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IN THIS ISSUE

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U.S. DEPARTMENT OF COMMERCE
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REX M. WHITTON, Administrator

Long-Range Research and Development Program for Individual Transportation Systems

BY THE OFFICE OF RESEARCH AND DEVELOPMENT BUREAU OF PUBLIC ROADS

By[1] **RICHARD C. HOPKINS, RICHARD M. MICHAELS, F. WILLIAM PETRING, CURTIS L. SHUFFLEBARGER, JR., DAVID SOLOMON, and ASRIEL TARAGIN,**
Traffic Operations Research Division

Public Roads officials believe that the Nation's increasing standard of living and its rapidly changing technology require that a research program be undertaken to develop individual transportation systems to fulfill future requirements. To meet this need, Public Roads has proposed the long-range research and development program for individual transportation systems described in this article. The need for the program and its objectives are spelled out; and the three phases envisioned are outlined: Systems analysis, research and development, and prototype testing.

The systems analysis phase will determine the basic criteria governing the performance of any system of individual transportation and will develop a general systems concept. Because the systems analysis phase will provide the framework for the other two phases of the program, a detailed discussion of this important first phase is presented.

Ultimate objective for the total program is the determination of the most promising integrated systems concepts as a basis for completion of the research from which a prototype or prototypes of individual transportation systems can be developed for evaluation.

The long-range research and development program for individual transportation systems will not be accomplished in a short period of time or by any one agency. Public Roads has formulated the general plan and proposes to undertake the initial phases of the program. As the program develops, it is anticipated that there will be participation by the States, industry, and other interested groups.

Introduction

OUR PRESENT highway transportation system is highly effective for individual transportation. It serves the needs and desires of individuals very well. But complacency is dangerous in view of our rapidly changing technology and ever-increasing standard of living. The Interstate Highway System, when completed in 1972, is expected to alleviate congestion, to decrease travel time between origin and destination, and to contribute to an increase in safety, comfort, and convenience for travelers. But it is important to look beyond the completion of the Interstate System. This Nation must keep ahead of the continually changing demands by improving its transportation systems to satisfy individuals needs in the future.

It should be remembered that the Interstate System, as now being constructed, is the culmination of research and development that was started more than a generation ago. To meet the needs of the future, it is necessary to intensify our research and development efforts by utilizing new technology in a coordinated and integrated fashion. Hence, the Bureau of Public Roads is proposing the long-range research and development program for individual transportation systems described in this article.

A recent statement by Robert F. Baker, Director of the Office of Research and Development, Bureau of Public Roads, summarized this long-range program well:

"The accelerating requirements of the Nation make clear that a systematic, energetic research and development program is essential if the optimum transportation system to meet these needs is to become a reality. This program will define a range of alternative transportation system concepts that offer substantial improvements over present concepts. Initially, the program will consist of an intensive systems analysis to develop the basic criteria governing the performance of any system of individual transportation. The ultimate objective of the program will be to determine the optimum integrated systems concepts and to perform the research needed to develop prototypes for field evaluation."

To initiate the first phase of the program, the systems analysis, a set of specifications has been prepared by the Bureau of Public Roads after consideration of the many alternatives suggested by industry, university, and other transportation specialists. The long-range research and development program for individual transportation systems will not be accomplished in a short period of time or by any one agency. Public Roads has formulated the general plan and proposes to undertake the initial phases of the program. As the program develops, it will broaden to include participation by the States, industry, and other interested groups.

Need for the Program

The program described in this discussion has been evolved from an examination of individual transportation; that is, systems designed for individuals to move themselves or their possessions under their own control. This examination was especially related to the ways in which individual transportation may significantly change to meet the needs and requirements of a society that is itself undergoing rapid change. The program was developed because of the recognition that no transportation system can be permitted to drift, with the hope that it will be adequate indefinitely. No society so dependent on personal mobility as ours can afford such luxury. Hence, this program is concerned with the long-range future of individual transportation.

It is obvious from any examination of the highway transportation system that the purposes for which it exists do not depend upon the peculiar physical characteristics of that system. Highway transportation arose out of random invention and has developed as a system in large measure by trial and error. The ultimate reason for the dominance of the highway transportation system over other transportation systems lies in the fact that it better meets the needs of people for movement today. As shown in figure 1, highway transportation offers the individual the freedom to: (1) adapt his travel to a set of time criteria determined by himself, (2) expand the area that

[1] Presented before the special committee on Electronic Research in the Highway Field at the 42d annual meeting of the Highway Research Board, Washington, D.C., January 1963.

OBJECTIVE OF INDIVIDUAL TRANSPORTATION

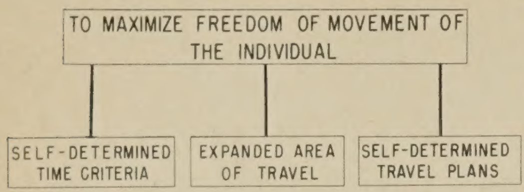

Figure 1.—Objective of individual transportation.

he can use to satisfy his particular needs, and (3) schedule travel according to his own plan and order of priority. Therefore, regardless of the mechanical methods employed, the objective of any system of individual transportation is to provide maximum freedom of movement so that the greatest possible number of people may satisfy their independent and individual needs for travel and for movement of goods.

Highway Transportation Only One Concept

It should be recognized that highway transportation is only one possible system concept of a tremendous variety of possible concepts that can be employed for individual transportation. Figure 2 shows it to be only one system of a surface-space transportation concept. An air-space concept, of which the ground-effects systems are an example, also can be conceived. Also possible is a time-space concept, of which closed-circuit television is an example. In addition, there may be other concepts that have not been considered, as well as systems formed of combinations of all. Consideration of these concepts poses questions as to whether (1) systems embodying them are technologically possible; (2) how the alternatives are to be defined; and (3) how determinations can be made as to the feasibility of these concepts, and whether the resultant transportation systems would offer measurable improvement over the highway transportation system now available. Many answers to these questions have been and are being suggested. Most, although not all, suggest modifications of the present highway transportation system. Some of the other answers include suggestions for pallet systems or ground-effect systems.

Highway transportation, which may be considered as a system because it operates as the result of the interaction of the three elements of driver, vehicle, and highway, has stimulated suggestions interesting because of their emphasis on one aspect. Almost all suggested modifications have pertained to the driver or, stated more generally, the control mechanism. Suggestions have ranged from driverless automobile systems to complex communication systems.

Although improvement of the existing system by use of sophisticated electronics or mechanical means in the control subsystem is necessary, it is frankly not known whether simply superimposing various devices on highway transportation can ever meet the long-term needs for individual movement. For example, is the control of the vehicle now so poor that new control systems must be added? If so, what kinds of systems? Shall there be a large central computer, which controls groups of vehicles by telemetry, or a small one located in the vehicle? Technologically, use of any of these techniques is possible, but which is the most efficient technique and how can efficiency be defined? Which technique is most reliable and how is its reliability to be measured? Which technique is the safest and how can its safety be proved?

Further, can an optimum solution to the problem be obtained without consideration of the design of other aspects of the highway transport system? What of the vehicle? Can the existing vehicle be modified or can a novel one be substituted that could be controlled more easily or more economically? Can the highway be designed to eliminate control problems? Each of these separate questions may be answered in one way or another. However, it is becoming increasingly obvious that over the long run, a significantly improved system cannot be obtained by treating its parts separately. To achieve a radically improved system of individual transportation, a complete and integrated system must be conceived, designed, and developed. This cannot be done by arbitrarily pursuing any one particular electronic or mechanical technique. Although this approach has been the historical precedent, such a procedure precludes valid comparisons and objective choices among the many possible alternatives.

Limitations of Arbitrary Approach

The limitations of pursuing one electronic or mechanical technique become very evident from a brief analysis of some proposed solutions to the control problem. For example, as indicated in figure 3, induction radio has been developed and is being suggested as a means for transmitting control information to the driver or his equivalent. Another suggested solution involves a system of detector units placed in the roadway that would form electronic blocks for the location of vehicles. However, it should be obvious that to use either of these devices in this manner would imply that a whole set of decisions had been made about the nature of the control problem and its solution. Thus, the use of induction radio techniques would imply a decision to use a system of radio frequency for information transmission rather than some kind of pavement-coding system. It would also imply that a decision has been made about telemetry and radar. In addition, a decision to use induction radio rather than a specialized central computer system would indicate a conclusion that in-auto computers are the way to solve the control problem. Finally, all of these decisions clearly would assume that electronic methods should be used to resolve the control problem.

However, within current limits of understanding of the true nature of the control problem, can mechanical methods of solution

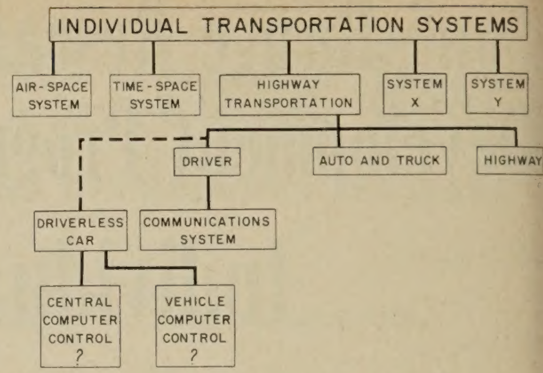

Figure 2.—Highway transportation—one system for individual transportation.

be ruled out? Further, can the current solution to system control—the human—be ruled out? After all, the human has capabilities that are difficult to rival mechanically. For example, the human can detect angular velocities as low as 5×10^{-5} radians/sec.; he can discriminate differences in frequency to an accuracy of 0.2 percent; he can estimate position relative to himself with an accuracy of 1 percent. These capabilities not only are unusually good but cost nothing to produce.

This discussion of just one aspect of the highway transportation system shows the tremendous complexity of the problem and the dangers that may arise from the arbitrary choice of one type of solution. This danger obviously applies to all the other aspects of the system. To operate in this arbitrary fashion would minimize the chances of ever knowing whether an efficient system had been selected.

The problem of individual transportation can be resolved only through a systematic analysis that starts from the essential requirements that any system must have to meet the objectives of individual transportation. Only from such an objective analysis can measures be developed to rationally evaluate alternative physical means so that the most effective systems may be selected. To achieve this selection a comprehensive and integrated program of research and development is required. Such an approach, which is the modern systems engineering approach, is the one that the Bureau of Public Roads proposes to use in the solution of the long-range problems in individual transportation.

The Program

The proposed program consists of three phases as shown in figure 4. The first phase is a SYSTEMS ANALYSIS, which will provide a framework for the next phase—an intensive RESEARCH and DEVELOPMENT effort—aimed at producing in the third phase one or more PROTOTYPES for testing. The initial phase of the program, the systems analysis, is a procedure for defining a complex problem in operational terms. In this way, the problem may be stated in analytical terms, thereby permitting the precise definition of alternative

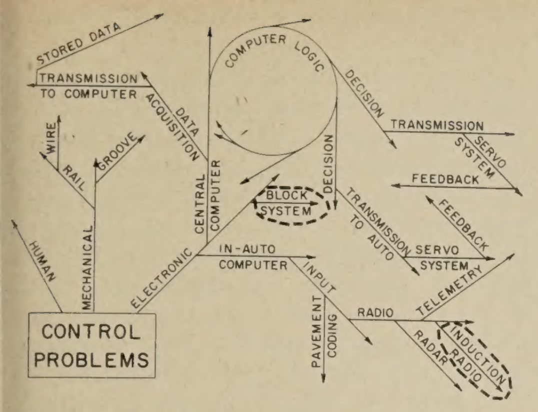

Figure 3.—Possible solutions to control problems.

systems, which can be designed and evaluated. Thus, the systems analysis will form the framework for the research and development phase.

The research and development phase of the program will encompass investigations of the various components of each of the alternative systems, particularly their interaction. A continuing process of evaluation will be used to determine whether the alternative systems selected meet the required performance criteria. Among other matters, economic considerations and questions of reliability and public acceptability of the systems will be investigated. After evaluation and research have been done, an intensive development effort is expected to make it possible to provide one or more prototype systems for testing.

Research, development, and evaluation will be a continuous and simultaneous process and considerable interaction is expected among these activities. From these feedback processes, it becomes apparent that the research and development phase will be modified as the systems analysis proceeds. Likewise, the systems analysis will provide a general but flexible framework for the research and development phase.

The third phase of the overall program will consist of testing one or more prototypes that have been produced during the research and development phase. This testing will be undertaken on a proving ground before the prototype is subjected to field tests. Again, there will be feedback between proving ground and field tests.

Similarly, the three phases of the overall program are interdependent; and, as mentioned earlier, the research and development phase will undoubtedly be modified from that which is initially selected. Thus, the systems analysis will, in effect, be modified as research and development proceeds. Similarly, modification also will occur from research and development to prototype testing. It is, therefore, conceivable that feedback from prototype testing to the systems analysis could revise the initial systems concept.

THE SYSTEMS ANALYSIS

The first phase in fulfilling the objective of this long-range program is to conduct an intensive systems analysis Because the systems analysis is so important in providing direction for the overall program, the remainder of this article will be devoted to it.

Systems analysis is described as the definition of a problem in operational terms, which then permits formulation of a systems concept. The problem is individual transportation, and the goal is to define this transportation system, formulate requirements for it, evaluate and select the most promising systems concepts, and plan for the subsequent phases.

This systems analysis will be essentially a theoretical, analytical effort by a team of engineers and systems analysts. It will not involve physical hardware or its application. It will involve the general or abstract principles of individual transportation. It will formulate mathematical models that present a clear, systematic picture of individual transportation.

This will be the first time that such a comprehensive systems analysis of a transportation system has been undertaken. Its output will provide a better understanding of the overall problem, a logical grasp of the most promising concepts, and identification of critical areas of needed research.

Figure 5 shows that the analysis will consist of three parts—a definition of performance requirements that the system must meet, the formulation of a generalized system concept, and a description of the alternative systems that may be derived from the generalized concept. The first two steps will constitute a purely theoretical study. The general model or concept of individual transportation to be formulated will be the most important, single product of this effort. The alternative systems shown at the bottom of figure 5 will then follow.

At this point it should be added that the relevant user categories that one thinks of today will be considered in the systems analysis. These categories are the transportation of individuals; the mass transportation of people, covering also the movement from origin to the mass transport vehicle and from such a vehicle to a destination; and the transportation of freight together with the special characteristics that such transportation requires.

Performance Requirements

As the first step—definition of performance requirements—a preliminary set of system requirements must be drafted in the early stages of this analysis. Such requirements will be the "guide posts" for the basic evaluation of proposed systems. It should be understood that they are preliminary, however, for they will be continually modified as the program progresses. Experience has shown that formulation of these requirements is a process of achieving a harmonious balance between practical means and ideal goals. A sound requirements statement is therefore an end product of the systems analysis even though in preliminary form it is used for guidance of the study itself.

The statement of performance requirements will define performance criteria that are the measures by which individual transporta-

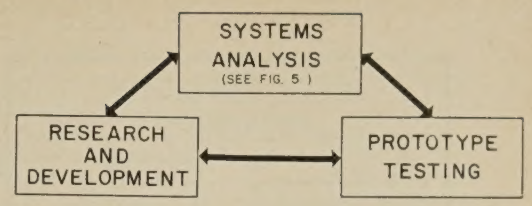

Figure 4.—The three interrelated phases in the long-range research and development program for individual transportation systems.

tion can be judged. It will also define the variables or quantities of such a system and their range of values. Some examples of criteria might be the probability of collision, the predictability of position, or the travel time between origin and destination. There may be many others similar to these. There may be other ways of specifying them. However, the criteria must define the system on a complete and rational basis. The variables, and their operating ranges may include such items as speed, flow rate, and size of vehicle. Again these are only examples of the qualities that describe the operation of a generalized concept.

Looking to the formulation of the generalized system concept, it should be noted that this concept is still completely theoretical and will be based on the performance requirements to be developed.

First, an examination will be made of the essential elements or components of any transportation system. These components include the vehicle, an operating medium, the control logic, and the human. The human, of course, must be considered both as a part of the control logic and as a system user. In each, there are various alternatives that might be listed in the light of present and future technology. The interaction of these four elements is highly critical.

Then operating rules will be generated. These are to be the bases by which may be specified the characteristics of individual transportation in terms of the performance criteria and system variables. These are the theoretical expressions of a generalized systems concept. The operating rules may be expressed as a set of equations and the variables could then be related in such a way as to meet the defined performance criteria. Thus, it could be that a description of individual transportation would be stated as a set of mathematical functions.

Once this generalized framework for individual transportation has been developed, any combination of vehicle, operating medium, and control logic can be tested. Ultimately, one or several of the possible combinations that best satisfy these equations will be chosen for more intensive analysis. This is not a simple straightforward procedure; there must be feedback and interaction among the various steps. The generated operating rules and the several alternative solutions will point to the competence of the original performance requirements. Conversely, the continuous refinement of this performance statement must be accurately reflected in the operating rules.

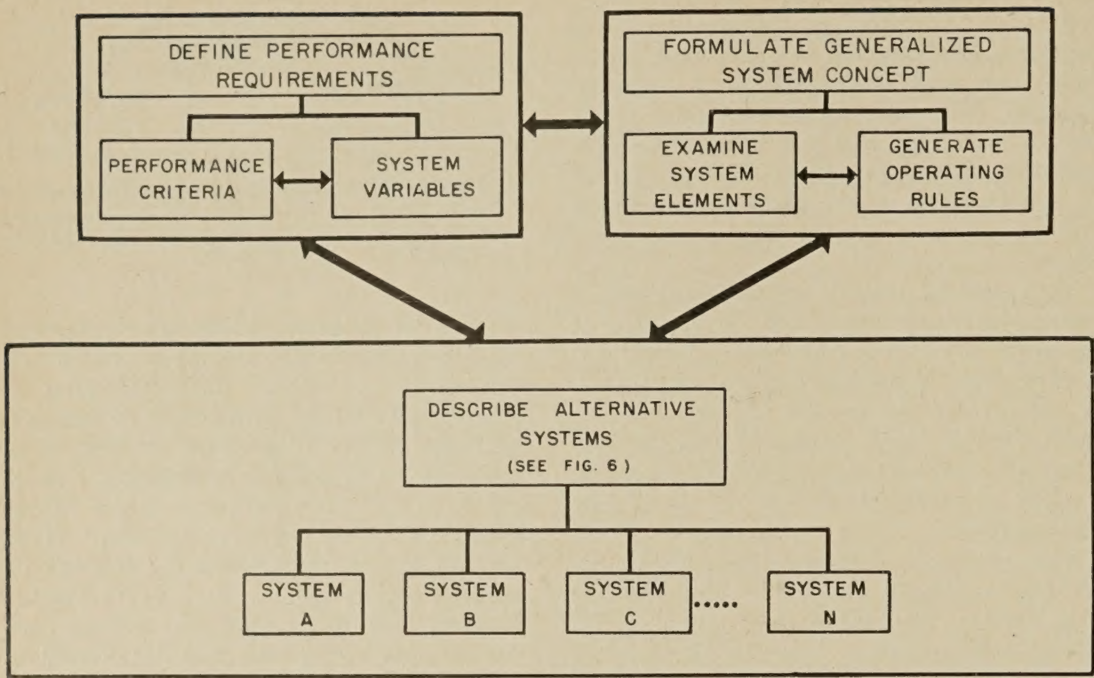

Figure 5.—Outline of the systems analysis for individual transportation.

Because this feedback process is of such vital importance to a systems analysis, the analysis can become extremely complex, particularly when dealing with a system so encompassing as individual transportation. Moreover, the systems analysis will form the basis for the entire long-range research and development program. Hence, it is evident that the systems analysis should be done as a single operation in order to provide a solid framework around which all succeeding steps can be taken.

Precaution must be taken to avoid initial error, because any concept adopted and implemented would undoubtedly involve a significant portion of our national effort. To prevent hasty judgment and preselection of the most obvious (or any other) form of individual transportation as the "only" solution, it is desirable to explore all alternative concepts that could possibly meet the same objectives. Therefore, the systems analysis must investigate feasibility from broad viewpoints and determine the detailed technical concepts worthy of further research, development, and evaluation. It will define various alternative system concepts, bring them into a common analytical frame of reference, and compare their relative effectiveness.

One result of the systems analysis, incidentally, might be to indicate that modification of the existing system is the optimum way to proceed in the research and development phase. But, if this is the case, it will be clearly established that other alternatives have been investigated and rejected, and the reasons for such rejection will be detailed. Thus, it has been shown that by a systems analysis of the criteria, the variables, and the components, one arrives at a theoretical expression of individual transportation. For the first time there will be a comprehensive model of a major transportation medium from which to select optimum solutions. This generalized concept will permit the preliminary testing of many individual system combinations and the selection of those that best satisfy the general expressions.

The Alternative Systems

It has been shown that the three interdependent operations illustrated in figure 5 comprise a theoretical systems analysis. A general procedure was outlined for defining the performance requirements and formulating a generalized system. Now the third operation, the description of alternative systems will be discussed. However, these three operations are interdependent and must therefore be undertaken as a carefully coordinated effort.

