U.S. DEPARTMENT OF AGRICULTURE

BUREAU OF PUBLIC ROADS

Public Roads

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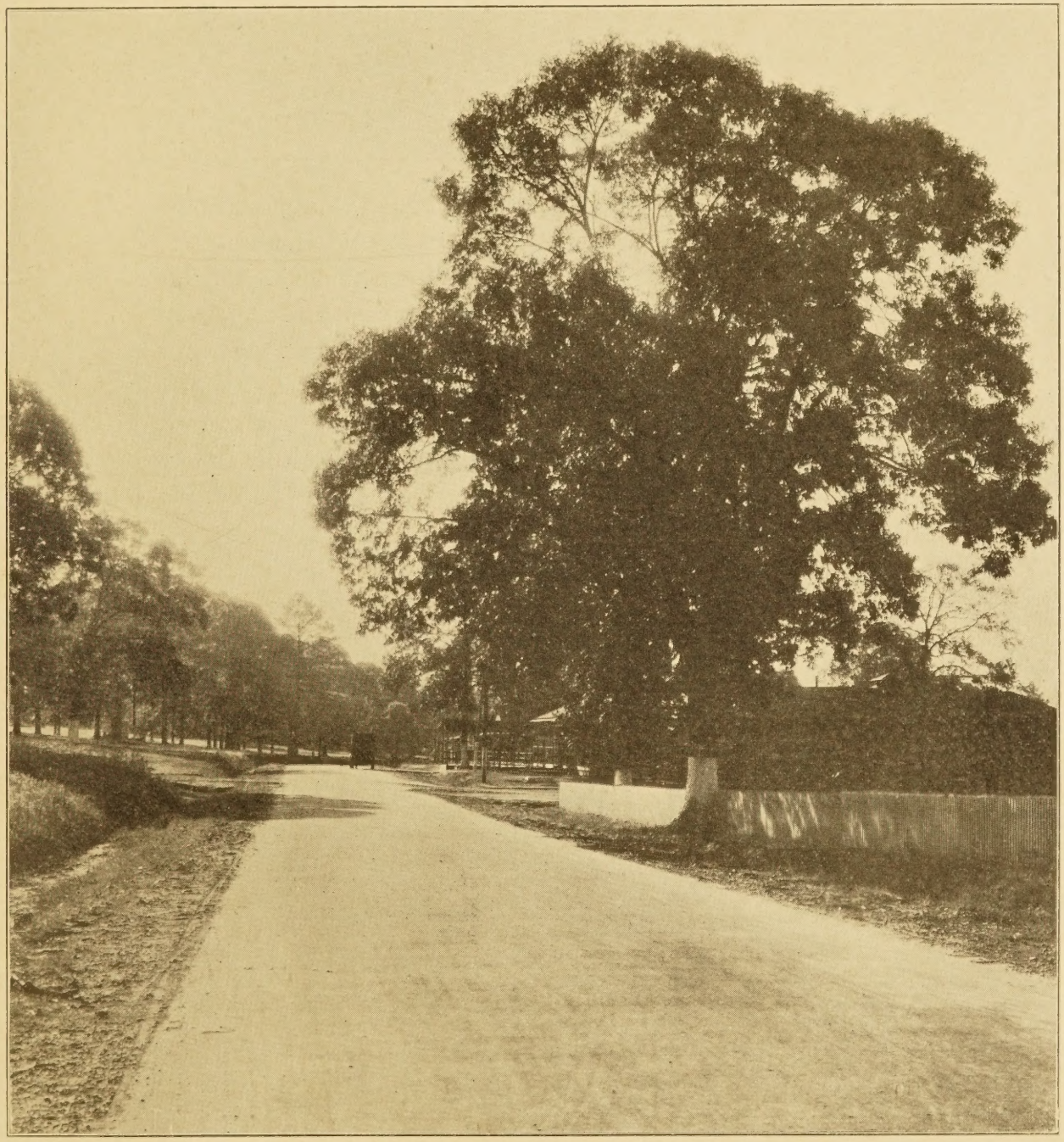

LOUISIANA FEDERAL AID PROJECT No. 22—ALEXANDRIA TO CAMP BEAUREGARD

WASHINGTON : GOVERNMENT PRINTING OFFICE : 1921

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U. S. DEPARTMENT OF AGRICULTURE

BUREAU OF PUBLIC ROADS

PUBLIC ROADS

TABLE OF CONTENTS

THOMAS H. MacDONALD . . . . . Chief of Bureau
P. ST. J. WILSON . . . . . Chief Engineer
H. S. FAIRBANK . . . . . Editor

ADDITIONAL COPIES

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PAPERS AND DISCUSSIONS AT THE HIGHWAY OFFICIALS' CONVENTION.

