Progress Report of Committee on Economics of Motor Vehicle Size and Weight

I. *Introduction* — The Committee on Economics of Motor Vehicle Size and Weight of the Highway Research Board is assembling data relating to factors involved in an economic solution of the freight vehicle size and weight problem. The present report covers only the commodity density and movement phase of the parent study, but it gives new and useful analysis of the volume of commodity movements by highway together with the weight characteristics of such highway freight. The secretary of the committee cautions against using the commodity data as the sole basis for the final solution to the size and weight problem.

II. *The Freight's the Weight* — Payload weights and gross vehicle weights are related to the shipping densities of commodities hauled and to the cargo volume capacities of freight vehicles. Within these factors lie the pressures for increased weight allowances for line haul highway freight services.

One phase of the committee's study was to determine the weight demand pattern of freight transported by highway. Such data previously have not been available. The collection of a great amount of commodity data is reported in the paper, including shipping densities (pounds per cubic foot) of all classes of freight, and the tonnages of each class of commodities that were transported in 1954 by each of the five main media of transportation in the United States; namely, railroad, highway, inland waterway, pipeline, and airway.

Reported in detail are the tonnages and shipping densities of the commodities moved by line haul highway freight. The charts of these data indicate that a preponderance of the general freight lies in the range of shipping densities between 25 and 50 pcf. For flowable commodities the shipping densities are still heavier. Approximately 48 percent of the highway freight weighs less than 50 pcf, whereas only 9 percent of highway freight weighs less than 25 pcf.

The report discusses the implications that arise when a shipping density of 50 pcf is considered as an end point for the weight of commodities which could be loaded so as to visibly fill the cargo bodies of large vehicle combinations. Using this shipping density with freight vehicles of maximum dimensions allowed by the AASHO Size and Weight Policy results in maximum gross vehicle weights of about 130,000 lb for one-cargo vehicle combinations and about 180,000 lb for two-cargo vehicle combinations.

I. Introduction

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• THE PROBLEM assigned the Highway Research Board's Committee on Economics of Motor Vehicle Size and Weight is a tangled one resulting from progressive changes in commercial motor vehicle construction, highway freight op-

eration, and highway construction. In the present era of highway transportation, this problem has some of the characteristics of the age-old conundrum of which came first, the chicken or the egg. To illustrate the committee's imbroglio, one simply substitutes "freight vehicle load" and "highway structural capacity" for "chicken" and "egg." Actually neither of these factors comes first, because both should go along together; but such has not been the case.

In almost every state there are pressures from the freight carriers for higher weight limitations, while the highway officials ponder seriously the problem of vehicle "overweights," and wonder what may be the end points in maximum gross vehicle weights. The fact that many highway vehicles have load potentials in excess of the designed load capacities of the highways is pertinent to this study, chiefly because it shows a need for establishing size and weight specifications that will be adequate in the future for the most economical carrying of typical loads of freight.

For a systematic determination of optimum size and weight limits of motor freight vehicles for highways of the future, it is necessary to evaluate jointly the economic factors relating to motor freight vehicles and to highways. The economic factors include the costs of owning, maintaining, and operating various types and capacities of motor freight vehicles, plus those costs of constructing and maintaining compatible highway facilities as may be properly assigned to freight vehicles. An additional factor to be studied is the demand for various levels of payload and gross vehicle weights from the viewpoint of the weight characteristics of freight transported by highway in the United States. Separate studies of each of these three factors have been set up as phases of the overall study, and all will be used in the final solution.

The committee's project scope may be condensed into the question of the optimum size and weight specifications for highway freight vehicles that will result in the lowest over-all cost of highway freight transportation. This over-all cost includes both vehicular operating costs and the appropriate highway costs.

DIMINISHING RETURNS AN ELEMENT

In studying the economic trends of both vehicles and highway facilities, and the combination of the two, the problem of "diminishing returns" is encountered. As regards the economics of operating highway freight vehicles there still are unexplored cost areas. The first report of this committee gave definite indications that the number of ton-miles per gallon of fuel is improved as the gross weight is increased. Also, there was found to be a reduction in driving time per ton-mile as the gross weight increases. However, the trends in driving-time costs are limited by possible average road speeds of vehicles, and the fact that drivers' mileage wage rates currently increase, in most wage contracts, with the sizes of vehicles.

Larger vehicles, thinking in terms of very heavy capacity vehicles that are not mass-produced, require a greater capital investment than do smaller vehicles. The diminishing returns in this field and in other cost elements are being explored in one phase of the committee's study to find out the manner in which operating costs change as gross vehicle weights increase.

In the case of highway facilities, the diminishing return factor also is evident. The costs of pavements and bridges increase in relation to their load-carrying capacities, and in relation to the methods of load distribution to the road surface. The degree of increase of highway costs in relation to vehicle weights is beginning to be explored more fully (*2, 3*). More cost information is needed in this field, some of which will come from engineering data derived from the AASHO Road Test.