By way of definition, an alternative system is the combination of operating components that will accomplish a given objective in an acceptable manner. In this case, describing an alternative system means proposing a complete solution to the problem of improving individual transportation. By this process, several alternative systems, not just one, may evolve. But, a properly conducted systems analysis will produce the minimum number of maximum efficiency systems. Each system will be complete, and each system can be accurately described.

These alternative systems, as shown in figure 6, obviously cannot be named at this time. However, they might include such systems as the oft referred to but so far vaguely described "automated highway." One system might be a conveyor belt highway and another might be some form of pneumatic tube transport. Or, with visions on the horizon of the possibilities of the future, one system may utilize airborne vehicles guided by laser beams and propelled by the energy received from the lasers. Other systems concepts will complete some n number of alternatives.

As shown in figure 6, there will be a description of the operating characteristics of each alternative system, which will describe how the components within that system interact. The subsystems of which any system must be comprised will be described from all aspects. In this description, consideration of the environment will include analyzing the features of the areas through which the system itself will operate, such as the land areas of the business district, the city, the suburbs, and the rural areas. It will also include solutions for those problems of entrance, exit, and storage of vehicles within the system. And, of course, it will describe the effects of environmental problems such as weather.

The subsystems will be described from the viewpoints of the various user groups. Of these, the largest group will consist of those who are desirous of improved personal transportation. But full consideration will also be given to that group of individuals who wish to join with others to share improved mass transportation; and to a third group, which will include those individuals who desire to improve the movement of freight. There will also be a description of the probability of acceptance of each given alternative system. This may well be based on a description of its comparability with the present highway system or it may use some other datum for evaluation. It will, of course, include a complete description of the readjustment necessary in our economy to accept the new and proposed systems.

Figure 6 also shows the four categories of basic components in any transportation system: the vehicle, the operating medium, the control logic, and the human. Close interconnection must exist among all four of these component categories. It is not feasible to develop one of the components without full consideration of the others.

The vehicle will be considered as a container for that which is to be transported. In each alternative system the vehicle will be comprised of some combination of power sources and propulsion techniques, as shown in figure 7. This 2 × 2 matrix shows some existing and familiar vehicles. But many other vehicles could be placed in the matrix. The self-powered, externally propelled vehicle does not exist at present. However, a systems analysis would generically describe new and unique vehicles that in concept may make use of such techniques, and it is entirely possible that such a vehicle could be developed. The systems analysis will describe the useful characteristics of the proposed vehicles and contrast them with undesirable characteristics such as air pollution. From such descriptive comparisons of vehicles, the usefulness of each as a system component will become evident. These will be generalized rather than detailed, technical descriptions.

The operating medium of any alternative system in this systems analysis will be described by its features as a "highway." The term highway is used in the sense of the AASHO definition, "A general term denoting a public way for purposes of vehicular travel, including the entire area within the right-of-way." As has been mentioned, the operating medium of an alternative system may well be the conventional highway, with or without some modification. However, unconventional media such as the ground pathway, various types of structures, air, and many others need to be considered and compared for the description of alternative systems. Different subsystems possibly will require different media to promote the most efficient movement of traffic in each particular area. The description of the operating medium will also indicate what provision must be made for such foreign objects as pedestrians, animals, and debris.

The control logic of a system is that combination of techniques and devices employed to regulate the operation of that system and is outlined by the closed loop diagram shown in figure 8. For each system, the analysis will show what information needs to be acquired and how it will be obtained. The conception and design of the processing and analyzing equipment that will be necessary to convert these data into operational decisions can then be described. The best means of communicating these decisions to the mechanical equipment or the human, which will translate them into the necessary action, can be specified. The control logic loop is closed by including the reaction, or feedback, which will detect and correct the performance errors. The description of the control logic will also include such things as the handling of nonconforming vehicles, failures in the logic itself or in other parts of the system, and the accommodation of personal emergencies.

It is also evident that as each alternative system is described, the role of the human must be considered both as an active system element and as a rider. No analysis need assume the preconceived notion of complete automation. The amazing ability of the human to accomplish perceptive and control tasks has been previously pointed out. The capabilities and limitations of the human will be studied and the results of these studies will determine the areas where he may be utilized in guidance and control. The human may well be the monitor of an automated system; or the alternative system may be designed for human control that is to be automatically monitored. The factors of fatigue and vigilance also will be completely studied and described in each alternative system.

The human as a rider in the system will have great bearing on the acceptability of the system. Studies of the tolerance of the human to motion and to changes in motion in all directions will, of course, need to be made. Also, it will be necessary to specify the training that will be required to fit the human to each new system. These and other human characteristics will bear equally with the other components on the utility and acceptability of any system to the potential user.

Finally, a benefit-cost analysis will complete each alternative system description. It is evident that in all areas it will not be possible to indicate these items in terms of dollars. However, where it is not possible to estimate an exact cost in one alternative, the same base of comparison will be extended to the other alternatives. Of principal importance, however, is that the comparative cost between alternative systems be properly made. These costs, of course, can be categorized as initial, operating, and maintenance, and the benefits can be identifiable in each system. Those benefits which cannot be expressed in dollars and cents will be expressed in such terms as comfort and convenience to the potential user.

Thus out of the systems analysis will come a description of alternative types of systems that meet the requirements for individual transportation. In addition, the systems analysis will define the research and development needed to produce a prototype, as shown in figure 6. Included will be a complete description of the research and development program needed to determine the feasibility of and the design requirements for a prototype system. In addition, the cost of the research will be included and the probability of success in producing a prototype for testing will be estimated. It is recognized that some aspects of such a program will be only broadly identified in the systems analysis phase but will be detailed as research and development proceeds.

From this discussion, it can be seen that the systems analysis is a logical approach to the challenge of today—namely, to lay the foundations for the rational evolution of individual transportation systems of the future.

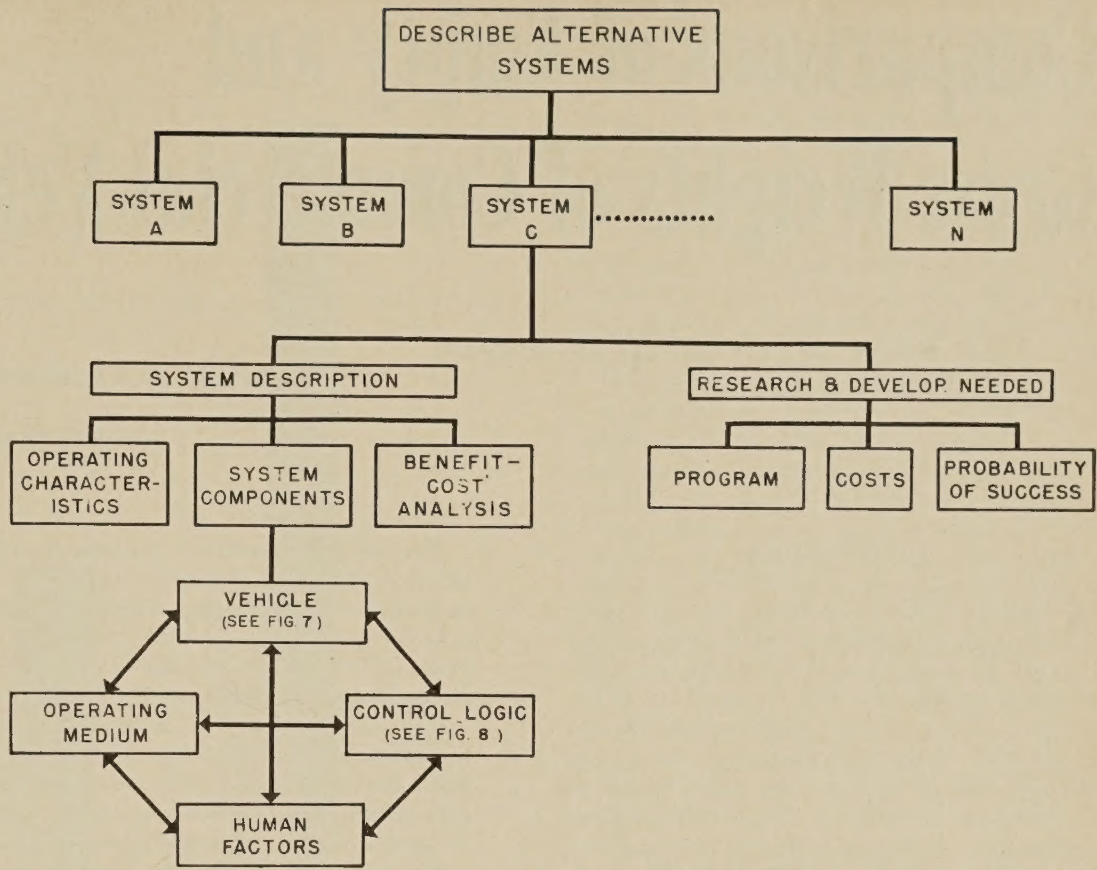

Figure 6.—Description of alternative systems including research and development needed.

VEHICLE

		POWER AND PROPULSION MEANS	
		PROPULSION: SELF	PROPULSION: EXTERNAL
POWER	SELF	AUTOMOBILE DIESEL TRAIN GROUND EFFECTS MACHINE	?
POWER	EXTERNAL	TROLLEY ELECTRIC TRAIN	CONVEYOR BELT IMPELLER SYSTEM SKI LIFT

Figure 7.—Various combinations of vehicle power and propulsion.

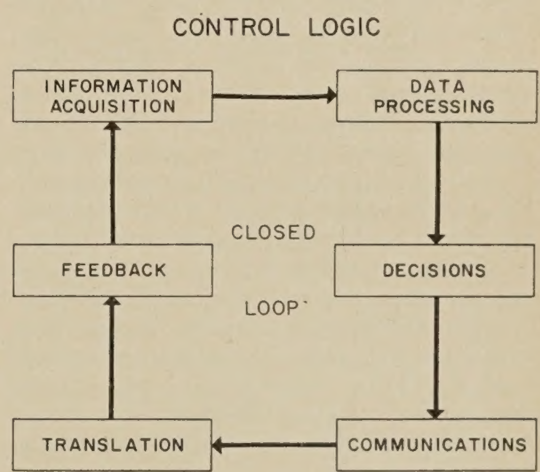

Figure 8.—Control logic considered as a closed loop process.

Comparisons of Empty and Gross Weights of Commercial Vehicles

BY THE BUREAU OF PUBLIC ROADS

Reported[1] by LAURENCE L. LISTON, Transportation Economist
Office of Research and Development
and STANLEY F. BIELAK, Transportation Economist
Office of Highway Plannin

The need for a uniform weight classification base for commercial vehicles and the possibility of determining such a base from available information are described in this article. Because more adequate descriptions of commercial vehicles would permit better research and planning for the highways now being planned and built for the more than 100 million vehicles expected by 1972, an analysis has been made of available information.

Comparisons were made of data samples on commercial vehicles taken from the 1957 and 1961 loadometer studies and from special California vehicle records. Each sample group of data was satisfactorily representative of the total available information and correlations from selected groups of data were made by empty weights and by registered gross weights of vehicles.

The tabulations and the accompanying graphic materials are expected to be useful as guides in the solution of many vehicle classification problems. This analysis revealed that it would be very difficult, if not impossible, to develop a usable set of weight relationships from present registration data. However, the data considered in this study tend to give each other mutual support and the results of the 1957 loadometer study remain generally applicable.

Introduction

A SIGNIFICANT portion of highway research is dependent on the basic data that can be obtained on the numbers and types of motor vehicles that are, or are likely to be, in use. It is somewhat of an oddity that in this Nation of highly developed motor-vehicle mobility, one of the greatest single problems of highway research is the understanding, description, and cataloging of the numbers and kinds of vehicles in use for which highways must be provided.

There are nearly 80 million vehicles in the United States, and highways are now being planned and built for the more than 100 million expected 10 years from now. Yet, although each motor vehicle is required to be registered each year with a State motor vehicle department, it is possible to describe these 80 million vehicles in only the most general terms from the basic annual records. Although considerably more uniform information would be desirable on passenger vehicles the primary concern is the lack of uniform data on the types and weights of the truck fleet that at present is comprised of more than 12 million vehicles. The problems encountered are (1) the amount and quality of the data required and recorded on the annual registration application and on the registration certificate, and (2) the different weight bases used by the States for tax purposes. It often is not possible to combine, or to compare, the information on trucks registered in two neighboring States because the weight classification for tax purposes is entirely different. One State may register vehicles on the basis of the empty weight of the power unit, and another State may register its vehicles on the basis of the owner's declared maximum gross weight of vehicle and load. Data gathering is further complicated because the State using empty weight has no means for gross weight identification, and the State using gross weight frequently does not require the empty weight of the power unit for its records. Any significant comparison of the effect of the bases used for truck registration should include the numbers of vehicles registered by each method. The application of the three main weight classifications employed in State registration systems to the truck fleets in 1931, 1951, and 1961 is shown in figure 1. During the period from 1931 to 1961 truck registrations increased nearly fourfold, from 3.6 million to 12.3 million.[2]

Disparity in the methods of registration required has also been disappearing since 1931 when 26 States registered about 945,000 trucks on the basis of the manufacturers' rated capacities; 13 States registered approximately 1.6 million trucks on the basis of empty weight, and the remaining 10 States registered 1.1 million trucks on the basis of declared gross vehicle weight. By 1961 only Alabama retained the requirement for registration on the basis of manufacturers' rated capacity—239,000 trucks were registered. The rest of the States required trucks to be registered either by empty weight or by some form of declared gross weight. A total of 3.3 million trucks was registered in 14 States by empty weight, and 8.8 million trucks were registered in 36 States by declared gross weight. Except for the small 2-axle truck, commonly appearing as a pick up or panel vehicle and having characteristics similar to a passenger car, the many different types and sizes of trucks and combinations that compound the problems of classification and taxation are shown in silhouette in figure 2.

In this article several samples of data tha relate vehicle empty weights and registere gross weights have been compared in orde to establish a set of usable weight correlation by visual vehicle classes. The resultant weigh comparisons are given in tabular form an both the vehicle distributions and their pe centage counterparts shown. These compari sons (tables 11–17) provide an additiona classification tool for research and plannin activities.

The research covered by this report wil have many uses, important to the Federal an the State governments. The data presente can be used as an aid in the analysis of th application and equitability of road-user taxes and they are expected to enhance the effective ness of administration of motor-vehicle ta laws. They will be useful in determining th probable effects of legislation proposed, an they also will be of value to those concerne with highway planning, and to industry i materials, product, and market research.

Vehicle Classification Studies

One of the early efforts to count and classif commercial motor vehicles was a comprehen sive study of registrations and fees reported i *The Taxation of Motor Vehicles in 1932*, b G. P. St. Clair, PUBLIC ROADS, vol. 15, No. 8 Oct. 1934, pp. 185–214. Information for thi study was compiled by the Bureau of Publi Roads from State and local motor-vehicl records and from questionnaires that requeste data on vehicles and taxes in considerabl

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[1] Presented at the 42d annual meeting of the Highway Research Board, Washington, D.C., January 1963.

[2] Data for the 1931 and 1951 comparisons were collected from 48 States and the District of Columbia. Information from Alaska and Hawaii have been included in 1961 figures.

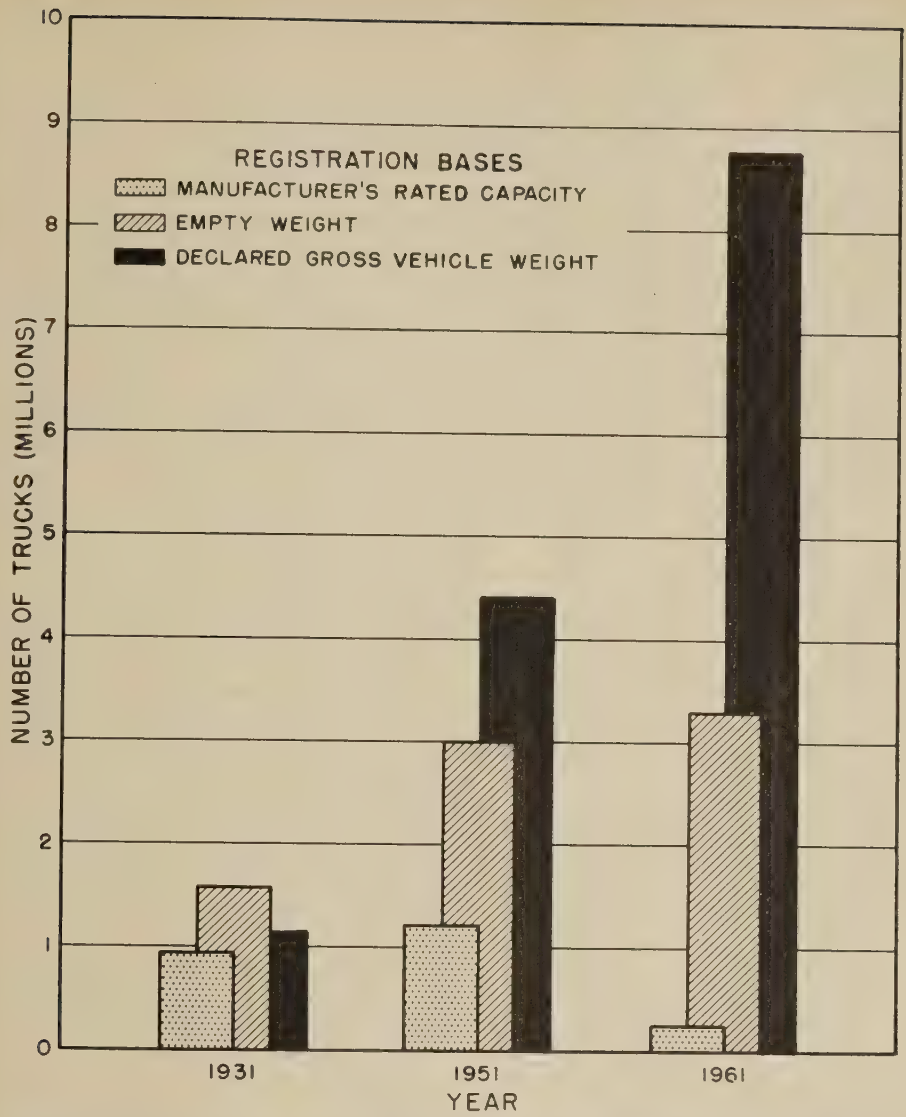

Figure 1.—Number of trucks and combinations registered in 1931, 1951, and 1961, segregated by registration base. Data for 1931 and 1951 are comparable but 1961 data include registrations in Alaska and Hawaii in the empty weight bar.

detail. Another study, known as the Nationwide Truck and Bus Inventory, was begun in 1940 by the Bureau of Public Roads in cooperation with the States. Although the work was eventually completed, it was expensive, and it used manufacturers' rated capacities as a uniform measure of truck weight. Since the use of that classification was rapidly waning, the study had limited value for comparing current vehicle classification data, and the results of the study have not been published.

The next major vehicle classification study was made by the Bureau of Public Roads, in cooperation with the States, to provide basic information for the highway cost allocation study that was required by Section 210 of the Highway Revenue Act of 1956. The findings of this classification study were included in the comprehensive series of highway cost allocation study reports made to the Congress, and also were published in 1960 by the Bureau of Public Roads as the *Classification of Motor Vehicles, 1956–57*. This study is the most recent inventory of highway rolling stock, and it will be referred to in this report as the classification study.

When the classification study was undertaken, an effort was made by Public Roads and State authorities to obtain the needed data in each of the States. Intensive reviews were made of the existing registration records, special questions were added to some motor-vehicle registration application forms for the following year, and special questionnaires were mailed to vehicle owners by many States in an effort to obtain information to supplement the data in the registration files. A valuable lesson was learned during this study. The motor-vehicle data needed for highway research were unavailable from any public source in a usable form. Even if it had been possible to obtain a complete summary and analysis of the vehicle records of each State, the data obtained would have been so lacking in uniformity that it would have been impossible, with the knowledge then available, to combine them into a workable, usable body of data for use in research. One result of these findings is the cooperative effort of the States and Public Roads to develop standard vehicle descriptions and information that will be useful to both government and industry. As a result of this effort, substantial progress is being made under the auspices of the American Association of Motor Vehicle Administrators.

Many differences existed in the registration requirements and records of the States but the one that posed the greatest problem was the requirement of several States for registration of vehicles on the basis of empty weight or on variations of gross and empty weights. Most States registered and recorded vehicles on the basis of the owners' declared gross weight (the weight of the vehicle, fully equipped and ready for service, plus the maximum load to be carried).

When it is necessary, in studies of motor vehicles or motor-vehicle revenues, to bring the basic motor-vehicle data of all States into uniformity, a relationship must be established between the bases and all of the data must be converted to a uniform structure for analysis.

To properly analyze the composition of the vehicle fleet, an understanding of the factors affecting the selection of the vehicles in use is necessary. Tax structures, terrain, kind of goods transported, and literally dozens of factors affect owners' vehicle selections. Some carriers may elect to buy lightweight power equipment to perform the same job that is done by another carrier with heavier and costlier power units. The lighter power units would depreciate more rapidly but, because of other factors, they might provide lower overall operation cost. The subject of vehicle ownership and operating costs is discussed in considerable detail in the report *Line-Haul Trucking Costs in Relation to Vehicle Gross Weights*, by Hoy Stevens, Highway Research Board Bulletin 301, 1961.

