .083E^2$
500	m.p.m. = $1.153 + .255E + .093E^2$
550	m.p.m. = $1.164 + .279E + .103E^2$
600	m.p.m. = $1.154 + .313E + .113E^2$

where; m.p.m. = travel time in minutes per mile, and
E = rate of rise and fall in feet per 100 feet.

The next operation was the development of six charts similar to Figure 25, which shows the directional travel time related to the rate of rise and fall, and the rise in percentage of the total rise and fall for a weight-power ratio of 400. A chart was prepared for 100, 200, 300, 400, 500, and 600 lb. per net horsepower.

The curves in Figure 25 converge to a travel time of about 1.2 minutes per mile for a level section, a rate of rise and fall of zero. This, of course, is identical to that shown on Figure 23 since directional is equal to composite travel time for level sections. Just as was the case for composite gasoline consumption, the curve for the 45 to 54 percent group falls half way between those for 0 to 4 and 95 to 100 percent groups. The observed data for the other groups, which contained only a few sections on which to base the analyses, were very erratic. This was not the case for directional gasoline consumption, but it was to be expected for directional travel time, because the latter is so dependent on driver behavior on descending grades. One driver will descend a long hill at 5 miles per hour and another will come down at 15 miles per hour. The test drivers were no exception to the rule. The curves for the groups, other than for the 0 to 4, 45 to 54, and 95 to 100 percent groups which were based on very consistent data, were interpolated assuming that there was a straight-line relation between travel time and rise in the direction of travel for any rate of rise and fall.

The data developed for the six weight-power ratios, (Figure 25 is an example,) were replotted so that there was a set of results for each of the eleven percentage groups. The resulting charts are Figures 26 to 35, inclusive. Figure 23 serves a dual purpose. It is to be used for the 45 to 54 percent group as well as for the composite travel time. These figures show the relation between the directional travel time, the rate of rise and fall, the weight-power ratio, and the rise in the direction of travel expressed in a percentage of the total rise and fall.

The results indicated by Figures 26 to 35, inclusive, are to be used in much the same manner as the corresponding sets of data, Figures 11 to 20, inclusive, which pertain to directional gasoline consumption. For example, it is relatively simple to determine the time required for a vehicle to make a round trip on a 10-mile section of highway for the following assumed conditions:

1.	Gross vehicle weight in pounds	eastbound	80,000
		westbound	30,000
2.	Net brake horsepower		200
3.	Weight-power ratio	eastbound	400
		westbound	150
4.	Rate of rise and fall		3.0
5.	Rise in direction of travel	eastbound	68%
		westbound	32%

The directional travel time for the eastbound trip is read from Figure 29 for a weight-power ratio of 400, and for the westbound trip from Figure 32 for a weight-power ratio of 150. It is 2.8 and 1.4 minutes per mile, respectively. The elapsed time is 2.8 x 10 + 1.4 x 10, or 42 minutes.

The directional travel time shown in Figure 35 is in reality for downhill operations. These data have a limited application because the supporting data were observed for grades that were greater than one mile in length. For downhill operation on sections less than one mile in length, where sight distance and curvature are not restrictive, the values for directional travel time shown in Figure 35 should not be used. The travel time for operation down short grades steeper than 3 percent should be slightly less than that shown for level sections, a zero rate of rise and fall. For short grades of 3 percent or less, the travel time should approximate that shown for level sections.

RESULTS CHECKED BY OTHER STUDIES

The proof of the pudding is certainly in the eating. For that reason a careful search was made to find results of other research that could be used to either verify or disqualify the results that are reported in this paper. This investigation was not too successful since very little research pertaining to commercial vehicles has been done in this particular field.

The Bureau of Public Roads in cooperation with the Maryland State Roads Commission conducted a time study[2] of commercial vehicles using a 21.5-mile section of U. S. 40 between Frederick and Hagerstown, Maryland, and a 21.0-mile section of alternate U. S. 40 between the same cities. The alternate route is a complete relocation. For purposes of simplification the two routes are designated as Old U. S. 40 and New U. S. 40. This was a unique study in that it was the first known attempt to relate the performance of commercial vehicles in the traffic stream to their weight-power ratio and the rate of rise and fall. A comparison between the composite travel time observed on the Old and New U. S. 40 for various weight-power ratios and that read from Figure 23 for the same average ratios is made in Table 11. The two sets of composite travel time in minutes per mile for each route compare closely considering the entire range of weight-power ratios.

The Oregon State Highway Department has conducted the only known research

[2]Unpublished.

on gasoline consumption that has produced results similar to those discussed in this report. They tested five gasoline-powered vehicles, taken from general service, ranging from a gross weight of 9,180 to 44,370 lb. The procedure and the results of the tests are reported in Highway Department Technical Bulletin No. 5, dated 1937. The results therefore relate to vehicles manufactured prior to 1937.

A comparison between the composite gasoline consumption determined by the Oregon study and this study is made in Table 12 for three rates of rise and fall. The comparison is limited to a top gross weight of 60,000 lb. as that was the maximum extrapolation of the data in the Oregon study.

The results for the rates of rise and fall of 3.0 and 6.0 are in fairly close agreement and have the same characteristic curves. The composite gasoline consumption read from Figure 8 is less than the Oregon value. The two sets of results for the rate of rise and fall of zero are another matter. They have common values for 10,000 lb. but sharply diverge thereafter. There is no valid explanation for this wide variance in the two sets of values for the rate of rise and fall of zero. The fact that the Oregon results are generally higher would be expected, since considerable improvements have been made in the efficiency of motor trucks during the past 15 years. Also, the Oregon results are based on relatively short individual grades where the results in Figure 8 are for long sections that include a variety of grades and vertical curves.

POSSIBLE USES OF RESULTS DEMONSTRATED

A common problem confronting the highway engineer is the determination of the savings in vehicle operating costs that accrue to the operators through the construction of a highway on one location instead of another. Since a large part of the operating cost of commercial vehicles is composed of gasoline consumption and travel time, the results of this study will be an important implement in the hands of the highway engineer. This is particularly true since very little data have existed for commercial vehicles.

For an example, assume it is planned to construct either route A or route B. Both routes are 100 miles in length, but route A has a rate of rise and fall of 3.7 whereas route B has a rate of rise and fall of 2.3. The problem is to determine whether the savings in vehicle operating costs resulting from the reduction in rise and fall are sufficient to offset a greater construction cost.

For this hypothetical problem it is assumed that the annual average daily traffic over each route will be 9,000, and that commercial traffic will be 16 percent of the annual average daily traffic. It is also assumed for commercial vehicles that the gross vehicle weight characteristics and the weight-power characteristics will be similar to those observed on U. S. 40 in Maryland, and that they will be the same in each direction. The problem will be considered here only to the extent of determining the savings in gasoline and time for the commercial vehicles.

The savings in gasoline per day are shown in Table 13. The number of vehicles in each weight group are determined by multiplying the percentage of the total vehicles in each gross weight group by the total number of commercial vehicles which is 0.16 x 9,000, or 1,440. The composite gasoline consumption for the average gross vehicle weight of each weight group, is read from Figure 8 for the rates of rise and fall of 3.7 and 2.3 The savings in gallons per mile multiplied by 100 miles is the gasoline saved per vehicle. That value times the number of vehicles for the particular weight group is the total gasoline saved by all vehicles in that group. A total of 4,295 gallons per day, or 1,567,675 gallons per year is saved. At 25 cents per gallon, the savings in gasoline consumption for commercial vehicles are $391,919 per year, if route B is constructed instead of route A.

Time savings are computed in much the same manner in Table 14. The difference is that groups of weight-power ratios are used instead of groups of gross vehicle weights. The composite travel time is read from Figure 23. The total time saved by the 1,440 vehicles is 1,054 hours per day, or 384,710 hours per year. At an assumed rate of $2.00 per hour, the time savings are $769,420 per year.

The data in Tables 13 and 14 illustrate how the rate of gasoline consumption and travel time derived in this report can be applied to problems of highway economics. The application is extremely simple. The weight-power ratios for vehicles in the general traffic stream is the only variable that is presently not readily available. However, the Bureau of Public Roads is now having various States conduct special loadometer studies which will permit the determination of the weight-power ratio for commercial-vehicle operation in various sections of the country. When these studies are complete all the variables will be readily available.

The principal reason for the existence of the Committee on the Economics of Size and Weight is to determine the relative economies of operating various types of vehicles in relation to the cost of providing highway facilities for those vehicles. Only two segments of the operating costs have been determined by this study. However, they are important segments of the total cost. To illustrate how the data derived from the operation of the test vehicles can be applied to determine the gasoline and time economy of any commercial vehicle for a specific highway profile, Table 15 has been prepared.

Table 15 which is self-explanatory, demonstrates a method for computing factors that relate to economy of operation considering the composite gasoline consumption and travel time. It is to be clearly understood that only two segments of the total operating economy can be evaluated by the use of the computation form in Table 15. Overall cost comparisons cannot be made until other important factors, such as cost of tires, maintenance, depreciation, and overhead are determined.

CONCLUSIONS

The primary purpose of this report was to relate the gasoline consumption and travel time observed for commercial vehicles with the weight and power of the vehicle and with the rise and fall in the highway in such a manner that the results could be easily and successfully applied. The primary purpose has been accomplished through the provision of Figure 8 for composite gasoline consumption; Figures 11 to 20, inclusive, for directional gasoline consumption; Figure 23 for composite travel time; and Figures 26 to 35, inclusive, for directional travel time.

An important finding with respect to any highway section is that gasoline consumption and travel time vary in a definite manner with the rate of rise and fall, regardless of the length of section or the number and steepness of individual grades in the section. This simplifies the problem, for it makes it possible to apply the results to entire sections of highways. Individual grades do not have to be considered separately. The rate of rise and fall is easily determined from profile maps or by the use of an altimeter.

Other findings of equal importance are that the gasoline consumption is definitely related to the gross weight and the travel time to the weight-power ratio. Although the position of weight-power ratios in the normal commercial traffic is not presently defined for many sections of the country, special loadometer surveys sponsored by the Bureau of Public Roads should produce the necessary data. It is to be remembered when using the rates of travel time presented in this report that the weight-power ratio is expressed in lb. per net horsepower and not lb. per gross horsepower.

A most significant fact is that the results can be currently applied to paved highways and gasoline powered commercial vehicles in any part of the country. They are definitely not limited to the characteristics of the two test routes or the seven test vehicles. The examples which illustrate how the factors can be applied to common problems indicate that the results of this study will have many uses and that they are a contribution toward the solution of the problem of motor vehicle size and weight. The work on the other phases of the project which are planned to provide the remaining segments of the vehicle operating costs should be hastened.

Table 1 -- Description of the test sections in order of the rate of rise and fall

Section 1/	Rate of rise & fall	Length of section	Rise and fall - Eastbound			Rise in percentage of total rise & fall		Remarks
			Rise	Fall	Total	EB 2/	WB 3/	
	Ft/100 Ft.	miles	feet	feet	feet	%	%	
15-16	0.8	12.79	247	260	507	49	51	Gently rolling
12-13	0.9	6.17	266	28	294	91	9	West slope of Blue Mt.
8-9	1.2	28.25	775	1,085	1,860	42	58	Gently rolling
1-2	1.3	6.88	324	156	480	68	32	Gradual climb to base of Laurel Hill
6-7	1.3	19.21	784	535	1,319	59	41	Gently rolling
14-15	1.3	11.01	214	563	777	28	72	Gradual climb to base of Blue Mt.
3-4	1.4	4.31	75	251	326	23	77	Slight dip on west slope of Laurel Hill
9-10	1.4	6.31	397	56	453	88	12	West slope of Rays Hill
10-11	1.4	9.32	119	585	704	17	83	East slope of Rays & Sideling Hill
1-16	1.4	148.71	5,391	5,936	11,327	48	52	Entire Turnpike course
T-U	1.4	14.83	399	661	1,060	38	62	Gently rolling
11-12	1.6	18.19	669	834	1,503	45	55	Gently rolling
S-T	1.7	30.28	1,398	1,363	2,761	51	49	Gently rolling
13-14	1.9	2.11	0	214	214	0	100	East slope of Blue Mt.
2-3	2.0	6.69	693	20	713	97	3	West slope of Laurel Mt.
4-5	2.2	7.04	817	0	817	100	0	West slope of Laurel Mt.
5-6	2.3	3.63	11	439	450	2	98	East slope of Laurel Mt.
A-B	2.4	19.77	1,340	1,191	2,531	53	47	Moderately rolling
7-8	2.5	6.80	0	910	910	0	100	East slope of Allegheny Mt.
I-J	2.5	26.98	1,572	1,975	3,547	44	56	Moderately rolling
G-H	3.1	4.20	612	65	677	90	10	West slope of Bald Knob
A-U	3.3	149.39	12,762	13,495	26,257	49	51	Entire US Route 11 & 30 course
E-G	3.9	5.72	900	291	1,191	76	24	West slope of Bald Knob
N-O	4.1	4.06	354	521	875	40	60	Heavily rolling
K-L	4.8	1.04	0	264	264	0	100	East slope of Rays Hill
P-Q	4.9	3.40	153	730	883	17	83	East slope of Scrub Mt.
J-K	5.0	4.29	1,040	103	1,143	91	9	West slope of Rays Hill
D-E	5.1	9.61	1,237	1,327	2,564	48	52	Heavily rolling
L-M	5.1	1.88	507	4	511	99	1	West slope of Sideling Mt.
H-I	6.2	4.96	67	1,563	1,630	4	96	East slope of Bald Knob
B-C	6.3	4.02	1,340	6	1,346	100	0	West slope of Laurel Mt.
C-D	6.4	2.41	0	820	820	0	100	East slope of Laurel Mt.
Q-R	6.6	3.61	1,249	9	1,258	100	0	West slope of Tuscorora Mt.
R-S	7.0	3.88	0	1,432	1,432	0	100	East slope of Tuscorora Mt.
M-N	7.3	3.02	0	1,170	1,170	0	100	East slope of Sideling Mt.
O-P	7.9	1.43	594	0	594	100	0	West slope of Scrub Mt.

1/ Numbered sections are on Pennsylvania Turnpike
Lettered sections are on US Routes 11 & 30

2/ Eastbound

3/ Westbound

Table 2 -- Description of the test vehicles

Test vehicle No.	Type of vehicle 1/	Powered unit																Towed units		Gross vehicle weights	Weight-Power Ratio	Over-all vehicle length
		Type	Piston displacement	Torque (lb-ft)		Horsepower		Transmission gear ratios					Aux. trans. 2/ gear ratios			Rear axle ratio	Tire size	Type	Tire size			
				Max.	Net	Max.	Net	1st	2d	3d	4th	5th	UD	D	OD							
			Cu. in.																	pounds	lbs/net HP	Ft.
1	2	4 x 2	361	273-1000	262-1000	136-3000	113-2600	7.43	4.57	2.97	1.66	1.00	-	-	-	7.16	11.00x20	-	-	20,000 24,000 26,500	177 211 236	21
2	3	6 x 4	501	400-1100	382-1100	165-2800	146-2600	5.90	3.60	1.84	1.00	0.75	1.29	1.00	0.75	8.15	11.00x20	-	-	36,500 44,500 54,000	250 305 369	26
3	2-S1	4 x 2	331	270-1200	257-1300	128-3000	112-2800	7.58	4.38	2.39	1.478	1.00	-	-	-	7.13 & 9.55	11.00x20	1-axle semitrailer	11.00x20	33,000 41,500 50,000	293 372 448	40
4	2-S2	4 x 2	504	403-1200	330-1200	184-2900	160-2800	8.08	4.67	2.62	1.38	1.00	1.25	1.00	0.84	7.74	11.00x20	2-axle semitrailer	11.00x22	50,000 62,000 74,500	313 387 465	43
5	3-S2	6 x 4	602	464-1300	-	200-2600	180-2600	6.27	3.46	1.73	1.00	-	1.495	1.00	0.84	8.15	11.00x22	2-axle semitrailer	11.00x22	63,000 80,000 96,000	350 445 534	45
6	3-3	6 x 4	855	660-1440	-	245-2200	224-2200	6.25	3.47	1.74	1.00	0.67	2.59	1.00	0.75	6.00	11.00x20	3-axle full trailer	11.00x20	80,000 100,500 119,500	358 449 534	62
7	3-S2-2	6 x 4	1090	930-1300	-	295-2000	276-2000	5.48	3.11	1.75	1.00	0.77	2.24	1.00	0.84	5.77	11.00x22	2-axle semitrailer 2-axle full trailer	11.00x22 11.00x22	93,500 116,500 139,500	339 421 505	77

1/

Code	Type
2	2-axle single-unit truck
3	3-axle single-unit truck
2-S1	2-axle tractor, 1-axle semitrailer
2-S2	2-axle tractor, 2-axle semitrailer
3-S2	3-axle tractor, 2-axle semitrailer
3-3	3-axle truck, 3-axle trailer
3-S2-2	3-axle tractor, 2-axle semitrailer, 2-axle trailer

2/ UD -- Under drive
D -- Direct
OD -- Over drive

Table 3 --Results of test made on gasoline used by test vehicles

Type of test		Sample Number												
		1	2	3	4	5	6	7	8	9	10	11	12	13
A. S.T.M. octane no.		78	78	78	78	78	78	78	78	78	78	78	78	78
Reid vapor pressure lb/sq.in.		7	8	7	8	8	7	8	7	8	7	8	7	8
Sulfur	percent	0.10	0.10	0.12	0.12	0.10	0.12	0.11	0.10	0.12	0.09	0.09	0.13	0.12
Distillation:														
First drop	°C	42	36	37	34	40	41	38	34	37	37	36	36	38
5 percent distilled	°C	60	53	52	50	61	56	55	50	53	48	50	52	57
10 percent distilled	°C	67	60	61	58	67	64	63	58	60	59	58	61	65
15 percent distilled	°C	73	67	68	64	73	69	70	64	67	66	64	68	72
20 percent distilled	°C	78	73	74	70	80	76	78	70	73	72	71	75	78
30 percent distilled	°C	90	86	86	84	92	87	90	82	86	86	85	89	92
40 percent distilled	°C	102	98	98	96	103	99	101	96	98	100	96	102	107
50 percent distilled	°C	113	110	110	108	115	111	114	107	111	115	110	115	120
60 percent distilled	°C	128	123	123	121	128	124	125	120	126	126	125	127	134
70 percent distilled	°C	142	134	138	137	141	134	139	135	141	140	140	142	146
80 percent distilled	°C	156	155	154	153	158	156	152	154	157	155	159	162	163
90 percent distilled	°C	181	179	178	180	182	178	179	176	180	176	178	183	183
95 percent distilled	°C	197	198	195	196	198	195	192	191	197	192	192	194	198
End Point		214	212	212	216	214	214	212	212	214	209	217	214	215
Recovery	percent	97.8	97.0	97.2	97.3	98.0	97.3	98.1	98.0	97.5	98.2	98.2	98.2	97.8
Residue	percent	1.8	1.8	1.6	1.6	1.7	1.6	1.6	1.0	1.6	1.3	1.0	1.2	1.1
Loss	percent	0.4	1.2	1.2	1.1	0.3	1.1	1.3	1.0	0.9	0.5	0.8	0.8	1.1
Barometric pressure mm of mercury		756	754	756	754	756	756	756	753	756	749	756	756	753

Table 4 -- Comparison of the average spot speeds observed for the normal commercial traffic and for the test vehicles at the same locations

Type of location	Average speeds in miles per hour --		
	Normal commercial traffic		Test vehicles
	Single units	Combination units	
Level tangent - Pa. Turnpike	45	47	50
Level tangent - U S 30	41	41	46
Up 3 percent grade - Pa. Turnpike	32.0	21.0	18
Down 3 percent grade - Pa. Turnpike	52.0	57.0	54

Table 5.--Daily traffic volumes on the test sections of each test route

1948 Average Daily Traffic on U S 30 & 11			1948 Average Daily Traffic on Pennsylvania Turnpike		
Section	Volume 1/	Percentage of trucks	Section	Volume 1/	Percentage of trucks
A-B	6,800	18	1 - 2	6,260	25
B-C	1,950	18	2 - 3	6,260	25
C-D	1,950	18	3 - 4	6,260	25
D-E	1,950	18	4 - 5	6,180	26
E-F	1,450	18	5 - 6	6,180	26
F-G	1,450	18	6 - 7	6,180	26
G-H	1,450	18	7 - 8	6,060	26
H-I	1,450	18	8 - 9	6,545	24
I-J	2,350	20	9 -10	6,545	24
J-K	1,300	18	10 -11	5,320	26
K-L	1,300	18	11 -12	5,320	26
L-M	1,300	18	12 -13	5,110	26
M-N	1,300	18	13 -14	5,110	26
N-O	1,300	18	14 -15	5,030	26
O-P	2,250	18	15 -16	5,030	26
P-Q	2,250	18			
Q-R	950	18			
R-S	950	18			
S-T	3,400	11			
T-U	2,200	11			

1/ Maximum recorded on any portion of the section.

Table 6 -- Summary of composite gasoline consumption for 13 sections with an average rate of rise and fall of 1.3 feet per 100 feet

Test section	Rate rise and fall	Gasoline consumption in gallons per mile by vehicle number and gross vehicle weight in thousands of pounds																				
		Vehicle No. 1			Vehicle No. 2			Vehicle No. 3			Vehicle No. 4			Vehicle No. 5			Vehicle No. 6			Vehicle No. 7		
		20.0	24.0	26.5	36.5	44.5	54.0	33.0	41.5	50.0	50.0	62.0	74.5	63.0	80.0	96.0	80.0	100.5	119.5	93.5	116.5	139.5
	Ft./100 Ft.																					
15-16	0.8	.134	.144	.145	.191	.212	.240	.177	.185	.202	.244	.255	.263	.274	.291	.325	.340	.362	.377	.317	.353	.375
12-13	0.9	.133	.143	.133	.173	.224	.243	.165	.175	.214	.196	.230	.266	.259	.301	.335	.345	.374	.399	.305	.363	.408
8-9	1.2	.147	.151	.147	.204	.226	.245	.183	.182	.185	.222	.243	.265	.268	.297	.309	.332	.366	.425	.319	.359	.383
1-2	1.3	.138	.154	.151	.219	.224	.253	.180	.185	.225	.240	.262	.280	.281	.321	.324	.369	.410	.453	.350	.392	.501
6-7	1.3	.143	.156	.151	.215	.223	.246	.186	.198	.245	.230	.266	.281	.286	.319	.349	.359	.391	.428	.346	.407	.415
14-15	1.3	.141	.153	.151	.180	.204	.233	.174	.183	.187	.202	.233	.249	.268	.272	.292	.301	.349	.393	.329	.334	.352
3-4	1.4	.144	.158	.142	.213	.226	.239	.186	.205	.211	.239	.292	.325	.264	.302	.313	.353	.400	.432	.399	.460	.529
9-10	1.4	.136	.148	.144	.198	.215	.228	.177	.212	.235	.258	.261	.266	.271	.295	.307	.336	.355	.425	.365	.395	.414
10-11	1.4	.136	.161	.146	.202	.225	.255	.185	.188	.190	.206	.266	.275	.266	.303	.337	.350	.395	.441	.350	.395	.433
1-16	1.4	.142	.153	.151	.205	.221	.247	.185	.191	.215	.236	.265	.282	.278	.313	.339	.353	.396	.440	.347	.403	.431
T-U	1.4	.151	.159	.158	.210	.231	.254	.190	.209	.225	.262	.270	.283	.308	.338	.346	.396	.438	.457	.365	.394	.418
11-12	1.6	.142	.154	.151	.194	.212	.224	.183	.192	.195	.234	.263	.290	.271	.285	.316	.324	.358	.385	.333	.384	.372
8-T	1.7	.148	.159	.156	.222	.244	.269	.190	.211	.228	.250	.274	.304	.307	.338	.364	.412	.452	.493	.381	.450	.488
Totals	17.1	1.835	1.993	1.926	2.626	2.887	3.176	2.361	2.516	2.757	3.019	3,380	3.629	3.601	3.975	4.256	4.570	5.046	5.548	4.506	5.089	5.519
Averages	1.3	.141	.153	.148	.202	.222	.244	.182	.194	.212	.232	.260	.279	.277	.306	.327	.352	.388	.427	.346	.391	.424

Table 7 -- Grouping of control sections by the percentage that the rise is of the total rise and fall