From accelerated road tests, such as the AASHO Road Test in Illinois, can come two general types of information. First, there will be a recheck of the empirical engineering formulas used in the

design of conventional pavements. Second, from the relative performance of the thicker pavement structures subjected to the heavier loadings will come data that may permit predictions of the costs of building highway facilities for freight vehicles with gross weights much higher than those allowed by present weight limitations. A real need exists for estimates of costs of pavements with a range of axle capacities much above the conventional 18,000-lb single-axle and 32,000-lb tandem-axle weights, so that there may be developed a scale of highway costs for different levels of gross and axle load concentrations that can be related to a scale of vehicular operating costs to develop over-all costs of transportation.

PAYLOAD WEIGHTS AND CUBIC CAPACITIES

To determine what maximum weight limits need be considered, as well as to determine the degree to which freight carriers and shippers may use to advantage any given level of size and weight specifications, an analysis was made of the tonnages, shipping densities, and range of possible payload weights of commodities moved by highway freight. This is one phase of the committee's project for which all available data have been collected. This study has been made by Malcolm F. Kent, who has used published data where available, and to fill in the gaps in data has contacted many original sources of information, such as government agencies and trade associations. His report deals primarily with the shipping weight and volume characteristics of freight, and the potential payloads with different commodities. Using tonnage transported as the criterion of the commercial importance of any series of commodities, it will be apparent why the report touches only slightly on the problems of "balloon" freight. Almost anyone will agree, after seeing the data, that the weight problem appears more pressing than the size problem. However, cubic capacity is a problem in certain sections of the industry. Size and weight must both be considered in the over-all problem, but they differ in their relation to highway costs in that size affects geometric design and weight affects structural design.

In thinking about size allowances, one can start from the dimensions recommended in the size and weight policy of the American Association of State Highway Officials. These recommendations are width, 8 ft; height, 12 ft 6 in.; length for tractor semitrailer, 50 ft; and length for other combinations, 60 ft. However, not all of the states permit the vehicle dimensions set in the AASHO policy.

For example, in 26 of the states certain of the vehicle size allowances exceed the AASHO size specifications. Two states (Connecticut and Rhode Island) allow 102 in. in over-all width. Twenty states now allow heights above 12 ft 6 in.; 16 to 13 ft 6 in.; and 2 to 14 ft; hence, width and height appear to be indicated as fields for further study. Eleven western states and 8 north-central and eastern states allow tractor semitrailer and full trailer combinations, whereas the AASHO policy does not permit this type of combination. From the dry freight carriers' viewpoint, tractor semitrailer and full trailer combinations have many desirable features, whereas the truck full trailer combinations allowed in the AASHO policy appear eminently suitable for much liquid hauling. Looking into the future and thinking of future highways, the possible economies in the use of three-cargo-vehicle combinations of greater over-all lengths should not be overlooked. These several size factors indicate that there is need for the development of optimum vehicle dimensions that can be uniformly permitted in all states.

One purpose of the commodity density study was to determine the pattern of shipping densities and annual tonnages of commodities moved by highway in the United States. To do this Mr. Kent had to assemble data regarding commodity movements by the five major forms of transportation. These data are reported, not for the purpose of comparing the quantities moved by each form

of transportation, but to indicate the degree of similarity in commodity shipping densities. An important purpose of this commodity study was to find out if there were optimum levels in payload weights and gross combination weights that would satisfy a preponderance of the commodities transported by highway. The findings indicate that there are such levels which are within the limits of feasible automotive design. However, as the payload requirements of the freight do not, *per se*, provide the economic solution to the size and weight problem, the data of this report must not be used alone to forecast future size and weight limitations. The reported findings are intended primarily to define the areas of gross vehicle weights and dimensions that need to be considered in the economic solution of the problem, and to show the distribution of commodity shipping densities in the universe of highway freight.

REFERENCES

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II. The Freight's the Weight

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• THE PLANNING of highways for the transportation of freight is concerned with the prediction of the size and weight of the line haul highway freight vehicles which may be encountered in the future. Before there can be any conclusive estimation of future vehicle weights there is a need for a study of certain features of the pattern of weight demands for highway freight transportation. Such a study of demand is in line with general commercial practices wherein the demand for a product influences the form, weight, and quantity to be produced.

The present study is one phase of a broader study being made by the Committee on Economics of Motor Vehicle Size and Weight of the Highway Research Board. An objective of this more comprehensive study is to develop data regarding the economic factors involved in the establishment of optimum size and weight specifications for highway freight vehicles and for correlated highway design and construction standards.

Previously there was not available a comprehensive study of the tonnages and shipping densities in pounds per cubic foot (pcf) of freight moved by highway. The present study, herein reported, is based on data for the calendar year 1954. The study analyzes the characteristics of commodities transported by line haul highway freight vehicles, in terms of shipping densities of goods as they move in commerce in the United States.

A first objective of this study was to find out the pattern of the shipping density characteristics of commodities moved by highway and the relationship of payloads of various commodities to the gross weights of practical highway freight vehicles. Another objective of the study was to determine if there are end points in payload weights beyond which there are no significant demands