Sources of Data for Weight Comparisons

1957 traffic and loadometer data

During the course of the extensive 1957 motor-vehicle traffic counting, classification, and loadometer operations, approximately 600,000 vehicles were weighed, and data concerning empty weight, registered weight, make, body, axle arrangement, and other items on vehicle classification and operation were obtained. More than 150,000 commercial vehicles, for which weight data were complete, were selected from the group of 600,000 for special study to relate empty and registered gross vehicle weights. Gross vehicle weight was available from the registration certificates for only vehicles registered on that basis, but it is believed that a good representative sample was obtained because States using this basis were very well distributed geographically. In this article, the data concerning the 150,000 commercial vehicles is referred to as the "1957 loadometer data." Information from more recent weighing studies and spot vehicle classification counts made by the States have been added to the 1957 loadometer data. The locations of the weighing stations were selected with the objective of making the data collected from them representative of the vehicles being used in that area.

1961 loadometer data

Rather than wait until the 1961 loadometer study had been completed and the complete record of weighings was available for use, a special group of data was collected from a limited sample of vehicles throughout the United States. This sample was obtained as

Table 1.—Trucks and combinations, observed during 1957 and 1961 loadometer studies, grouped by number of axles and by registered gross vehicle weights [1]

Registered gross vehicle weight	Single-unit trucks				Combinations consisting of—											
					Tractor and semitrailer						Truck and full trailer				Tractor, semi-trailer and full trailer	
	2-axles		3-axles		3-axles (2-S1)		4-axles (2-S2)		5-axles (3-S2)		3-axles (2-1)		5-axles (3-2)		5-axles (2-S1-2)	
Pounds	*No.*	*Pct.*	*No.*	*Pct.*	*No.*	*Pct.*	*No.*	*Pct.*	*No.*	*Pct.*	*No.*	*Pct.*	*No.*	*Pct.*	*No.*	*Pct.*
0-3,999	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------
4,000-4,999	49,279	36.0	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------
5,000-5,999	26,846	19.6	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------
6,000-7,999	12,767	9.3	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------
8,000-9,999	6,637	4.9	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------
10,000-11,999	5,456	4.0	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------
12,000-13,999	4,560	3.3	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------
14,000-15,999	4,236	3.1	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------
16,000-17,999	6,855	5.0	152	2.1	2	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------
18,000-19,999	4,431	3.2	47	0.6	106	1.6	--------	--------	--------	--------	28	9.2	--------	--------	--------	--------
20,000-21,999	5,761	4.2	65	0.9	77	1.2	--------	--------	--------	--------	14	4.6	--------	--------	--------	--------
22,000-23,999	3,000	2.2	106	1.5	93	1.5	29	0.3	--------	--------	17	5.5	--------	--------	--------	--------
24,000-25,999	4,732	3.5	193	2.6	241	3.8	35	0.4	--------	--------	14	4.6	--------	--------	--------	--------
26,000-27,999	1,153	0.8	205	2.8	127	2.0	22	0.2	--------	--------	16	5.2	--------	--------	--------	--------
28,000-29,999	294	0.2	214	2.9	187	3.0	11	0.1	--------	--------	14	4.6	--------	--------	--------	--------
30,000-31,999	520	0.4	322	4.4	394	6.3	38	0.4	--------	--------	14	4.6	--------	--------	--------	--------
32,000-35,999	103	0.1	708	9.6	1,040	16.5	47	0.5	--------	--------	38	12.4	--------	--------	--------	--------
36,000-39,999	103	0.1	1,174	16.0	987	15.7	101	1.1	--------	--------	53	17.3	--------	--------	--------	--------
40,000-44,999	97	0.1	1,657	22.5	2,188	34.8	280	3.2	--------	--------	86	28.1	--------	--------	--------	--------
45,000-49,999	41	--------	2,273	30.9	301	4.8	361	4.1	191	3.3	12	3.9	--------	--------	--------	--------
50,000-54,999	21	--------	233	3.2	376	6.0	1,843	20.8	151	2.6	--------	--------			1	1.5
55,000-59,999	9	--------	--------	--------	66	1.0	4,061	45.9	192	3.3	--------	--------	17	2.4	--------	--------
60,000-64,999	56	--------	--------	--------	104	1.7	1,737	19.6	1,070	18.3	--------	--------	5	0.7	2	2.9
65,000-69,999	--------	--------	--------	--------	6	0.1	261	3.0	1,216	20.9	--------	--------	42	5.9	4	5.9
70,000-74,999	--------	--------	--------	--------	--------	--------	34	0.4	2,595	44.5	--------	--------	311	43.5	28	41.2
75,000-79,999	--------	--------	--------	--------	--------	--------	--------	--------	416	7.1	--------	--------	319	44.6	30	44.1
80,000 and over	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	21	2.9	3	4.4
TOTAL	136,957	100.0	7,349	100.0	6,295	100.0	8,860	100.0	5,831	100.0	306	100.0	715	100.0	68	100.0

[1] Data from 1957 and 1961 special, field - weighing reports are combined in this table. The portion of the table boxed by heavy lines represents 90 percent or more of the vehicles in each vehicle type.

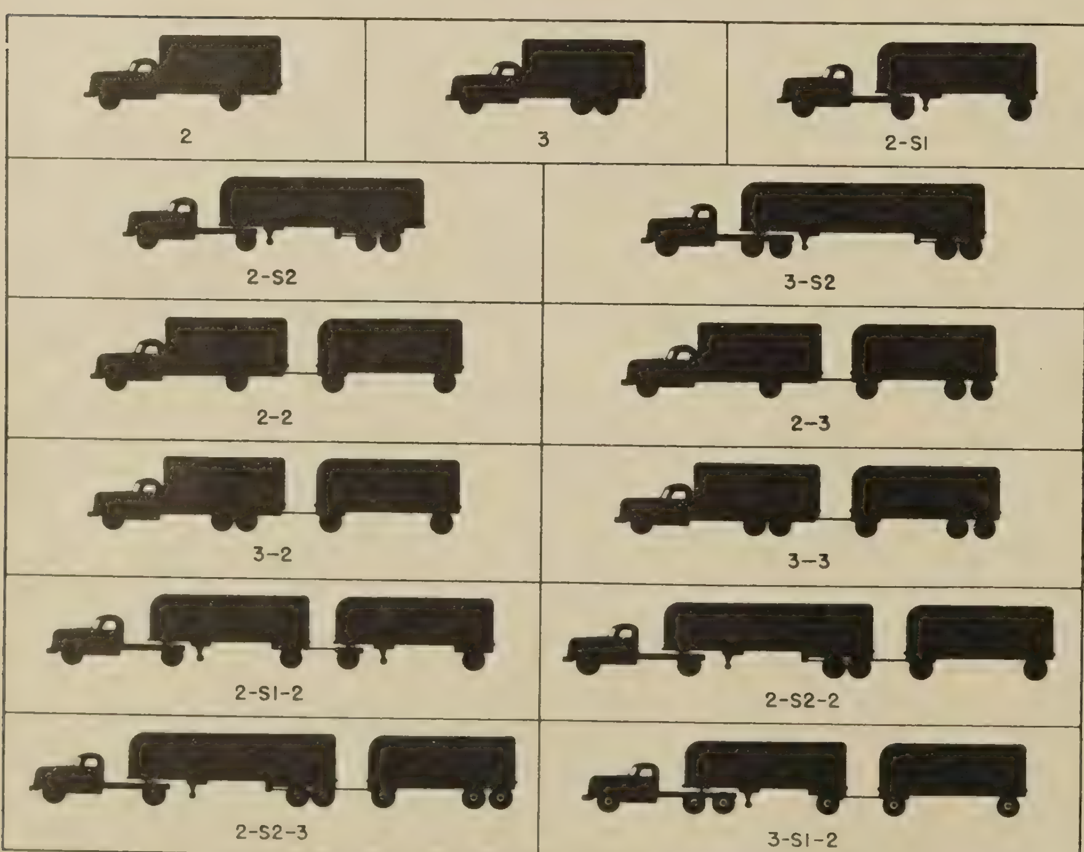

Figure 2.—Commercial vehicle types as designated by code based on axle arrangement.

a part of the regular loadometer study, but was collected at the first station or first two stations operated in each State at the beginning of the weighing operations. The study instructions stipulated that vehicles were to be weighed at each station until at least 10 loaded and 10 empty vehicles of each visual type, as shown in figure 2, had been observed.

A field crew member was assigned to interview each driver and to obtain registration card information while the vehicle was being weighed by other members of the crew. These data were placed on punch cards, which were forwarded to the Washington office of the Bureau of Public Roads. In order to check the accuracy of the sample, Public Roads sent the record of each of these vehicles to the State in which it was registered to be verified against the registration file. It is believed that this check eliminated many of the inconsistencies, which might otherwise have gone undetected, and that data for the resultant group of vehicles identified in this article as the "1961 loadometer data" have a relatively high degree of accuracy. Although the sample was not expanded, a comparison of the data with those obtained from other sources showed the information to be representative in all major weight cells. The usable sample from the 1961 loadometer data totaled approximately 14,000 vehicles, and the information gathered included empty and gross

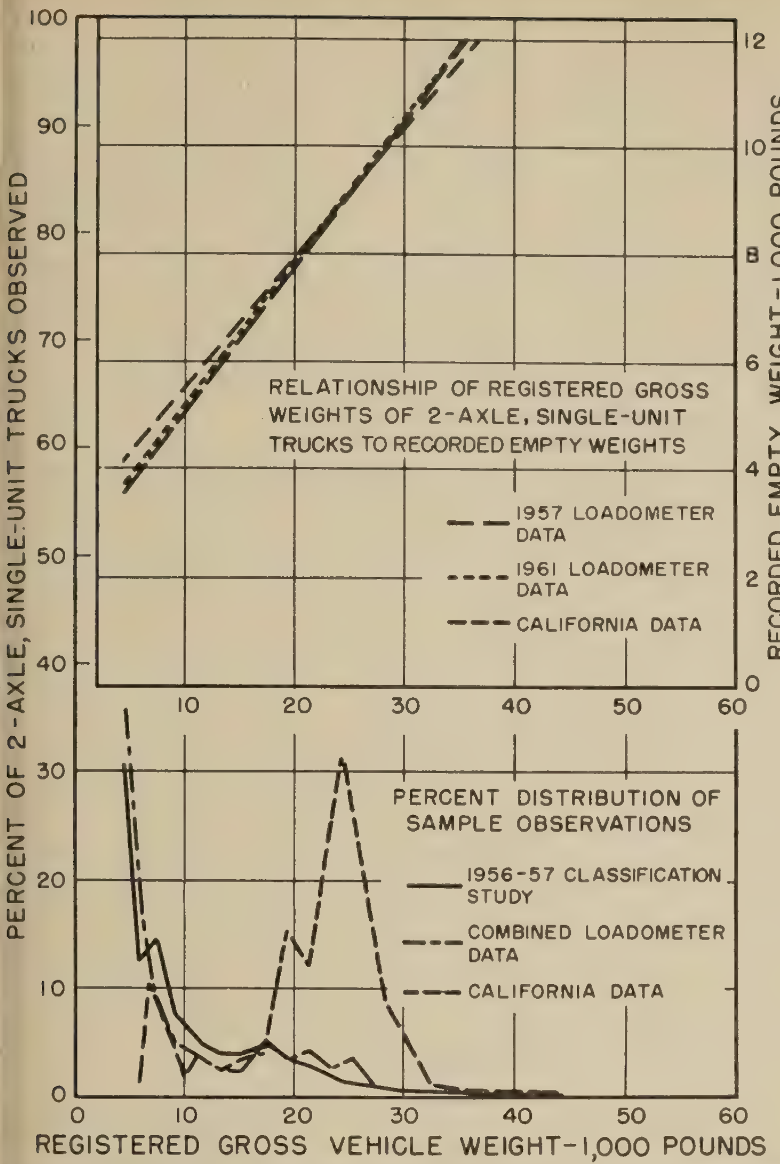

Figure 3.—Empty to gross weight relationships and relative distribution of 2-axle, single-unit trucks.

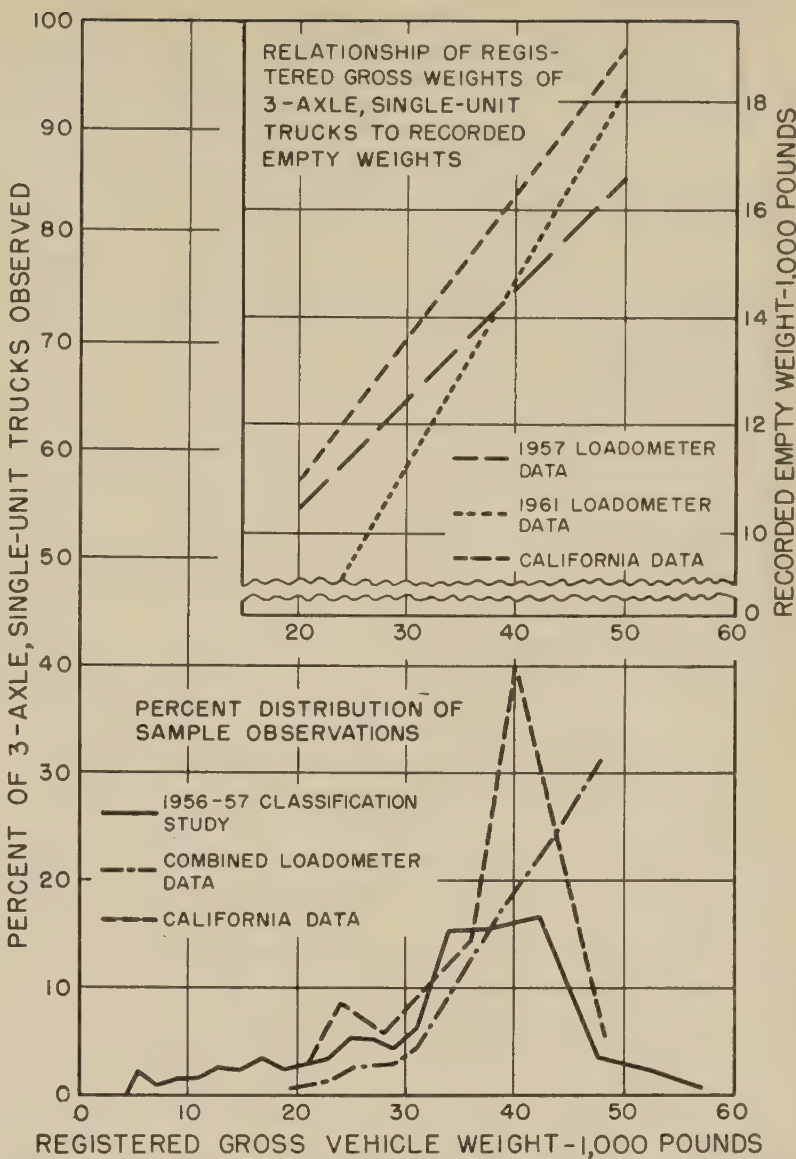

Figure 4.—Empty to gross weight relationships and relative distribution of 3-axle, single-unit trucks.

weights, vehicle type, number of axles, body type, class of use, some information on fuel used, year model, make of vehicle, and commodity carried. Only the information that applies specifically to weight comparisons has been summarized here. Processing of the remaining data is in progress and, if these data are found to be representative, they will be used in other studies.

Some unexplained differences were noted in a comparison of the 1957 and 1961 loadometer data. These differences probably were caused by the highway system coverage and the distribution of the loadometer stations. Because of the scope and purpose of the 1957 loadometer study, more urban stations were included and a greater coverage of secondary and local road systems was obtained. The 1961 loadometer data, however, are more indicative of the type of vehicles used on main rural highways.

California data

The third group of data used in preparation of this article was obtained from the State of California for vehicles registered under the Uniform Proration Compact. California maintains an excellent file on motor-vehicle fleets that are registered in other States on different registration bases and that are operated in California under the Proration Compact. Uniform empty and gross weight data and other vehicle information were available for these vehicles. The California authorities permitted the authors to use the information and provided much assistance in interpreting it. This availability of another source of data was an important factor in the decision to present this study.

Unlike the truck samples obtained in the loadometer surveys, the California data represented principally over-the-road fleets from the Western States. The records included the declared gross vehicle weight of the vehicle or combination; the empty weight of the power unit; and the type of carrier, make, year model, and number of axles; and the type of motor fuel used. Data on approximately 8,000 vehicles were supplied by the State, and information on 6,700 has been used in the comparisons in this article. Information on approximately 1,300 vehicles could not be included in the study because one or more of the basic weight factors had not been included in the reports to the State.

Data from other sources

The State motor-vehicle registration authorities make their annual registration counts, by vehicle type, available to the Bureau of Public Roads and other interested groups. These data are consolidated in Public Roads tables MV-1 through MV-11 [3] for use by government transportation and planning authorities, industry marketing groups, and private individuals. A few States prepare special tabulations on commercial vehicles by weight classes for their own uses, and copies of these have been supplied to the Bureau of Public Roads for studies of vehicle characteristics, distribution, and use.

Discussion of Data

Registered gross weights by vehicle types

A summary is shown in table 1 for the vehicles registered on a gross weight basis for which empty weights were available; these data were obtained in the 1957 and 1961 loadometer surveys. Numbers and percentages of vehicles of each type are given by registered gross weights. Heavy lines in the table enclose data for approximately 90 percent of the vehicles in each visual type. The extremes, representing approximately 10 percent of the vehicles, are "fenced out" above and below the main group. Thus a visual comparison

[3] Bureau of Public Roads tables MV-1 through MV-11, *Highway Statistics*, issued annually.

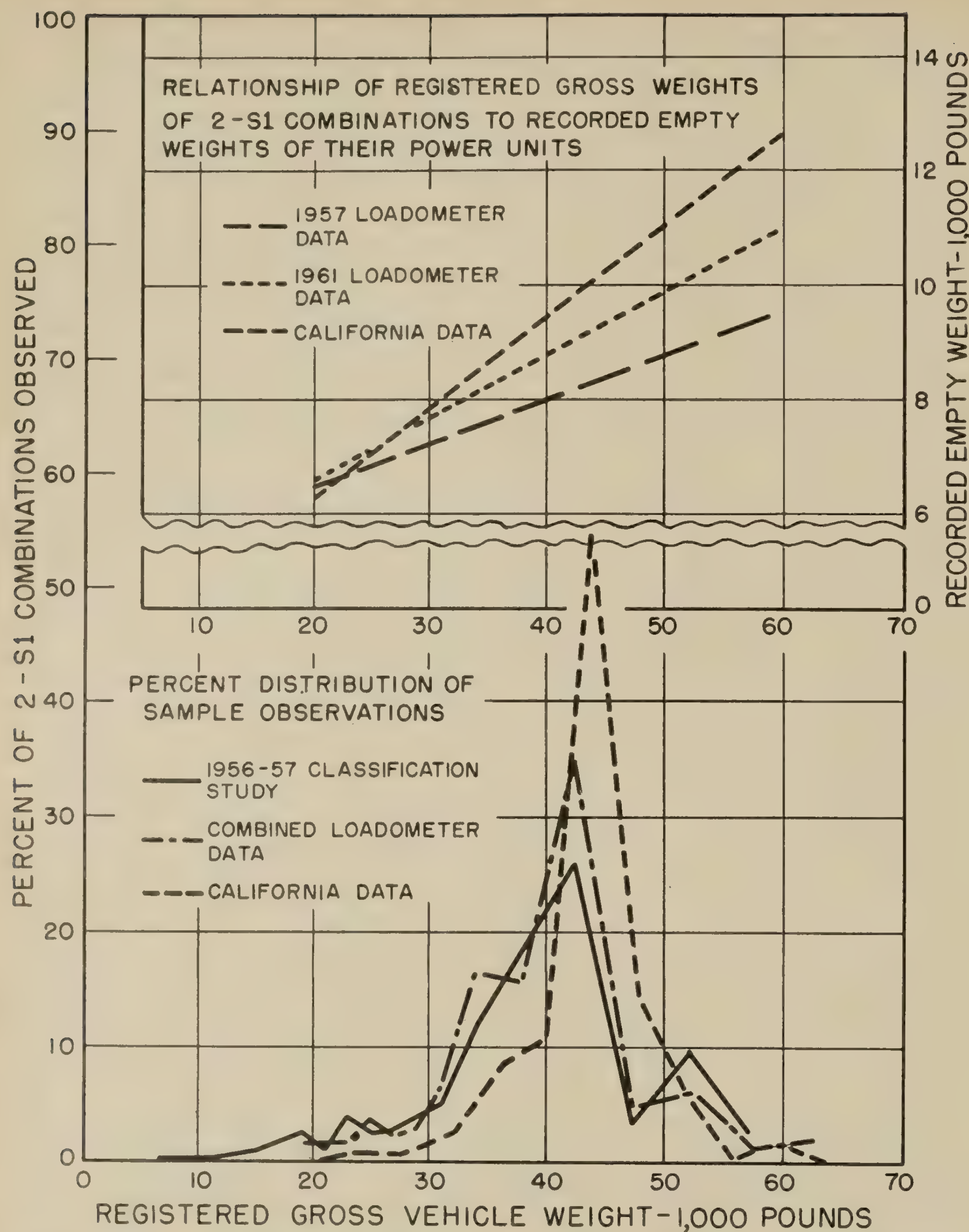

Figure 5.—Empty to gross weight relationships and relative distribution of 3-axle, tractor-semitrailer combinations (2–S1).

can be made of the total range of the data. This comparison shows the approximately 90-percent spread of gross weights for each of the vehicle types, and it illustrates that as the vehicles became larger the gross weight range was smaller. Registered gross weights for each vehicle type, however, overlap the weights for both adjacent vehicle types.