Percentage Group	Section	Direction of travel 1/	Rate of rise & fall	Rise in percentage of total rise & fall
%			Ft/100 Ft.	%
95 - 100	13-14	WB	1.9	100
	2-3	EB	2.0	97
	4-5	EB	2.2	100
	5-6	WB	2.3	98
	7-8	WB	2.5	100
	K-L	WB	4.8	100
	L-M	EB	5.1	99
	H-I	WB	6.2	96
	B-C	EB	6.3	100
	C-D	WB	6.4	100
	Q-R	EB	6.6	100
	R-S	WB	7.0	100
	M-N	WB	7.3	100
	O-P	EB	7.9	100
85 - 94	12-13	EB	0.9	91
	9-10	EB	1.4	88
	G-H	EB	3.1	90
	J-K	EB	5.0	91
75 - 84	3-4	WB	1.4	77
	10-11	WB	1.4	83
	E-G	EB	3.9	76
	P-Q	WB	4.9	83

Table 7 -- Continued sheet 2

Percentage Group	Section	Direction of travel 1/	Rate of rise & fall	Rise in percentage of total rise & fall
%			Ft/100 Ft.	%
65 - 74	14-15	WB	1.3	72
	1-2	EB	1.3	68
55 - 64	8-9	WB	1.2	58
	6-7	EB	1.3	59
	T-U	WB	1.4	62
	I-J	WB	2.5	56
	N-O	WB	4.1	60
45 - 54	15-16	WB	0.8	51
	15-16	EB	0.8	49
	1-16	WB	1.4	52
	1-16	EB	1.4	48
	11-12	EB	1.6	45
	11-12	WB	1.6	55
	S-T	EB	1.7	51
	S-T	WB	1.7	49
	A-B	EB	2.4	53
	A-B	WB	2.4	47
	A-U	WB	3.3	51
	A-U	EB	3.3	49
	D-E	WB	5.1	52
	D-E	EB	5.1	48
35 - 44	8-9	EB	1.2	42
	6-7	WB	1.3	41
	T-U	EB	1.4	38
	I-J	EB	2.5	44
	N-O	EB	4.1	40

Table 7 -- Continued sheet 3

Percentage Group	Section	Direction of travel 1/	Rate of rise & fall	Rise in percentage of total rise & fall
%			Ft/100 Ft.	%
25 - 34	14-15	EB	1.3	28
	1-2	WB	1.3	32
15 - 24	3-4	EB	1.4	23
	10-11	EB	1.4	17
	E-G	WB	3.9	24
	P-Q	EB	4.9	17
5 - 14	12-13	WB	0.9	9
	9-10	WB	1.4	12
	G-H	WB	3.1	10
	J-K	WB	5.0	9
0 - 4	13-14	EB	1.9	0
	2-3	WB	2.0	3
	4-5	WB	2.2	0
	5-6	EB	2.3	2
	7-8	EB	2.5	0
	K-L	EB	4.8	0
	L-M	WB	5.1	1
	H-I	EB	6.2	4
	B-C	WB	6.3	0
	C-D	EB	6.4	0
	Q-R	WB	6.6	0
	R-S	EB	7.0	0
	M-N	EB	7.3	0
	O-P	WB	7.9	0

1/ WB - Westbound
EB - Eastbound

Table 8 -- Summary of directional gasoline consumption for those sections that have a rise of 95 - 100 percent of the total rise and fall

Section	Direction of travel	Rate rise and fall	Gasoline consumption in gallons per mile by vehicle number and gross vehicle weight in thousands of pounds																				
			No. 1			No. 2			No. 3			No. 4			No. 5			No. 6			No. 7		
			20.0	24.0	26.5	36.5	44.5	54.0	33.0	41.5	50.0	50.0	62.0	74.5	63.0	80.0	96.0	80.0	100.5	119.5	93.5	116.5	139.5
		Ft/100 Ft.																					
13-14	WB	1.9	.232	.223	.227	.341	.389	.483	.360	.346	.327	.460	.498	.588	.450	.611	.754	.659	.659	.986	.583	.787	.953
2-3	EB	2.0	.203	.221	.251	.350	.451	.496	.304	.358	.382	.451	.481	.616	.532	.659	.744	.695	.684	.979	.648	.765	.984
4-5	EB	2.2	.207	.241	.281	.399	.510	.544	.355	.354	.526	.565	.591	.673	.568	.730	.801	.670	.848	1.082	.683	.847	1.017
5-6	WB	2.3	.220	.253	.245	.286	.218	.438	.311	.380	.507	.430	.534	.581	.496	.634	.774	.636	.667	.956	.631	.758	.893
7-8	WB	2.5	.256	.303	.294	.400	.462	.582	.385	.438	.613	.578	.641	.726	.593	.750	.884	.803	.978	1.194	.762	1.003	1.091
Totals		10.9	1.118	1.241	1.298	1.776	2.030	2.543	1.715	1.876	2.355	2.484	2.745	3.184	2.639	3.384	3.957	3.463	3.836	5.197	3.307	4.160	4.878
Averages		2.2	.224	.248	.260	.355	.406	.509	.343	.375	.471	.497	.549	.637	.528	.677	.791	.693	.767	1.039	.661	.832	.976
K-L	WB	4.8	.336	.380	.432	.600	.730	.856	.490	.634	.778	.673	.980	1.269	.971	1.134	1.480	1.163	1.288	1.836	1.163	1.346	2.192
L-M	EB	5.1	.382	.441	.505	.718	.867	1.074	.696	.718	.888	.973	1.186	1.516	1.202	1.410	1.702	1.473	1.867	2.468	1.468	1.760	2.335
Totals		9.9	.718	.821	.937	1.318	1.597	1.930	1.186	1.352	1.666	1.646	2.166	2.785	2.173	2.544	3.182	2.636	3.155	4.304	2.631	3.106	4.527
Averages		5.0	.359	.411	.468	.659	.798	.965	.593	.676	.833	.823	1.083	1.392	1.086	1.272	1.591	1.318	1.577	2.152	1.316	1.553	2.264
H-I	WB	6.2	.470	.514	.627	.790	1.064	1.254	.780	.909	1.161	1.068	1.421	1.756	1.383	1.645	2.120	1.710	2.181	2.724	1.768	2.147	2.594
B-C	EB	6.3	.517	.629	.632	.731	1.075	1.338	.769	.826	1.259	1.234	1.557	1.789	1.547	1.993	2.286	2.010	2.562	3.199	1.896	2.435	2.968
C-D	WB	6.4	.452	.502	.635	.635	1.037	1.299	.768	.813	1.133	1.004	1.373	1.722	1.468	1.681	2.062	1.672	2.087	2.539	1.556	2.141	2.348
Q-R	EB	6.6	.510	.623	.609	.856	1.121	1.318	.476	.906	1.258	1.158	1.570	1.753	1.587	1.898	2.132	1.947	2.612	2.889	1.798	2.338	2.772
Totals		25.5	1.949	2.268	2.503	3.012	4.297	5.209	2.793	3.534	4.811	4.464	5.921	7.020	5.985	7.217	8.600	7.339	9.442	11.351	7.018	9.061	10.682
Averages		6.4	.487	.567	.626	.753	1.074	1.302	.698	.884	1.203	1.116	1.480	1.755	1.496	1.804	2.150	1.835	2.360	2.838	1.754	2.265	2.671
R-S	WB	7.0	.534	.577	.724	1.082	1.232	1.443	.876	1.162	1.342	1.262	1.606	2.160	1.660	2.005	2.412	1.992	2.719	3.356	2.036	2.572	3.216
M-N	WB	7.3	.550	.612	.718	1.212	1.344	1.550	.897	1.119	1.476	1.321	1.735	2.242	1.748	2.146	2.599	2.215	2.589	3.380	2.274	2.606	3.722
U-P	EB	7.9	.573	.720	.700	.979	1.272	1.503	.886	1.126	1.440	1.398	1.720	2.006	1.706	2.104	2.490	2.241	2.909	3.538	2.132	2.490	3.230
Totals		22.2	1.657	1.909	2.142	3.273	3.848	4.496	2.659	3.407	4.258	3.981	5.061	6.408	5.114	6.255	7.501	6.451	8.217	10.274	6.442	7.668	10.168
Averages		7.4	.552	.636	.714	1.091	1.283	1.499	.886	1.136	1.419	1.327	1.687	2.136	1.705	2.085	2.500	2.150	2.739	3.425	2.147	2.556	3.389

Table 9 -- Summary of composite travel time for 7 sections with an average rate of rise and fall of 2.3 feet per 100 feet

Direction of travel	Rate rise and fall	Travel time in minutes per mile by vehicle number and pounds per net horsepower																				
		No. 1			No. 2			No. 3			No. 4			No. 5			No. 6			No. 7		
		177	211	236	250	305	369	293	372	448	313	387	465	350	445	534	358	449	534	339	421	505
	Ft/100 Ft.																					
13-14	1.9	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	2.37	1.90	1.90	1.90	1.90	2.37	2.85	1.90	1.90	2.37	1.90	2.37	2.85
4-5	2.2	1.42	1.56	1.71	1.56	1.85	1.99	1.71	1.85	2.27	1.85	1.85	2.13	1.99	2.27	2.56	1.85	2.27	2.27	2.13	2.27	2.42
5-6	2.3	1.10	1.38	1.93	1.65	1.93	1.93	1.65	2.20	2.20	1.65	1.65	2.48	1.65	2.20	2.20	1.65	1.93	2.20	1.93	2.48	2.20
2-3	2.0	1.34	1.49	1.49	1.49	1.49	1.79	1.49	1.79	2.09	1.64	1.94	2.24	1.79	2.09	2.24	1.64	1.94	2.09	1.64	1.64	2.09
A-B	2.4	1.72	1.72	1.97	1.72	1.82	2.23	1.92	1.82	2.12	1.82	1.97	2.28	2.07	2.07	2.07	1.97	2.10	2.23	2.12	2.42	2.73
7-8	2.5	1.62	1.62	1.62	1.77	1.91	2.06	1.70	1.91	2.21	1.77	2.06	2.50	2.06	2.35	2.65	2.06	2.35	2.65	1.91	2.35	2.65
I-J	2.5	1.63	1.85	2.08	1.70	1.93	2.30	2.04	2.04	2.15	1.89	2.11	2.30	2.22	2.19	2.41	1.93	2.04	2.52	2.00	2.00	2.67
Totals	15.8	10.73	11.52	12.70	11.79	12.83	14.20	12.41	13.51	15.41	12.52	13.48	15.83	13.68	15.54	16.98	13.00	14.53	16.33	13.63	15.53	17.61
Average	2.3	1.53	1.65	1.81	1.68	1.83	2.03	1.77	1.93	2.20	1.79	1.93	2.26	1.95	2.22	2.43	1.86	2.08	2.33	1.94	2.22	2.52

Table 10-- Summary of directional travel time for those sections that have a rise of 95 - 100 percent of the total rise and fall

Section	Direction of travel	Rate rise and fall	Travel time in minutes per mile by vehicle number and pounds per net horsepower																				
			No. 1			No. 2			No. 3			No. 4			No. 5			No. 6			No. 7		
			177	211	236	250	305	369	293	372	448	313	387	465	350	445	534	358	449	534	339	421	505
		Ft/100 Ft.																					
13-14	WB	1.9	1.90	1.90	1.42	1.90	2.37	2.85	1.90	1.90	2.85	2.37	2.85	2.85	2.37	3.32	3.79	2.85	2.85	3.32	2.37	2.85	4.27
2-3	EB	2.0	1.49	1.79	1.79	1.94	1.94	2.39	2.09	2.54	2.84	2.24	2.69	2.99	2.39	3.14	3.29	2.24	2.69	3.29	2.24	2.39	2.99
4-5	EB	2.2	1.71	1.85	1.99	2.13	2.42	2.70	2.27	2.56	3.13	2.56	2.42	3.13	2.70	3.27	3.70	2.70	3.27	3.41	2.70	2.27	3.55
5-6	WB	2.3	1.38	1.93	1.93	1.93	2.48	2.48	1.93	2.48	3.31	2.20	2.48	3.03	2.20	3.03	3.31	2.20	2.48	2.75	2.20	2.75	3.03
7-8	WB	2.5	1.91	2.06	2.06	2.21	2.65	2.79	2.06	2.94	3.38	2.50	2.94	3.82	2.79	3.53	3.97	2.94	3.68	4.12	2.65	3.38	4.42
Totals		10.9	8.39	9.53	9.19	10.11	11.86	13.21	10.25	12.42	15.51	11.87	13.38	15.82	12.45	16.29	18.06	12.93	14.97	16.89	12.16	13.64	18.26
Average		2.2	1.68	1.91	1.84	2.02	2.37	2.64	2.05	2.48	3.10	2.37	2.68	3.16	2.49	3.26	3.61	2.59	2.99	3.38	2.43	2.73	3.65
K-L	WB	4.8	2.88	2.88	2.88	3.84	3.84	3.84	3.84	3.84	4.81	3.84	4.81	6.72	4.81	5.77	7.69	4.81	4.81	5.77	4.81	4.81	8.65
L-M	EB	5.1	3.19	3.72	4.25	3.72	5.32	5.85	5.32	5.85	5.85	5.32	5.32	7.96	5.32	6.38	9.04	5.32	6.38	7.44	5.85	5.85	8.51
Totals		9.9	6.07	6.60	7.13	7.56	9.16	9.69	9.16	9.69	10.66	9.16	10.13	14.68	10.13	12.15	16.73	10.13	11.19	13.21	10.66	10.66	17.16
Average		4.95	3.04	3.30	3.56	3.78	4.58	4.84	4.58	4.84	5.33	4.58	5.06	7.34	5.06	6.08	8.36	5.06	5.60	6.60	5.33	5.33	8.58
H-I	WB	6.2	3.83	3.83	4.64	4.03	5.24	8.27	5.24	6.05	7.46	5.24	7.06	9.07	5.44	7.46	10.89	6.45	8.47	8.87	6.45	7.26	9.68
B-C	EB	6.3	3.73	4.48	4.73	4.98	6.22	7.22	6.22	7.22	7.71	5.97	7.47	9.21	6.97	8.46	10.96	7.22	9.21	10.70	6.72	8.71	11.46
C-D	WB	6.4	3.32	4.14	4.97	4.14	5.39	9.12	5.39	5.80	6.63	5.80	6.63	7.46	6.22	7.05	9.94	7.05	7.46	8.70	5.80	7.46	9.54
G-R	EB	6.6	3.61	4.44	5.27	3.69	5.55	6.66	6.11	6.66	8.03	5.27	6.94	8.03	6.94	8.03	10.54	7.22	9.44	8.60	7.22	7.77	9.44
Totals		25.5	14.49	16.89	19.61	17.04	22.40	31.27	22.96	25.73	29.83	22.28	28.10	33.77	25.57	31.00	42.33	27.94	34.58	36.87	26.19	31.20	40.12
Average		6.4	3.62	4.22	4.90	4.26	5.60	7.82	5.74	6.43	7.46	5.57	7.02	8.44	6.39	7.75	10.58	6.98	8.64	9.22	6.55	7.80	10.03
R-S	WB	7.0	4.12	4.38	4.89	5.41	6.44	8.25	5.92	6.96	8.76	6.18	7.73	9.80	7.73	8.76	11.86	7.47	10.31	10.31	7.22	7.98	11.09
M-N	WB	7.3	3.97	4.63	5.96	4.96	6.62	11.26	6.29	6.95	8.60	6.29	7.94	9.93	6.95	9.26	11.58	8.60	9.93	9.93	9.93	8.60	11.26
O-P	EB	7.9	4.19	4.89	6.29	5.59	5.59	8.39	6.99	7.69	8.39	7.69	8.39	9.09	6.99	8.39	11.88	8.39	9.79	11.18	7.69	8.39	10.48
Totals		22.2	12.28	13.90	17.14	15.96	18.65	27.90	19.20	21.60	25.75	20.16	24.06	28.82	21.67	26.41	35.32	24.46	30.03	31.42	24.84	24.97	32.83
Average		7.4	4.09	4.63	5.71	5.32	6.22	9.30	6.40	7.20	8.58	6.72	8.02	9.61	7.22	8.80	11.77	8.15	10.01	10.47	8.28	8.32	10.94

Table 11 -- Comparison of the composite travel time of commercial vehicles actually observed on sections of US 40 in Maryland with that obtained from figure 23

Group	Weight-Power Ratio: Average 1/		Travel time in minutes per mile			
			Old US 40 2/		New US 40 3/	
	Old US40	New US40	Actual	Figure 23	Actual	Figure 23
lbs/max. HP	lbs/Net HP	lbs/Net HP				
100 - 149	141	138	2.1	1.7	1.7	1.6
150 - 199	191	188	2.2	2.0	1.8	1.8
200 - 249	246	242	2.4	2.3	2.1	2.1
250 - 299	304	296	2.5	2.6	2.4	2.4
300 - 349	364	360	2.7	3.0	2.5	2.7
350 - 399	416	414	2.9	3.3	2.7	3.0

1/ Computed from pounds per maximum horsepower on basis that net horsepower is 90 percent of the maximum horsepower

2/ Rate of rise and fall of 4.1

3/ Rate of rise and fall of 3.7

Table 12 -- Comparison of the composite gasoline consumption determined by the Oregon State Highway Department with that obtained from figure 8

Gross Weight	Composite gasoline consumption for rates of rise and fall of --					
	0		3.0		6.0	
	Oregon	Figure 8	Oregon	Figure 8	Oregon	Figure 8
pounds						
10,000	0.09	.09	0.10	.09	0.13	.13
20,000	0.15	.12	0.17	.16	0.26	.24
30,000	0.20	.14	0.24	.21	0.37	.35
40,000	0.24	.16	0.30	.26	0.48	.46
50,000	0.28	.18	0.36	.31	0.60	.56
60,000	0.32	.19	0.41	.36	0.71	.66

Table 13.—Gasoline saved daily by commercial vehicle traffic using Route B instead of Route A

Assumptions: (1) Annual average daily traffic of 9,000 on each route
(2) Commercial vehicles 16 percent of annual daily traffic
(3) Gross weight characteristics similar to those on U S 40 in Maryland

Gross weight		Percentage of total vehicles	Number of vehicles	Composite gasoline 1/ consumption			Total 2/ gasoline saved per vehicle	Total gasoline saved all vehicles
Group	Average			Route A	Route B	Saving		
1000 lbs	pounds			gal./mile	gal./mile	gal./mile	gallons	gallons
5-14.9	9,800	37.9	545	0.10	0.09	0.01	1.00	545
15-24.9	19,600	33.7	485	0.17	0.14	0.03	3.00	1,455
25-34.9	29,300	12.2	176	0.23	0.19	0.04	4.00	704
35-44.9	41,000	7.7	111	0.30	0.24	0.06	6.00	666
45-54.9	48,300	6.3	91	0.34	0.27	0.07	7.00	637
55 & over	59,900	2.2	32	0.41	0.32	0.09	9.00	288
Totals		100.0	1,440					4,295

1/ Route A has rate of rise and fall of 3.7; Route B has rate of rise and fall of 2.3.

2/ For 100-mile section of each route

Table 14.--Time saved daily by commercial vehicle traffic using Route B instead of Route A

Assumptions: (1) Annual average daily traffic of 9,000 on each route
(2) Commercial vehicles 16 percent of annual average daily traffic
(3) Weight-power characteristics similar to those on U S 40 in Maryland

Weight-Power ratio		Percentage of total vehicles	Number of vehicles	Composite travel 2/ time			Total 3/ time saved per vehicle	Total time saved all vehicles
Group	Average 1/			Route A	Route B	Saving		
lbs/max HP	lbs/net HP			min/mile	min/mile	min/mile	minutes	minutes
0-99	91	18.9	272	1.35	1.20	0.15	15.0	4,080
100-149	140	20.1	290	1.60	1.35	0.25	25.0	7,250
150-199	191	23.7	341	1.85	1.50	0.35	35.0	11,935
200-249	246	12.6	182	2.15	1.60	0.55	55.0	10,010
250-299	303	6.8	98	2.40	1.75	0.65	65.0	6,370
300-349	364	7.8	112	2.70	1.90	0.80	80.0	8,960
350-399	406	5.7	82	2.90	2.00	0.90	90.0	7,380
400-499	488	3.7	53	3.30	2.20	1.10	110.0	5,830
Over 500	595	.7	10	3.85	2.45	1.40	140.0	1,400
Totals		100.0	1,440					63,215 (1054 hrs.)

1/ Computed from pounds per maximum horsepower on basis that net horsepower is 90 percent of the maximum horsepower.

2/ Route A has rate of rise and fall of 3.7; Route B has rate of rise and fall of 2.3.

3/ For 100-mile section of each route.

Table 15.--Computation form for using the results for composite gasoline consumption and travel time to determine the operating economy in terms of ton-miles per gallon and ton-miles per hour for any commercial vehicle

Item No.	Items	Units	Values
1	Total rise and fall of highway	feet	Obtained from profile map or by altimeter
2	Length of highway	feet	Obtained from profile map or calibrated odometer
3	Rate of rise and fall of highway	ft./100 ft.	Item 1 times 100 divided by Item 2
4	Type of vehicle or combination		Type being studied
5	Net engine horsepower	hp.	Obtained from mfgrs. specifications
6	Empty (tare) weight	pounds	From scale
7 a	Payload (net) weight	pounds	Assumed
b		tons	Item 7a divided by 2000
8 a	Gross vehicle or combination weight	pounds	Item 6 plus Item 7a
b		tons	Item 8a divided by 2000
9	Weight-power ratio	lbs./net hp.	Item 8a divided by Item 5
10 a	Gasoline consumption	gal./mile	Read from figure 8 for Items 3 and 8a
b		mile/gal.	1 divided by Item 10a
11 a	Travel time	min./mile	Read from figure 23 for Items 3 and 9
b		miles/hour	60 divided by Item 11a
12 a	Gross ton-miles per gallon		Item 8b times Item 10b
b	Payload ton-miles per gallon		Item 7b times Item 10b
13 a	Gross ton-miles per hour		Item 8b times Item 11b
b	Payload ton-miles per hour		Item 7b times Item 11b

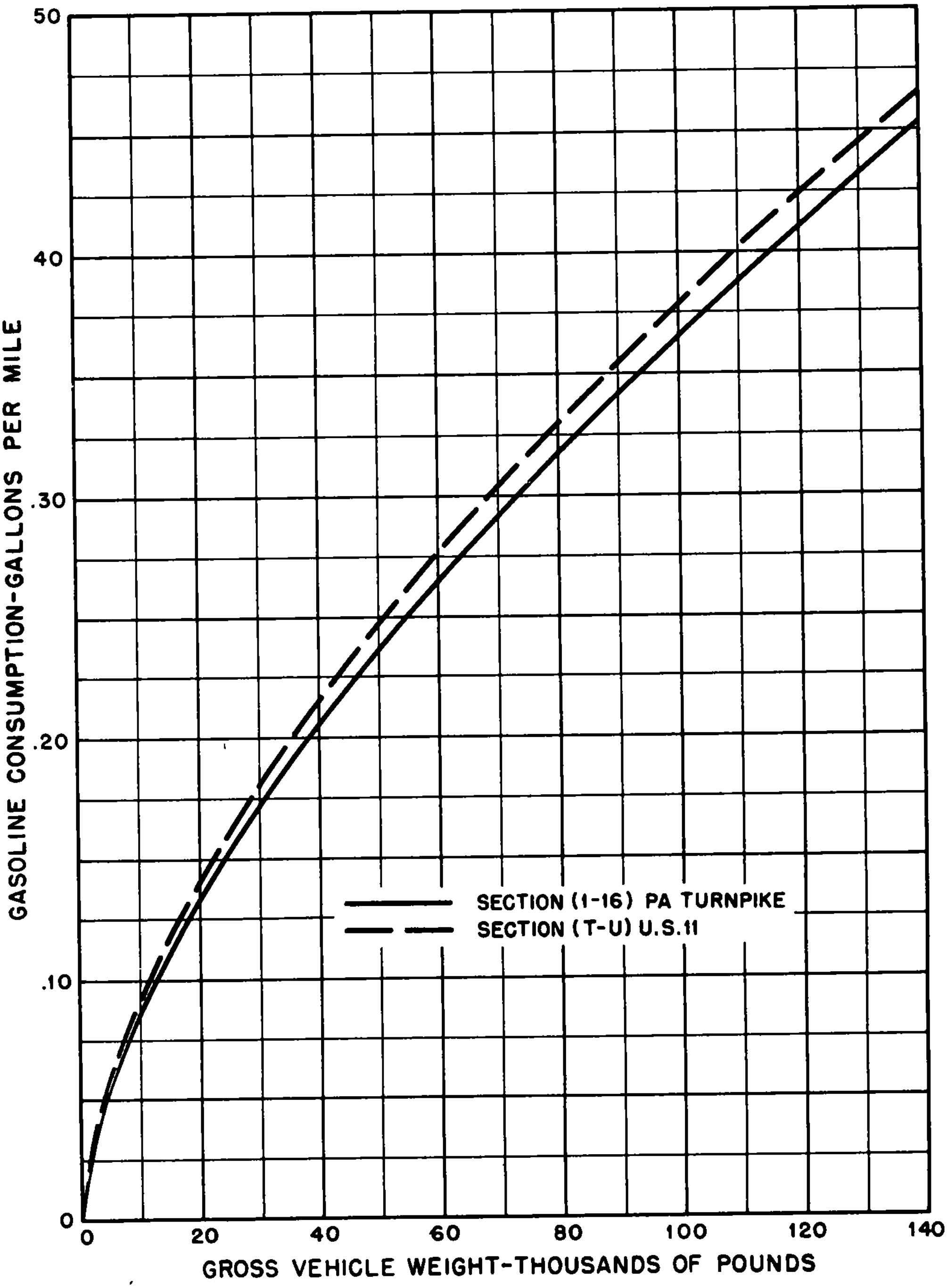

FIGURE 2-COMPARISON OF COMPOSITE GASOLINE CONSUMPTION FOR THE PENNSYLVANIA TURNPIKE AND FOR A SECTION OF U.S. 11, EACH WITH A RATE OF RISE AND FALL OF 1.4 FEET PER 100 FEET