THE sixth annual convention of the American Association of State Highway Officials was held at Washington, D. C., from December 13 to 16, 1920.

Representatives of the highway departments of every State with the exception of Washington were present and took part in the interesting discussion of highway problems which developed.

One of the most gratifying features was the spirit of mutual helpfulness and harmony which pervaded the meetings. The animating purpose of all those in attendance appeared to be the fixed determination to build up for America a splendid system of highways in the shortest possible time.

Following the practice begun last year PUBLIC ROADS will devote this and subsequent issues to as complete a report of the papers and discussions as it is found possible to print. It will not be possible in every case to give the complete text of every paper, but there will be as little condensation as possible.

Resolutions adopted by the convention were as follows:

EXTENSION OF FEDERAL AID.

Whereas necessary highway improvement will be seriously retarded in every State and possibly cease in some States unless Federal aid is continued; and

Whereas such reduction or cessation would seriously affect commerce and the public welfare in all of the States:

Resolved, That the American Association of State Highway Officials, representing every State in the Union, urges strongly that Congress shall at this session extend further the provisions for Federal assistance to the States in a manner and amount proportionate to the existing needs, and accordingly strongly urges the passage by this Congress of House bill 14905, known as the McArthur bill.

FEDERAL AID FOR HIGHWAY RESEARCH.

Resolved, That we recommend to Congress that it give by suitable legislation such authority to the Secretary of Agriculture as may enable him to grant aid to the States for highway research, any sum granted to any State to be on condition that the State contribute an equal sum, the particular research agency and the scope and extent of the research program in any State to be as mutually agreed between the Secretary of Agriculture and the highway department in such State.

SURPLUS WAR MATERIALS.

Resolved, That we recommend to Congress that it pass further legislation that will permit further distribution to the States of surplus war material and equipment suitable for use by State highway departments.

THANKS TO THE BUREAU OF PUBLIC ROADS.

Resolved, That we extend to the Bureau of Public Roads, Mr. Thomas H. MacDonald, chief, the hearty thanks and appreciation of the members of this association for the many courtesies extended to the association and the individual members thereof during this convention.

THANKS TO THE WASHINGTON HOTEL.

Resolved, That we extend to the management of the Washington Hotel our thanks for and appreciation of the courtesies extended to the association, adding very materially to the success of the convention.

ON THE DEATH OF SENATOR BANKHEAD.

Whereas by the death of Senator John Hollis Bankhead this association has lost one of its best friends and associates, who gave unsparingly of his time and energy in the furtherance of better roads for the United States: Therefore be it

Resolved, That the American Association of State Highway Officials in session at Washington, D. C., this 16th day of December, does hereby extend the heartfelt sympathies of its members to his wife and family, and the secretary is hereby instructed to convey to the family this expression of the unanimous sentiment of the association, and to tell them that the good work accomplished by Senator Bankhead will always remain a monument to his memory in this country.

ON THE DEATH OF GEORGE W. COOLEY.

Whereas the Hon. George W. Cooley, former State engineer of Minnesota and one of the original members of this association, has completed his work and passed beyond since our last meeting: Therefore be it

Resolved, That the American Association of State Highway Officials in session at Washington, D. C., this 16th day of December, does, by unanimous rising vote, extend to his wife and family its heartfelt sympathies and desires to express its recognition of the service of Mr. Cooley in the development of better roads in the United States, in which movement Mr. Cooley was one of the pioneers and a consistent supporter. The members of the association realize that Mr. Cooley's life and work have been extremely successful, still they can not help but grieve for the loss of his kindly sympathetic personality which has been an inspiration to many of the members of the association.

ON THE DEATH OF ED SCOTT.

Whereas the cause of highway development has lost an able and devoted servant, and this association a valuable member, through the death of Ed Scott, member of the State Road Department of Florida: Therefore be it

Resolved, That this association extend to the family of Mr. Scott and to the State of Florida its deepest sympathy on account of their irreparable loss. Be it further.

Resolved, That the secretary of this association be instructed to forward a copy of this resolution to the family of Mr. Scott and to the State Road Department of Florida.

ASSOCIATION OFFICERS FOR 1920.

The following officers were elected by the American Association of State Highway Officials at the Washington meeting:

President, W. S. Keller, State highway engineer, Alabama.

Vice president, S. E. Bradt, superintendent of highways, Illinois.