The 1961 loadometer data presented in this study for the 2-axle trucks cannot be separated into 4-tire and 6-tire classes. Other sources [4] have shown however that, taken as separate groups, the 2-axle, 4-tire class would show a rapid diminution of numbers over 8,000 pounds and, with the greater load flexibility permitted by additional tires, the 2-axle, 6-tire class would peak at about 12,000 to 18,000 pounds and would taper off slowly in numbers at approximately 28,000 pounds. Within the enclosed area of the table, the data for successive vehicle types form a group of steps to the larger gross weights.

[4] *Classification of Motor Vehicles, 1956–57*, Bureau of Public Roads, U.S. Department of Commerce, 1960.

Comparison of 1957 and 1961 loadometer data and California data

Table 2 shows the California data by registered gross weights and by visual vehicle types. The heavy lines used, as in table 1, enclose approximately 90 percent of the vehicles in each type. A comparison of the vehicle distributions from the loadometer weighings shown in table 1 with those obtained from the California data included in table 2 reveals considerable disparity in the information from the two sources. Because vehicles represented in the California data were used principally in intercity service, much less dispersion in gross weights was noted in these data than in the information obtained from the loadometer studies.

Frequency distributions and least squares comparisons of empty to gross weights are shown in figures 3–9 for the main visual types of vehicles. The California data, represented by the medium-length dash least squares lines in the upper panels of these figures, with certain exceptions, showed that the average empty weights of vehicles in relation to given gross weights were higher than the empty weight to gross weight relations recorded by loadometer data. A similar empty weight relationship was not recorded for the 3–S2 vehicle combinations; the slope of the line for the 1961 loadometer data, shown in figure 7, suggests the effect of too small a sample. However, this relationship of the empty to gross weight probably is not entirely accurate as the Public Roads' vehicle classification counts indicate that use of the 3–S2 vehicle combinations has become more widespread geographically than in 1957, and therefore the relationship of empty to gross weight could have been different than shown by the 1961 loadometer data.

As shown in figure 8, an exception to the higher empty weights in relation to gross weights was recorded in the 1957 loadometer data, which included information on an unusually large number of 3–2 truck-trailer combinations registered at 50,000 to 55,000 pounds gross combination weight and reported as having empty weights of more than 16,000 pounds for the truck alone. Such a reported distribution of so many 3–2 combinations at 55,000 pounds in 1957 was not normal because in the classification study nearly 97 percent of the 3–2 combinations were reported to have been registered at more than 60,000 pounds gross combination weight.

A percentage comparison of the gross weight distribution of combined 1957 and 1961 loadometer data and of the California data with the nationwide gross weight distribution of all vehicles of each type reported in the 1956–57 classification study is given in the bottom panels of figures 3–6. As shown in figure 3, the loadometer data distribution by gross weight was close to that for the classification study. This close relationship implies that the gross weights for vehicles sampled in the loadometer studies were relatively proportional to the gross weights for all such vehicles registered. But, as stated earlier, the California data, consisting largely of registrations of over-the-road 2-axle, 6-tire vehicles showed a much larger sample for vehicles having 18,000 to 26,000 pounds gross weights. The 2-axle classification given in figure 3 includes both the 2-axle, 4-tire and the 2-axle, 6-tire vehicles. Nationwide more than 90 percent of the 2-axle, 4-tire vehicles were registered for gross weights under 8,000 pounds. More than 67 percent of the 2-axle, 6-tire trucks were registered for gross weights in excess of 12,000 pounds, and nearly 47 percent were registered for gross weights in excess of 16,000 pounds.

Figures 4 through 9 show that the gross weights of the sampled vehicles in the loadometer studies follow closely the gross weight distributions of the vehicle population. Gross weight comparisons for information from the classification study have not been included in figures 7 through 9 for the 3–S2, 3–2, and the

2–S1–2 vehicle combinations because these vehicles generally are registered for the State maximum permitted gross weights of over 60,000 pounds and their registrations were shown in the classification study in that maximum weight class.

Combined loadometer data

In figure 10, straight lines illustrate the empty to gross weight relationships obtained by the least squares method. The lines in this figure were based on the combined data from the loadometer surveys, and they provide a quick visual comparison of relationships for five vehicle types. The lines for the single-unit trucks follow a parallel course, they overlap in the gross weights from 22,000 to 32,000 pounds, and they are separated by about 1,500 pounds of empty weight. This greater empty weight is accounted for largely by the third axle in the 3-axle truck. The slope of these two lines is much steeper than the slope of the lines for the tractor power units, shown in combination as 2–S1, 2–S2, and 3–S2, because the payload carrying body is included in the empty weight for single-unit trucks but is not included for the combination vehicles. A considerable gross vehicle weight overlap is shown for the 2–S1 and 2–S2 combinations because of differences in size and weight requirements; some States require an additional axle to carry loads that can be carried by the 2–S1 combination in other States. Also, factors of terrain, power requirements, and types of loads carried are considered by operators in their choice of vehicles.

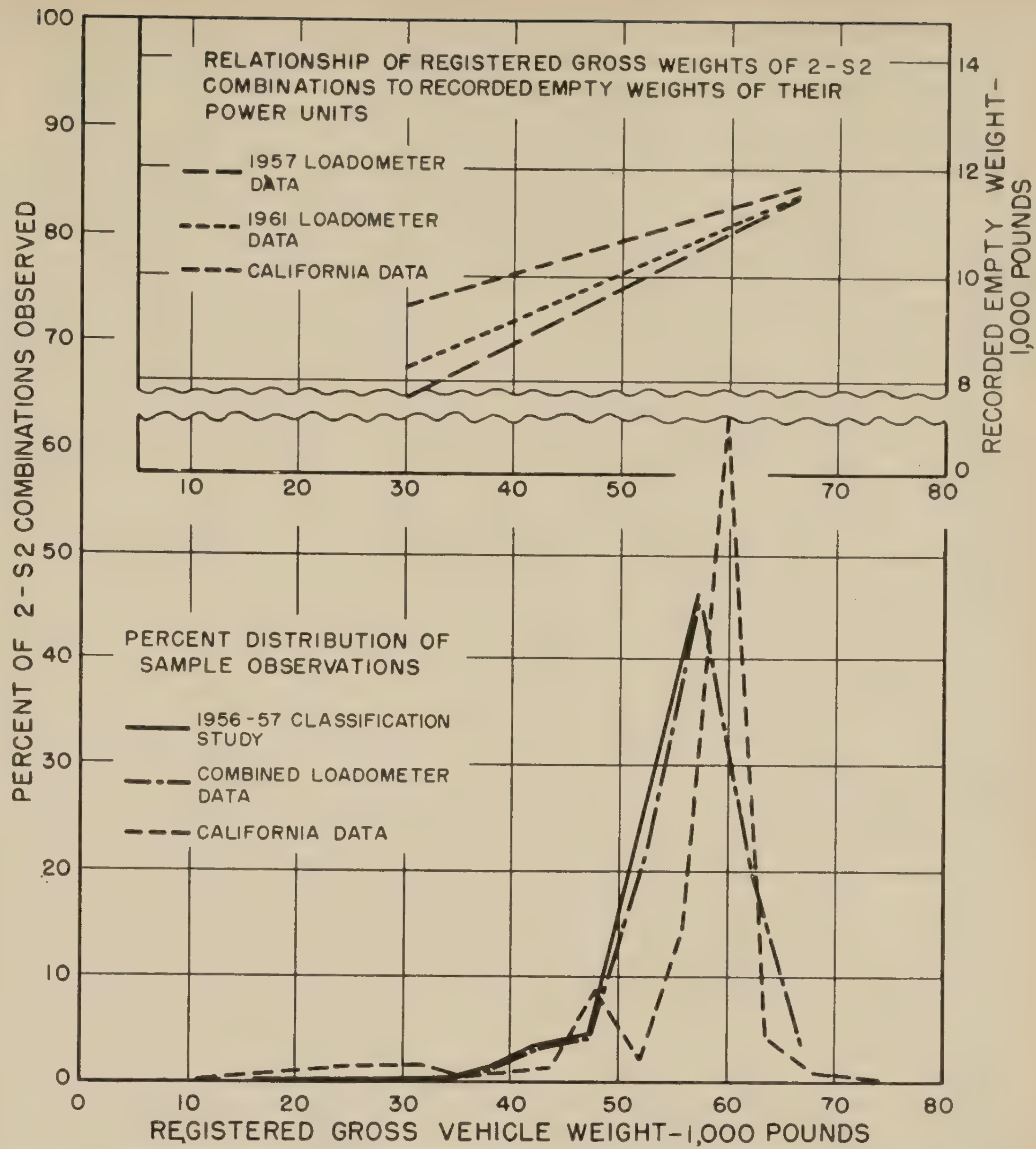

Figure 6.—Empty to gross weight relationships and relative distribution of 4-axle, tractor-semitrailer combinations (2-S2).

Comparison of 1957 and 1961 loadometer data

A percentage comparison of the distribution of gross weights of vehicles from the 1957 loadometer data with the distribution of the gross weights of vehicles from the 1961 loadometer data is shown in table 3. The 1957 study was designed to sample vehicles on all types of rural and urban highways as uniformly as possible, but the 1961 data were obtained to a larger extent at stations on main rural roads. The comparison shown in table 3 indicates that the traffic on main rural roads has a much greater concentration of heavy vehicles than the total traffic on all types of rural and urban highways.

Table 3 is complemented by table 4, which shows a distribution of the same vehicles by empty weights of the trucks and power units for the 1957 and 1961 loadometer surveys. The information in both of these tables shows that the empty and gross weights were consistently heavier in the 1961 loadometer data. In tables 3 and 4 the percentage distributions for each weight group, within each vehicle type, have been cumulated inversely as an additional check on the differences between the 1957 and 1961 loadometer data. At first glance it might appear that trucks and combinations have gotten heavier since 1957, and to some degree this may be true. However, evidence from continuing vehicle and classification counts have led the authors to conclude that most of the difference between the two sets of data was caused by the difference in the size and scope of the samples.

To show a more complete cross-section of information on the three vehicle types given in tables 3 and 4, a set of two-way frequency distributions of empty weight to gross vehicle weight has been given for each of the three vehicle types separately for the 1957 and 1961 loadometer samples in tables 5–10. With the data arrayed in this manner it is possible to examine either the frequency distribution by empty weights of vehicles in a given class interval of registered gross weight, or the distribution by registered gross weights of vehicles in a given class interval of empty weight. Both numerical and percentage distributions are given, and heavy lines enclose approximately 90 percent of the vehicles in each empty weight group. When special consideration is given to the 90-percent portion of the sample in each table, the array of each vehicle type is much more compact. Although an appreciable number of vehicles are shown at the extremes, those having heavy empty weights and light gross weights and those having light empty weights and heavy gross weights constituted only a small proportion of all vehicles in that class. A large proportion of some vehicles of a given empty weight were concentrated in two or three gross-weight intervals.

Conversion tables

Tables 11 through 17 give the comparisons of empty weights to gross weights of the combined 1957 and 1961 loadometer data for seven of the most commonly used types of vehicles. Information on all the vehicles for which the weight data collected was usable for this article has been included in these tables. They give the numbers and percentages (horizontally) of the gross weight distribution of these vehicles. The numbers of vehicles that had unusual empty to gross weight relationships have been included even though they represent a very small percentage. The 166,000 vehicles that were classified by weights are representative of the national distribution of vehicles and their classification provides a tool for the solution of problems of weight conversions. These data will be useful for making revenue estimates, as well as being a working tool in many areas of market research.

The process of conversion is illustrated as follows. Assume that table 13 was considered appropriate, in a given situation, for con-

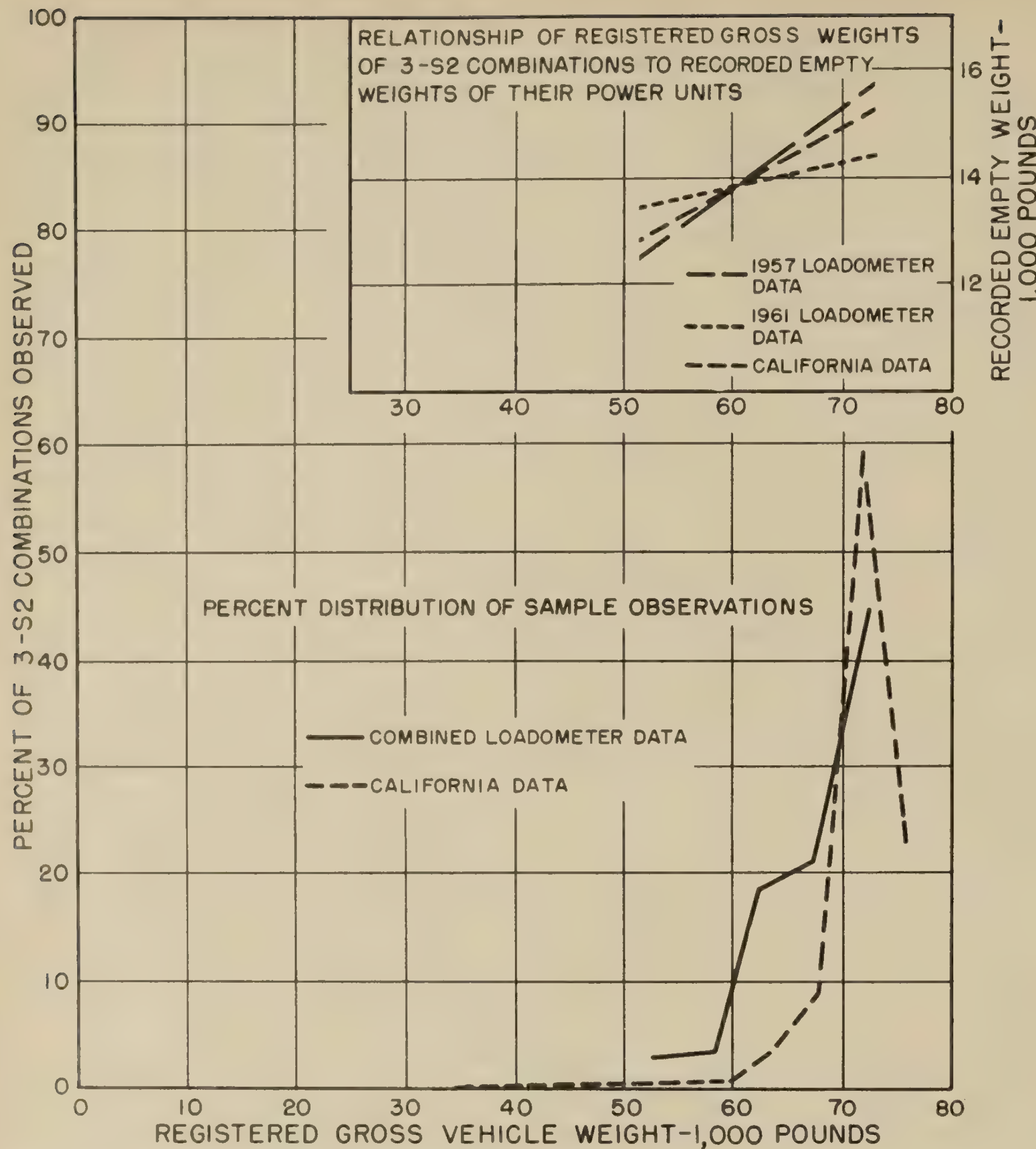

Figure 7.—Empty to gross weight relationships and relative distribution of 5-axle, tractor-semitrailer combinations (3–S2).

verting 3-axle, tractor-semitrailer (2–S1) combinations registered by empty tractor weights into an array representing their probable distribution by registered gross weight of combination in a State requiring that method of registration. The number of vehicles in each class interval of empty weight should be multiplied by the corresponding horizontal percentages in table 13, and the numbers so obtained should be added vertically to obtain the distribution by registered gross weights. Conversely, a conversion from registered gross weight of combination to empty weight of tractor can be performed by distributing the number of vehicles in each gross weight class interval proportionate to the corresponding vertical distribution of vehicles by empty weights in table 13 and then adding the numbers so obtained horizontally.

Weight relationship of trailer and combination

In figure 11, a scattergram of the mean average empty weights and the lines of best fit reflect the approximate empty to gross weight relationship of tractors and semitrailers shown in the California data. Straight lines were computed for 1- and 2-axle, semitrailers and for the 2- and 3-axle tractor trucks used with them. The scattergram shows a wide range of empty weights of semitrailers in each type of tractor-semitrailer combination and at all gross weight levels. However, regardless of the type of combination, whether 2–S1, 2–S2, or 3–S2, even with substantial increases in gross combination weights, only moderate increases were noted in the semitrailer average empty weight. But for the tractor truck power units a much steeper gradation in empty weight in relation to gross weight is shown.

Empty weight to gross weight ratios

Employing the power unit relationship used in figure 10 and the data from the semitrailer line in figure 11, empty weight to gross weight ratios shown in table 18 indicate that vehicle gross weights ranged from 1.2 times the empty weight at the low-weight interval of the smallest vehicle to a high of 2.8 at the high-weight interval for the larger vehicles. It may be of some significance that a vehicle type selected and registered at near the maximum weight of its class is capable of operating with the most favorable empty weight to gross weight ratio. The results for the upper gross weight limit of each vehicle type are similar for all five vehicle types.

Range of conversion

Figures 12 through 18 illustrate both the wide range of empty weights for each gross weight, and the range that contained approximately 90 percent of the vehicles. Although the 90-percent range eliminates the extremes, the band of weight comparison is still too wide to allow the use of a point of conversion. It would be very difficult, if not impossible, to develop a usable set of weight relationships that would permit a point, or even a narrow band, of weight conversion to be used for any purpose.

Conclusions

In general, data from the vehicle weight comparison series included in *Classification of Motor Vehicles, 1956–57*, the information from the 1957 and 1961 loadometer data, and the California data tend to give each other strong mutual support. Therefore, the results of the 1957 loadometer study remain generally applicable, and the study reported in this article is a further refinement of the data. In applying weight comparison factors from any of the data, however, some caution should be exercised to allow for the increasing trend toward use of diesel-powered vehicles and for the anticipated effects of any changes in vehicle size and weight laws.

The 1961 loadometer data and the California data have provided information that permits the addition of another large vehicle combination to the vehicle weight comparison series—the 2–S1–2. This combination was not covered in earlier studies. Additional investigation in this area is warranted, not only to obtain more data on the vehicle weight relationships, but also to keep the findings from these investigations up-to-date. Comprehensive studies of vehicles on a carefully tailored regional basis would provide information even more usable. In the selection of regions for these studies the State size and weight restrictions, the geographic features, and the predominance of certain types of vehicles favored for their adaptability to commerce or terrain of the region should be considered.

The vehicle weight comparison tables 11–17 present a reasonable nationwide picture of the relationship between recorded empty and registered gross weights of different vehicle types. These comparisons demonstrate clearly that it would not be practicable to try to develop a set of weight relationships that would permit a point, or even a narrow band, of weight conversion to be used for any purpose. Conditions in individual States may be such that modifications or adaptations of the data shown in tables 11–17 may be required before they can be applied. However, the data provide a useful tool that can serve as a guide, or reference point, for local conversion problems. The local situation would have to dictate any adjustment factors necessary to make the data in these tables applicable to the problems being considered.