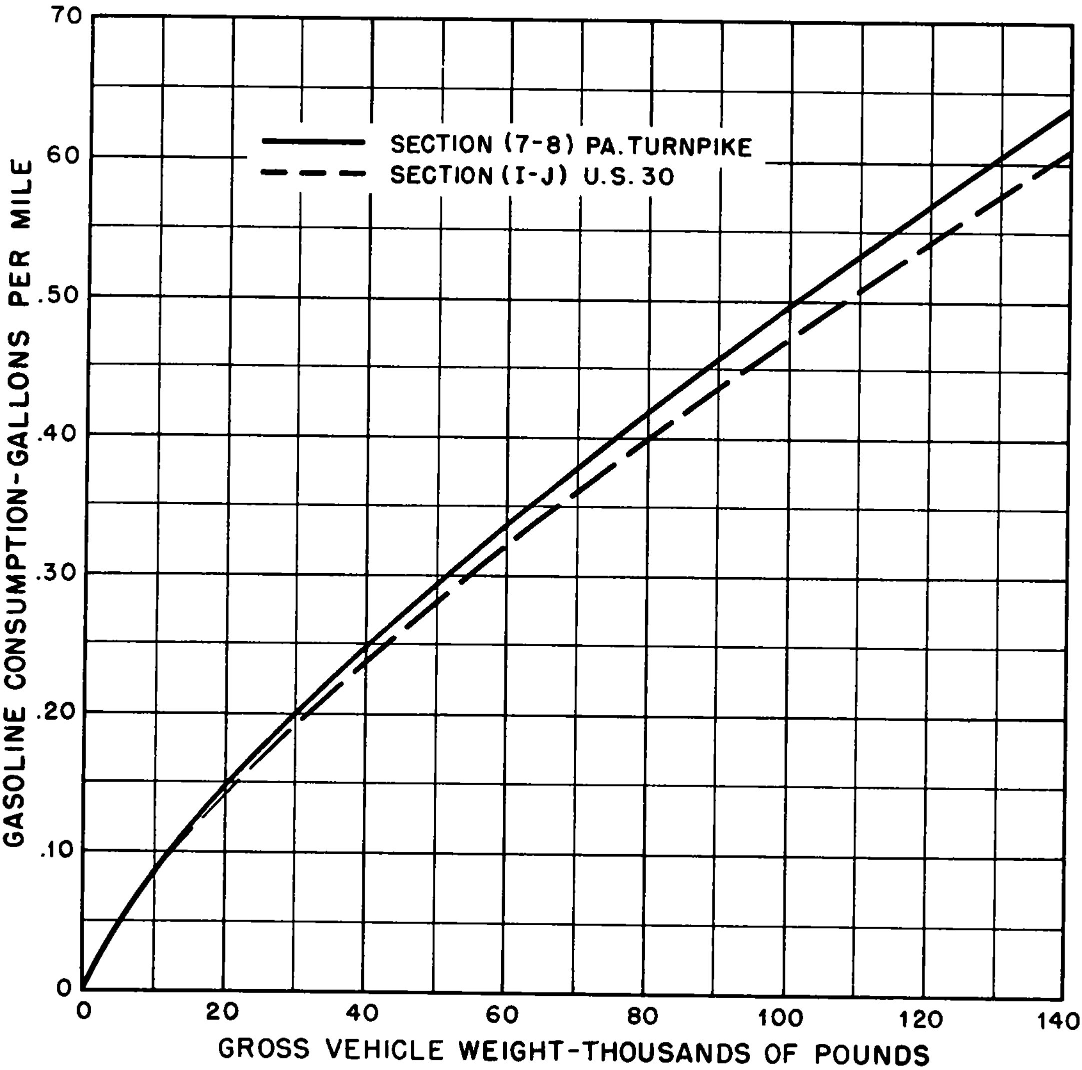

FIGURE 3-COMPARISON OF THE COMPOSITE GASOLINE CONSUMPTION FOR A SECTION OF THE PENNSYLVANIA TURNPIKE AND FOR A SECTION OF U.S. 30, EACH WITH A RATE OF RISE AND FALL OF 2.5 FEET PER 100 FEET

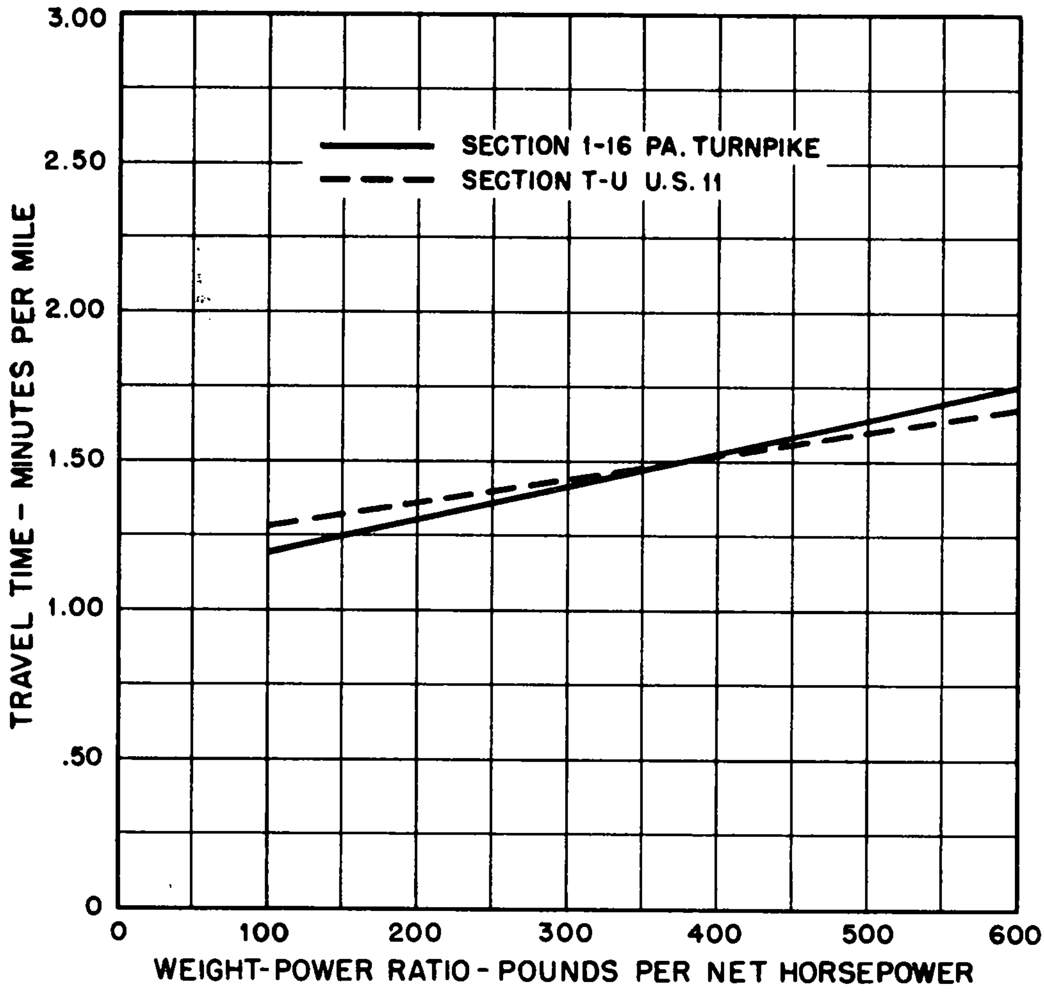

FIGURE 4 - COMPARISON OF THE COMPOSITE TRAVEL TIMES FOR THE PENNSYLVANIA TURNPIKE AND FOR A SECTION OF U.S. 11, EACH WITH A RATE OF RISE AND FALL OF 1.4 FEET PER 100 FEET

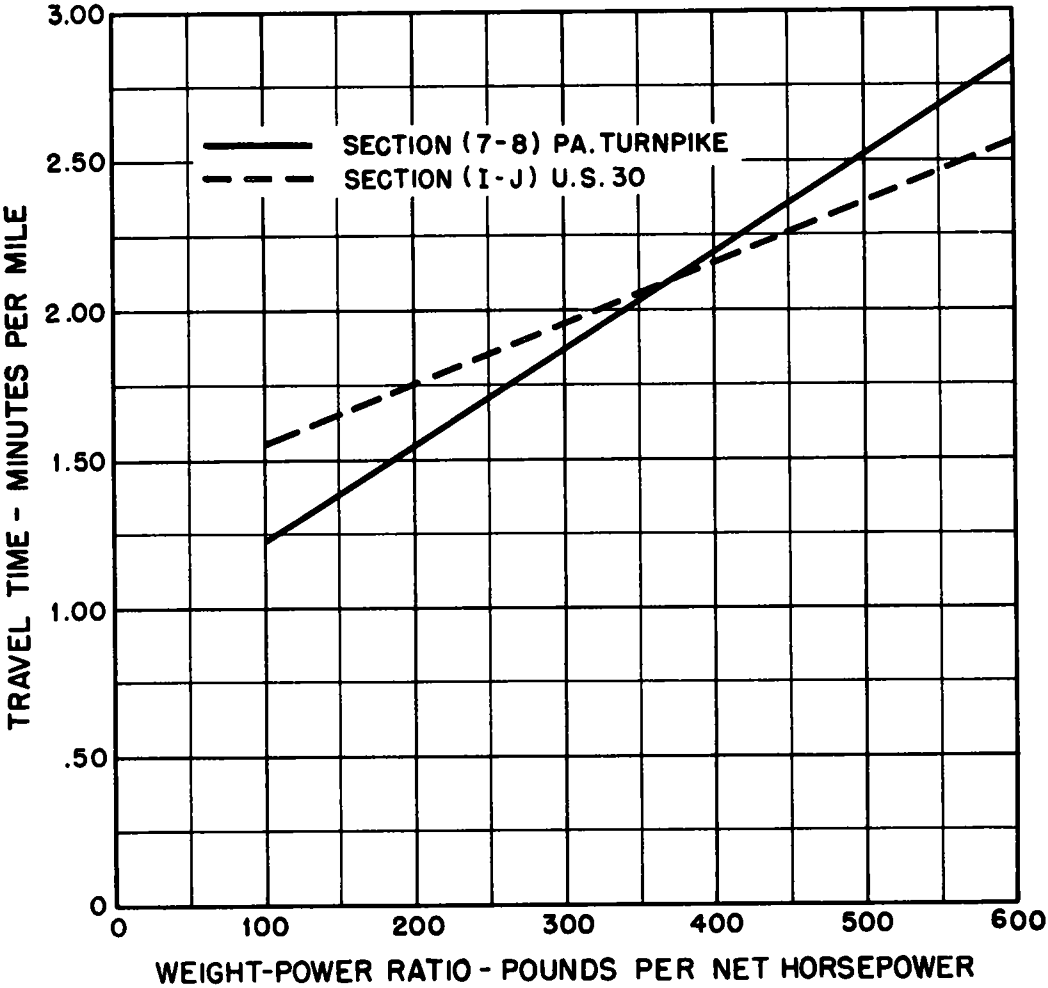

FIGURE 5 - COMPARISON OF THE COMPOSITE TRAVEL TIMES FOR A SECTION OF THE PENNSYLVANIA TURNPIKE AND FOR A SECTION OF U.S. 30 EACH WITH A RATE OF RISE AND FALL OF 2.5 FEET PER 100 FEET

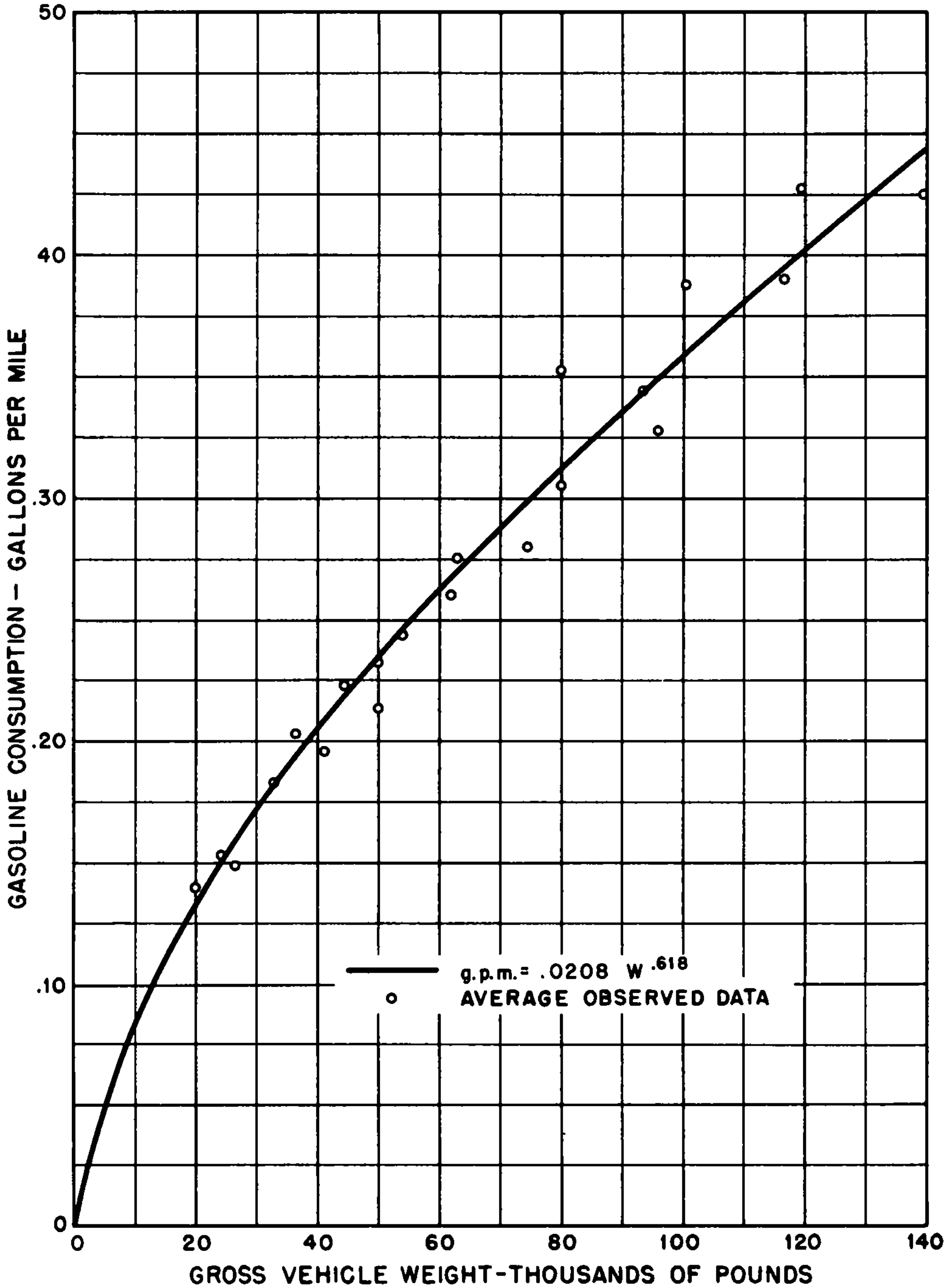

FIGURE 6-COMPOSITE GASOLINE CONSUMPTION FOR 13 SECTIONS WITH AN AVERAGE RATE OF RISE AND FALL OF 1.3 FEET PER 100 FEET RELATED TO GROSS VEHICLE WEIGHT

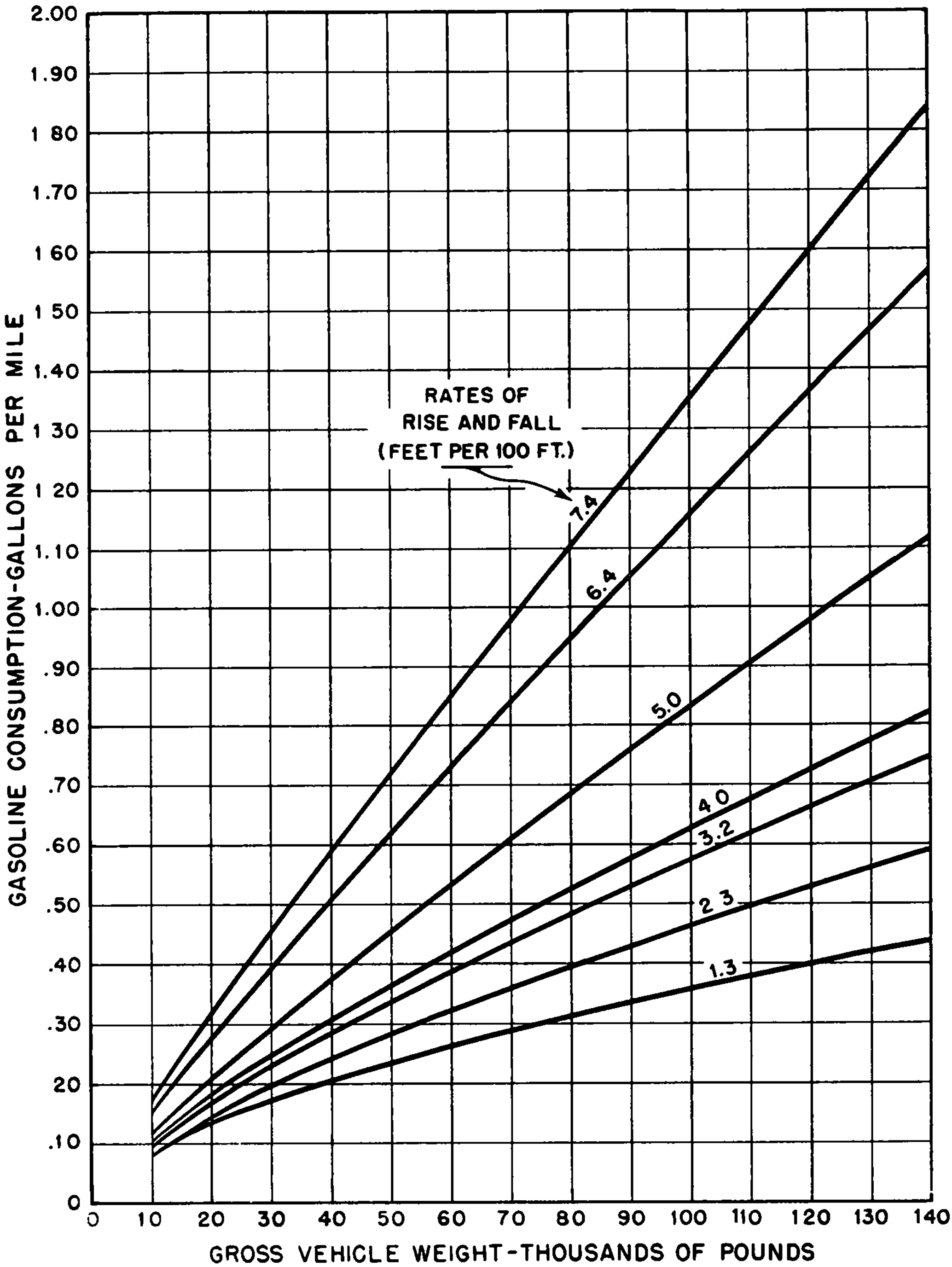

FIGURE 7 - COMPOSITE GASOLINE CONSUMPTION FOR VARIOUS RATES OF RISE AND FALL RELATED TO THE GROSS VEHICLE WEIGHT

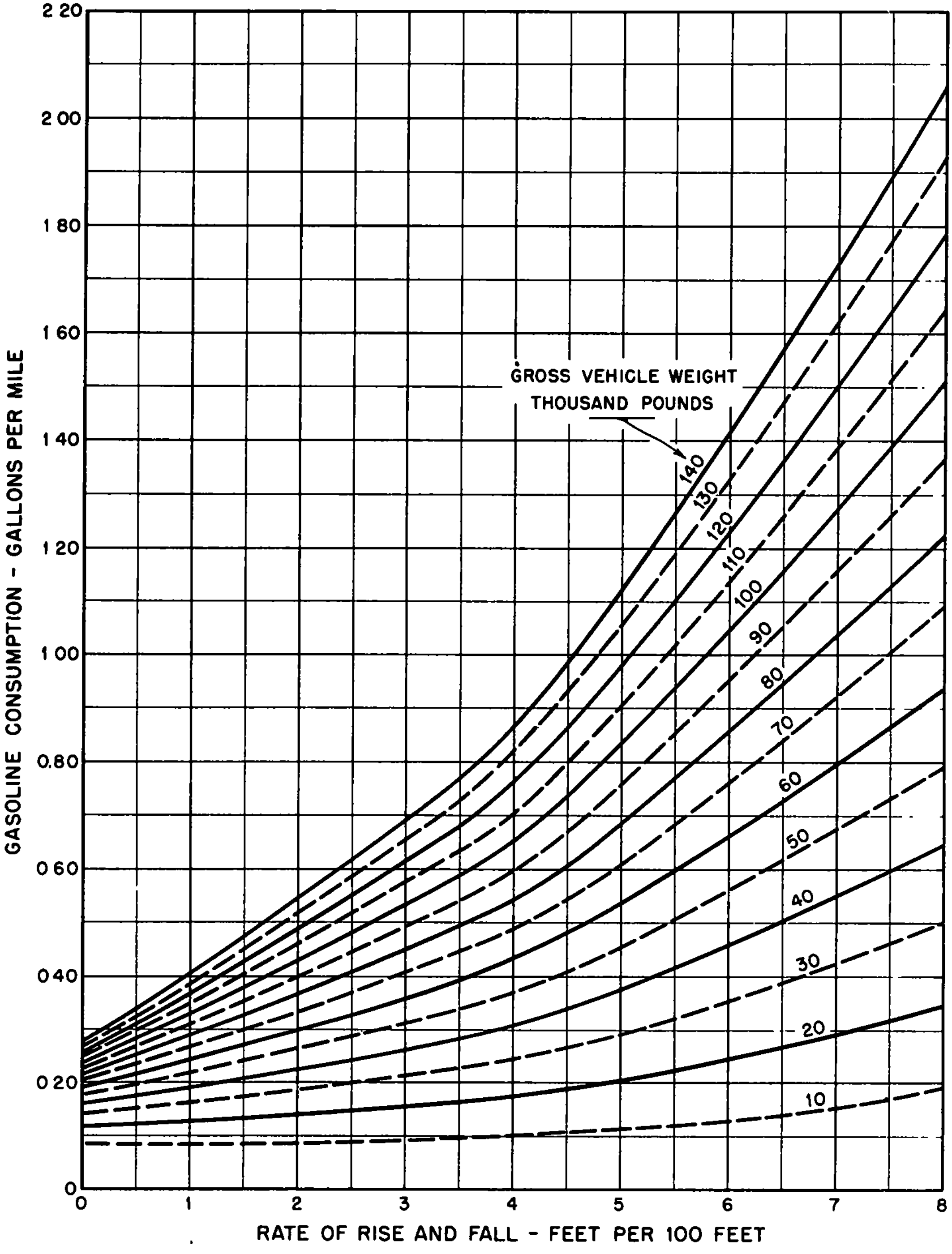

FIGURE 8-COMPOSITE GASOLINE CONSUMPTION FOR VARIOUS GROSS WEIGHTS RELATED TO THE RATE OF RISE AND FALL (ALSO GASOLINE CONSUMPTION WHEN RISE IS 45-54 PERCENT OF TOTAL RISE AND FALL)