Secretary, J. H. Mullen, chief engineer, Minnesota.

Treasurer, L. A. Gillette, State highway engineer, New Mexico.

Executive committee:

Austin B. Fletcher, State highway engineer, California, 1925.

W. R. Neel, State highway engineer, Georgia, 1925.

Rollen J. Windrow, State highway engineer, Texas, 1923.

Paul D. Sargent, chief engineer, Maine, 1922.

Members of the executive committee whose terms hold over are: George P. Coleman, chairman, State highway commissioner, Virginia, 1922; Thomas H. MacDonald, chief, Bureau of Public Roads, 1924; George E. Johnson, State engineer, Nebraska, 1924; Ira R. Browning, State road engineer, Utah, 1923; W. D. Uhler, chief engineer, Pennsylvania, 1921; C. J. Bennett, State highway commissioner, Connecticut, 1921.

The Address of the Secretary of Agriculture.

E. T. MEREDITH, Secretary of Agriculture.

I AM genuinely glad to have the privilege of welcoming to Washington the American Association of State Highway Officials, an organization composed of men upon whose shoulders rests the responsibility for providing the Nation with highway facilities equal to its needs. I do not think it is an exaggeration to say that no single thing will contribute more largely to the development of our national life and the upbuilding of our country as a whole than the great highway system upon the construction of which the institutions we represent are now engaged.

The national road-building program, authorized by the Federal aid road act of July 11, 1916, has clearly demonstrated that the Federal and State Governments can cooperate closely and successfully in large undertakings. And yet I have heard it frequently stated that such large national problems can not be successfully dealt with under our dual system of government. One group says that there is a tendency for the National Government to encroach upon the field of the States, while another thinks that the Federal Government in order to make its work effective should extend its authority to the smallest political unit. Both groups, apparently, find no difficulty in agreeing that the States and the National Government are working at cross-purposes. Let us not be disturbed by these voices. Similar expressions have been heard since the first days of the Continental Congress, and 145 years of successful operation has not silenced them. But all of us here, I am sure, have faith in our Government, in the stability of its dual character, and in the ability and willingness of the Federal authorities and the authorities of the 48 States to work harmoniously and successfully under it. We all realize, I know, that satisfactory cooperation requires a genuine feeling of mutual confidence and good will and an earnest desire and willingness to be helpful to each other. This is clearly indicated by the manner in which our respective organizations have worked together in the common task of building good roads for the Nation.

PROMPT ACTION IMPERATIVE.

The matter of largest immediate concern to us is the making of adequate provision for the continuation of the road-building plan embodied in the Federal-aid road act of 1916 beyond the period covered by the existing appropriations. Prompt action in this matter is imperative for a number of reasons. The complete success of the work as a whole depends in no small measure upon the certainty with which we and those who work with us can plan ahead for a number of years. Forty of the State legislatures will be in session this winter, when it will be necessary for them to make the requisite provision for meeting future Federal apportionments. Furthermore, we are now threatened with a situation which we feared would exist when our soldiers were returning from overseas. Unemployment is already in evidence in some sections of the country and may become more general. A continuation of this great program of public improvement will help to take up the slack in employment. The Federal-aid road work should be so provided for that it can go forward upon short notice in any district and at any time. It is impossible, however, to develop great construction operations quickly. Months must intervene between the making of appropriations and the paying out of money for labor. I am told that ordinarily a year and a half will elapse between the time when funds are made available for road operations and the time when they can be paid out in considerable amounts. We should know, therefore, without delay whether the necessary appropriations will be provided for the continuation of the existing program during the next five years.

ROAD BUILDING A MEASURE OF PROGRESS.

Immediate action is desirable also in order that our national vision of highway building as one of the greatest public undertakings during the next quarter of a century may not be obscured. This vision has come only after years of debate and opposition, and it has required a national catastrophe to awaken the public as a whole to the inadequacy of our transportation facilities and to the fact that we must depend largely upon our highways, in conjunction with motor vehicles, when a sudden expansion in transportation is necessary. Our experiences during the past three years clearly indicate that the failure earlier to inaugurate a sound highway improvement program has retarded the development of one of our most vital national requirements. The need of better transportation facilities, particularly in rural communities, is too well known to require discussion. Indeed, the degree of transportation development has become a measure of progress in any community, and the part played by it in the betterment of social conditions is generally understood. Certainly it is one of the most important factors in the improvement of rural life.