Table 2.—Trucks and combinations grouped by number of axles and by registered gross vehicle weights, from California interstate proration records [1]

Registered gross vehicle weight	Single-unit trucks				Combinations consisting of—											
					Tractor and semitrailer						Truck and full trailer				Tractor, semi-trailer and full trailer	
	2-axles		3-axles		3-axles (2-S1)		4-axles (2-S2)		5-axles (3-S2)		3-axles (2-1)		5-axles (3-2)		5-axles (2-S1-2)	
Pounds	*No.*	*Pct.*	*No.*	*Pct.*	*No.*	*Pct.*	*No.*	*Pct.*	*No.*	*Pct.*	*No.*	*Pct.*	*No.*	*Pct.*	*No.*	*Pct.*
0-3,999																
4,000-4,999																
5,000-5,999	8	1.3														
6,000-7,999	70	11.2														
8,000-9,999	40	6.4														
10,000-11,999	21	3.3					1	0.1								
12,000-13,999	15	2.4					1	0.1			1	7.7				
14,000-15,999	22	3.5														
16,000-17,999	24	3.8														
18,000-19,999	96	15.2														
20,000-21,999	74	11.7	1	2.8	2	0.1										
22,000-23,999	112	17.8			1	0.1	3	0.4			4	30.8				
24,000-25,999	85	13.5	3	8.3	9	0.7	8	1.2			4	30.8				
26,000-27,999	43	6.8	1	2.8	4	0.3					1	7.7				
28,000-29,999	8	1.3	1	2.8	3	0.2	11	1.6			2	15.3				
30,000-31,999	7	1.1			24	1.8	9	1.3					1	0.2		
32,000-35,999	3	0.5			15	1.1	2	0.3								
36,000-39,999			11	30.6	140	10.4	3	0.4	3	0.1	1	7.7				
40,000-44,999	1	0.2	17	47.2	818	60.5	8	1.2	5	0.2						
45,000-49,999			2	5.5	226	16.7	64	9.3	1				2	0.4		
50,000-54,999					81	6.0	45	6.6	8	0.3			2	0.4		
55,000-59,999					22	1.7	310	45.3	16	0.5			3	0.6		
60,000-64,999					2	0.1	207	30.2	89	3.0			2	0.4	11	2.1
65,000-69,999					1	0.1	10	1.5	289	9.6			13	2.5	1	0.2
70,000-74,999					2	0.1	2	0.3	2,160	71.6			86	16.7	101	19.5
75,000-79,999					2	0.1	1	0.2	445	14.7			406	78.8	405	78.2
80,000 and over																
TOTAL	629	100.0	36	100.0	1,352	100.0	685	100.0	3,016	100.0	13	100.0	515	100.0	518	100.0

[1] The portion of the table boxed by heavy lines represents 90 percent or more of the vehicles in each vehicle type.

Table 3.—Comparison of relative numbers of motor vehicles observed in the 1957 and 1961 loadometer studies by gross vehicle weight groups

Registered gross vehicle weight	Single-unit trucks				Vehicle combinations							
	2-axle				3-axle (2-S1)				4-axle (2-S2)			
	1957		1961		1957		1961		1957		1961	
Pounds	*Pct.*	*Cumulated Pct.* [1]	*Pct.*	*Cumulated Pct.* [1]	*Pct.*	*Cumulated Pct.* [1]	*Pct.*	*Cumulated Pct.* [1]	*Pct.*	*Cumulated Pct.* [1]	*Pct.*	*Cumulated Pct.* [1]
Under [2] 5,000	36.1	100.0	32.8	100.0								
Under [2] 18,000					(3)	(3)	0.2	100.0				
Under [2] 24,000									0.2	100.0	0.6	100.0
5,000-5,999	19.9	63.9	13.1	67.2								
6,000-7,999	9.0	44.0	15.8	54.1								
8,000-9,999	4.7	35.0	8.0	38.3								
10,000-11,999	3.9	30.3	5.4	30.3								
12,000-13,999	3.3	26.4	4.3	24.9								
14,000-15,999	3.2	23.1	1.6	20.6								
16,000-17,999	5.1	19.9	2.2	19.0								
18,000-19,999	3.3	14.8	2.6	16.8	1.9	100.0	0.3	99.8				
20,000-21,999	4.3	11.5	2.9	14.2	1.4	98.1	0.3	99.5				
22,000-23,999	2.2	7.2	2.4	11.3	1.7	96.7	0.3	99.2				
24,000-25,999	3.4	5.0	3.9	8.9	4.3	95.0	1.3	98.9	0.5	99.8	0.2	99.4
26,000-27,999	0.8	1.6	1.7	5.0	2.3	90.7	0.4	97.6	0.3	99.3	0.1	99.2
28,000-29,999	0.2	0.8	0.6	3.3	3.3	88.4	1.4	97.2	0.1	99.0	0.1	99.1
30,000-31,999	0.4	0.6	0.9	2.7	6.9	85.1	2.8	95.8	0.5	98.9	0.1	99.0
32,000-35,999	(3)	(3)	0.9	1.8	18.2	78.2	6.8	93.0	0.6	98.4	0.3	98.9
36,000-39,999	0.1	0.2	0.4	0.9	15.7	60.0	15.3	86.2	1.3	97.8	0.6	98.6
40,000-44,999	0.1	0.1	0.2	0.5	33.6	44.3	41.2	70.9	3.4	96.5	2.3	98.0
45,000-49,999	(3)	(3)	0.1	0.3	4.0	10.7	9.4	29.7	4.6	93.1	2.1	95.7
50,000-54,999	(3)	(3)	(3)	(3)	5.6	6.7	8.1	20.3	24.4	88.5	6.8	93.6
55,000-59,999	(3)	(3)	0.1	0.2	0.7	1.1	3.0	12.2	47.6	64.1	39.2	86.8
60,000-64,999					0.4	0.4	8.6	9.2	14.2	16.5	40.5	47.6
65,000-69,999									2.1	2.3	6.2	7.1
60,000 and over [2]	(3)	(3)	0.1	0.1								
65,000 and over [2]					(3)	(3)	0.6	0.6				
70,000 and over [2]									0.2	0.2	0.9	0.9
TOTAL	100.0		100.0		100.0		100.0		100.0		100.0	

[1] Percentages in this column are an inverse cumulation of the percentages in the preceding column.
[2] Open-end weight classes are shown for each visual vehicle type at the lower end and upper end of the weight classification scale. Each open-end class applies to a specific visual vehicle type.
[3] Less than 0.1 percent.

676589—63——3

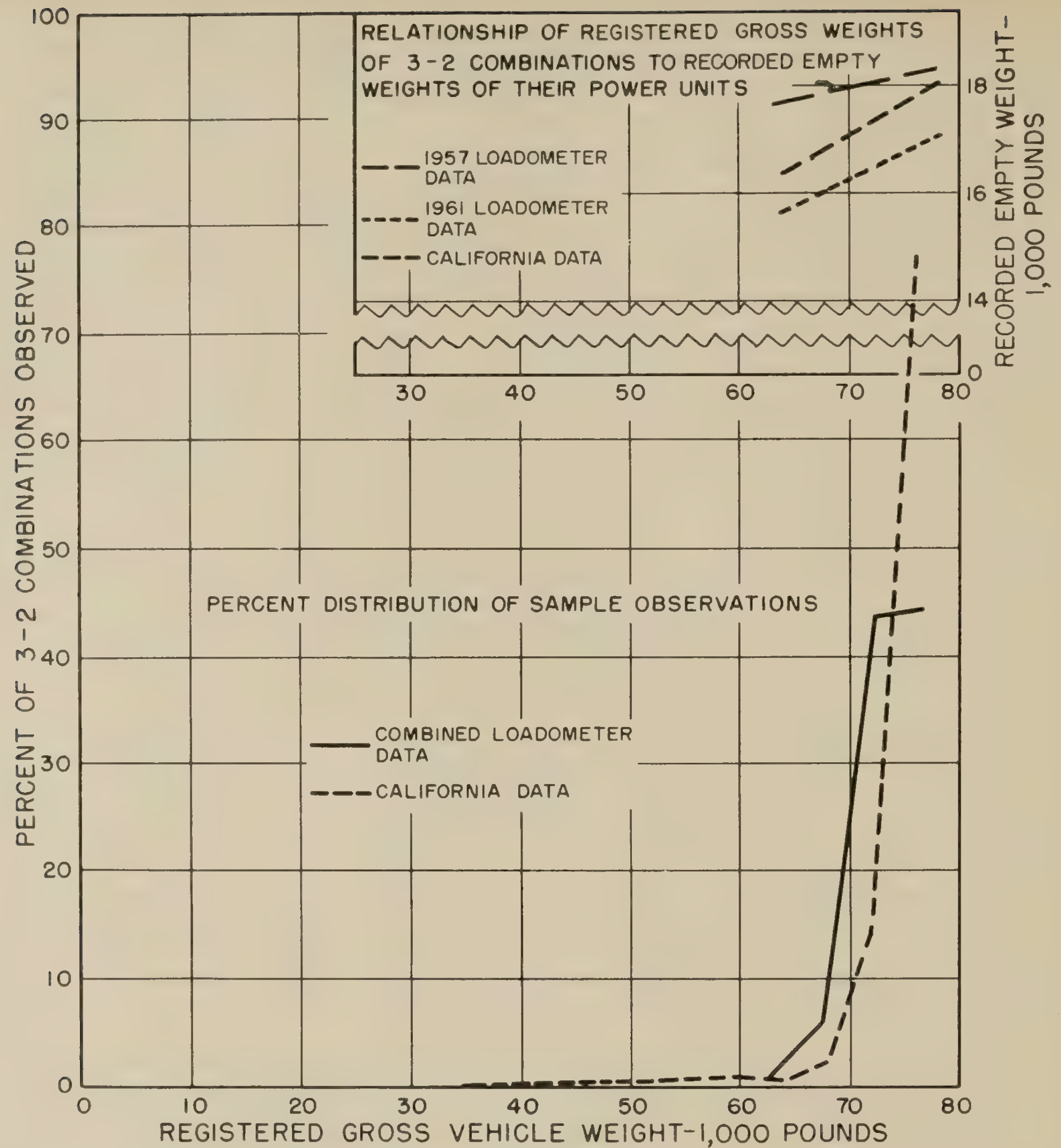

Figure 8.—Empty to gross weight relationships and relative distribution of 5-axle, truck-full trailer combinations (3–2).

Table 4.—Comparison of relative numbers of motor vehicles observed in the 1957 and 1961 loadometer studies by recorded empty weights of power units

Recorded empty weight of power unit	Single-unit trucks				Vehicle combinations							
	2-axle				3-axle (2–S1)				4-axle (2–S2)			
	1957		1961		1957		1961		1957		1961	
Pounds	*Pct.*	*Cumulated Pct.*[1]	*Pct.*	*Cumulated Pct.*[1]	*Pct.*	*Cumulated Pct.*[1]	*Pct.*	*Cumulated Pct.*[1]	*Pct.*	*Cumulated Pct.*[1]	*Pct.*	*Cumulated Pct.*[1]
Under [2] 3,000	1.8	100.0	1.5	100.0								
Under [2] 5,000					4.0	100.0	0.5	100.0	0.1	100.0	0.3	100.0
3,000–3,999	42.4	98.2	39.4	98.5								
4,000–4,999	22.1	55.8	24.0	59.1								
5,000–5,999	7.8	33.7	9.5	35.1	9.1	96.0	2.6	99.5	0.6	99.9	0.8	99.7
6,000–6,999	7.8	25.9	7.2	25.6	22.0	86.9	7.3	96.9	3.7	99.3	2.8	98.9
7,000–7,999	7.3	18.1	3.6	18.4	23.4	64.9	16.7	89.6	4.7	95.6	2.6	96.1
8,000–8,999	5.1	10.8	4.1	14.8	18.4	41.5	24.3	72.9	9.7	90.9	8.5	93.5
9,000–9,999	2.7	5.7	3.5	10.7	14.3	23.1	18.3	48.6	23.7	81.2	15.0	85.0
10,000–10,999	1.4	3.0	2.6	7.2	5.2	8.8	15.8	30.3	26.0	57.5	23.1	70.0
11,000–11,999	0.6	1.6	1.8	4.6	3.6	3.6	6.8	14.5	12.4	31.5	20.4	46.9
12,000–12,999	0.4	1.0	1.1	2.8					12.4	19.1	18.2	26.5
13,000–13,999									4.5	6.7	5.7	8.3
12,000 and over [2]					(3)	(3)	7.7	7.7				
13,000 and over [2]	0.6	0.6	1.7	1.7								
14,000 and over [2]									2.2	2.2	2.6	2.6
TOTAL	100.0		100.0		100.0		100.0		100.0		100.0	

[1] Percentages in this column are an inverse cumulation of the percentages in the preceding column.
[2] Open-end weight classes are shown for each visual vehicle type at the lower end and upper end of the weight classification scale. Each open-end class applies to only one visual vehicle type.
[3] Less than 0.1 percent.

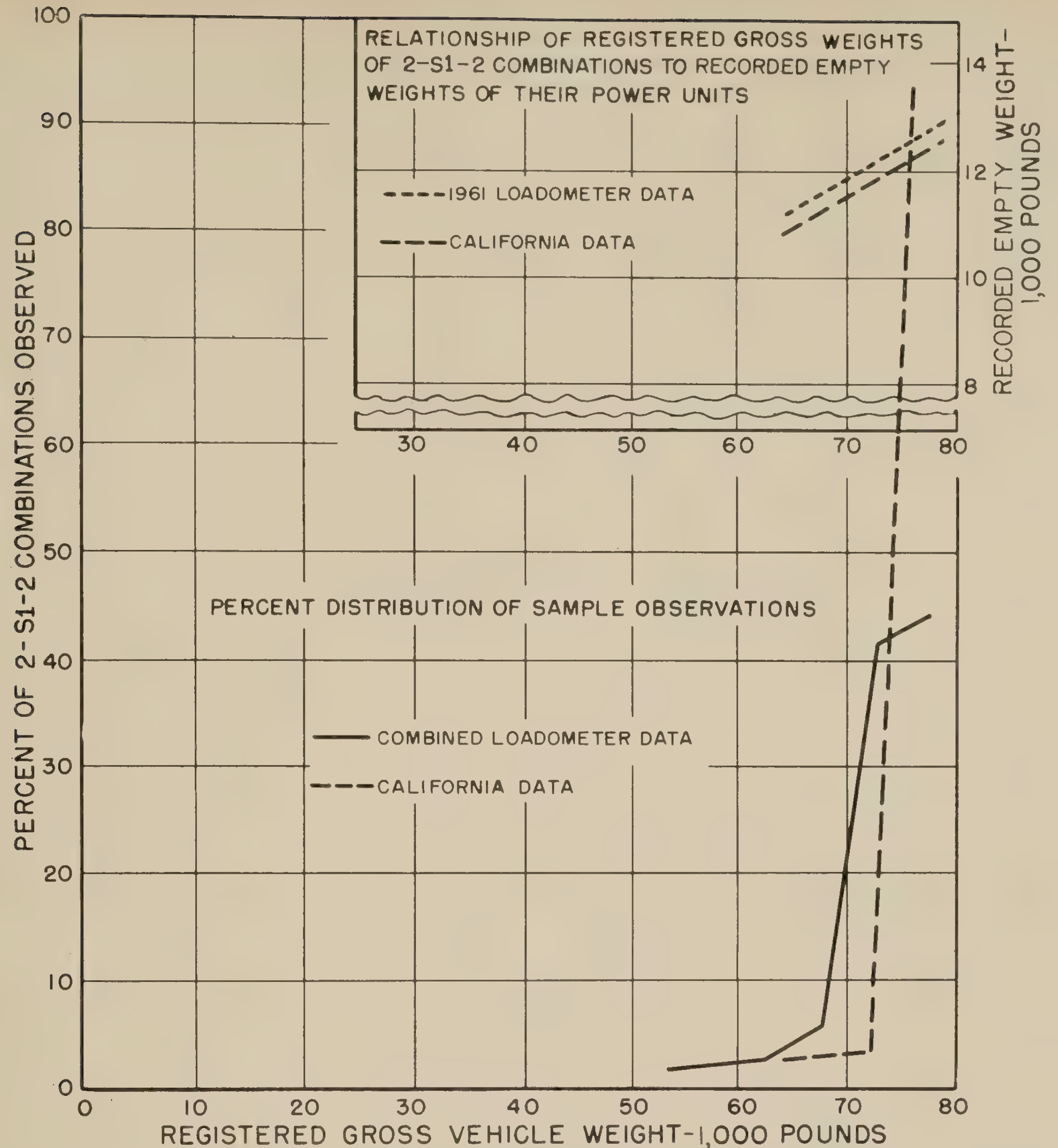

Figure 9.—Empty to gross weight relationships and relative distribution of 5-axle, tractor-semitrailer, full trailer combinations (2–S1–2).

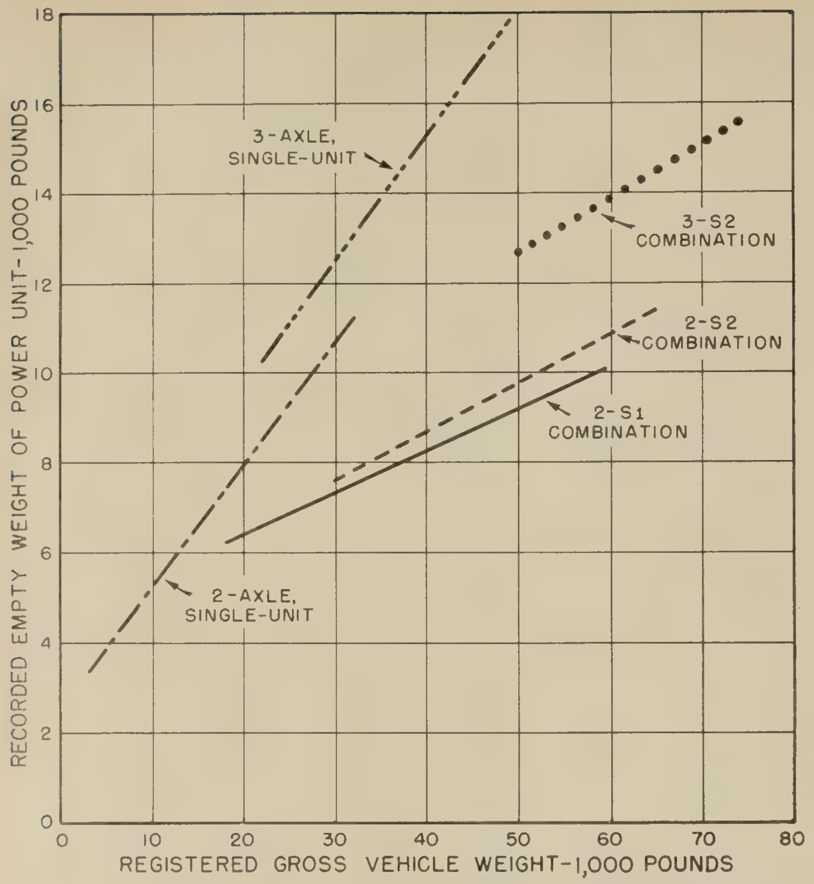

Figure 10.—Relationship of the recorded empty weights of the power units to the registered gross weights of the vehicles based on combined 1957 and 1961 loadometer data.

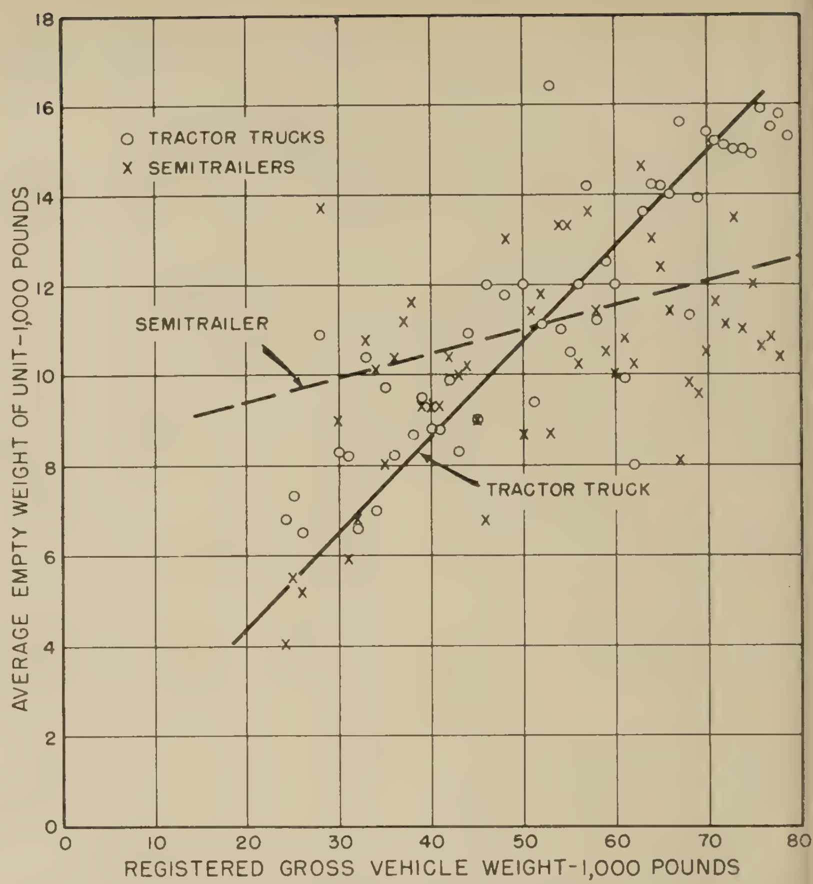

Figure 11.—Scattergram of average empty weight of tractor trucks and of semitrailers by registered gross combination weight, and lines of best fit (California data).