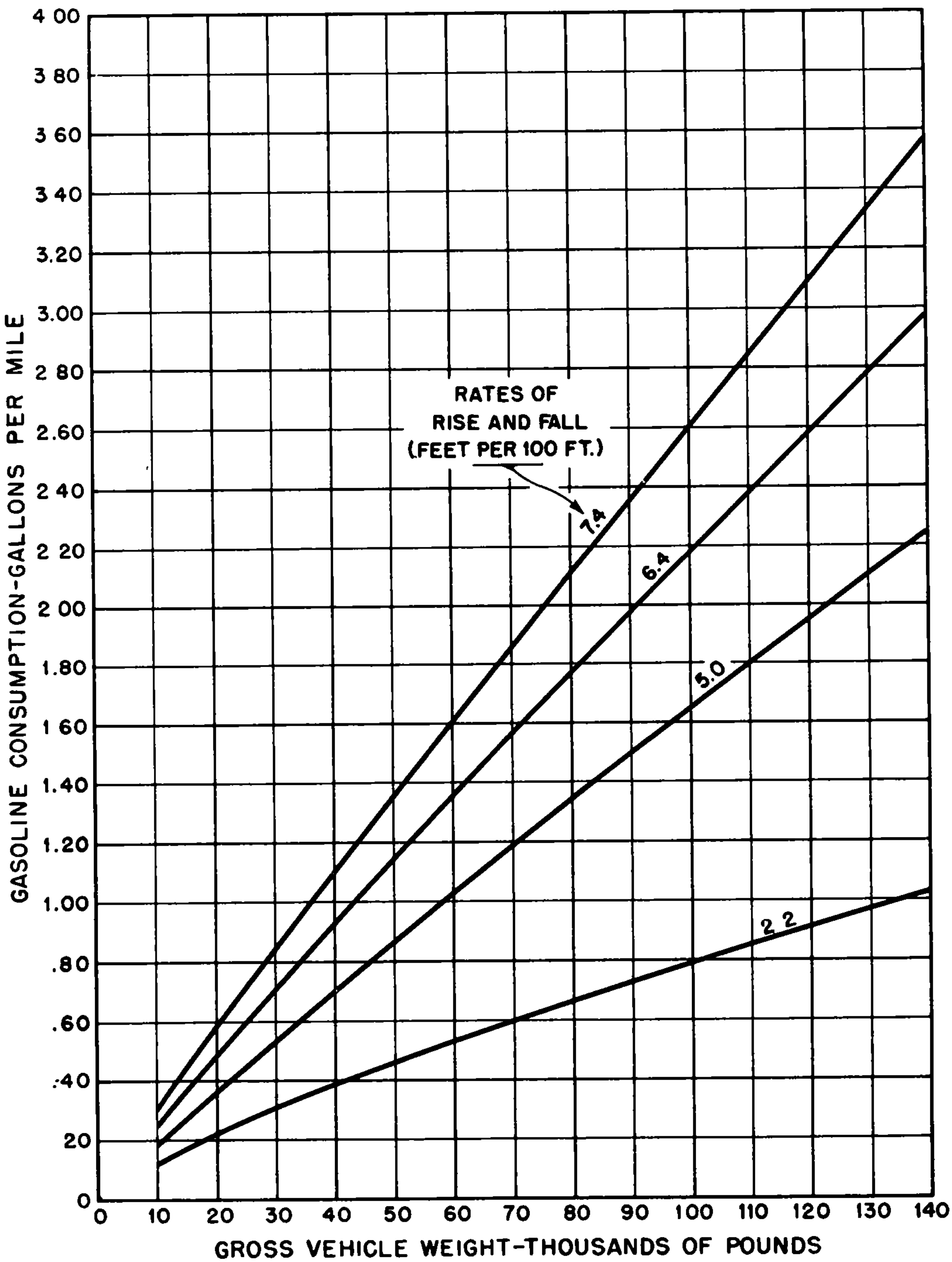

FIGURE 9-DIRECTIONAL GASOLINE CONSUMPTION FOR VARIOUS RATES OF RISE AND FALL RELATED TO GROSS VEHICLE WEIGHT WHEN THE RISE IS 95-100 PERCENT OF THE TOTAL RISE AND FALL

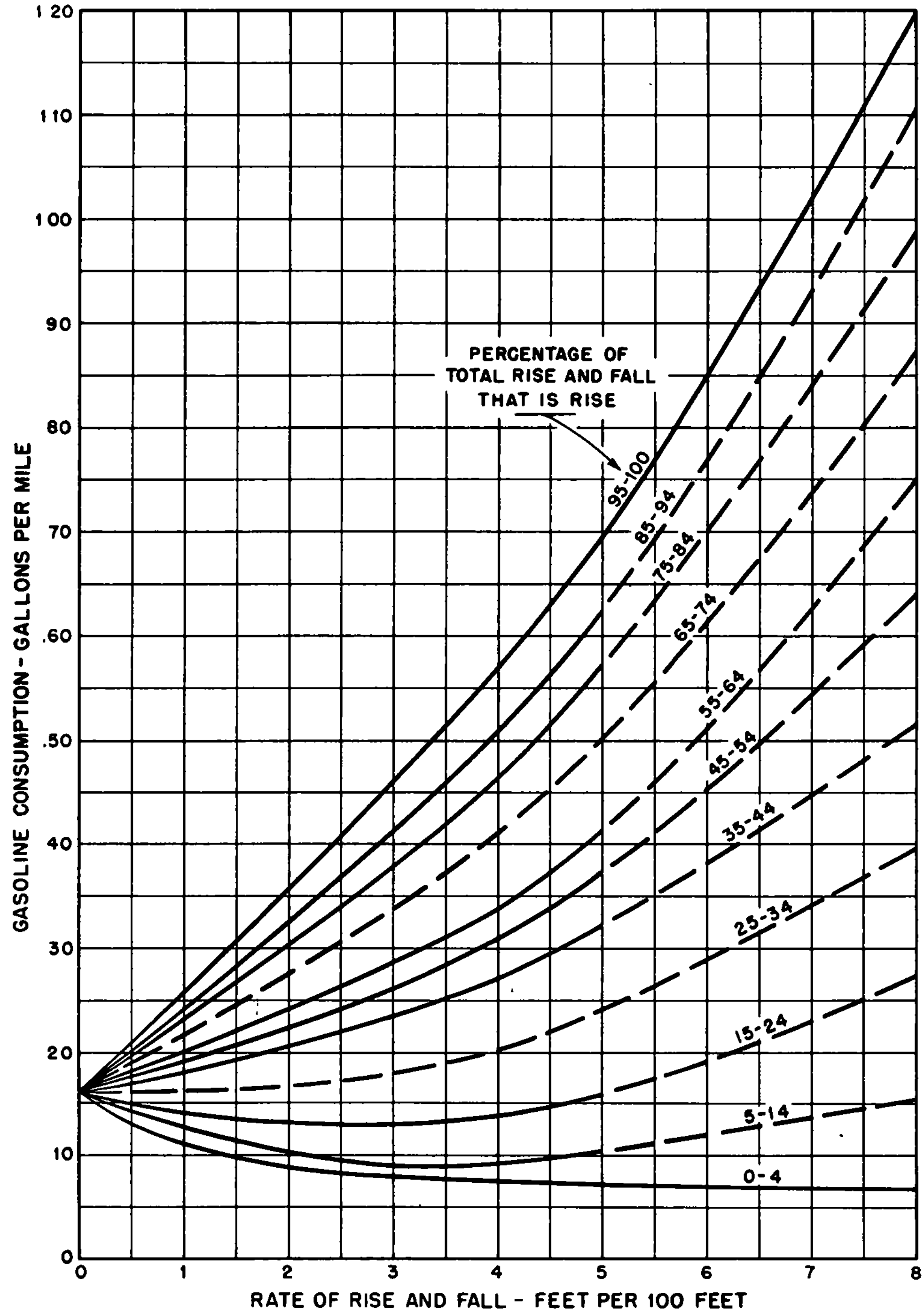

FIGURE 10-DIRECTIONAL GASOLINE CONSUMPTION RELATED TO THE RATE OF RISE AND FALL FOR A GROSS VEHICLE WEIGHT OF 40,000 POUNDS WHEN THE RISE IS VARIOUS PERCENTAGES OF THE TOTAL RISE AND FALL

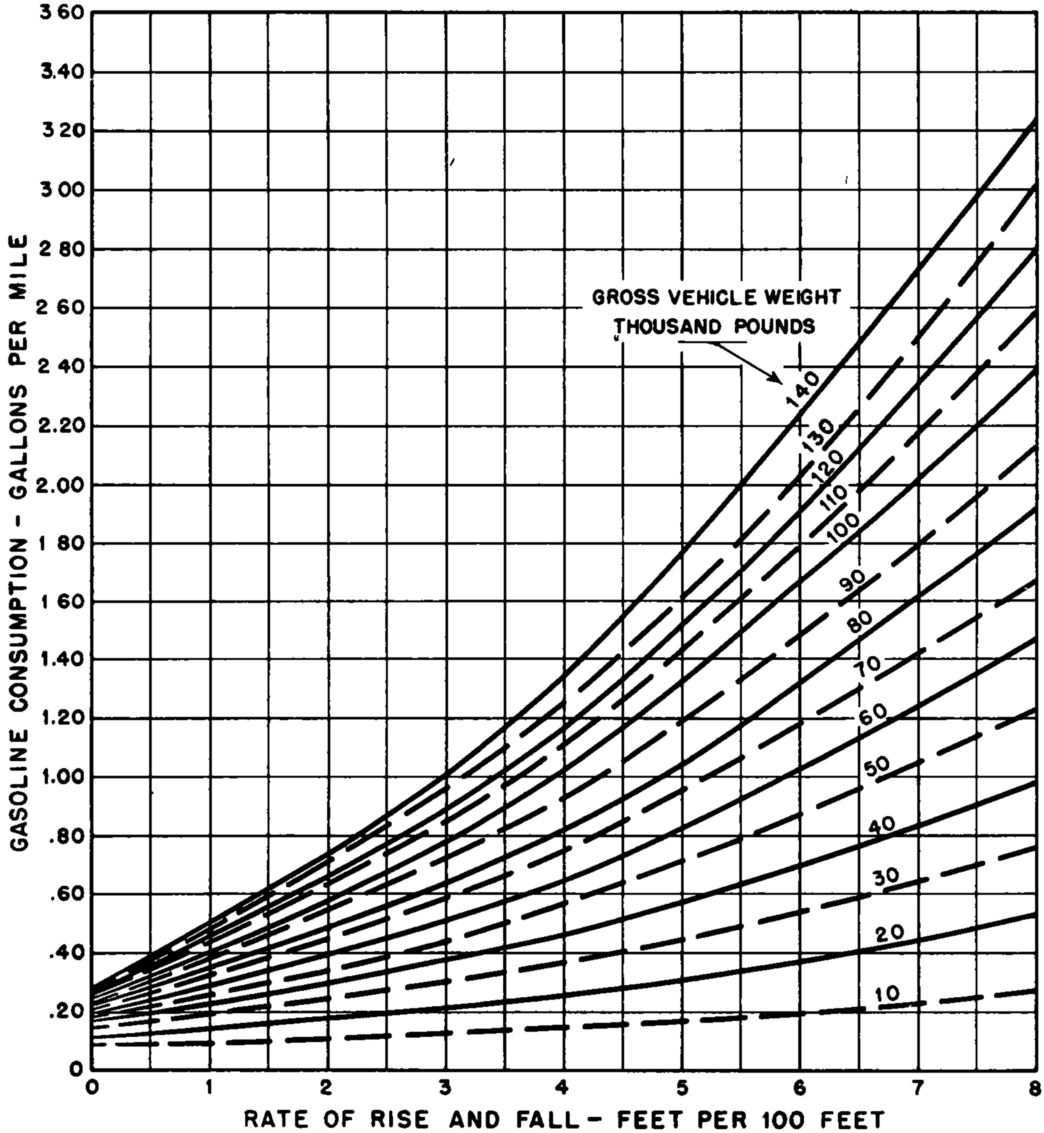

FIGURE 13 - DIRECTIONAL GASOLINE CONSUMPTION FOR VARIOUS GROSS VEHICLE WEIGHTS RELATED TO THE RATE OF RISE AND FALL WHEN THE RISE IS 75-84 PERCENT OF THE TOTAL RISE AND FALL

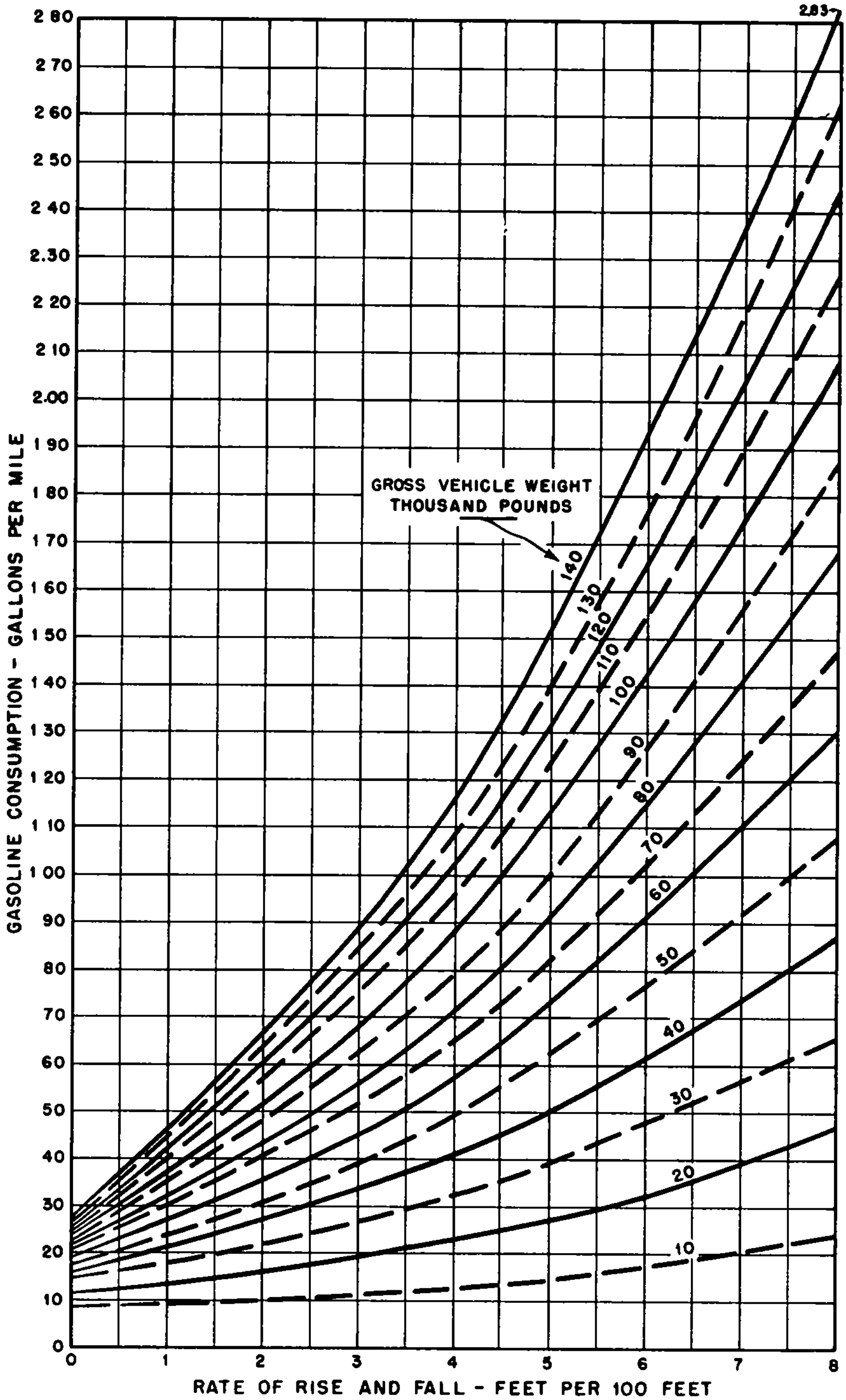

FIGURE 14 - DIRECTIONAL GASOLINE CONSUMPTION FOR VARIOUS GROSS VEHICLE WEIGHTS RELATED TO THE RATE OF RISE AND FALL WHEN THE RISE IS 65-74 PERCENT OF THE TOTAL RISE AND FALL

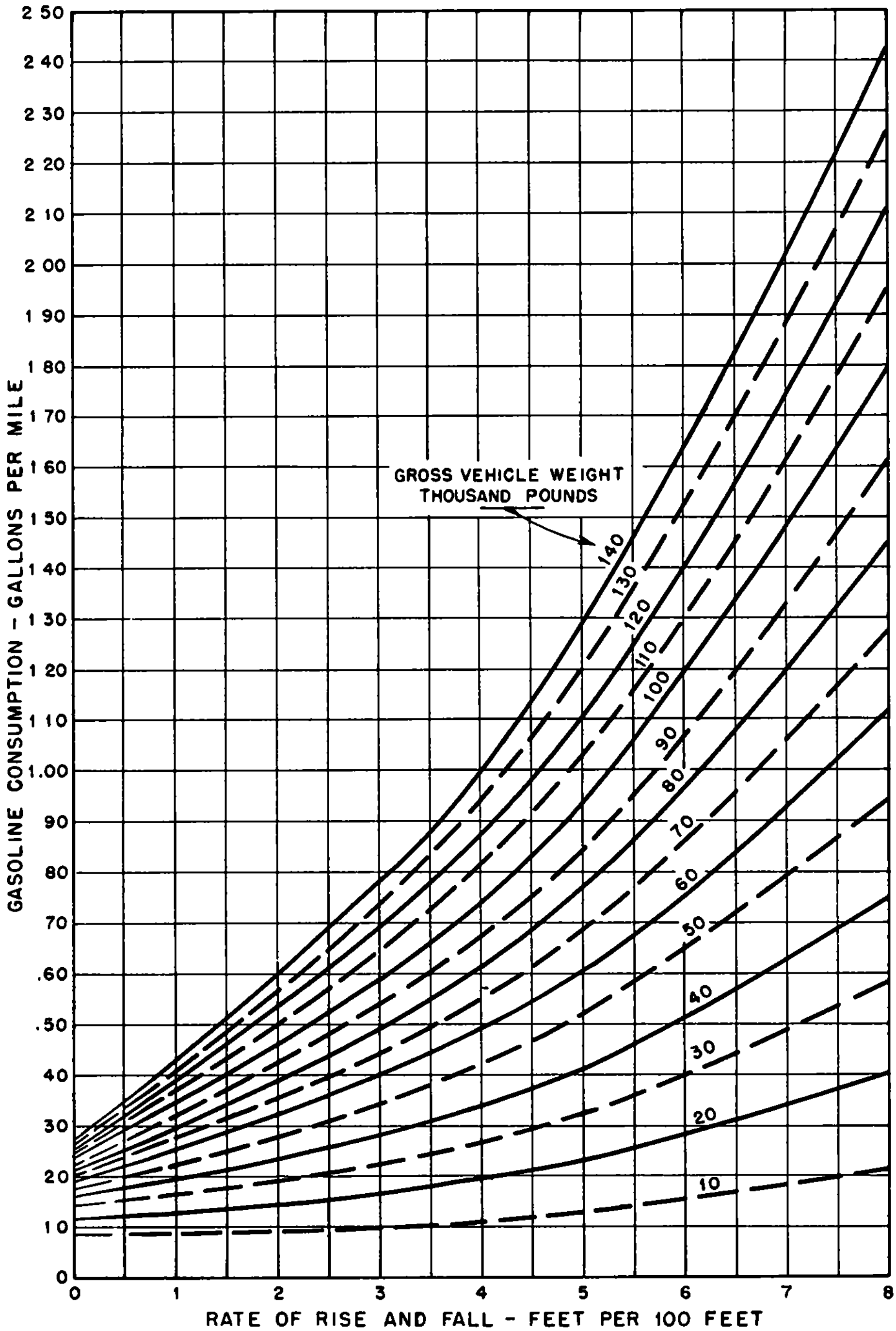

FIGURE 15 - DIRECTIONAL GASOLINE CONSUMPTION FOR VARIOUS GROSS VEHICLE WEIGHTS RELATED TO THE RATE OF RISE AND FALL WHEN THE RISE IS 55-64 PERCENT OF THE TOTAL RISE AND FALL

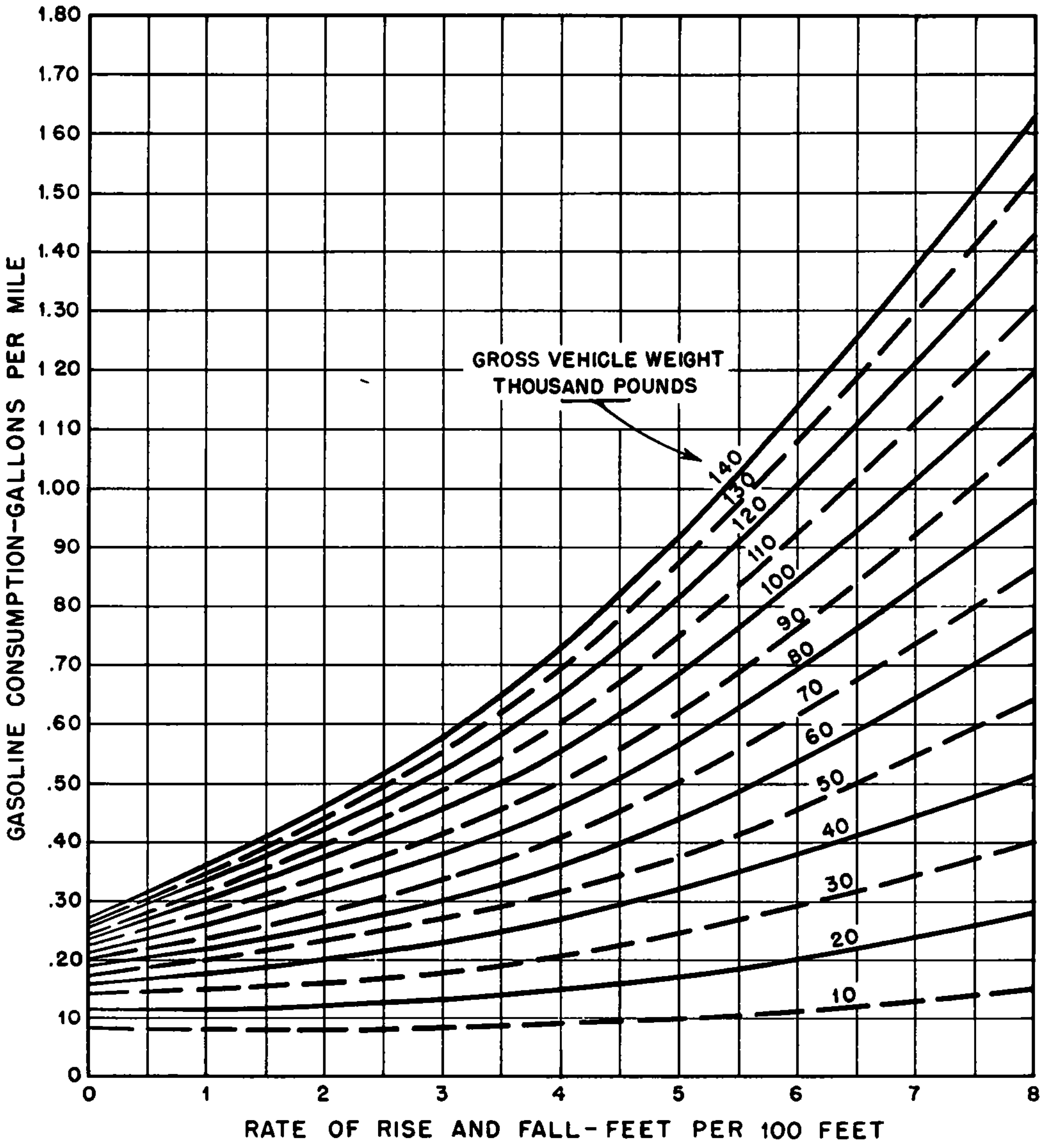

FIGURE 16 – DIRECTIONAL GASOLINE CONSUMPTION FOR VARIOUS GROSS VEHICLE WEIGHTS RELATED TO THE RATE OF RISE AND FALL WHEN THE RISE IS 35-44 PERCENT OF THE TOTAL RISE AND FALL