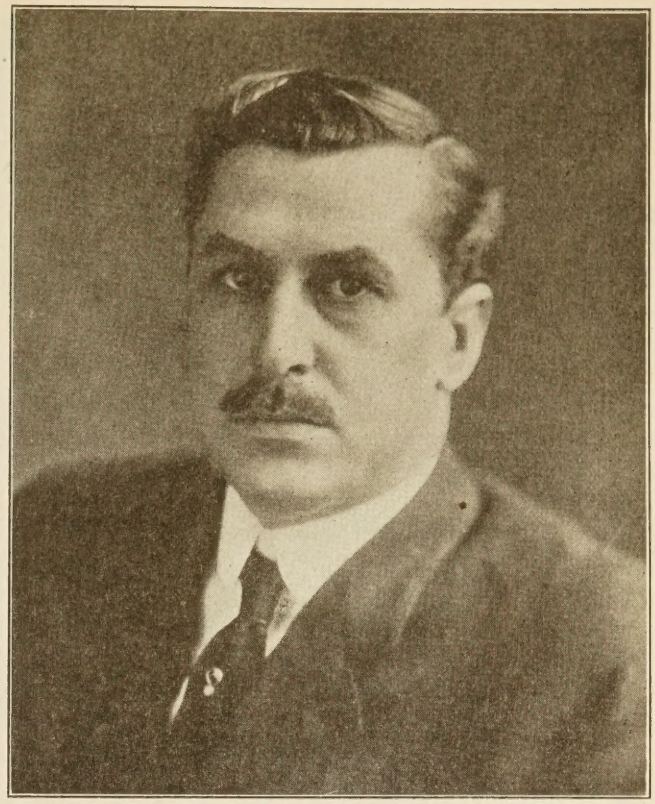
In my annual report for 1920 I have discussed the progress that has been made in highway construction under the Federal-aid road act, and I have pointed out the steps that have been taken to provide for the full correlation of the work of the department and the State highway agencies through the advisory board of highway officials. I have emphasized the fundamental importance of classifying our highways into groups or

systems of like importance, a problem which the board now has under active consideration. Only through a carefully prepared building plan can the work of the several highway agencies from year to year be placed on a systematic basis, a basis that will provide systems of highways so developed and connected that all classes of traffic will be adequately served. We can not ignore the fact that the actual construction of highways will be limited by physical factors for some years to come; and it seems clear that the only sound policy to follow in the circumstances is that of building roads in the order of their economic importance. Highways, as a general rule, are local institutions, and they must first of all carry the traffic originating in the immediate vicinity. Their normal function, therefore, is the short haul, connecting producing areas with rail shipping points and near-by markets. But we should classify our highways and then follow the classification persistently, to the end that as the principal roads in each State are completed they will connect with those of contiguous States, and thus automatically become links in a national system which will serve all parts of the country. In working out such a classification due consideration must be given to the military needs, and, as you know, provision has been made for cooperation with the War Department in making an extensive study to determine the roads which are required to meet these needs.

SOUNDNESS OF PLAN DEMONSTRATED.

The rapid improvement in the organization of the Federal and State highway departments, the development of adequate road legislation in the various States, the response of the States in making funds available to meet the Federal apportionments, and the progress of construction work during a period beset with every possible discouraging condition and limitation have completely demonstrated the soundness of the existing Federal-aid plan. Future legislation should not disturb the principles embodied in the act of 1916, which have been tried out and found to be so satisfactory, and only those changes should be made which experience has clearly shown to be desirable.

As the period covered by the original act as amended will terminate with the close of the present fiscal year, and in order that there may be no halting in the work, I have urged in my annual report that the Congress, at its next session, provide additional funds, to be expended under the terms of existing legislation with certain modifications at the rate of $100,000,000 a year for a period of five years, beginning with July 1, 1921. The principal modifications relate to the problem confronting the Western States in highway work because of the existence in many of them of large areas of public land, and to the maintenance of Federal-aid roads by the State highway agencies rather than by the counties. Your association at its meeting in December, 1919, unanimously approved the continuance of the present plan of Federal participation in road building with these and other modifications.



E. T. MEREDITH, SECRETARY OF AGRICULTURE.

PROVISION FOR FOREST ROADS.

I have urged also that provision be made for the continued building, on an adequate scale, of roads within or adjacent to the national forests. The forest-road systems are very closely related to those of the States, and the major projects form important links in essential State and interstate highways. There are approximately 15,000 miles of roads within the forests which connect with State and county highway systems. The building of forest roads, therefore, is an important part of the general road development plan of the West. In addition, the transportation of forest products, the protection and administration of the forests themselves, and their utilization for recreational purposes are all dependent upon the construction and maintenance of serviceable roads.