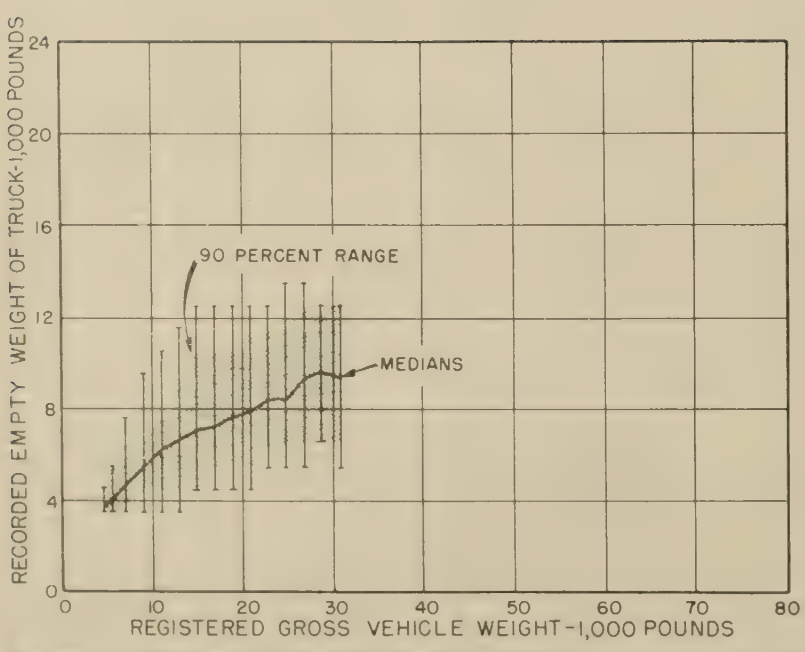

Figure 12.—Range of recorded empty weights of 2-axle trucks registered by gross vehicle weights, based on the combined 1957 and 1961 loadometer data.

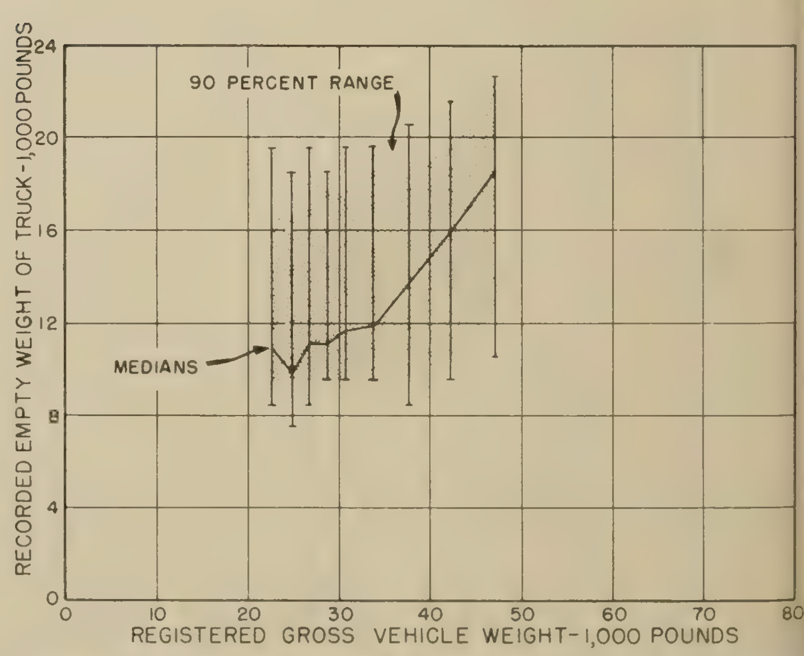

Figure 13.—Range of recorded empty weights of 3-axle trucks registered by gross vehicle weights, based on the combined 1957 and 1961 loadometer data.

Table 5.—Comparison of number and percent of 2-axle, single-unit trucks by recorded empty weights and by registered gross vehicle weights, 1957 loadometer data [1]

Recorded empty weight of truck (pounds)	Registered gross vehicle weight (pounds)																						Total	
	4,000–4,999	5,000–5,999	6,000–7,999	8,000–9,999	10,000–11,999	12,000–13,999	14,000–15,999	16,000–17,999	18,000–19,999	20,000–21,999	22,000–23,999	24,000–25,999	26,000–27,999	28,000–29,999	30,000–31,999	32,000–35,999	36,000–39,999	40,000–44,999	45,000–49,999	50,000–54,999	55,000–59,999	60,000 and over	Number	Percent of total
0–2,999:																								
Number	1,614	621	66	1	2	3	1	----	----	----	2	1	----	----	----	----	----	----	----	----	----	----	2,311	1.8
Percent	69.9	26.9	2.9	(2)	0.1	0.1	(2)	----	----	----	0.1	(2)	----	----	----	----	----	----	----	----	----	----		
3,000–3,999:																								
Number	34,176	15,530	4,804	955	123	22	11	6	4	1	----	----	----	----	----	----	----	----	----	----	----	----	55,632	42.4
Percent	61.5	27.9	8.7	1.7	0.2	(2)	(2)	(2)	(2)	(2)	----	----	----	----	----	----	----	----	----	----	----	----		
4,000–4,999:																								
Number	11,618	7,968	4,948	2,079	1,223	459	220	273	145	79	10	----	1	----	2	----	1	1	----	1	----	----	29,028	22.1
Percent	40.0	27.5	17.0	7.2	4.2	1.6	0.8	0.9	0.5	0.3	(2)	----	(2)	----	(2)	----	(2)	(2)	----	(2)	----	----		
5,000–5,999:																								
Number	----	1,979	1,738	1,793	1,388	945	659	893	335	208	79	109	27	5	10	----	3	----	----	2	----	----	10,203	7.8
Percent	----	19.4	17.0	17.6	13.6	9.3	6.7	8.8	3.3	2.0	0.8	1.1	0.3	(2)	0.1	----	(2)	----	----	(2)	----	----		
6,000–6,999:																								
Number	----	----	300	1,068	1,438	1,312	1,103	1,854	976	1,176	342	501	120	9	43	6	8	15	6	2	----	2	10,281	7.8
Percent	----	----	2.9	10.4	14.0	12.8	10.7	18.0	9.5	11.4	3.3	4.9	1.2	0.1	0.4	0.1	0.1	0.1	0.1	(2)	----	(2)		
7,000–7,999:																								
Number	----	----	10	257	758	730	967	1,832	1,107	1,672	646	1,369	160	22	80	5	12	11	13	2	----	1	9,654	7.3
Percent	----	----	0.1	2.7	7.8	7.6	10.0	19.0	11.5	17.3	6.7	14.2	1.7	0.2	0.8	0.1	0.1	0.1	0.1	(2)	----	(2)		
8,000–8,999:																								
Number	----	----	----	22	184	533	511	1,011	886	1,181	802	1,201	186	31	103	6	13	13	6	6	----	5	6,700	5.1
Percent	----	----	----	0.3	2.7	8.0	7.6	15.1	13.2	17.6	12.0	17.9	2.8	0.5	1.5	0.1	0.2	0.2	0.1	0.1	----	0.1		
9,000–9,999:																								
Number	----	----	----	6	23	245	321	453	474	698	414	539	177	60	75	1	5	5	1	1	1	15	3,514	2.7
Percent	----	----	----	0.2	0.7	7.0	9.2	12.9	13.5	19.9	11.8	15.4	5.0	1.7	2.1	(2)	0.1	0.1	(2)	(2)	(2)	0.4		
10,000–10,999:																								
Number	----	----	----	----	7	51	246	214	154	288	291	311	136	37	38	2	13	5	3	3	1	23	1,823	1.4
Percent	----	----	----	----	0.4	2.8	13.5	11.7	8.4	15.8	15.9	17.1	7.5	2.0	2.1	0.1	0.7	0.3	0.2	0.2	(2)	1.3		
11,000–11,999:																								
Number	----	----	----	----	----	8	63	117	62	94	132	187	81	20	34	5	3	3	3	----	----	6	818	0.6
Percent	----	----	----	----	----	1.0	7.7	14.3	7.6	11.5	16.1	22.9	9.9	2.4	4.1	0.6	0.4	0.4	0.4	----	----	0.7		
12,000–12,999:																								
Number	----	----	----	----	----	4	12	51	58	88	71	91	79	35	23	11	6	1	4	----	----	----	534	0.4
Percent	----	----	----	----	----	0.7	2.2	9.6	10.9	16.5	13.3	17.0	14.8	6.6	4.3	2.1	1.1	0.2	0.7	----	----	----		
13,000 and over:																								
Number	----	----	----	----	----	1	2	23	79	109	76	201	87	39	61	16	19	32	----	3	4	----	752	0.6
Percent	----	----	----	----	----	0.1	0.3	3.1	10.5	14.5	10.1	26.7	11.6	5.2	8.1	2.1	2.5	4.3	----	0.4	0.5	----		
TOTAL:																								
Number	47,408	26,098	11,866	6,181	5,146	4,313	4,146	6,727	4,280	5,594	2,865	4,510	1,054	258	469	52	83	86	36	20	6	52	131,250	100.0
Percent	36.1	19.9	9.0	4.7	3.9	3.3	3.2	5.1	3.3	4.3	2.2	3.4	0.8	0.2	0.4	(2)	0.1	0.1	(2)	(2)	(2)	(2)		

[1] The portion of the table boxed by heavy lines represents 90 percent or more of the vehicles in each empty weight group.
[2] Less than 0.1 percent.

Table 6.—Comparison of number and percent of 2-axle, single-unit trucks by recorded empty weights and by registered gross vehicle weights, 1961 loadometer data [1]

Recorded empty weight of truck (pounds)	Registered gross vehicle weight (pounds)																						Total number	Percent of total
	4,000–4,999	5,000–5,999	6,000–7,999	8,000–9,999	10,000–11,999	12,000–13,999	14,000–15,999	16,000–17,999	18,000–19,999	20,000–21,999	22,000–23,999	24,000–25,999	26,000–27,999	28,000–29,999	30,000–31,999	32,000–35,999	36,000–39,999	40,000–44,999	45,000–49,999	50,000–54,999	55,000–59,999	60,000 and over		
0–2,999:																								
Number	64	18	5					1															88	1.5
Percent	72.7	20.5	5.7					1.1																
3,000–3,999:																								
Number	1,348	445	365	73	9	2	2	2	1			1									1		2,249	39.4
Percent	60.0	19.8	16.2	3.3	0.4	0.1	0.1	0.1	(2)			(2)									(2)			
4,000–4,999:																								
Number	459	228	376	159	86	34	9	1	4	9	2	4										1	1,372	24.0
Percent	33.4	16.6	27.4	11.6	6.3	2.5	0.6	0.1	0.3	0.7	0.1	0.3										0.1		
5,000–5,999:																								
Number		57	132	137	97	71	8	17	6	3	5	4		1		3							541	9.5
Percent		10.5	24.4	25.3	17.9	13.1	1.5	3.2	1.1	0.6	0.9	0.7		0.2		0.6								
6,000–6,999:																								
Number			23	82	101	99	20	27	19	11	8	12	3	3		1							409	7.2
Percent			5.6	20.1	24.7	24.2	4.9	6.6	4.7	2.7	2.0	2.9	0.7	0.7		0.2								
7,000–7,999:																								
Number				2	10	17	12	28	28	29	24	44	8		3	1	1				1		208	3.6
Percent				1.0	4.8	8.2	5.8	13.5	13.5	13.9	11.5	21.1	3.8		1.4	0.5	0.5				0.5			
8,000–8,999:																								
Number				2	2	13	20	19	36	35	33	54	8	6	5	2	1						236	4.1
Percent				0.8	0.8	5.5	8.5	8.1	15.3	14.8	14.0	22.9	3.4	2.6	2.1	0.8	0.4							
9,000–9,999:																								
Number					2	6	12	13	30	26	30	36	23	5	8	4	1	1					197	3.5
Percent					1.0	3.1	6.1	6.6	15.2	13.2	15.2	18.3	11.7	2.5	4.1	2.0	0.5	0.5						
10,000–10,999:																								
Number					1	2	4	7	12	25	15	29	28	4	6	7	3	1	1			1	146	2.6
Percent					0.7	1.4	2.7	4.8	8.2	17.1	10.3	19.9	19.2	2.7	4.1	4.8	2.0	0.7	0.7			0.7		
11,000–11,999:																								
Number				1	2	2	1	5	11	14	7	18	12	7	8	7	2	3			1		101	1.8
Percent				1.0	2.0	2.0	1.0	4.9	10.9	13.9	6.9	17.8	11.9	6.9	7.9	6.9	2.0	3.0			1.0			
12,000–12,999:																								
Number						1	1	5	1	9	3	7	12	7	6	7	2		2				63	1.1
Percent						1.6	1.6	7.9	1.6	14.3	4.8	11.1	19.0	11.1	9.5	11.1	3.2		3.2					
13,000 and over:																								
Number							1	3	3	6	8	13	5	3	15	19	10	6	2	1		2	97	1.7
Percent							1.0	3.1	3.1	6.2	8.2	13.4	5.1	3.1	15.5	19.6	10.3	6.2	2.1	1.0		2.1		
TOTAL:																								
Number	1,871	748	901	456	310	247	90	128	151	167	135	222	99	36	51	51	20	11	5	1	3	4	5,707	100
Percent	32.8	13.1	15.8	8.0	5.4	4.3	1.6	2.2	2.6	2.9	2.4	3.9	1.7	0.6	0.9	0.9	0.4	0.2	0.1	0.0	0.1	0.1		

[1] The portion of the table boxed by heavy lines represents 90 percent or more of the vehicles in each empty weight group.
[2] Less than 0.1 percent.

Table 7.—Comparison of number and percent of 3-axle, tractor-semitrailer combinations (2–S1) by tractor recorded empty weights and by registered gross vehicle weights, 1957 loadometer data [1]

Recorded empty weight of tractor (pounds)	Registered gross combination weight (pounds)															Total number	Percent of total
	0–17,999	18,000–19,999	20,000–21,999	22,000–23,999	24,000–25,999	26,000–27,999	28,000–29,999	30,000–31,999	32,000–35,999	36,000–39,999	40,000–44,999	45,000–49,999	50,000–54,999	55,000–59,999	60,000–64,999		
0–4,999:																	
Number	------	28	4	6	18	12	10	17	20	36	58	3	1	------	1	214	4.0
Percent	------	13.1	1.9	2.8	8.4	5.6	4.7	7.9	9.3	16.8	27.1	1.4	0.5	------	0.5		
5,000–5,999:																	
Number	------	25	15	39	48	16	32	40	88	64	97	12	10	1	2	489	9.1
Percent	------	5.1	3.1	8.0	9.8	3.3	6.5	8.2	18.0	13.1	19.8	2.5	2.0	0.2	0.4		
6,000–6,999:																	
Number	------	23	14	13	79	32	54	78	347	219	282	24	17	------	------	1,182	22.0
Percent	------	1.9	1.2	1.1	6.7	2.7	4.6	6.6	29.4	18.5	23.9	2.0	1.4	------	------		
7,000–7,999:																	
Number	------	17	28	18	34	20	25	146	315	263	336	24	28	1	2	1,257	23.4
Percent	------	1.4	2.2	1.4	2.7	1.6	2.0	11.6	25.1	20.9	26.7	1.9	2.2	0.1	0.2		
8,000–8,999:																	
Number	------	8	8	8	36	28	33	47	93	146	457	60	51	7	3	985	18.4
Percent	------	0.8	0.8	0.8	3.7	2.8	3.4	4.8	9.4	14.8	46.4	6.1	5.2	0.7	0.3		
9,000–9,999:																	
Number	------	2	5	4	8	10	11	26	70	68	360	67	120	14	2	767	14.3
Percent	------	0.3	0.7	0.5	1.1	1.3	1.4	3.4	9.1	8.9	46.9	8.7	15.6	1.8	0.3		
10,000–10,999:																	
Number	------	------	------	1	3	3	5	6	29	30	129	16	40	8	7	277	5.2
Percent	------	------	------	0.4	1.1	1.1	1.8	2.1	10.5	10.8	46.6	5.8	14.4	2.9	2.5		
11,000–11,999:																	
Number	------	------	------	1	3	2	4	8	15	19	86	8	34	7	7	194	3.6
Percent	------	------	------	0.5	1.6	1.0	2.1	4.1	7.8	9.8	44.3	4.1	17.5	3.6	3.6		
TOTAL:																	
Number	------	103	74	90	229	123	174	368	977	845	1,805	214	301	38	24	5,365	100.0
Percent	------	1.9	1.4	1.7	4.3	2.3	3.3	6.9	18.2	15.7	33.6	4.0	5.6	0.7	0.4		

[1] The portion of the table boxed by heavy lines represents 90 percent or more of the vehicles in each empty weight group.

Table 8.—Comparison of number and percent of 3-axle, tractor-semitrailer combinations (2–S1) by tractor recorded empty weights and by registered gross vehicle weights, 1961 loadometer data [1]

Recorded empty weight of tractor (pounds)	Registered gross combination weight (pounds)																Total number	Percent of total
	0–17,999	18,000–19,999	20,000–21,999	22,000–23,999	24,000–25,999	26,000–27,999	28,000–29,999	30,000–31,999	32,000–35,999	36,000–39,999	40,000–44,999	45,000–49,999	50,000–54,000	55,000–59,999	60,000–64,999	65,000 and over		
0–4,999:																		
Number	------	2	1	------	------	------	------	------	------	------	2	------	------	------	------	------	5	0.5
Percent	------	40.0	20.0	------	------	------	------	------	------	------	40.0	------	------	------	------	------		
5,000–5,999:																		
Number	------	------	------	------	------	------	1	1	8	5	7	1	1	------	------	------	24	2.6
Percent	------	------	------	------	------	------	4.2	4.2	33.3	20.8	29.1	4.2	4.2	------	------	------		
6,000–6,999:																		
Number	------	1	------	1	1	2	1	5	14	10	32	1	------	------	------	------	68	7.3
Percent	------	1.5	------	1.5	1.5	2.9	1.5	7.3	20.6	14.7	47.0	1.5	------	------	------	------		
7,000–7,999:																		
Number	------	------	------	1	3	1	6	5	14	47	68	3	3	4	------	------	155	16.7
Percent	------	------	------	0.7	1.9	0.7	3.9	3.2	9.0	30.3	43.9	1.9	1.9	2.6	------	------		
8,000–8,999:																		
Number	2	------	1	1	4	1	3	7	14	37	115	17	17	3	3	1	226	24.3
Percent	0.9	------	0.4	0.5	1.8	0.5	1.3	3.1	6.2	16.4	50.9	7.5	7.5	1.3	1.3	0.4		
9,000–9,999:																		
Number	------	------	1	------	3	------	------	5	7	24	77	21	14	5	13	------	170	18.3
Percent	------	------	0.6	------	1.8	------	------	3.0	4.1	14.1	45.3	12.4	8.2	2.9	7.6	------		
10,000–10,999:																		
Number	------	------	------	------	1	------	1	2	2	10	44	25	26	6	28	2	147	15.8
Percent	------	------	------	------	0.7	------	0.7	1.4	1.4	6.8	29.9	17.0	17.7	4.1	19.0	1.3		
11,000–11,999:																		
Number	------	------	------	------	------	------	------	------	4	3	22	5	6	4	17	2	63	6.8
Percent	------	------	------	------	------	------	------	------	6.4	4.8	34.9	7.9	9.5	6.3	27.0	3.2		
12,000 and over:																		
Number	------	------	------	------	------	------	1	1	------	6	16	14	8	6	19	1	72	7.7
Percent	------	------	------	------	------	------	1.4	1.4	------	8.3	22.2	19.5	11.1	8.3	26.4	1.4		
TOTAL:																		
Number	2	3	3	3	12	4	13	26	63	142	383	87	75	28	80	6	930	100.0
Percent	0.2	0.3	0.3	0.3	1.3	0.4	1.4	2.8	6.8	15.3	41.2	9.4	8.1	3.0	8.6	0.6		

[1] The portion of the table boxed by heavy lines represents 90 persent or more of the vehicles in each empty weight group.

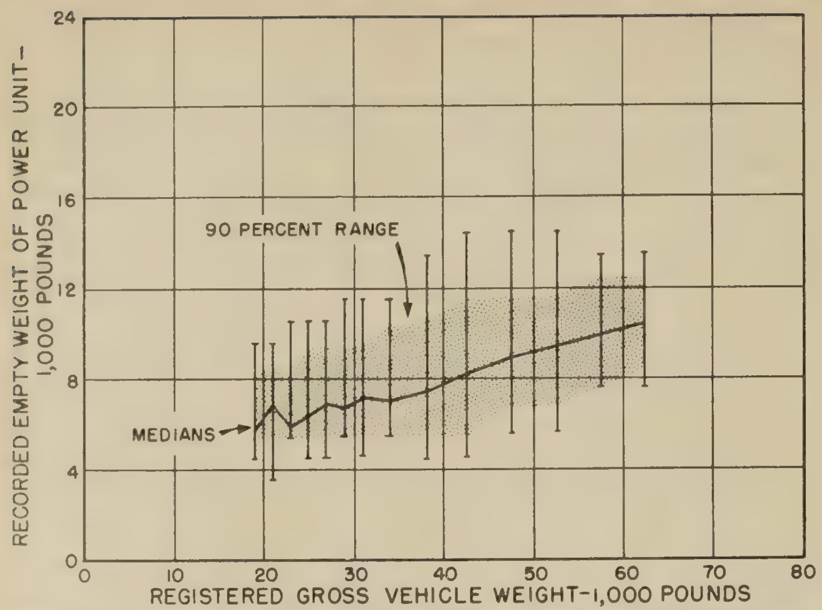

Figure 14.—Range of recorded tractor empty weights of 3-axle, tractor-semitrailer combinations (2–S1) registered by gross vehicle weights, based on the combined 1957 and 1961 loadometer data.