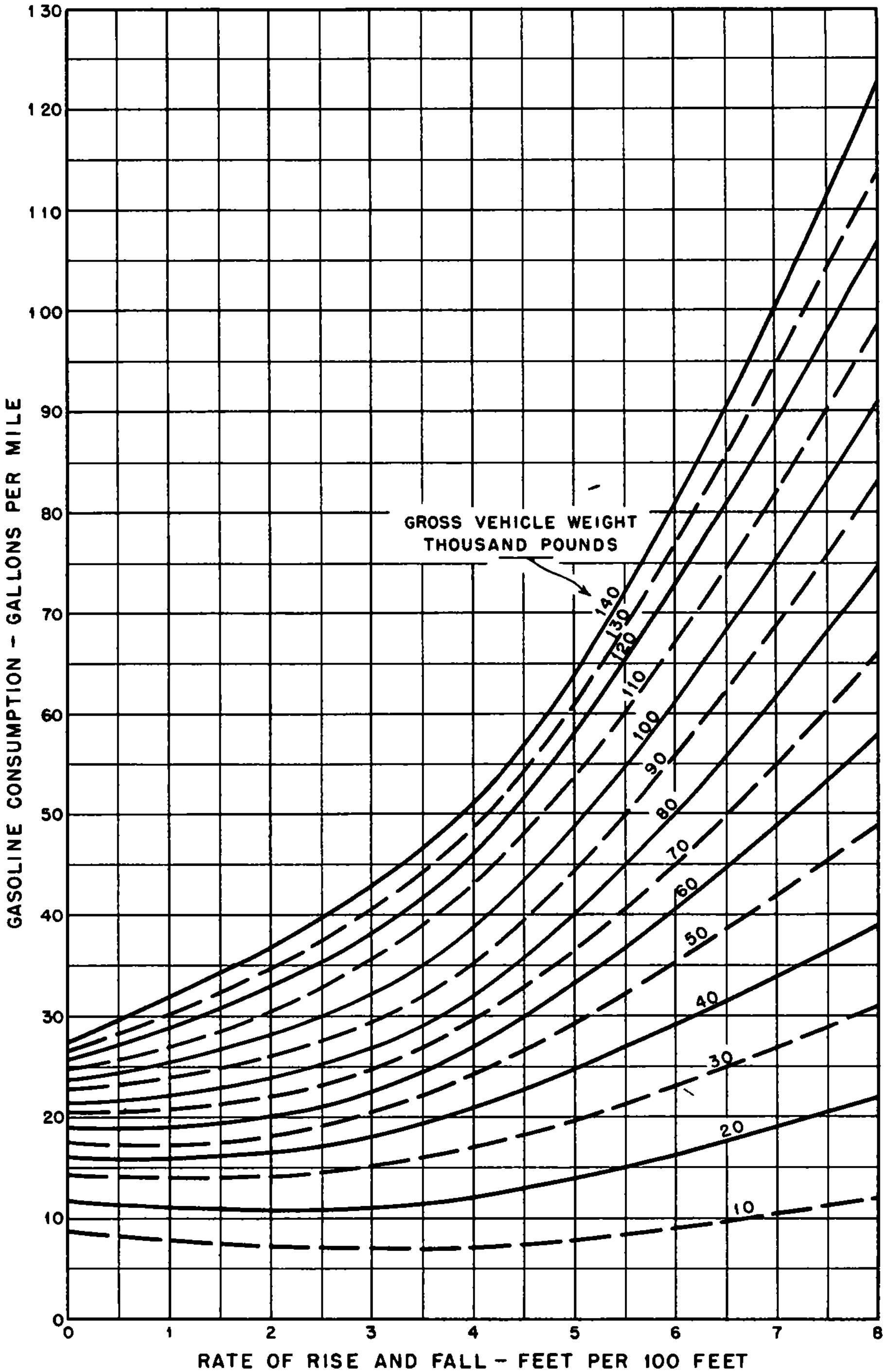

FIGURE 17 - DIRECTIONAL GASOLINE CONSUMPTION FOR VARIOUS GROSS VEHICLE WEIGHTS RELATED TO THE RATE OF RISE AND FALL WHEN THE RISE IS 25-34 PERCENT OF THE TOTAL RISE AND FALL

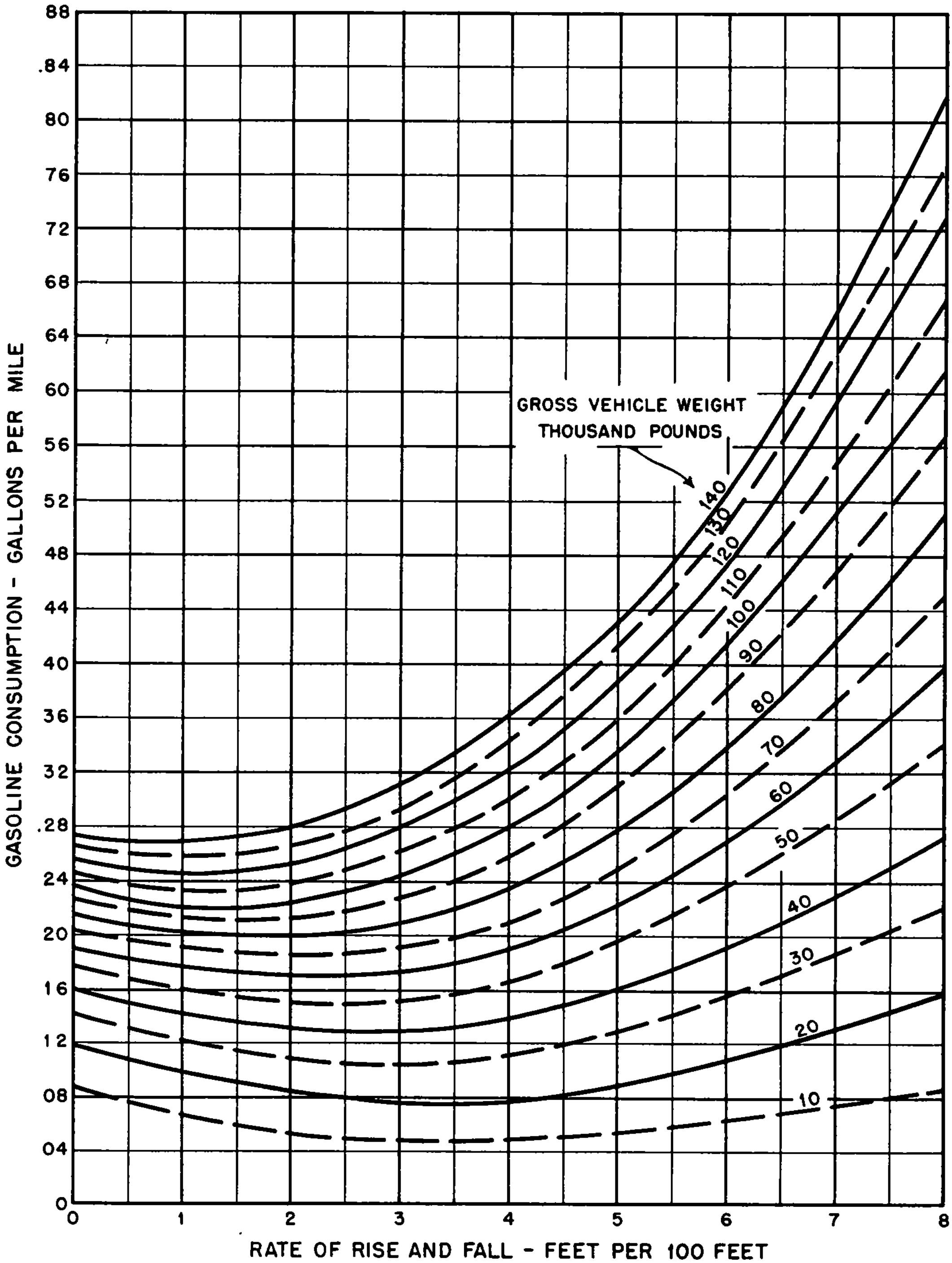

FIGURE 18 - DIRECTIONAL GASOLINE CONSUMPTION FOR VARIOUS GROSS VEHICLE WEIGHTS RELATED TO THE RATE OF RISE AND FALL WHEN THE RISE IS 15 - 24 PERCENT OF THE TOTAL RISE AND FALL

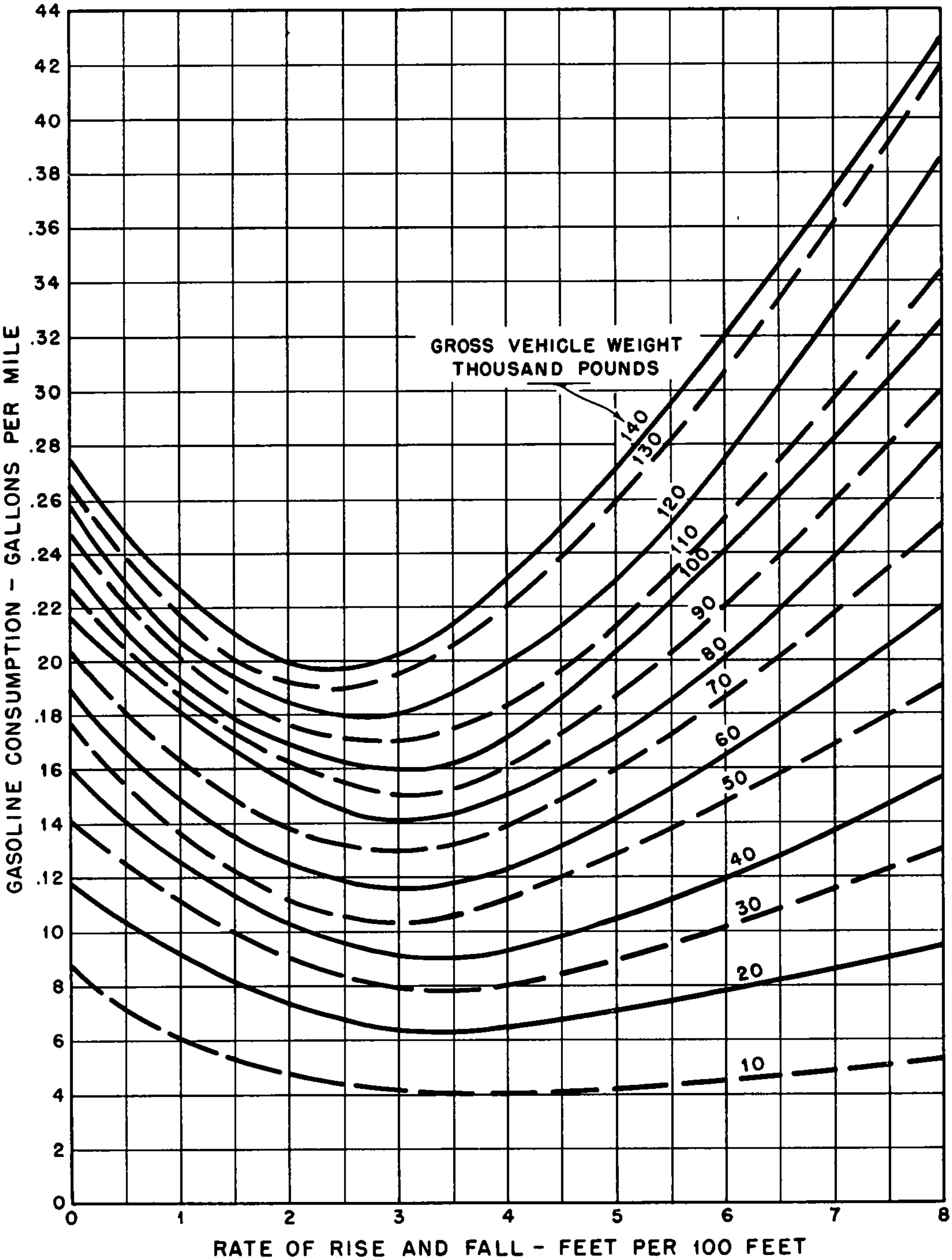

FIGURE 19 - DIRECTIONAL GASOLINE CONSUMPTION FOR VARIOUS GROSS VEHICLE WEIGHTS RELATED TO THE RATE OF RISE AND FALL WHEN THE RISE IS 5-14 PERCENT OF THE TOTAL RISE AND FALL

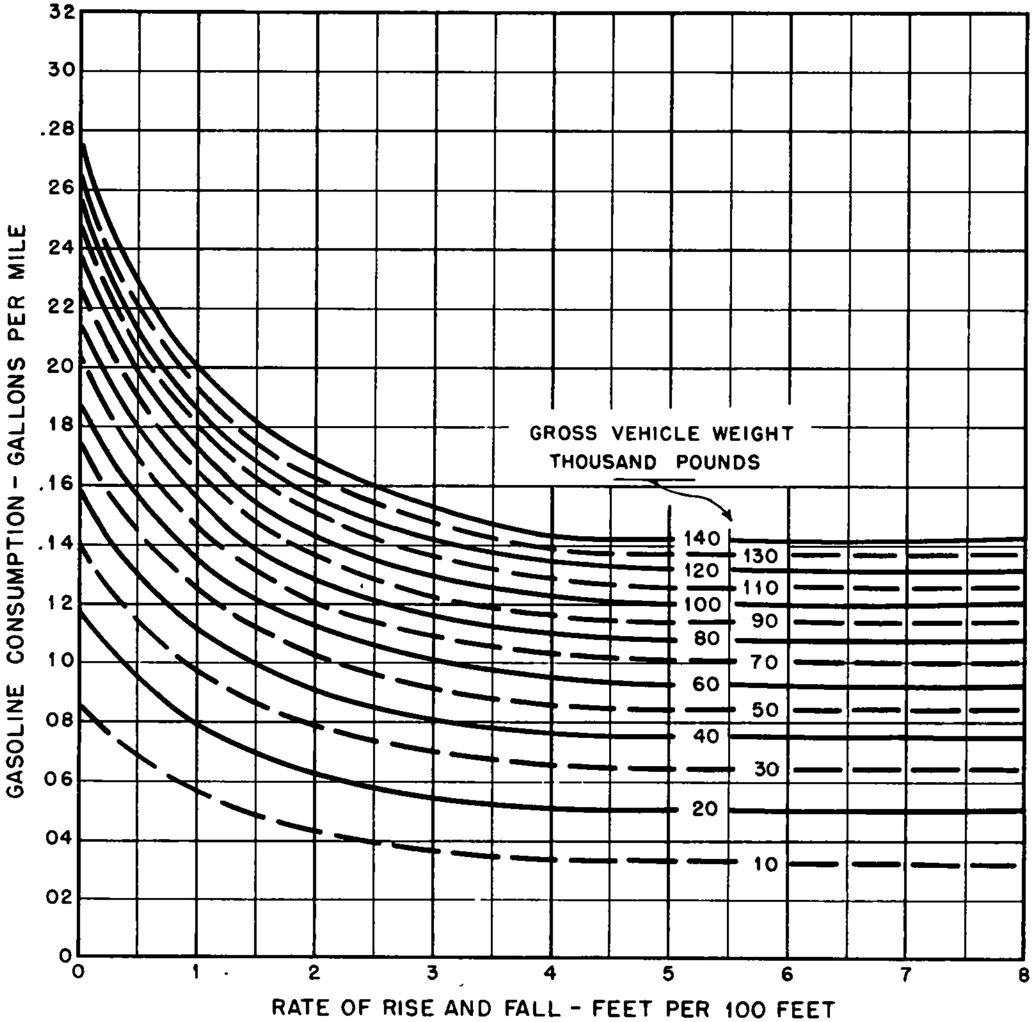

FIGURE 20 - DIRECTIONAL GASOLINE CONSUMPTION FOR VARIOUS GROSS VEHICLE WEIGHTS RELATED TO THE RATE OF RISE AND FALL WHEN THE RISE IS 0 - 4 PERCENT OF THE TOTAL RISE AND FALL

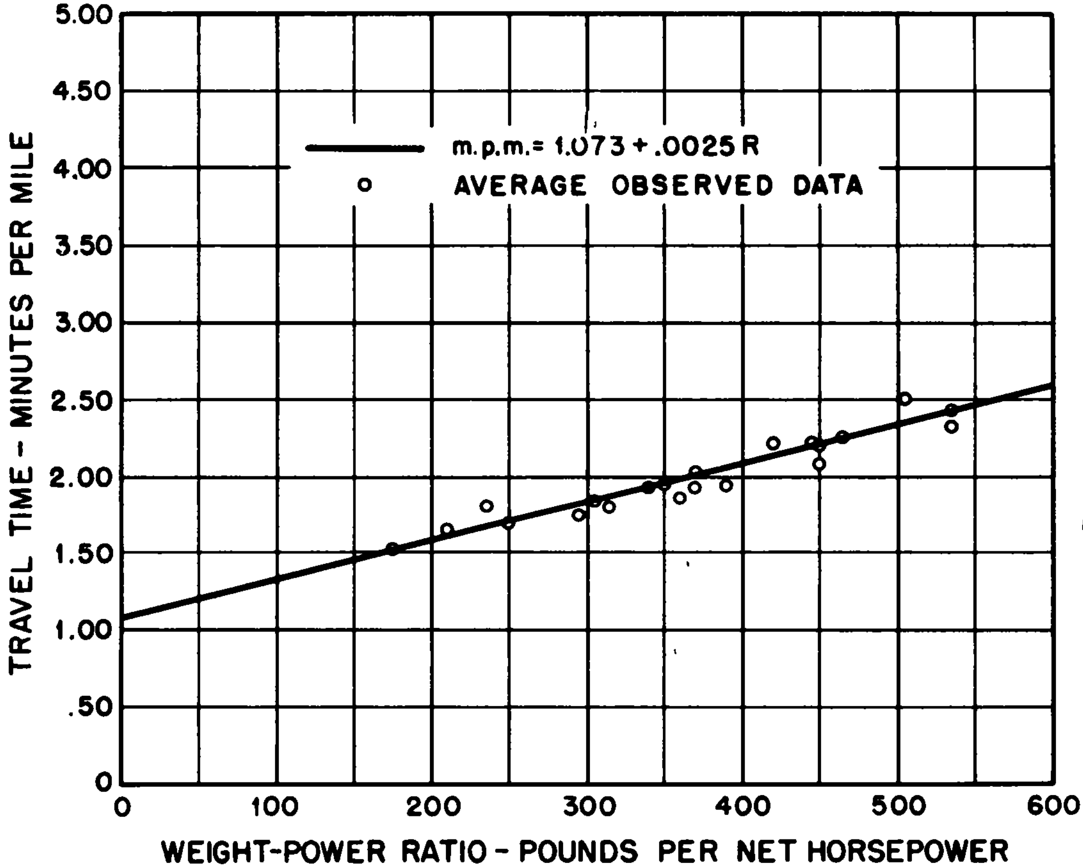

FIGURE 21 - AVERAGE COMPOSITE TRAVEL TIME FOR 7 SECTIONS WITH AN AVERAGE RATE OF RISE AND FALL OF 2.3 FEET PER 100 FEET RELATED TO THE WEIGHT-POWER RATIO

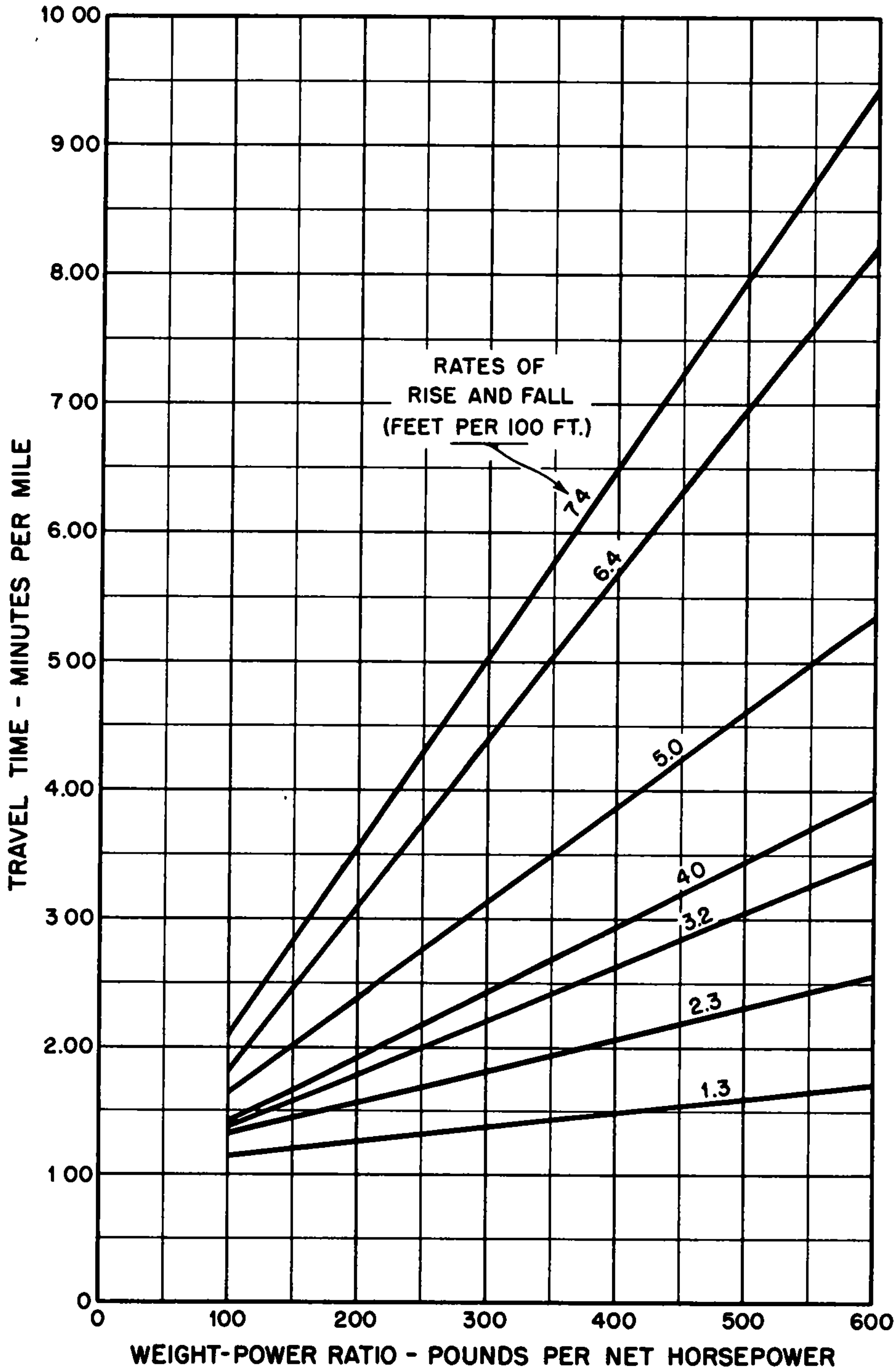

FIGURE 22 - COMPOSITE TRAVEL TIME FOR VARIOUS RATES OF RISE AND FALL RELATED TO THE WEIGHT-POWER RATIO

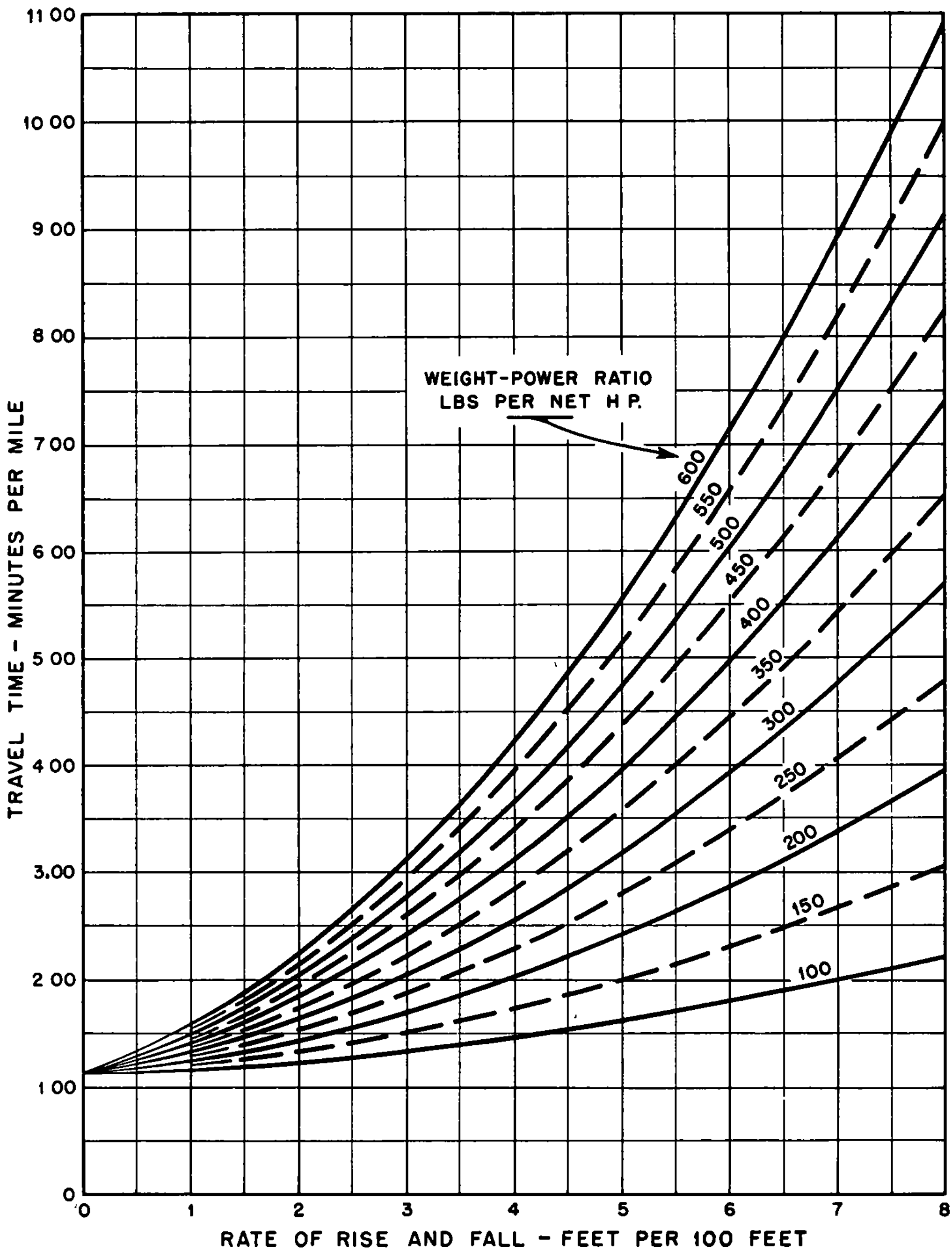

FIGURE 23 - COMPOSITE TRAVEL TIME FOR VARIOUS WEIGHT-POWER RATIOS RELATED TO THE RATE OF RISE AND FALL (ALSO TRAVEL TIME WHEN RISE IS 45-54 PERCENT OF TOTAL RISE AND FALL)

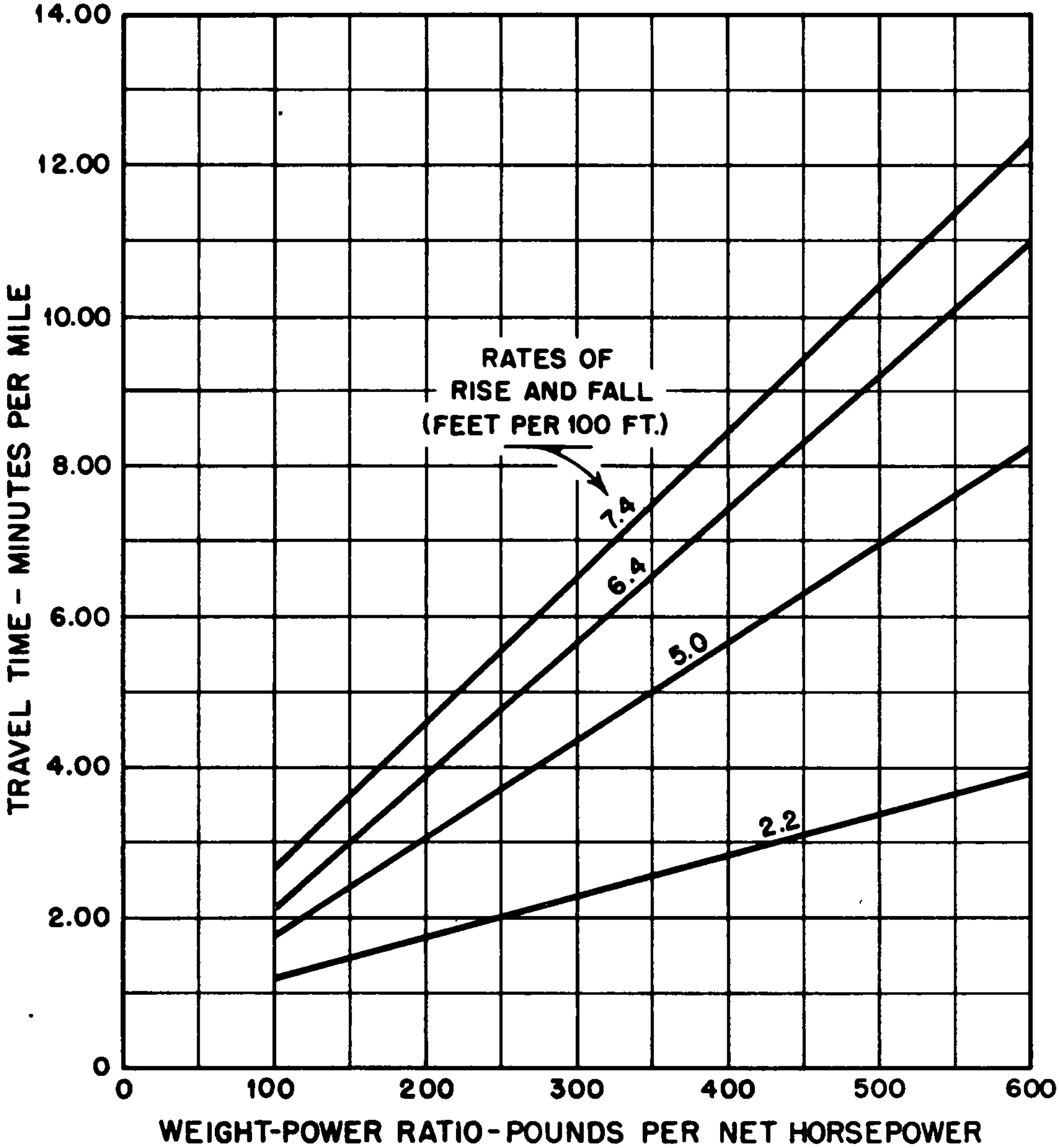

FIGURE 24-DIRECTIONAL TRAVEL TIME FOR VARIOUS RATES OF RISE AND FALL RELATED TO THE WEIGHT-POWER RATIO WHEN THE RISE IS 95 TO 100 PERCENT OF THE TOTAL RISE AND FALL

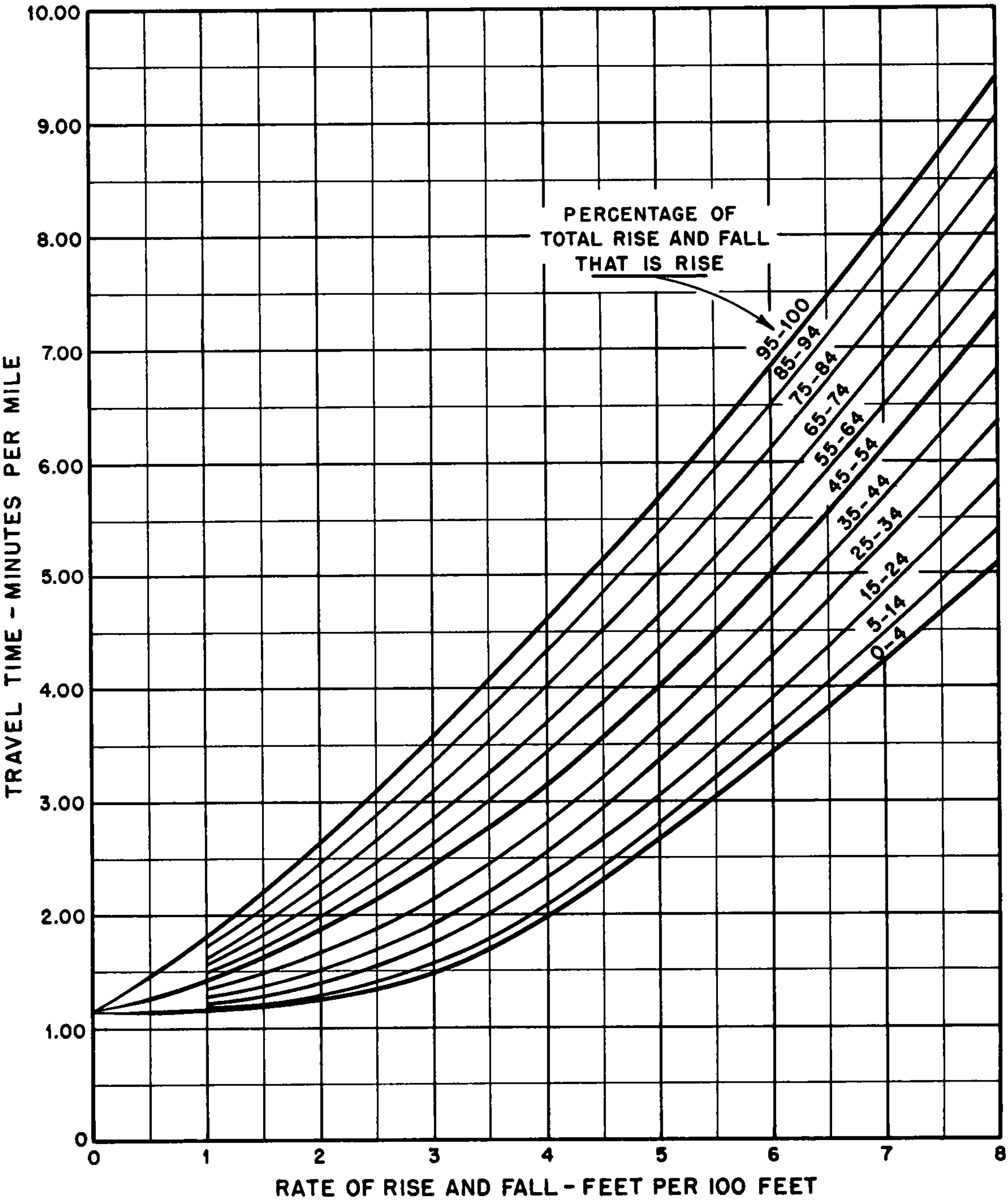

FIGURE 25-DIRECTIONAL TRAVEL TIME RELATED TO THE RATE OF RISE AND FALL FOR A WEIGHT-POWER RATIO OF 400 WHEN THE RISE IS VARIOUS PERCENTAGES OF THE TOTAL RISE AND FALL

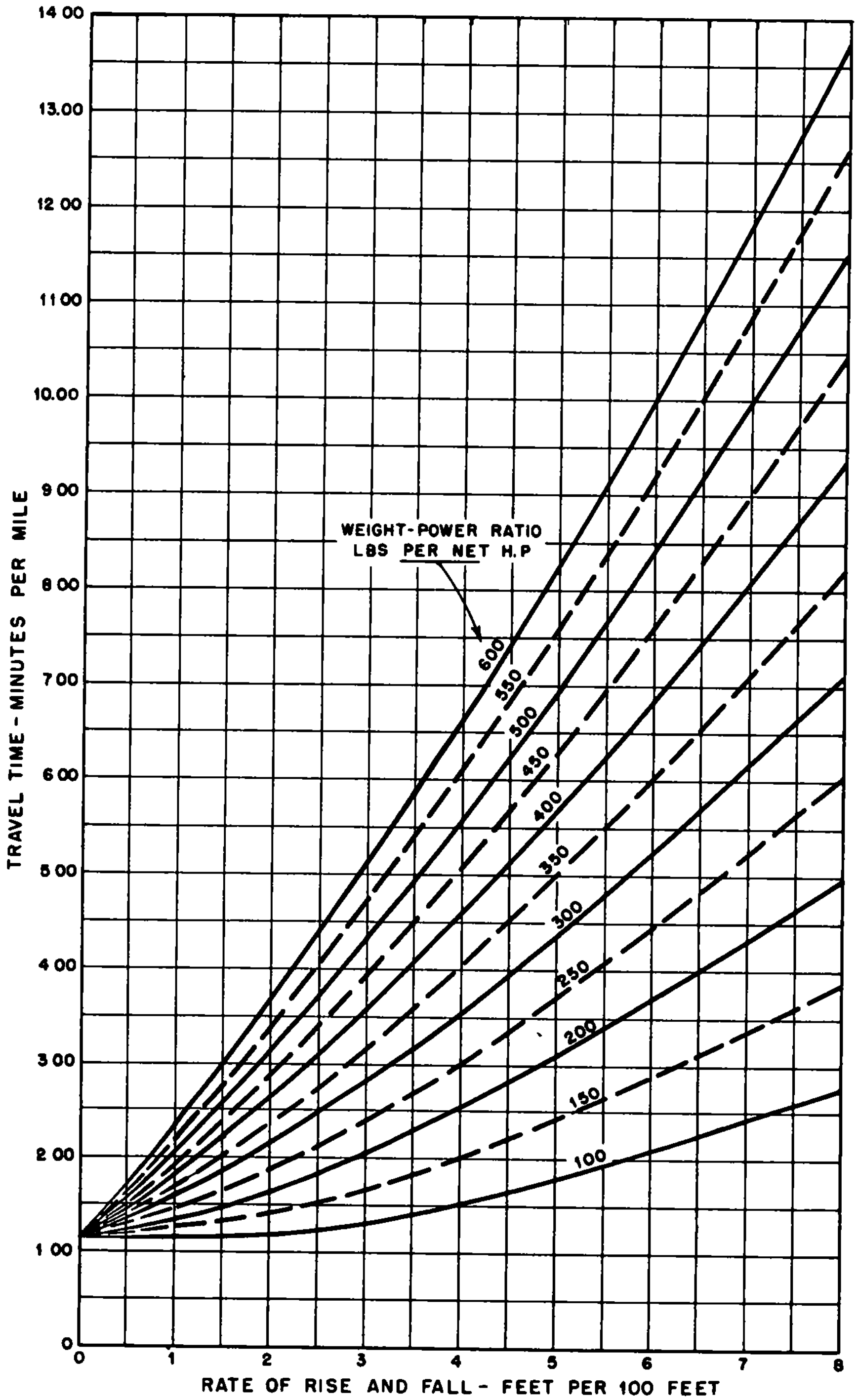

FIGURE 26 - DIRECTIONAL TRAVEL TIME FOR VARIOUS WEIGHT-POWER RATIOS RELATED TO THE RATE OF RISE AND FALL WHEN THE RISE IS 95-100 PERCENT OF THE TOTAL RISE AND FALL

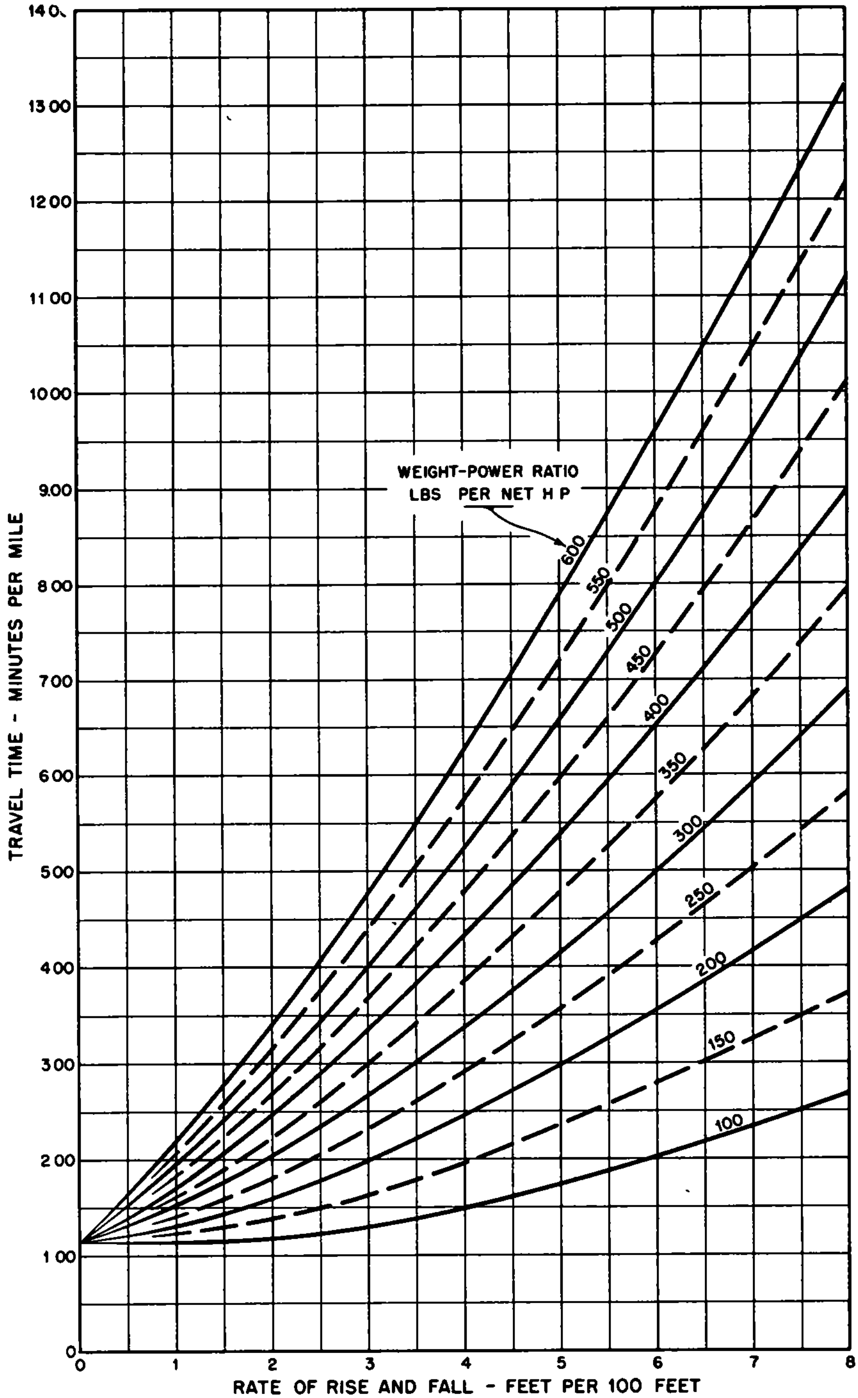

FIGURE 27 – DIRECTIONAL TRAVEL TIME FOR VARIOUS WEIGHT-POWER RATIOS RELATED TO THE RATE OF RISE AND FALL WHEN THE RISE IS 85-94 PERCENT OF THE TOTAL RISE AND FALL

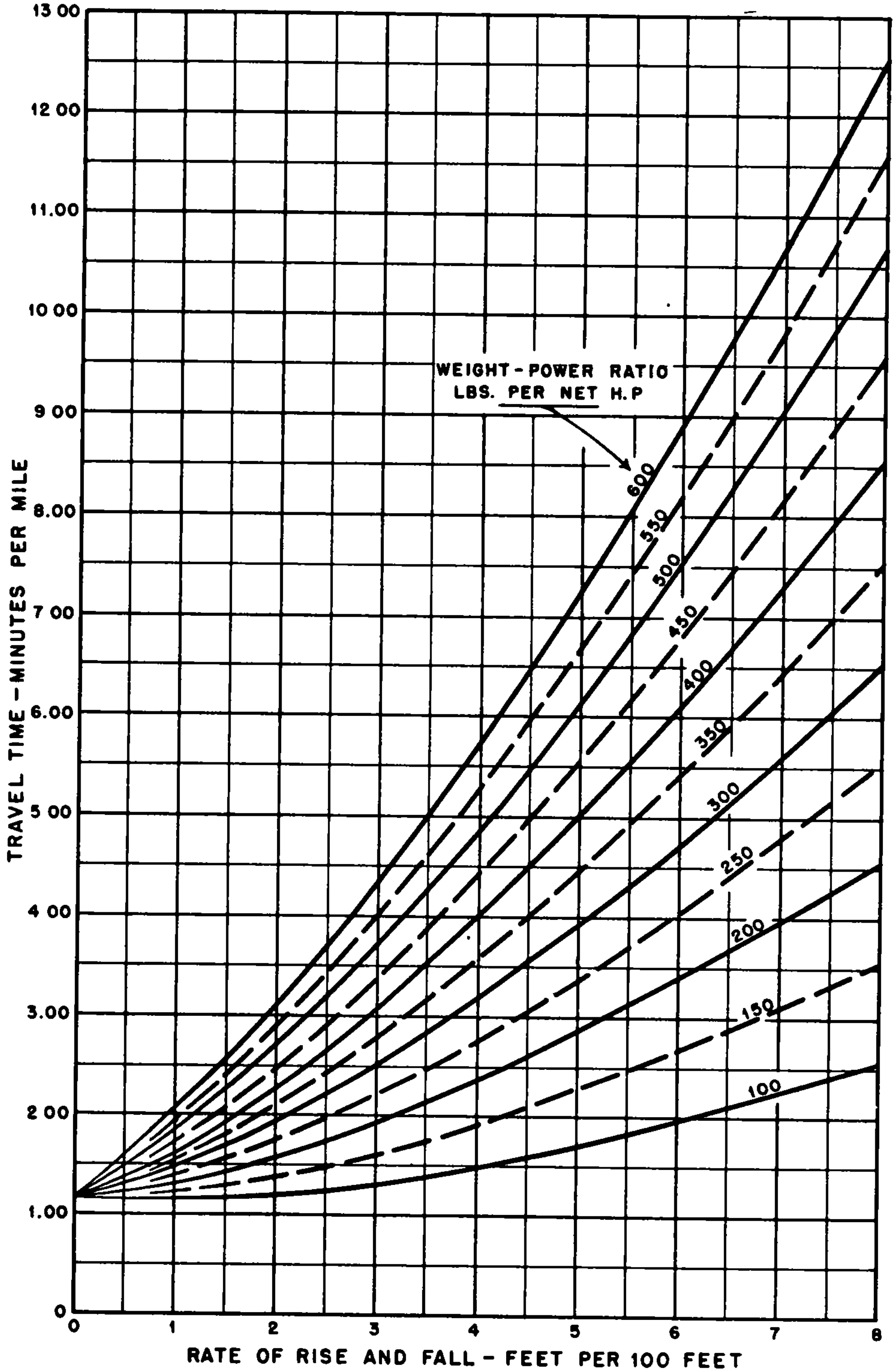

FIGURE 28 - DIRECTIONAL TRAVEL TIME FOR VARIOUS WEIGHT-POWER RATIOS RELATED TO THE RATE OF RISE AND FALL WHEN THE RISE IS 75-84 PERCENT OF THE TOTAL RISE AND FALL

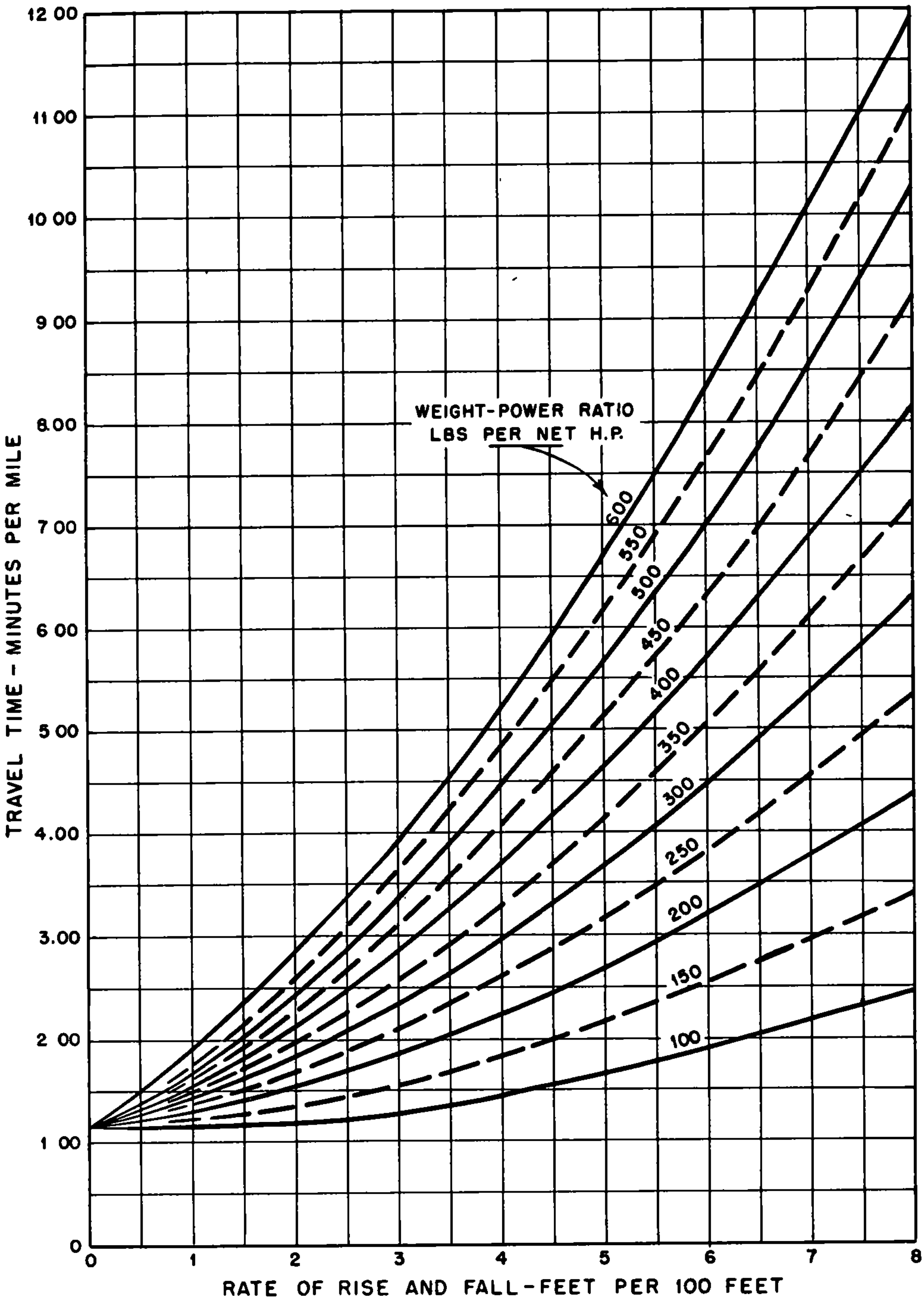

FIGURE 29 - DIRECTIONAL TRAVEL TIME FOR VARIOUS WEIGHT-POWER RATIOS RELATED TO THE RATE OF RISE AND FALL WHEN THE RISE IS 65-74 PERCENT OF THE TOTAL RISE AND FALL