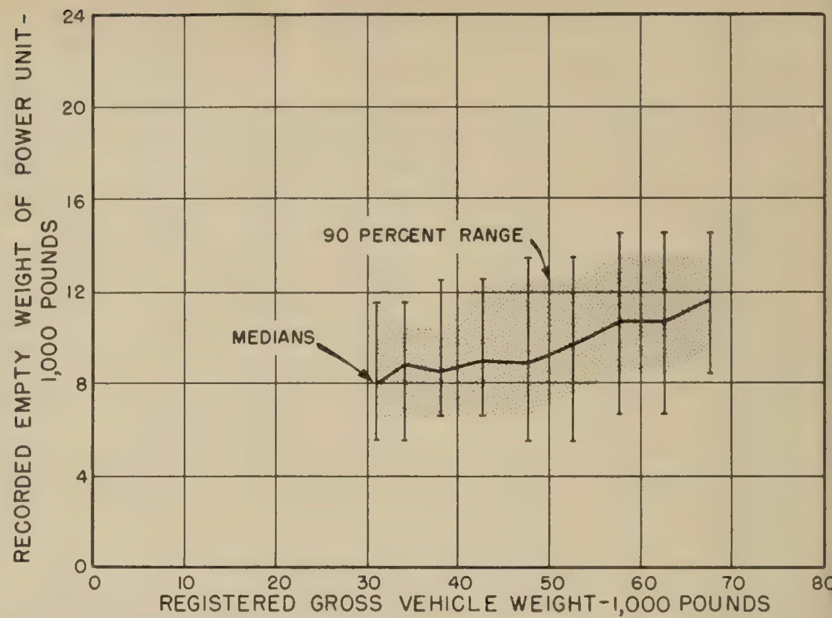

Figure 15.—Range of recorded tractor empty weights of 4-axle, tractor-semitrailer combinations (2–S2) registered by gross vehicle weights, based on the combined 1957 and 1961 loadometer data.

Table 9.—Comparison of number and percent of 4-axle, tractor-semitrailer combinations (2–S2) by tractor recorded empty weights and by registered gross vehicle weights, 1957 loadometer data [1]

Recorded empty weight of tractor (pounds)	Registered gross combination weight (pounds)														Total number	Percent of total
	0-23,999	24,000–25,999	26,000–27,999	28,000–29,999	30,000–31,999	32,000–35,999	36,000–39,999	40,000–44,999	45,000–49,999	50,000–54,999	55,000–59,999	60,000–64,999	65,000–69,999	70,000 and over		
0-4,999:																
Number	2							3	2						7	0.1
Percent	28.6							42.8	28.6							
5,000-5,999:																
Number	1	3	7	2	2	1	1	2	7	13	2	1			42	0.6
Percent	2.4	7.1	16.6	4.8	4.8	2.4	2.4	4.8	16.6	30.9	4.8	2.4				
6,000-6,999:																
Number	6	16	3	2	6	7	23	31	71	50	38	6			259	3.7
Percent	2.3	6.2	1.1	0.8	2.3	2.7	8.9	12.0	27.4	19.3	14.7	2.3				
7,000-7,999:																
Number	1	3	2	3	10	8	11	43	32	118	70	27		1	329	4.7
Percent	0.3	0.9	0.6	0.9	3.0	2.4	3.4	13.1	9.7	35.9	21.3	8.2		0.3		
8,000-8,999:																
Number	2	1	4	1	1	8	18	56	53	264	182	95			685	9.7
Percent	0.3	0.1	0.6	0.1	0.1	1.2	2.6	8.2	7.7	38.6	26.6	13.9				
9,000-9,999:																
Number	4	3	2	1	11	12	27	54	79	546	648	279	4	2	1,672	23.7
Percent	0.2	0.2	0.1	0.1	0.7	0.7	1.6	3.2	4.7	32.7	38.8	16.7	0.2	0.1		
10,000-10,999:																
Number	1	2	1	1	2	4	5	28	42	417	985	310	35	2	1,835	26.0
Percent	0.1	0.1	0.1	0.1	0.1	0.2	0.3	1.5	2.3	22.7	53.6	16.9	1.9	0.1		
11,000-11,999:																
Number			1		4	1	3	11	8	190	505	107	40	2	872	12.4
Percent			0.1		0.5	0.1	0.3	1.3	0.9	21.8	57.9	12.3	4.6	0.2		
12,000-12,999:																
Number	1	1					1	7	13	83	650	91	21	5	873	12.4
Percent	0.1	0.1					0.1	0.8	1.5	9.5	74.5	10.4	2.4	0.6		
13,000-13,999:																
Number		3					1	3	7	18	206	41	39		318	4.5
Percent		0.9					0.3	0.9	2.2	5.7	64.8	12.9	12.3			
14,000 and over:																
Number								1	8	21	64	44	9	5	152	2.2
Percent								0.7	5.3	13.8	42.1	28.9	5.9	3.3		
TOTAL:																
Number	18	32	20	10	36	41	90	239	322	1,720	3,350	1,001	148	17	7,044	100.0
Percent	0.2	0.5	0.3	0.1	0.5	0.6	1.3	3.4	4.6	24.4	47.6	14.2	2.1	0.2		

[1] The portion of the table boxed by heavy lines represents 50 percent or more of the vehicles in each empty weight group.

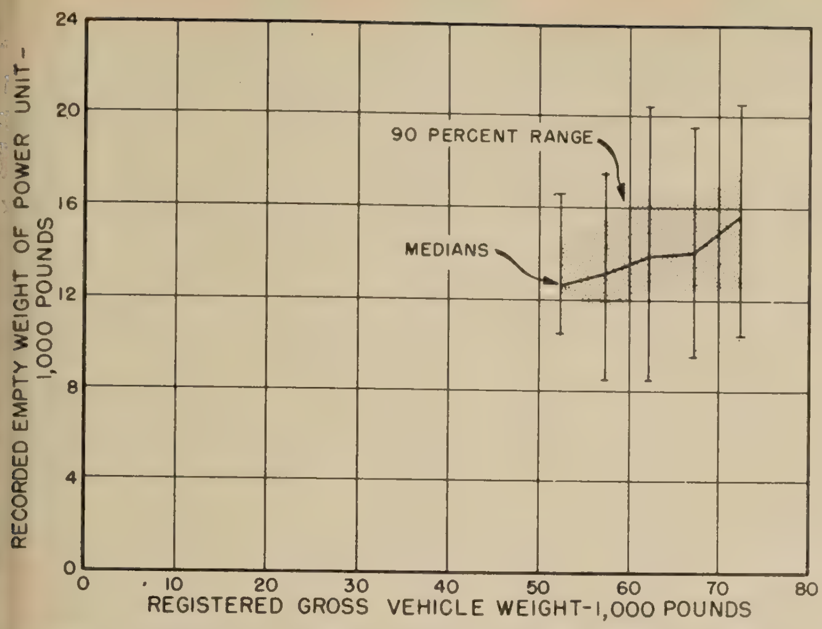

Figure 16.—Range of recorded tractor empty weights of 5-axle, tractor-semitrailer combinations (3–S2) registered by gross vehicle weights, based on the combined 1957 and 1961 loadometer data.

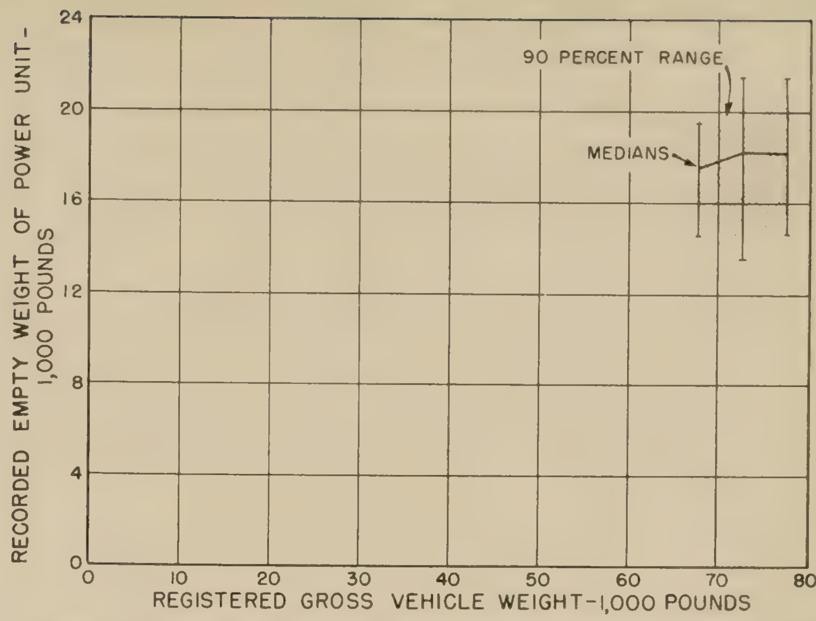

Figure 17.—Range of recorded truck empty weights of 5-axle, truck full-trailer combinations (3–2) registered by gross vehicle weights, based on the combined 1957 and 1961 loadometer data.

Table 10.—Comparison of number and percent of 4-axle, tractor-semitrailer combinations (2-S2) by tractor recorded empty weights and by registered gross vehicle weights, 1961 loadometer data[1]

Recorded empty weight of tractor (pounds)	Registered gross combination weight (pounds)														Total number	Percent of total
	0–23,999	24,000–25,999	26,000–27,999	28,000–29,999	30,000–31,999	32,000–35,999	36,000–39,999	40,000–44,999	45,000–49,999	50,000–54,999	55,000–59,999	60,000–64,999	65,000–69,999	70,000 and over		
0–4,999: Number		1							1	2		1		1	6	0.3
Percent		16.6							16.7	33.3		16.7		16.7		
5,000–5,999: Number	2	1							1	4	5	1			14	0.8
Percent	14.3	7.1							7.2	28.6	35.7	7.1				
6,000–6,999: Number	2	1			1			1	5	14	22	4			50	2.8
Percent	4.0	2.0			2.0			2.0	10.0	28.0	44.0	8.0				
7,000–7,999: Number							4		3	9	21	11			48	2.6
Percent							8.3		6.3	18.8	43.7	22.9				
8,000–8,999: Number	1					1	4	5	5	27	87	22	1	1	154	8.5
Percent	0.6					0.6	2.6	3.3	3.3	17.5	56.5	14.3	0.7	0.6		
9,000–9,999: Number						2	3	6	8	27	136	82	9		273	15.0
Percent						0.7	1.1	2.2	2.9	9.9	49.8	30.1	3.3			
10,000–10,999: Number	4			1	1	2		6	5	22	139	205	31	3	419	23.1
Percent	1.0			0.2	0.2	0.5		1.4	1.2	5.3	33.2	48.9	7.4	0.7		
11,000–11,999: Number						1		8	2	7	147	167	37	2	371	20.4
Percent						0.3		2.2	0.5	1.9	39.6	45.0	10.0	0.5		
12,000–12,999: Number	2		2					5	6	9	109	169	24	5	331	18.2
Percent	0.6		0.6					1.5	1.8	2.7	32.9	51.1	7.3	1.5		
13,000–13,999: Number								10	3	2	25	50	10	3	103	5.7
Percent								9.7	2.9	2.0	24.3	48.5	9.7	2.9		
14,000 and over: Number											20	24	1	2	47	2.6
Percent											42.5	51.1	2.1	4.3		
TOTAL: Number	11	3	2	1	2	6	11	41	39	123	711	736	113	17	1,816	100.0
Percent	0.6	0.2	0.1	0.1	0.1	0.3	0.6	2.3	2.1	6.8	39.2	40.5	6.2	0.9		

[1] The portion of the table boxed by heavy lines represents 90 percent or more of the vehicles in each empty weight group.

Table 11.—Table for estimating the distribution of 2-axle, single-unit trucks grouped by recorded empty weights, by groups of probable registered gross vehicle weights

Recorded empty weight of truck (pounds)	Registered gross vehicle weight (pounds)																						Total number	Percent of total
	4,000–4,999	5,000–5,999	6,000–7,999	8,000–9,999	10,000–11,999	12,000–13,999	14,000–15,999	16,000–17,999	18,000–19,999	20,000–21,999	22,000–23,999	24,000–25,999	26,000–27,999	28,000–29,999	30,000–31,999	32,000–35,999	36,000–39,999	40,000–44,999	45,000–49,999	50,000–54,999	55,000–59,999	60,000 and over		
0–2,999:																								
Number	1,678	639	71	1	2	3	1	1	--	--	2	1	--	--	--	--	--	--	--	--	--	--	2,399	1.8
Percent	70.0	26.7	3.0	[1]	0.1	0.1	[1]	[1]	--	--	0.1	[1]	--	--	--	--	--	--	--	--	--	--		
3,000–3,999:																								
Number	35,524	15,975	5,169	1,028	132	24	13	8	5	1	--	1	--	--	--	--	--	--	--	--	1	--	57,881	42.3
Percent	61.4	27.6	9.0	1.8	0.2	[1]	[1]	[1]	[1]	[1]	--	[1]	--	--	--	--	--	--	--	--	[1]	--		
4,000–4,999:																								
Number	12,077	8,196	5,324	2,238	1,309	493	229	274	149	88	12	4	1	--	2	--	1	1	--	1	--	1	30,400	22.2
Percent	39.7	27.0	17.5	7.4	4.3	1.6	0.8	0.9	0.5	0.3	[1]	[1]	[1]	--	[1]	--	[1]	[1]	--	[1]	--	[1]		
5,000–5,999:																								
Number	--	2,036	1,870	1,930	1,485	1,016	697	910	341	211	84	113	27	6	10	3	3	--	--	2	--	--	10,744	7.8
Percent	--	19.0	17.4	18.0	13.8	9.5	6.5	8.5	3.2	2.0	0.8	1.1	0.2	[1]	[1]	[1]	[1]	--	--	[1]	--	--		
6,000–6,999:																								
Number	--	--	323	1,150	1,539	1,411	1,123	1,881	995	1,187	350	513	123	12	43	7	8	15	6	2	--	2	10,690	7.8
Percent	--	--	3.0	10.8	14.4	13.2	10.5	17.6	9.3	11.1	3.3	4.8	1.2	0.1	0.4	0.1	0.1	0.1	[1]	[1]	--	[1]		
7,000–7,999:																								
Number	--	--	10	259	768	747	979	1,860	1,135	1,701	670	1,413	168	22	83	6	13	11	13	2	1	1	9,862	7.2
Percent	--	--	0.1	2.6	7.8	7.6	9.9	18.9	11.5	17.3	6.8	14.3	1.7	0.2	0.9	0.1	0.1	0.1	0.1	[1]	[1]	[1]		
8,000–8,999:																								
Number	--	--	--	24	186	546	531	1,030	922	1,216	835	1,255	194	37	108	8	14	13	6	6	--	5	6,936	5.1
Percent	--	--	--	0.3	2.7	7.9	7.7	14.9	13.3	17.5	12.0	18.1	2.8	0.5	1.6	0.1	0.2	0.2	0.1	0.1	--	[1]		
9,000–9,999:																								
Number	--	--	--	6	25	251	333	466	504	724	444	575	200	65	83	5	6	6	1	1	1	15	3,711	2.7
Percent	--	--	--	0.2	0.7	6.7	9.0	12.6	13.6	19.5	12.0	15.5	5.4	1.7	2.2	0.1	0.2	0.2	[1]	[1]	[1]	0.4		
10,000–10,999:																								
Number	--	--	--	--	8	53	250	221	166	313	306	340	164	41	44	9	16	6	4	3	1	24	1,969	1.4
Percent	--	--	--	--	0.4	2.7	12.7	11.2	8.4	15.9	15.5	17.3	8.3	2.1	2.2	0.5	0.8	0.3	0.2	0.2	0.1	1.2		
11,000–11,999:																								
Number	--	--	--	1	2	10	64	122	73	108	139	205	93	27	42	12	5	6	3	--	1	6	919	0.7
Percent	--	--	--	0.1	0.2	1.1	7.0	13.3	7.9	11.8	15.1	22.3	10.1	2.9	4.6	1.3	0.5	0.7	0.3	--	0.1	0.7		
12,000–12,999:																								
Number	--	--	--	--	--	5	13	56	59	97	74	98	91	42	29	18	8	1	6	--	--	--	597	0.4
Percent	--	--	--	--	--	0.8	2.2	9.4	9.9	16.3	12.4	16.4	15.2	7.0	4.9	3.0	1.3	0.2	1.0	--	--	--		
13,000 and over:																								
Number	--	--	--	--	--	1	3	26	82	115	84	214	92	42	76	35	29	38	2	4	4	2	849	0.6
Percent	--	--	--	--	--	0.1	0.4	3.1	9.7	13.5	9.9	25.2	10.8	4.9	9.0	4.1	3.4	4.5	0.2	0.5	0.5	0.2		
TOTAL:																								
Number	49,279	26,846	12,767	6,637	5,456	4,560	4,236	6,855	4,431	5,761	3,000	4,732	1,153	294	520	103	103	97	41	21	9	56	136,957	100.0
Percent	36.0	19.6	9.3	4.9	4.0	3.3	3.1	5.0	3.2	4.2	2.2	3.5	0.8	0.2	0.4	0.1	0.1	0.1	[1]	[1]	[1]	[1]		

[1] Less than 0.1 percent.

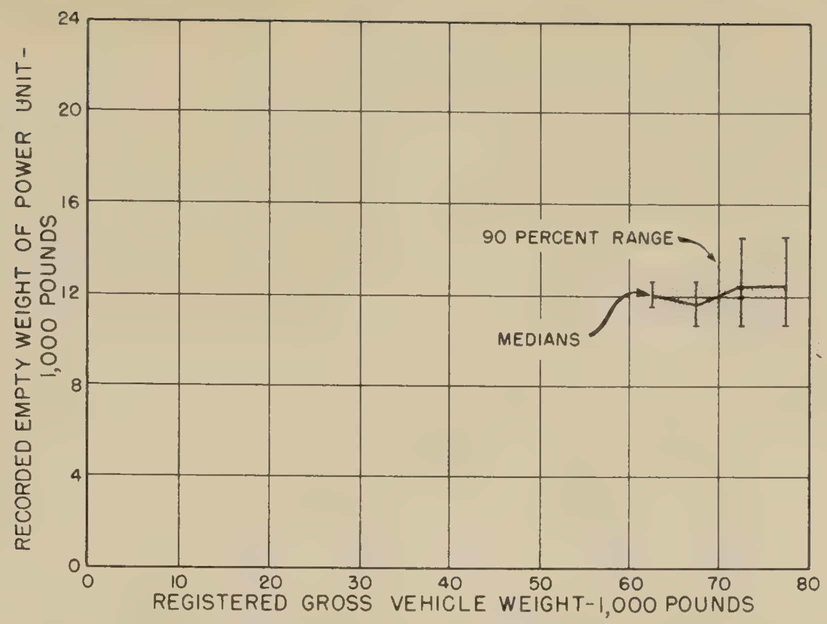

Figure 18.—Range of recorded tractor empty weights of 5-axle, tractor-semitrailer, full-trailer combinations (2-S1-2) registered by gross vehicle weights, based on the combined 1957 and 1961 loadometer data.