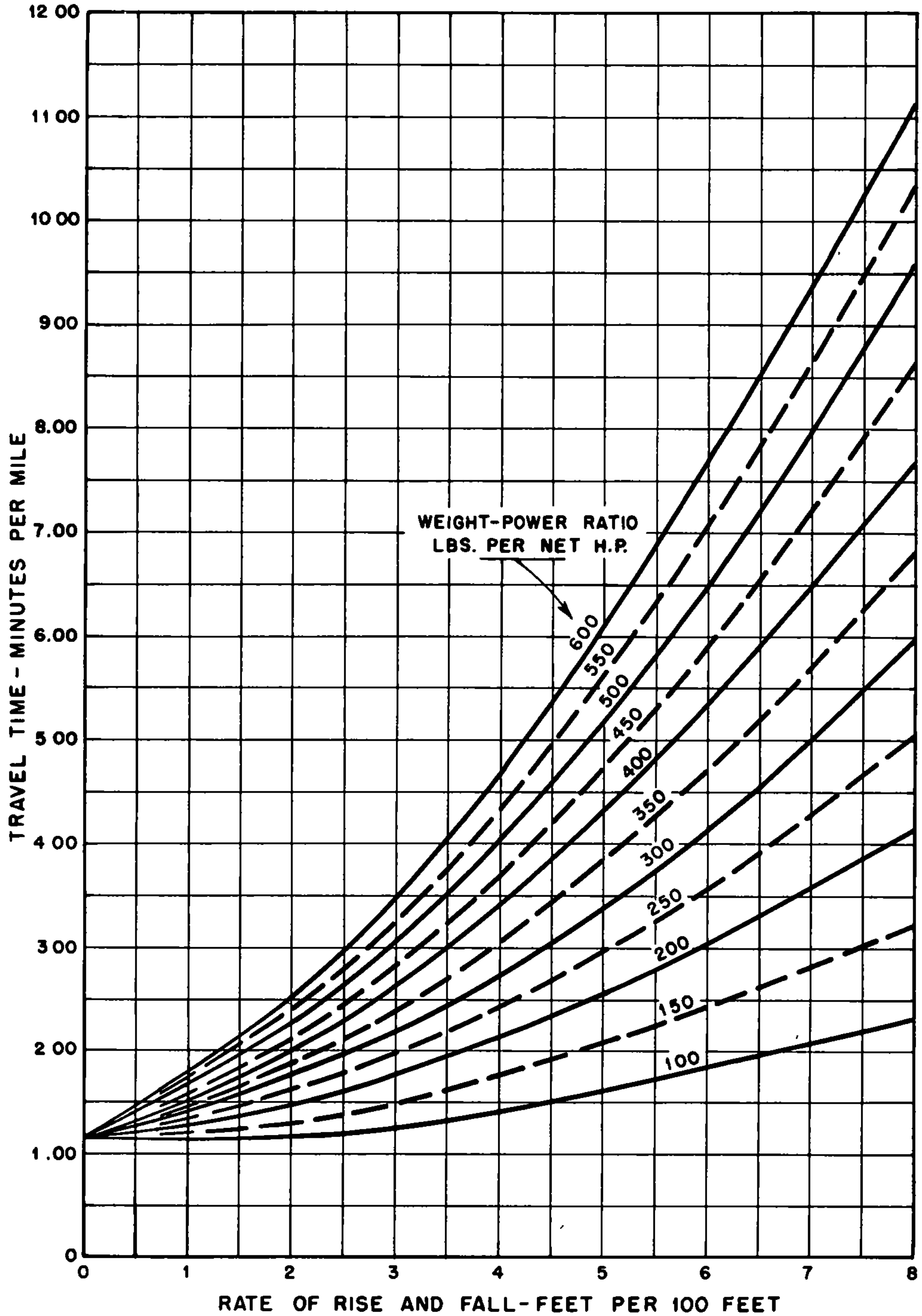

FIGURE 30-DIRECTIONAL TRAVEL TIME FOR VARIOUS WEIGHT-POWER RATIOS RELATED TO THE RATE OF RISE AND FALL WHEN THE RISE IS 55-64 PERCENT OF THE TOTAL RISE AND FALL

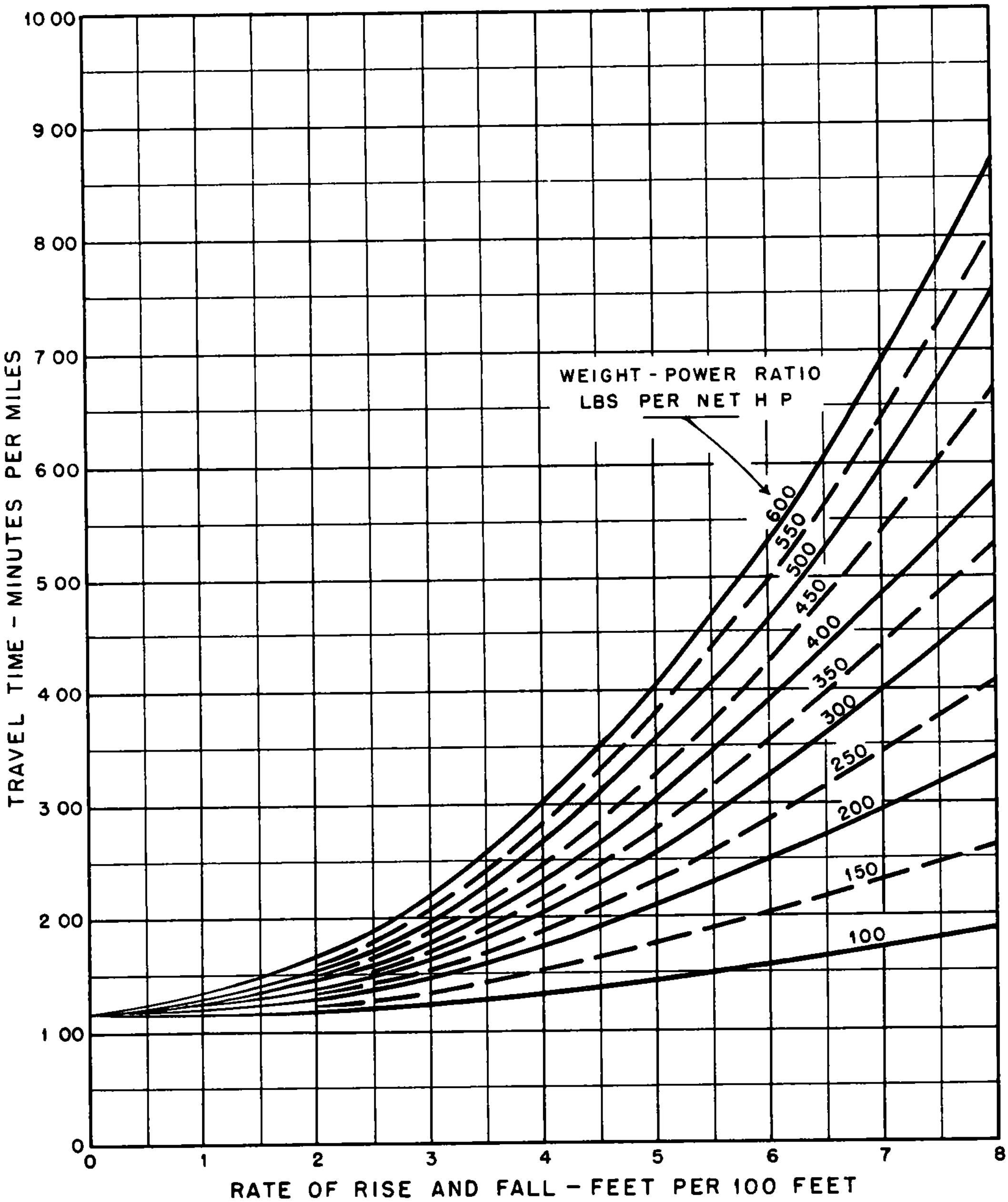

FIGURE 33 - DIRECTIONAL TRAVEL TIME FOR VARIOUS WEIGHT-POWER RATIOS RELATED TO THE RATE OF RISE AND FALL WHEN THE RISE IS 15-24 PERCENT OF THE TOTAL RISE AND FALL

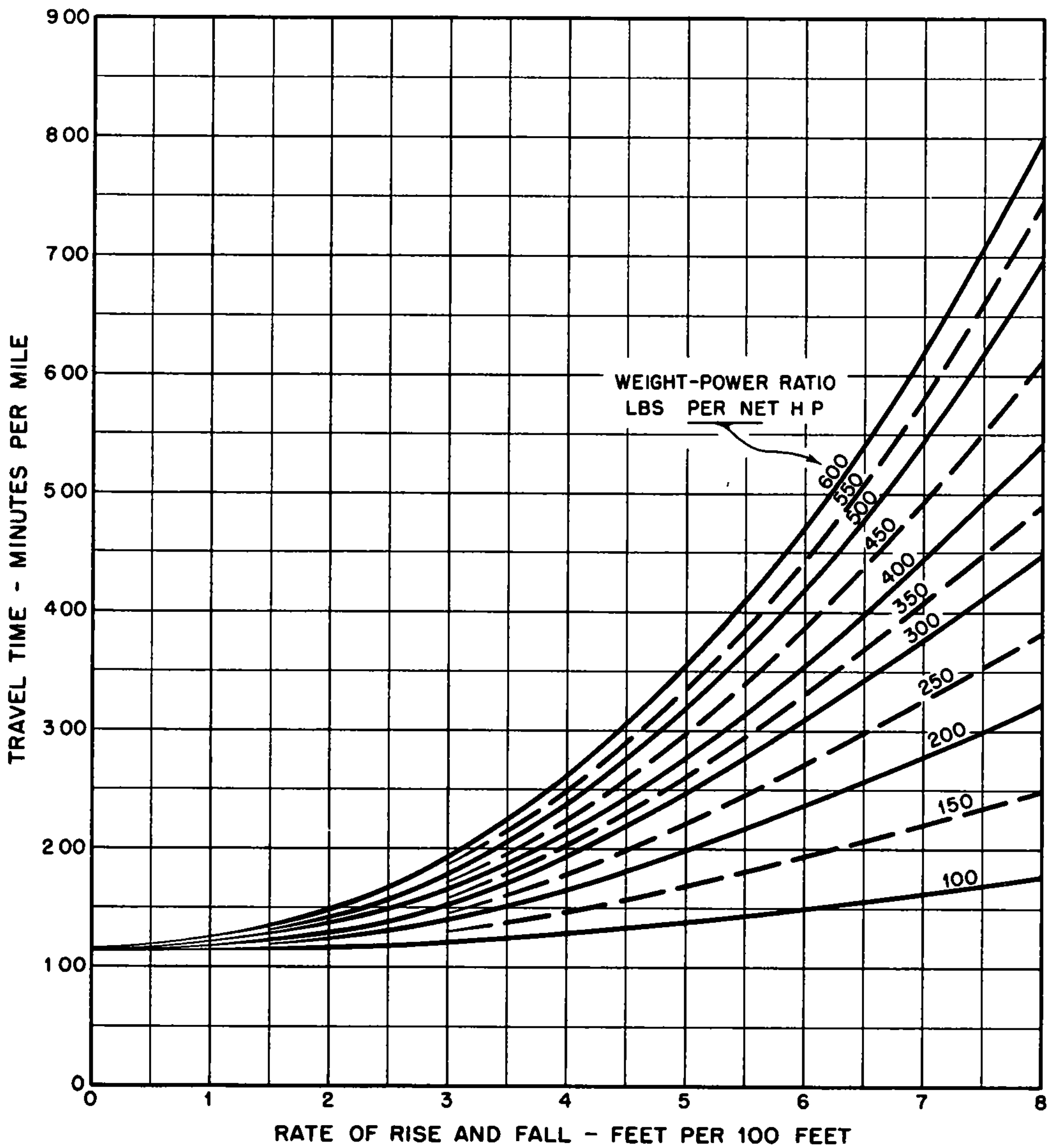

FIGURE 34 - DIRECTIONAL TRAVEL TIME FOR VARIOUS WEIGHT-POWER RATIOS RELATED TO THE RATE OF RISE AND FALL WHEN THE RISE IS 5-14 PERCENT OF THE TOTAL RISE AND FALL

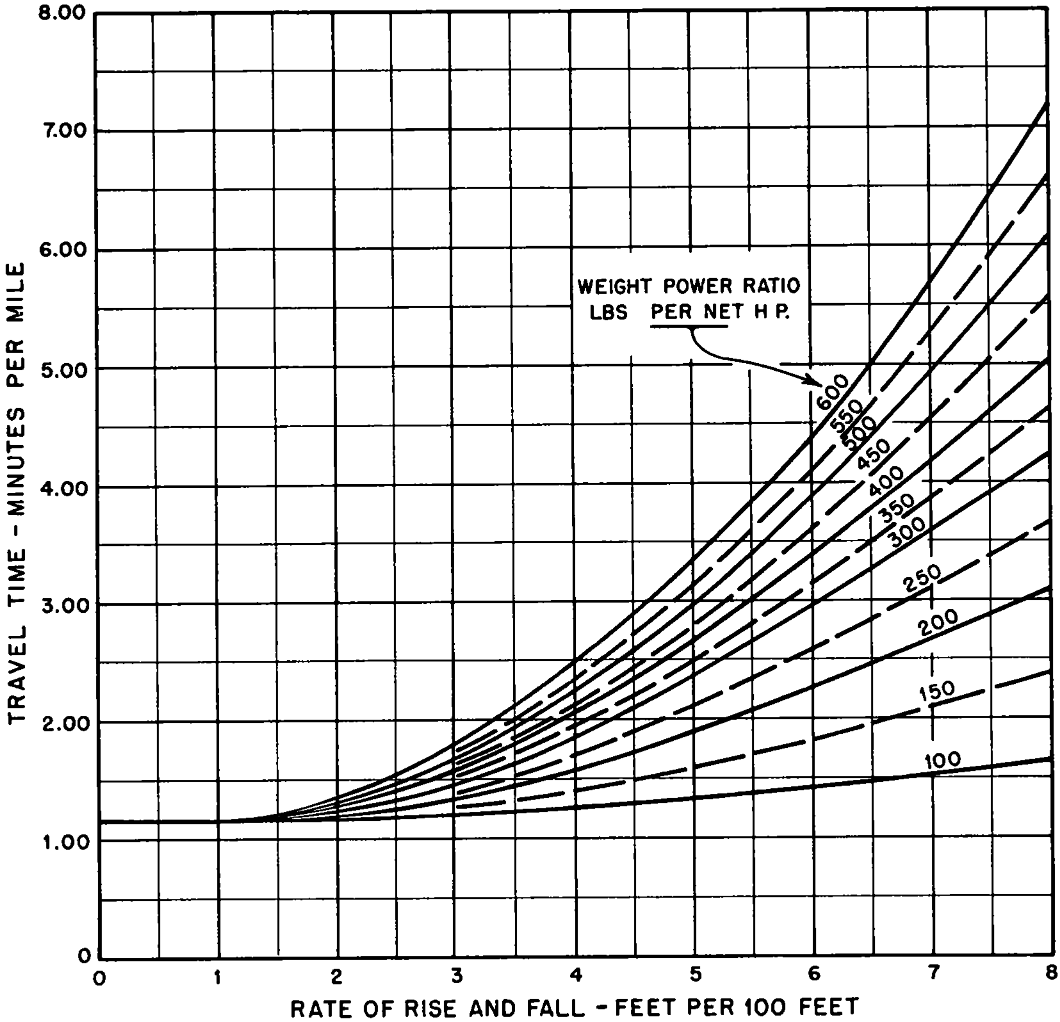

FIGURE 35 - DIRECTIONAL TRAVEL TIME FOR VARIOUS WEIGHT-POWER RATIOS RELATED TO THE RATE OF RISE AND FALL WHEN THE RISE IS 0-4 PERCENT OF THE TOTAL RISE AND FALL

APPENDIX A. - AVERAGE BASIC DATA FOR TEST VEHICLE NO. 1

U. S. 30 and 11

Section	Length of Section in Miles	Average Gasoline Consumption in Gallons for Gross Vehicle Weights in Pounds						Average Travel Time in Minutes for Gross Vehicle Weights in Pounds					
		26,675		23,760		20,030		26,675		23,760		20,030	
		WB	EB	WB	EB	WB	EB	WB	EB	WB	EB	WB	EB
A - B	19.77	3.20	3.58	2.91	3.61	2.94	3.21	38	40	34	33	36	31
B - C	4.02	.25	2.54	.19	2.53	.16	2.08	17	19	15	18	10	15
C - D	2.41	1.53	.17	1.21	.21	1.09	.10	12	07	10	04	08	03
D - E	9.61	2.31	1.93	1.97	1.87	1.87	1.68	24	23	21	19	19	17
E - F	4.11	.24	1.53	.16	1.47	.18	1.26	07	13	06	11	06	09
F - G	1.61	.41	.13	.38	.24	.36	.11	04	03	04	03	02	03
G - H	4.20	.24	1.22	.28	1.11	.36	1.07	07	10	06	08	06	07
H - I	4.96	3.11	.26	2.55	.25	2.33	.23	23	16	19	12	19	09
I - J	26.98	5.11	4.24	4.69	4.56	4.34	4.07	53	59	49	51	44	44
J - K	4.29	.32	2.07	.36	2.02	.33	1.57	12	16	09	16	09	13
K - L	1.04	.45	.05	.28	.10	.35	.06	03	03	03	03	03	02
L - M	1.88	.08	.95	.11	.83	.05	.72	04	08	03	07	03	06
M - N	3.02	2.17	.18	1.85	.12	1.66	.08	18	10	14	08	12	05
N - O	4.06	1.04	.74	.86	.76	.83	.64	09	13	08	08	07	08
O - P	1.43	.09	1.00	.09	1.03	.05	.82	06	09	05	07	04	06
P - Q	3.40	1.39	.40	1.14	.44	1.02	.36	11	10	10	08	08	06
Q - R	3.61	.22	2.20	.14	2.25	.15	1.84	15	19	13	16	10	13
R - S	3.88	2.81	.19	2.24	.14	2.07	.10	19	15	17	13	16	08
S - T	30.28	4.78	4.67	4.60	5.05	4.36	4.59	61	55	48	50	46	47
T - U	14.83	2.73	1.96	2.54	2.18	2.43	2.05	23	22	21	20	20	19
Totals	149.39	32.48	30.01	28.55	30.77	26.93	26.64	6:06	6:10	5:15	5:15	4:48	4:31

TURNPIKE

Section	Length of Section in Miles	WB	EB	WB	EB	WB	EB	WB	EB	WB	EB	WB	EB
1 - 2	6.88	.81	1.27	.92	1.20	.81	1.10	10	10	09	10	09	11
2 - 3	4.98	.50	1.68	.49	1.48	.56	1.36	07	12	08	12	07	10
3 - 4	6.02	.66	.56	.81	.55	.77	.46	07	05	06	05	06	05
4 - 5	7.04	.35	1.98	.51	1.70	.60	1.46	09	14	09	13	09	12
5 - 6	3.63	.89	.28	.92	.29	.80	.28	07	06	07	04	05	04
6 - 7	19.21	2.53	3.27	3.14	2.84	2.82	2.69	27	27	26	26	29	24
7 - 8	6.80	2.00	.33	2.06	.36	1.74	.40	14	08	14	08	13	09
8 - 9	28.25	4.20	4.09	4.66	3.88	4.47	3.81	38	36	36	36	39	36
9 - 10	6.31	.66	1.16	.69	1.00	.77	.95	08	09	06	09	08	08
10 - 11	9.32	1.63	1.10	1.87	1.12	1.54	1.00	16	12	15	12	10	12
11 - 12	18.19	2.79	2.70	3.07	2.53	2.80	2.35	25	24	25	24	23	23
12 - 13	6.17	.70	.95	.85	.90	.80	.83	09	07	07	09	08	09
13 - 14	2.11	.48	.18	.47	.18	.49	.20	03	03	04	03	04	04
14 - 15	11.01	1.98	1.35	2.06	1.29	1.86	1.24	17	13	15	14	15	13
15 - 16	12.79	1.94	1.77	2.06	1.63	1.94	1.49	17	16	17	15	16	15
Totals	148.71	22.12	22.67	24.58	20.95	22.77	19.62	3:34	3:22	3:24	3:20	3:21	3:15

Note: WB - Westbound
EB - Eastbound

APPENDIX B. - AVERAGE BASIC DATA FOR TEST VEHICLE NO. 2

U. S. 30 and 11

Section	Length of Section in Miles	Average Gasoline Consumption in Gallons for Gross Vehicle Weights in Pounds						Average Travel Time in Minutes for Gross Vehicle Weights in Pounds					
		53,860		44,530		36,500		53,860		44,530		36,500	
		WB	EB	WB	EB	WB	EB	WB	EB	WB	EB	WB	EB
A - B	19.77	6.03	6.19	5.12	4.42	4.06	4.47	45	44	36	35	34	34
B - C	4.02	.31	5.38	.35	4.32	.37	2.94	15	29	12	25	10	20
C - D	2.41	3.13	.17	2.50	.13	1.53	.11	22	06	13	07	10	04
D - E	9.61	4.28	3.67	3.78	3.04	2.75	2.45	29	33	24	23	20	19
E - F	4.11	.33	3.55	.42	2.22	.30	2.09	07	19	06	14	06	12
F - G	1.61	.81	.29	.64	.18	.62	.29	05	02	04	03	04	02
G - H	4.20	.50	2.32	.44	1.99	.86	1.53	06	15	07	10	05	09
H - I	4.96	6.22	.50	5.28	.51	3.92	.44	41	20	26	18	20	13
I - J	26.98	9.29	7.82	8.80	6.10	5.62	5.68	59	65	58	46	48	45
J - K	4.29	.66	4.17	.45	3.35	.60	2.63	13	24	10	20	09	14
K - L	1.04	.89	.13	.76	.07	.81	.17	04	06	04	03	04	04
L - M	1.88	.23	2.02	.25	1.63	.19	1.35	04	11	03	10	03	07
M - N	3.02	4.68	.25	4.06	.20	3.66	.26	34	17	20	08	15	09
N - O	4.06	1.90	1.52	1.55	1.09	1.59	1.00	12	14	10	15	09	08
O - P	1.43	.15	2.15	.24	1.82	.23	1.40	05	12	04	08	03	08
P - Q	3.40	2.81	.79	2.25	.54	2.53	.53	17	14	11	12	09	09
Q - R	3.61	.38	4.76	.25	4.05	.44	3.09	15	24	12	20	10	14
R - S	3.88	5.60	.33	4.78	.40	4.20	.47	32	23	25	18	21	15
S - T	30.28	8.15	8.15	8.31	6.49	7.86	5.59	56	50	51	52	47	47
T - U	14.83	4.73	2.83	4.34	2.52	4.09	3.15	26	24	24	18	21	17
Totals	149.39	61.08	56.99	54.57	45.07	46.23	39.64	7:27	7:32	6:00	6:05	5:08	5:10