Table 12.—Table for estimating the distribution of 3-axle, single-unit trucks grouped by recorded empty weights, by groups of probable registered gross vehicle weights

Recorded empty weight of truck (pounds)	Registered gross vehicle weight (pounds)													Total number	Percent of total
	Under 18,000	18,000–19,999	20,000–21,999	22,000–23,999	24,000–25,999	26,000–27,999	28,000–29,999	30,000–31,999	32,000–35,999	36,000–39,999	40,000–44,999	45,000–49,999	50,000 and over		
Under 9,000:															
Number	99	33	34	29	63	42	42	58	51	54	99	9	1	614	8.3
Percent	16.1	5.4	5.5	4.7	10.3	6.8	6.8	9.5	8.3	8.8	16.1	1.5	0.2		
9,000–9,999:															
Number	21	3	11	16	52	17	32	51	93	69	42	2	2	411	5.6
Percent	5.1	0.7	2.7	3.9	12.7	4.1	7.8	12.4	22.6	16.8	10.2	0.5	0.5		
10,000–10,999:															
Number	11	4	6	9	23	41	30	36	145	137	63	4	---	509	6.9
Percent	2.1	0.8	1.2	1.8	4.5	8.0	5.9	7.1	28.5	26.9	12.4	0.8	---		
11,000–11,999:															
Number	8	1	5	19	19	20	38	28	70	133	72	7	4	424	5.7
Percent	1.9	0.2	1.2	4.5	4.5	4.7	9.0	6.6	16.5	31.4	17.0	1.6	0.9		
12,000–12,999:															
Number	7	1	2	4	11	12	15	18	63	134	140	101	21	529	7.2
Percent	1.3	0.2	0.4	0.7	2.1	2.3	2.8	3.4	11.9	25.3	26.5	19.1	4.0		
13,000–13,999:															
Number	1	1	2	10	7	11	21	33	74	72	99	104	3	438	6.0
Percent	0.2	0.2	0.5	2.3	1.6	2.5	4.8	7.5	16.9	16.4	22.6	23.8	0.7		
14,000–14,999:															
Number	2	2	2	2	5	9	7	26	40	124	119	153	13	504	6.9
Percent	0.4	0.4	0.4	0.4	1.0	1.8	1.4	5.1	7.9	24.6	23.6	30.4	2.6		
15,000–15,999:															
Number	1	---	1	3	1	11	7	23	27	50	212	470	12	818	11.1
Percent	0.1	---	0.1	0.4	0.1	1.3	0.9	2.8	3.3	6.1	25.9	57.5	1.5		
16,000–16,999:															
Number	1	---	---	9	6	9	10	15	29	32	144	204	27	486	6.6
Percent	0.2	---	---	1.8	1.2	1.8	2.1	3.1	6.0	6.6	29.6	42.0	5.6		
17,000–17,999:															
Number	1	---	---	1	3	2	7	5	42	99	173	15	18	366	5.0
Percent	0.3	---	---	0.3	0.8	0.5	1.9	1.4	11.5	27.0	47.3	4.1	4.9		
18,000–18,999:															
Number	---	2	2	1	1	12	3	5	14	111	118	156	14	439	6.0
Percent	---	0.5	0.5	0.2	0.2	2.7	0.7	1.1	3.2	25.3	26.9	35.5	3.2		
19,000–19,999:															
Number	---	---	---	1	---	3	1	3	50	47	212	108	43	468	6.4
Percent	---	---	---	0.2	---	0.6	0.2	0.6	10.7	10.1	45.3	23.1	9.2		
20,000 and over:															
Number	---	---	---	2	2	16	1	21	10	112	164	940	75	1,343	18.3
Percent	---	---	---	0.1	0.1	1.2	0.1	1.6	0.8	8.3	12.2	70.0	5.6		
TOTAL:															
Number	152	47	65	106	193	205	214	322	708	1,174	1,657	2,273	233	7,349	100.0
Percent	2.1	0.6	0.9	1.5	2.6	2.8	2.9	4.4	9.6	16.0	22.5	30.9	3.2		

Table 13.—Table for estimating the distribution of 3-axle, tractor-semitrailer combinations (2-S1) grouped by recorded empty weights by groups of probable registered gross vehicle weights

Recorded empty weight of tractor (pounds)	Registered gross combination weight (pounds)																Total number	Percent of total
	Under 18,000	18,000–19,999	20,000–21,999	22,000–23,999	24,000–25,999	26,000–27,999	28,000–29,999	30,000–31,999	32,000–35,999	36,000–39,999	40,000–44,999	45,000–49,999	50,000–54,000	55,000–59,999	60,000–64,999	65,000 and over		
Under 5,000:																		
Number		30	5	6	18	12	10	17	20	36	60	3	1		1		219	3.5
Percent		13.7	2.3	2.7	8.2	5.5	4.6	7.8	9.1	16.4	27.4	1.3	0.5		0.5			
5,000–5,999:																		
Number		25	15	39	48	16	33	41	96	69	104	13	11	1	2		513	8.2
Percent		4.9	2.9	7.6	9.4	3.1	6.4	8.0	18.7	13.5	20.3	2.5	2.1	0.2	0.4			
6,000–6,999:																		
Number		24	14	14	80	34	55	83	361	229	314	25	17				1,250	19.9
Percent		1.9	1.1	1.1	6.4	2.7	4.4	6.7	28.9	18.3	25.1	2.0	1.4					
7,000–7,999:																		
Number		17	28	19	37	21	31	151	329	310	404	27	31	5	2		1,412	22.4
Percent		1.2	2.0	1.3	2.6	1.5	2.2	10.7	23.3	22.0	28.6	1.9	2.2	0.4	0.1			
8,000–8,999:																		
Number	2	8	9	9	40	29	36	54	107	183	572	77	68	10	6	1	1,211	19.2
Percent	0.2	0.7	0.7	0.7	3.3	2.4	3.0	4.5	8.9	15.1	47.2	6.4	5.6	0.8	0.5	(1)		
9,000–9,999:																		
Number		2	6		11	10	11	31	77	92	437	88	134	19	15		937	14.9
Percent		0.2	0.6	0.4	1.2	1.1	1.2	3.3	8.2	9.8	46.7	9.4	14.3	2.0	1.6			
10,000–10,999:																		
Number				1	4	3	6	8	31	40	173	41	66	14	35	2	424	6.7
Percent				0.2	0.9	0.7	1.4	1.9	7.3	9.4	40.8	9.7	15.6	3.3	8.3	0.5		
11,000–11,999:																		
Number				1	3	2	4	8	19	22	108	13	40	11	24	2	257	4.1
Percent				0.3	1.1	0.8	1.6	3.1	7.4	8.6	42.0	5.1	15.6	4.3	9.3	0.8		
12,000 and over:																		
Number							1	1		6	16	14	8	6	19	1	72	1.1
Percent							1.4	1.4		8.3	22.2	19.5	11.1	8.3	26.4	1.4		
TOTAL:																		
Number	2	106	77	93	241	127	187	394	1,040	987	2,188	301	376	66	104	6	6,295	100.0
Percent	(1)	1.6	1.2	1.5	3.8	2.0	3.0	6.3	16.5	15.7	34.8	4.8	6.0	1.0	1.7	0.1		

[1] Less than 0.1 percent.

Table 14.—Table for estimating the distribution of 4-axle, tractor-semitrailer combinations (2-S2) grouped by recorded empty weights, by groups of probable registered gross vehicle weights

Recorded empty weight of tractor (pounds)	Registered gross combination weight (pounds)														Total number	Percent of total
	Under 24,000	24,000–25,999	26,000–27,999	28,000–29,999	30,000–31,999	32,000–35,999	36,000–39,999	40,000–44,999	45,000–49,999	50,000–54,999	55,000–59,999	60,000–64,999	65,000–69,999	70,000 and over		
Under 5,000:																
Number	2	1						3	3	2		1		1	13	0.1
Percent	15.4	7.7						23.1	23.1	15.3		7.7		7.7		
5,000–5,999:																
Number	3	4	7	2	2	1	1	2	8	17	7	2			56	0.6
Percent	5.3	7.1	12.5	3.6	3.6	1.8	1.8	3.6	14.2	30.4	12.5	3.6				
6,000–6,999:																
Number	8	17	3	2	7	7	23	32	76	64	60	10			309	3.5
Percent	2.6	5.5	1.0	0.6	2.3	2.3	7.4	10.4	24.6	20.7	19.4	3.2				
7,000–7,999:																
Number	1	3	2	3	10	8	15	43	35	127	91	38		1	377	4.3
Percent	0.3	0.8	0.5	0.8	2.7	2.1	3.9	11.4	9.3	33.7	24.1	10.1		0.3		
8,000–8,999:																
Number	3	1	4	1	1	9	22	61	58	291	269	117	1	1	839	9.5
Percent	0 4	0.1	0.5	0.1	0.1	1.1	2.6	7.3	6.9	34.7	32.1	13.9	0.1	0.1		
9,000–9,999																
Number	4	3	2	1	11	14	30	60	87	573	784	361	13	2	1,945	22.0
Percent	0.2	0.2	0.1	0.1	0.5	0.7	1.5	3.0	4.5	29.5	40.3	18.6	0.7	0.1		
10,000–10,999:																
Number	5	2	1	2	3	6	5	34	47	439	1,124	515	66	5	2,254	25.4
Percent	0.2	0.1	(1)	0.1	0.1	0.3	0.2	1.5	2.1	19.5	49.9	22.9	2.9	0.2		
11,000–11,999:																
Number			1		4	2	3	19	10	197	652	274	77	4	1,243	14.0
Percent			0.1		0.3	0.2	0.2	1.5	0.8	15.9	52.5	22.0	6.2	0.3		
12,000–12,999:																
Number	3	1	2				1	12	19	92	759	260	45	10	1,204	13.6
Percent	0.3	0.1	0.2				0.1	1.0	1.6	7.6	63.0	21.6	3.7	0.8		
13,000–13,999:																
Number		3					1	13	10	20	231	91	49	3	421	4.8
Percent		0.7					0.2	3.1	2.4	4.8	54.9	21.6	11.6	0.7		
14,000 and over:																
Number								1	8	21	84	68	10	7	199	2.2
Percent								0.5	4.0	10.6	42.2	34.2	5.0	3.5		
TOTAL:																
Number	29	35	22	11	38	47	101	280	361	1,843	4,061	1,737	261	34	8,860	100.0
Percent	0.3	0.4	0.2	0.1	0.4	0.5	1.1	3.2	4.1	20.8	45.9	19.6	3.0	0.4		

[1] Less than 0.1 percent.

Table 15.—Table for estimating the distribution of 5-axle, tractor-semitrailer combinations (3–S2) grouped by recorded empty weights, by groups of probable registered gross vehicle weights

Recorded empty weight of tractor (pounds)	Registered gross combination weight (pounds)							Total number	Percent of total
	Under 50,000	50,000–54,999	55,000–59,999	60,000–64,999	65,000–69,999	70,000–74,999	75,000 and over		
Under 12,000:									
Number	136	48	55	197	129	172	5	742	12.7
Percent	18.3	6.5	7.4	26.5	17.4	23.2	0.7		
12,000–12,999:									
Number	27	57	42	215	316	207	8	872	15.0
Percent	3.1	6.6	4.8	24.7	36.2	23.7	0.9		
13,000–13,999:									
Number	12	20	42	164	183	234	5	660	11.3
Percent	1.8	3.0	6.4	24.8	27.7	35.5	0.8		
14,000–14,999:									
Number	11	16	36	199	145	438	13	858	14.7
Percent	1.3	1.9	4.2	23.2	16.9	51.0	1.5		
15,000–15,999:									
Number	2	7	8	167	154	345	45	728	12.5
Percent	0.3	1.0	1.1	22.9	21.1	47.4	6.2		
16,000–16,999:									
Number	2	2	2	93	211	205	34	549	9.4
Percent	0.4	0.4	0.4	16.9	37.3	38.4	6.2		
17,000–17,999:									
Number	1	-----	3	17	37	712	49	819	14.1
Percent	0.1	-----	0.4	2.1	4.5	86.9	6.0		
18,000 and over:									
Number	-----	1	4	18	41	282	257	603	10.3
Percent	-----	0.2	0.7	3.0	6.8	46.7	42.6		
TOTAL:									
Number	191	151	192	1,070	1,216	2,595	416	5,831	100.0
Percent	3.3	2.6	3.3	18.3	20.9	44.5	7.1		

Table 16.—Table for estimating the distribution of 5-axle truck, full-trailer combinations (3–2) grouped by recorded empty weights, by groups of probable registered gross vehicle weights

Recorded empty weight of truck (pounds)	Registered gross combination weight (pounds)						Total number	Percent of total
	Under 60,000	60,000–64,999	65,000–69,999	70,000–74,999	75,000–79,999	80,000 and over		
Under 14,000:								
Number	10	2	3	14	7	-----	36	5.0
Percent	27.8	5.6	8.3	38.9	19.4	-----		
14,000–14,999:								
Number	-----	-----	2	21	7	1	31	4.3
Percent	-----	-----	6.5	67.7	22.6	3.2		
15,000–15,999:								
Number	1	1	5	11	28	1	47	6.6
Percent	2.1	2.1	10.7	23.4	59.6	2.1		
16,000–16,999:								
Number	-----	-----	5	31	57	5	98	13.7
Percent	-----	-----	5.1	31.6	58.2	5.1		
17,000–17,999:								
Number	1	-----	11	52	52	2	118	16.5
Percent	0.8	-----	9.3	44.1	44.1	1.7		
18,000–18,999:								
Number	-----	1	11	87	54	5	158	22.1
Percent	-----	0.6	7.0	55.0	34.2	3.2		
19,000–19,999:								
Number	-----	1	5	75	56	3	140	19.6
Percent	-----	0.7	3.6	53.6	40.0	2.1		
20,000–20,999:								
Number	5	-----	-----	10	40	4	59	8.3
Percent	8.5	-----	-----	16.9	67.8	6.8		
21,000–21,999:								
Number	-----	-----	-----	2	18	-----	20	2.8
Percent	-----	-----	-----	10.0	90.0	-----		
22 000 and over:								
Number	-----	-----	-----	8	-----	-----	8	1.1
Percent	-----	-----	-----	100.0	-----	-----		
TOTAL:								
Number	17	5	42	311	319	21	715	100.0
Percent	2.4	0.7	5.9	43.5	44.6	2.9		

Table 17.—Table for estimating the distribution of 5-axle, tractor-semitrailer full trailer combinations (2-S1-2) grouped by recorded empty weights, by groups of probable registered gross vehicle weights

Recorded empty weight of tractor (pounds)	Registered gross combination weight (pounds)							Total number	Percent of total
	50,000–54,999	55,000–59,999	60,000–64,999	65,000–69,999	70,000–74,999	75,000–79,999	80,000 and over		
Under 10,000:									
Number	1					1		2	3.0
Percent	50.0					50.0			
10,000–10,999:									
Number				1	6	2		9	13.2
Percent				11.1	66.7	22.2			
11,000–11,999:									
Number			1	2	6	4	1	14	20.6
Percent			7.1	14.3	42.9	28.6	7.1		
12,000–12,999:									
Number			1	1	14	9	2	27	39.7
Percent			3.7	3.7	51.9	33.3	7.4		
13,000–13,999:									
Number						7		7	10.3
Percent						100.0			
14,000 and over:									
Number					2	7		9	13.2
Percent					22.2	77.8			
TOTAL:									
Number	1		2	4	28	30	3	68	100.0
Percent	1.5		2.9	5.9	41.2	44.1	4.4		

Table 18.—Empty weight to gross weight ratios of single-unit trucks and tractor-semitrailers, at selected gross vehicle weights

Vehicle type	Ratio of gross vehicle weight to—	
	Empty weight of power unit only	Empty weight of entire vehicle
Single-unit trucks:		
2-axle		
4,000 pounds GVW	1.2	
32,000 pounds GVW	2.7	
3-axle		
22,000 pounds GVW	2.2	
50,000 pounds GVW	2.8	
Vehicle combinations:		
3-axle (2-S1)		
20,000 pounds GVW	3.2	1.3
50,000 pounds GVW	5.5	2.5
4-axle (2-S2)		
30,000 pounds GVW	3.9	1.7
65,000 pounds GVW	5.8	2.8
5-axle (3-S2)		
50,000 pounds GVW	4.0	2.1
75,000 pounds GVW	4.8	2.7

New Publications

HIGHWAY PROGRESS, 1962

Annual Report of the Bureau of Public Roads, Fiscal Year 1962

The Bureau of Public Roads, U.S. Department of Commerce, presents a review of the accomplishments of the Federal-aid highway program and of its many other activities during the fiscal year 1962 in its annual report, *Highway Progress, 1962.*

Included in the 112-page illustrated publication is a descriptive account of the tremendous progress made during fiscal year 1962 on construction of the National System of Interstate and Defense Highways and in improvement of primary highways, secondary roads, and urban arterials under the regular Federal-aid program. Also described is the highway construction work undertaken directly by the Bureau of Public Roads in national forests and parks and on other Federal lands, as well as Public Roads' activities in providing technical assistance to foreign countries to further their program of highway development.

Also reported on at length are the activities and accomplishments of Public Roads in highway planning and design, urban transportation planning, safety, and its extensive and varied research and development program. Included as an appendix in the report are 19 statistical tables covering the progress and activities of the Federal-aid program during the fiscal year 1962.

Highway Progress, 1962, is available from the Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C., at 35 cents per copy.

Standard Plans for Highway Bridges

The Bureau of Public Roads has recently issued a 4-volume set of *Standard Plans for Highway Bridges (1962)* to replace the 1956 edition of *Standard Plans for Highway Bridge Superstructures.* The new plans are available from the Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C., and may be ordered singly for $1.00 each or as a complete set for $4.00: Vol. I—*Concrete Superstructures;* Vol. II—*Structural Steel Superstructures;* Vol. III—*Timber Bridges;* and Vol. IV—*Typical Continuous Bridges.*

The first three volumes are a substantial revision of the 1953 and 1956 editions of this publication and the fourth volume presents additional information. Volumes I and II contain plans for superstructures for simple concrete and steel bridges respectively; Volume III contains plans for substructures and superstructures for timber bridges; and Volume IV contains complete detailed plans for typical 4-span continuous concrete and steel bridges.

These plans will serve as useful guides to State, county, and local highway departments in the development of suitable and economical bridge designs for primary, secondary, and urban highways. The plans provide information sufficiently complete to approach contract drawings as nearly as practicable. For any given bridge location, however, requirements imposed by site conditions will necessitate modification of the plans.

STATUS OF IMPROVEMENT

THE NATIONAL SYSTEM OF INTERSTATE AND DEFENSE HIGHWAYS

Estimated Travel by Motor Vehicles in 1961

BY THE CURRENT PLANNING DIVISION
BUREAU OF PUBLIC ROADS

Reported by THEODORE S. DICKERSON,
Highway Research Engineer

MOTOR-VEHICLE travel in the United States in 1961 totaled 737.5 billion vehicle-miles, an increase of 2.6 percent over the travel in 1960. The travel data were compiled from information supplied by the State highway departments and toll authorities. Total travel for 1962, based on information for the first 10 months of the year is estimated at 767 billion vehicle-miles, a 4-percent increase over 1961.

The proportions of travel by road system and by vehicle type changed little from 1960 to 1961. Of the 1961 travel, 40 percent was on main rural roads comprising 14 percent of the Nation's total of 3.6 million miles of roads and streets. Another 46 percent of the travel was on urban streets, which comprise only 12 percent of the total mileage. Local rural roads accounted for only 14 percent of the travel but make up 74 percent of the total mileage.

Passenger cars represented 84 percent of the vehicles and accounted for 82 percent of the travel in 1961; trucks and truck combinations accounted for 16 percent of the vehicles and 17 percent of the travel; buses accounted for less than 1 percent of both vehicles and travel.

Average vehicle performance in 1961 differed very little from that reported for 1960. The average motor vehicle traveled 9,648 miles in 1961, almost half of it in cities, and consumed 776 gallons of fuel at a rate of 12.44 miles per gallon. The average passenger car traveled 9,465 miles and consumed 658 gallons of fuel, at a rate of 14.38 miles per gallon. The average commercial bus traveled a little more and the average truck a little less in 1961 than in 1960, but their average rates of fuel consumption did not change appreciably.

The travel and related information for 1961 is shown in table 1 by road system and vehicle type. Such data have been reported in PUBLIC ROADS magazine for a number of years; the latest, for 1960, appeared in vol. 32, No. 1, April 1962, p. 11.

Table 1.—Estimated motor-vehicle travel in the United States and related data for calendar year 1961 [1]

Vehicle type	Motor-vehicle travel: Main rural road travel	Motor-vehicle travel: Local rural road travel	Motor-vehicle travel: Total rural travel	Motor-vehicle travel: Urban travel	Motor-vehicle travel: Total travel	Number of vehicles registered	Average travel per vehicle	Motor-fuel consumption: Total	Motor-fuel consumption: Average per vehicle	Average travel per gallon of fuel consumed
	Million vehicle-miles	*Million vehicle-miles*	*Million vehicle-miles*	*Million vehicle-miles*	*Million vehicle-miles*	*Thousands*	*Miles*	*Million gallons*	*Gallons*	*Miles/gal.*
Passenger cars [2]	233, 011	79, 426	312, 437	292, 120	604, 557	63, 870	9, 465	42, 033	658	14. 38
Buses:										
Commercial	878	156	1, 034	1, 812	2, 846	75. 2	37, 846	610	8, 112	4. 67
School and nonrevenue	627	664	1, 291	259	1, 550	205. 5	7, 543	220	1, 071	7. 05
All buses	1, 505	820	2, 325	2, 071	4, 396	280. 7	15, 661	830	2, 957	5. 30
All passenger vehicles	234, 516	80, 246	314, 762	294, 191	608, 953	64, 151	9, 492	42, 863	668	14. 21
Trucks and combinations	62, 679	20, 461	83, 140	45, 442	128, 582	12, 291	10, 461	16, 443	1, 338	7. 82
All motor vehicles	297, 195	100, 707	397, 902	339, 633	737, 535	76, 442	9, 648	59, 306	776	12. 44

[1] For the 50 States and District of Columbia.
[2] Includes taxicabs; also motorcycles (595,669 registered).

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Federal Role in Highway Safety, House Document No. 93 (1959). 60 cents.

Highway Cost Allocation Study:
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- Final Report, Parts I–V, House Document No. 54 (1961). 70 cents.
- Final Report, Part VI: Economic and Social Effects of Highway Improvement, House Document No. 72 (1961). 25 cents.

The 1961 Interstate System Cost Estimate, House Document No. 49 (1961). 20 cents.

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Map of U.S. showing routes of National System of Interstate and Defense Highways, Federal-aid Primary Highway System, and U.S. Numbered Highway System. Scale 1 inch equals 80 miles. 25 cents.

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