TURNPIKE

Section	Length of Section in Miles	Gasoline 53,860 WB	Gasoline 53,860 EB	Gasoline 44,530 WB	Gasoline 44,530 EB	Gasoline 36,500 WB	Gasoline 36,500 EB	Time 53,860 WB	Time 53,860 EB	Time 44,530 WB	Time 44,530 EB	Time 36,500 WB	Time 36,500 EB
1 - 2	6.88	1.13	2.34	.57	2.52	1.12	1.90	08	13	08	12	08	09
2 - 3	4.98	.56	3.32	.26	3.02	.87	2.34	08	16	07	13	07	13
3 - 4	6.02	1.17	.89	.51	.94	1.03	.81	06	05	07	07	07	05
4 - 5	7.04	.59	3.83	.33	3.59	.57	2.81	08	19	08	17	07	15
5 - 6	3.63	1.59	.31	.79	.42	1.04	.39	09	05	09	04	07	04
6 - 7	19.21	4.28	5.18	3.60	4.98	3.73	4.53	27	31	26	27	23	24
7 - 8	6.80	3.96	.35	3.14	.26	2.72	.28	19	08	18	08	15	09
8 - 9	28.25	6.50	6.15	6.06	6.69	6.18	5.34	38	36	37	33	35	34
9 - 10	6.31	.93	1.95	1.22	1.96	.99	1.50	07	13	09	09	07	08
10 - 11	9.32	3.23	1.53	2.19	1.65	2.52	1.25	23	12	15	12	14	11
11 - 12	8.19	4.25	3.91	4.09	3.61	3.96	3.06	20	26	24	22	23	22
12 - 13	6.17	1.14	1.85	1.24	1.51	1.09	1.05	08	09	08	09	06	08
13 - 14	2.11	1.02	.23	.82	.40	.72	.22	06	03	05	04	04	04
14 - 15	11.01	3.08	2.06	3.12	1.60	2.60	1.36	17	11	16	10	14	11
15 - 16	12.79	3.37	2.79	2.66	2.05	2.86	2.03	18	15	16	19	17	14
Totals	148.71	36.80	36.69	30.60	35.20	32.00	28.87	3:42	3:42	3:33	3:26	3:14	3:11

Note: WB - Westbound
EB - Eastbound

APPENDIX C. - AVERAGE BASIC DATA FOR TEST VEHICLE NO. 3

U. S. 30 and 11

Section	Length of Section in Miles	Average Gasoline Consumption in Gallons for Gross Vehicle Weights in Pounds						Average Travel Time in Minutes for Gross Vehicle Weights in Pounds					
		50,130		41,700		32,850		50,130		41,700		32,850	
		WB	EB	WB	EB	WB	EB	WB	EB	WB	EB	WB	EB
A - B	19.77	4.67	5.19	4.13	4.51	3.65	5.09	39	46	36	36	37	39
B - C	4.02	.37	5.06	.32	3.32	.24	3.09	17	31	15	29	11	25
C - D	2.41	2.73	.13	1.96	.31	1.85	.11	16	07	14	05	13	05
D - E	9.61	3.20	3.09	2.91	2.59	2.64	2.53	28	31	23	25	25	23
E - F	4.11	.12	2.90	.15	2.13	.17	2.33	06	20	06	17	04	16
F - G	1.61	.60	.24	.62	.17	.48	.09	04	02	04	02	05	03
G - H	4.20	.34	2.01	.27	1.83	.39	1.89	06	14	06	13	06	13
H - I	4.96	5.76	.37	4.51	.36	3.87	.43	37	19	30	17	26	15
I - J	26.98	7.43	6.18	6.75	5.67	6.03	4.97	58	58	57	52	52	58
J - K	4.29	.53	3.67	.44	2.93	.41	3.09	12	28	10	24	09	19
K - L	1.04	.36	.11	.66	.15	.51	.08	05	02	04	02	04	03
L - M	1.88	.39	1.67	.12	1.35	.17	1.31	04	11	05	11	04	10
M - N	3.02	4.46	.20	3.38	.21	2.71	.22	26	16	21	12	19	11
N - O	4.06	1.53	1.10	1.37	.96	1.24	.88	13	12	11	10	09	10
O - P	1.43	.15	2.06	.07	1.61	.07	.37	06	12	05	11	04	10
P - Q	3.40	2.48	.50	2.12	.53	1.55	.46	16	10	12	09	13	10
Q - R	3.61	.31	4.54	.24	3.56	.27	1.72	15	29	13	24	10	22
R - S	3.88	5.21	.31	4.51	.20	3.40	.23	34	19	27	15	23	15
S - T	30.28	6.75	7.04	5.91	6.88	5.87	5.63	57	52	50	52	51	55
T - U	14.83	3.96	2.71	3.72	2.49	3.49	2.15	26	20	24	20	23	20
Totals	149.39	51.35	49.08	44.16	41.76	39.01	36.67	7:05	7:19	6:13	6:26	5:48	6:22

TURNPIKE

Section	Length of Section in Miles	50,130 WB	50,130 EB	41,700 WB	41,700 EB	32,850 WB	32,850 EB	50,130 WB	50,130 EB	41,700 WB	41,700 EB	32,850 WB	32,850 EB
1 - 2	6.88	1.17	1.93	.92	1.63	.73	1.75	11	14	07	11	09	10
2 - 3	4.98	.43	2.56	.43	2.40	.51	2.04	08	19	08	17	07	14
3 - 4	6.02	1.13	.69	.95	.60	1.07	.53	07	07	07	05	07	06
4 - 5	7.04	.38	3.70	.46	2.49	.53	2.50	09	22	08	18	08	16
5 - 6	3.63	1.84	.48	1.38	.21	1.13	.22	12	05	09	06	07	06
6 - 7	19.21	4.15	5.25	3.53	4.07	3.51	3.66	31	31	26	22	27	28
7 - 8	6.80	4.17	.24	2.98	.16	2.62	.28	23	07	20	06	14	07
8 - 9	28.25	5.86	4.59	5.65	4.62	5.38	4.96	43	37	38	38	39	35
9 - 10	6.31	.60	1.34	.76	1.92	.82	1.41	08	11	07	11	08	12
10 - 11	9.32	2.47	1.07	2.40	.82	2.36	1.09	21	12	16	12	17	12
11 - 12	18.19	3.99	3.10	3.75	2.93	3.66	3.00	30	26	26	23	25	23
12 - 13	6.17	.99	1.64	.86	1.29	.84	1.21	07	11	08	10	08	09
13 - 14	2.11	.69	.14	.73	.14	.76	.14	06	04	04	03	04	04
14 - 15	11.01	2.55	1.56	2.58	1.44	2.40	1.44	19	12	18	13	13	14
15 - 16	12.79	2.75	2.40	2.63	2.09	2.47	2.07	19	18	17	15	18	17
Totals	148.71	33.17	30.69	30.01	26.81	28.79	26.30	4:14	3.56	3:39	3:30	3:31	3:33

Note: WB - Westbound
EB - Eastbound

APPENDIX D. - AVERAGE BASIC DATA FOR TEST VEHICLE NO. 4

U. S. 30 and 11

Section	Length of Section in Miles	Average Gasoline Consumption in Gallons for Gross Vehicle Weights in Pounds						Average Travel Time in Minutes for Gross Vehicle Weights in Pounds					
		74,380		61,850		50,080		74,380		61,850		50,080	
		WB	EB	WB	EB	WB	EB	WB	EB	WB	EB	WB	EB
A - B	19.77	6.53	7.20	5.53	6.45	4.77	5.40	46	44	39	39	34	37
B - C	4.02	.63	7.19	.37	6.26	.25	4.96	30	37	15	30	12	24
C - D	2.41	4.15	.52	3.31	.13	2.42	.10	18	10	16	07	14	04
D - E	9.61	5.17	4.36	4.02	3.56	3.19	2.80	34	29	26	25	22	20
E - F	4.11	.32	4.17	.22	3.64	.28	2.81	06	22	06	18	06	14
F - G	1.61	1.02	.10	.84	.20	.65	.17	07	04	04	02	03	02
G - H	4.20	.32	3.12	.41	2.69	.40	2.02	06	14	06	14	06	11
H - I	4.96	8.71	.40	7.05	.31	5.30	.36	45	22	35	16	26	13
I - J	26.98	10.56	8.36	9.00	7.71	7.83	6.47	66	59	60	54	51	51
J - K	4.29	.85	5.65	.54	4.66	.57	3.71	21	28	12	22	09	20
K - L	1.04	1.32	.10	1.02	.09	.70	.12	07	03	05	04	04	03
L - M	1.88	.13	2.95	.12	2.23	.16	1.83	05	15	05	10	03	10
M - N	3.02	6.77	.13	5.24	.21	3.99	.16	30	17	24	14	19	09
N - O	4.06	2.37	1.47	1.91	1.45	1.45	1.12	16	12	13	12	09	08
O - P	1.43	.15	2.87	.15	2.46	.18	2.00	09	13	05	12	05	11
P - Q	3.40	3.86	.74	2.90	.66	2.28	.57	18	12	15	09	12	10
Q - R	3.61	.39	6.33	.27	5.67	.25	4.18	23	29	14	25	10	19
R - S	3.88	8.38	.29	6.23	.29	4.90	.25	38	22	30	19	24	15
S - T	30.28	8.97	9.49	7.89	8.73	7.56	7.61	59	58	52	54	46	50
T - U	14.83	4.91	2.97	4.61	3.44	4.49	3.32	25	18	24	21	21	18
Totals	149.39	75.51	68.41	61.63	60.84	51.62	49.96	8:29	7:48	6:46	6:47	5:36	5:49

TURNPIKE

Section	Length of Section in Miles	74,380 WB	74,380 EB	61,850 WB	61,850 EB	50,080 WB	50,080 EB	74,380 WB	74,380 EB	61,850 WB	61,850 EB	50,080 WB	50,080 EB
1 - 2	6.88	.99	2.56	1.24	2.36	1.16	2.14	08	12	09	10	09	10
2 - 3	4.98	.56	4.12	.49	3.22	.35	3.02	09	20	08	18	07	15
3 - 4	6.02	1.31	.84	1.34	1.19	1.21	.86	07	06	07	06	07	05
4 - 5	7.04	.48	4.74	.50	4.16	.48	3.98	08	22	09	17	09	18
5 - 6	3.63	2.11	.30	1.94	.24	1.56	.24	11	07	09	04	08	04
6 - 7	19.21	4.86	5.94	4.80	5.43	4.40	4.42	29	29	29	31	27	27
7 - 8	6.80	4.94	.19	4.36	.43	3.93	.18	26	08	20	09	17	08
8 - 9	28.25	7.79	7.19	7.24	6.50	6.50	6.04	42	38	37	38	36	38
9 - 10	6.31	.91	2.46	1.06	2.24	1.27	1.99	07	12	09	12	07	10
10 - 11	9.32	3.52	1.61	3.39	1.56	2.50	1.33	20	12	22	13	16	12
11 - 12	18.19	5.19	4.46	4.96	4.59	4.69	3.83	29	25	27	26	24	23
12 - 13	6.17	1.14	2.14	.91	1.94	.83	1.59	08	11	07	09	08	08
13 - 14	2.11	1.24	.26	1.05	.22	.97	.22	06	03	06	03	05	02
14 - 15	11.01	3.51	1.96	3.43	1.68	2.84	1.61	18	12	16	12	15	12
15 - 16	12.79	3.51	3.21	3.42	3.10	3.29	2.95	18	15	16	15	17	17
Totals	148.71	42.06	41.98	40.13	38.86	35.98	34.40	4:06	3:52	3:51	3:43	3:32	3:29

Note: WB - Westbound
EB - Eastbound

APPENDIX E. - AVERAGE BASIC DATA FOR TEST VEHICLE NO. 5

U. S. 30 and 11

Section	Length of Section in Miles	Average Gasoline Consumption in Gallons for Gross Vehicle Weights in Pounds						Average Travel Time in Minutes for Gross Vehicle Weights in Pounds					
		96,140		80,080		62,930		96,140		80,080		62,930	
		WB	EB	WB	EB	WB	EB	WB	EB	WB	EB	WB	EB
A - B	19.77	7.66	8.17	6.74	7.78	6.09	7.43	39	44	40	41	41	41
B - C	4.02	.79	9.19	.37	8.01	.32	6.22	30	44	16	34	16	28
C - D	2.41	4.97	.23	4.05	.17	3.54	.12	24	09	17	05	15	06
D - E	9.61	6.17	4.87	4.81	4.62	4.58	4.29	38	30	29	25	27	24
E - F	4.11	.25	4.97	.25	4.43	.24	3.44	08	25	07	20	06	16
F - G	1.61	1.23	.28	.99	.22	.92	.29	06	02	04	02	06	03
G - H	4.20	.43	3.70	.39	3.33	.40	2.70	08	18	06	16	06	13
H - I	4.96	10.52	.82	8.16	.42	6.86	.36	54	25	37	16	27	14
I - J	26.98	12.59	10.12	10.76	9.59	9.78	8.89	72	58	62	56	66	55
J - K	4.29	.91	6.59	.70	5.80	.56	4.70	15	32	10	24	10	23
K - L	1.04	1.54	.13	1.18	.08	1.01	.08	08	03	06	02	05	02
L - M	1.88	.20	3.20	.10	2.65	.15	2.26	06	17	05	12	04	10
M - N	3.02	7.85	.53	6.48	.25	5.28	.20	35	21	28	13	21	11
N - O	4.06	2.87	1.88	2.37	1.63	2.06	1.62	17	15	12	10	12	11
O - P	1.43	.22	3.56	.10	3.01	.18	2.44	08	17	06	12	05	10
P - Q	3.40	4.43	.95	3.54	.83	3.10	.92	22	12	16	09	14	10
Q - R	3.61	.51	7.70	.39	6.85	.32	5.73	23	38	17	29	12	25
R - S	3.88	9.36	.54	7.78	.35	6.44	.34	46	25	34	17	30	14
S - T	30.28	11.00	11.10	9.68	10.77	9.66	10.42	67	59	55	57	55	55
T - U	14.83	6.42	3.87	5.94	4.10	5.09	4.06	27	16	25	18	29	17
Totals	149.39	89.92	82.40	74.78	74.89	66.58	66.51	9:13	8:30	7:12	6:58	6:47	6:28

TURNPIKE

Section	Length of Section in Miles	96,140 WB	96,140 EB	80,080 WB	80,080 EB	62,930 WB	62,930 EB	96,140 WB	96,140 EB	80,080 WB	80,080 EB	62,930 WB	62,930 EB
1 - 2	6.88	1.37	3.08	1.52	2.90	1.32	2.53	08	16	11	14	08	10
2 - 3	4.98	.63	4.98	.51	4.41	.60	3.56	09	22	07	21	07	16
3 - 4	6.02	1.66	1.03	1.64	.95	1.34	.94	08	06	07	06	07	05
4 - 5	7.04	.49	5.64	.66	5.14	.53	4.00	09	26	09	23	08	19
5 - 6	3.63	2.81	.43	2.30	.28	1.80	.24	12	05	11	05	08	04
6 - 7	19.21	6.33	7.08	5.87	6.37	5.07	5.91	34	38	31	34	28	29
7 - 8	6.80	6.01	.16	5.10	.15	4.03	.15	27	09	24	08	19	10
8 - 9	28.25	9.59	7.90	8.77	8.03	8.03	7.14	48	40	42	40	36	34
9 - 10	6.31	1.20	2.69	1.15	2.58	1.11	2.31	08	14	07	12	07	11
10 - 11	9.32	4.69	1.58	4.05	1.58	3.43	1.53	23	12	21	12	17	11
11 - 12	18.19	6.45	5.02	5.76	4.62	5.36	4.48	32	28	29	26	26	23
12 - 13	6.17	1.22	2.37	1.32	2.39	1.16	2.04	08	13	08	12	06	10
13 - 14	2.11	1.59	.26	1.29	.27	.95	.28	08	03	07	03	05	02
14 - 15	11.01	4.57	1.85	4.03	1.96	3.91	1.99	24	14	19	12	18	12
15 - 16	12.79	4.64	3.67	4.00	3.45	3.81	3.21	19	15	17	16	16	16
Totals	148.71	53.25	47.74	47.97	45.08	42.45	40.31	4:37	4:21	4:10	4:04	3:36	3:32

Note: WB - Westbound
EB - Eastbound

APPENDIX F. - AVERAGE BASIC DATA FOR TEST VEHICLE NO. 6

U. S. 30 and 11

Section	Length of Section in Miles	Average Gasoline Consumption in Gallons for Gross Vehicle Weights in Pounds						Average Travel Time in Minutes for Gross Vehicle Weights in Pounds					
		119,530		100,680		80,170		119,530		100,680		80,170	
		WB	EB	WB	EB	WB	EB	WB	EB	WB	EB	WB	EB
A - B	19.77	10.32	11.49	8.85	10.37	8.40	9.63	41	46	37	37	38	40
B - C	4.02	.42	12.86	.49	10.30	.55	8.44	25	43	22	37	20	29
C - D	2.41	6.12	.32	5.03	.32	4.03	.32	21	09	18	09	17	07
D - E	9.61	8.03	7.59	6.20	5.73	5.58	4.81	29	32	25	21	23	20
E - F	4.11	.59	7.38	.62	5.61	.66	4.79	06	26	06	22	06	16
F - G	1.61	1.64	.21	1.11	.39	.79	.46	05	03	05	02	03	02
G - H	4.20	.94	4.95	1.00	4.04	.77	3.44	06	17	05	14	06	13
H - I	4.96	13.51	.53	10.82	.46	8.48	.76	44	24	42	16	32	13
I - J	26.98	17.96	16.97	15.49	12.61	12.85	11.62	67	69	60	50	53	50
J - K	4.29	1.21	9.38	1.00	7.69	1.06	6.09	16	29	14	26	13	21
K - L	1.04	1.91	.21	1.34	.14	1.21	.19	06	04	05	03	05	03
L - M	1.88	.38	4.64	.38	3.51	.37	2.87	03	14	04	12	03	10
M - N	3.02	10.21	.21	7.82	.29	6.69	.43	30	18	30	12	26	11
N - O	4.06	3.75	2.85	3.00	2.03	2.61	2.04	15	14	13	10	10	10
O - P	1.43	.14	5.06	.24	4.16	.17	3.21	07	16	06	14	06	12
P - Q	3.40	5.77	1.37	4.61	1.33	3.73	1.16	21	13	17	09	14	09
Q - R	3.61	.49	10.43	.41	9.43	.63	7.03	20	31	18	34	17	26
R - S	3.88	13.02	.21	10.55	.38	7.73	.49	40	29	40	15	29	16
S - T	30.28	15.11	14.76	13.71	13.71	12.44	12.54	55	59	52	54	52	54
T - U	14.83	8.72	4.84	7.71	5.29	6.84	4.92	29	20	26	19	24	19
Totals	149.35	120.24	116.26	100.38	97.79	85.59	85.24	8:06	8:36	7:25	6:56	6:37	6:21

TURNPIKE

1 - 2	6.88	1.82	4.43	1.76	4.55	1.65	3.43	10	16	08	15	08	15
2 - 3	4.98	.90	6.55	1.06	4.58	.66	4.65	07	22	07	18	06	15
3 - 4	6.02	2.11	1.61	1.73	2.09	1.98	1.06	08	05	06	07	07	06
4 - 5	7.04	.89	7.62	1.19	5.97	1.02	4.72	09	24	09	23	07	19
5 - 6	3.63	3.47	.94	2.42	.91	2.31	.76	10	05	09	05	08	05
6 - 7	19.21	7.66	8.80	7.02	8.02	6.43	7.35	31	32	26	29	26	30
7 - 8	6.80	8.12	.88	6.65	.74	5.46	.93	28	08	25	07	20	07
8 - 9	28.25	12.05	9.77	10.85	9.83	9.36	9.42	43	37	39	33	37	35
9 - 10	6.31	1.79	3.56	1.59	2.90	1.45	2.79	08	12	06	11	07	10
10 - 11	9.32	5.67	2.55	4.88	2.49	4.12	2.41	20	11	18	10	16	11
11 - 12	18.19	7.79	6.21	6.88	6.17	6.37	5.43	29	21	25	22	25	23
12 - 13	6.17	1.79	3.12	1.96	2.66	1.72	2.54	07	13	07	10	08	09
13 - 14	2.11	2.08	.34	1.39	.57	1.39	.41	07	03	06	03	06	03
14 - 15	11.01	5.91	2.75	5.05	2.63	4.01	2.61	21	10	16	10	15	10
15 - 16	12.79	5.48	4.17	5.21	4.05	4.68	4.02	18	15	18	14	17	14
Totals	148.71	67.53	63.30	59.64	58.16	52.61	52.53	4:16	3:54	3:45	3:37	3:33	3:32

Note: WB - Westbound
EB - Eastbound

APPENDIX G. - AVERAGE BASIC DATA FOR TEST VEHICLE NO. 7

U. S. 30 and 11

Section	Length of Section in Miles	Average Gasoline Consumption in Gallons for Gross Vehicle Weights in Pounds						Average Travel Time in Minutes for Gross Vehicle Weights in Pounds					
		139,500		116,300		93,510		139,500		116,300		93,510	
		WB	EB	WB	EB	WB	EB	WB	EB	WB	EB	WB	EB
A - B	19.77	9.59	12.76	10.05	9.69	8.73	9.43	46	62	43	37	41	42
B - C	4.02	.93	11.93	.53	9.79	.50	7.62	25	46	14	35	14	27
C - D	2.41	5.66	.35	5.16	.32	3.75	.21	23	12	18	06	14	04
D - E	9.61	9.41	7.83	7.27	6.22	5.52	5.71	36	40	30	26	23	25
E - F	4.11	.58	6.84	.68	5.60	1.15	4.15	08	26	05	22	06	17
F - G	1.61	1.69	.32	1.23	.38	.86	.26	07	04	05	02	05	02
G - H	4.20	.89	5.11	.78	3.93	.68	3.05	08	18	05	14	05	12
H - I	4.96	12.87	.85	10.65	.58	8.77	.77	48	28	36	12	32	12
I - J	26.98	18.10	15.88	15.11	11.17	13.40	10.46	82	63	59	50	59	49
J - K	4.29	1.78	9.44	.95	7.41	.93	5.65	24	35	10	25	10	21
K - L	1.04	2.28	.20	1.40	.20	1.21	.13	09	06	05	03	05	03
L - M	1.88	.35	4.39	.32	3.31	.35	2.76	06	16	03	11	03	11
M - N	3.02	11.24	.42	7.87	.32	6.87	.23	34	18	26	09	30	11
N - O	4.06	3.87	2.74	3.06	2.05	2.50	1.71	18	17	11	11	10	08
O - P	1.43	.24	4.62	.17	3.56	.17	3.05	09	15	05	12	05	11
P - Q	3.40	5.77	1.70	4.81	1.08	3.71	1.03	22	16	17	08	14	10
Q - R	3.61	.71	10.01	.57	8.44	.52	6.49	24	34	16	28	18	26
R - S	3.88	12.48	.78	9.98	.35	7.90	.32	43	31	31	13	28	14
S - T	30.28	13.58	16.00	14.48	12.74	11.65	11.46	63	57	56	51	51	50
T - U	14.83	7.57	4.82	7.15	4.54	6.56	4.29	28	26	28	19	25	17
Totals	149.39	119.59	116.99	102.22	91.68	85.73	78.78	9:23	9:30	7:03	6:34	6:38	6:12

TURNPIKE

Section	Length of Section in Miles	139,500 WB	139,500 EB	116,300 WB	116,300 EB	93,510 WB	93,510 EB	139,500 WB	139,500 EB	116,300 WB	116,300 EB	93,510 WB	93,510 EB
1 - 2	6.88	2.26	4.65	1.78	3.61	1.53	3.30	10	15	08	13	07	07
2 - 3	4.98	.97	6.18	1.34	5.12	.73	4.34	07	20	06	16	06	15
3 - 4	6.02	2.62	1.93	1.66	1.66	1.92	1.52	10	07	08	07	06	06
4 - 5	7.04	1.01	7.16	.94	5.96	.89	4.81	09	25	07	16	09	19
5 - 6	3.63	3.24	.94	2.75	.86	2.29	.75	11	05	10	09	08	05
6 - 7	19.21	7.48	8.46	7.32	8.32	5.96	7.32	28	30	27	28	26	27
7 - 8	6.80	7.42	.66	6.82	.84	5.18	.81	30	07	23	08	18	08
8 - 9	28.25	11.36	10.84	10.95	9.32	9.39	8.63	39	39	38	35	34	35
9 - 10	6.31	1.55	3.04	3.94	3.26	1.58	3.01	07	10	12	10	07	10
10 - 11	9.32	5.50	2.59	2.80	2.92	4.16	2.35	21	10	13	13	16	12
11 - 12	18.19	7.25	6.26	6.97	6.99	6.27	5.85	27	25	28	23	24	22
12 - 13	6.17	1.81	3.22	2.05	3.04	1.52	2.25	07	11	08	11	08	09
13 - 14	2.11	2.01	.42	1.66	.54	1.23	.40	09	03	06	04	05	04
14 - 15	11.01	5.05	2.71	4.73	2.64	4.56	2.68	17	11	17	11	18	11
15 - 16	12.79	5.31	4.30	5.03	4.00	4.43	3.68	18	14	16	14	15	15
Totals	148.71	64.84	63.36	60.74	59.08	51.64	51.70	4:10	3:52	3:47	3:38	3:27	3:25

Note: WB - Westbound
EB - Eastbound

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