We are gathered here as a family. The institutions we represent are dedicated to public service and we are seeking in our activities to attain a common object. Certainly, therefore, we may discuss our affairs with the candor that should characterize the interchange among members of the same household. We are in general agreement regarding the future highway building policy and program. We know what is required in the way of money and legislative authority for the successful carrying out of the great undertaking devolving upon us. We ought to be equally certain of what we shall require of ourselves.

RESEARCH IMPORTANT IN ROAD BUILDING.

Perhaps the most important contribution we ourselves can make is in the improvement of methods for the construction and maintenance of the roads that will be built within the next quarter of a century, so that they will serve the needs of the country to the best advantage for the longest possible time. I do not need to remind you gentlemen of the basic importance of research as applied to road building. So much has already been accomplished through research effort that we may be inclined to think that not much more work of this character is needed, and that the requirements of the day relate merely to the application of knowledge already available. We can not afford to fall into that error. Research is more essential now than ever before. We are confronted, in the great undertaking before us, with serious problems of the most pressing nature, about which we know comparatively little. I do not mean to imply that we are neglecting the research problems involved in this task. As a matter of fact, the department, in cooperation with the National Research Council and your organization, has instituted deep and far-reaching investigations which, when completed, will solve many of the problems involved in the construction and maintenance of good roadways under a heavy and constantly increasing traffic. I do wish to emphasize the fact, however, that the highway agencies, State and National, must not lose sight of the fundamental importance of continuous additions to the body of scientific knowledge regarding road building, and that every opportunity must be availed of to promote this character of work if we are to justify the responsibilities reposed in us and insure the wise and systematic expenditure of the large sums provided for highway construction.

I wish for you a most successful meeting, and I am confident that from your deliberations and discussions will come much that will be helpful to all those interested in the problem of better roads.

The President's Address.

Paul D. Sargent, Chief Engineer, State Highway Commission, Maine.

THERE has never been a year since the beginning of systematic road improvement in this country when so much was expected of the road building organizations and when so little, comparatively speaking, has been accomplished. We were all proud a year ago to announce that more than $600,000,000 would be available from Federal and State sources for road construction in 1920. The war had been brought to a successful termination; industries converted to the manufacture of war materials were closing down and had not resumed peace-time production; a large supply of labor seemed to be in sight; State highway departments were bending every energy in preparation for the greatest year's program in their history. Contracts were let in the fall of 1919 and during the first four months of 1920 in order that contractors could have opportunity to get construction work under way at the earliest possible date. By May or early June it was apparent that our hopes were not to be realized. Prices bid for work were extremely high and at each successive opening of bids prices increased. New York, I believe, was the first State to revise its scheme for a large program of construction by announcing in May that no more work would be let until prices became stabilized but that every effort would be made to secure the completion of unfinished contracts of earlier years, and to carry out their projected maintenance program. Shortly thereafter many other States reduced their construction programs to cover only 20 to 25 per cent of the work originally planned for the year.

DELAY IN HIGHWAY WORK.

I have no data on conditions throughout the country but it is my belief that not over 25 per cent of the projected program of highway construction has been carried out.

It was soon learned that there was everywhere a shortage of labor for highway work and that wages were as high as, and in many cases higher than, had ever before been paid. We also learned that it would be difficult to secure construction materials or equipment requiring rail haul. One case may serve to illustrate the difficulties of this kind. I had a contractor who ordered a construction outfit in May with a promise of delivery June 15. The plant was ready for delivery on time, but the railroad would not handle it, and delivery was actually made in September, a part of the haul on each end being made by motor truck.

On account of conditions, and to appease the public demand for highway construction, resort has been had to various methods of carrying on work. Contracts have been let on a cost-plus-percentage basis, on a cost-plus-fixed fee, with and without bonus and penalty, and much work has been undertaken on a straight force-account or day-labor basis. Many departments have entered into construction arrangements which would never have been countenanced under normal conditions. In many cases types of construction have been changed from those originally planned because it was impossible to secure materials to carry out the work as designed. In my own State we have surfaced several roads with gravel from local deposits, where we had planned to build a bituminous macadam. We have also built subgrade, culverts, and foundation work on several jobs and put a surface of 3 or 4 inches of gravel on them, hoping to be able to lay the pavement during 1921. These improvements will give immediate relief where conditions have previously been bad.

There is something to be said in favor of this method of construction even in normal times. Undoubtedly many failures of expensive pavements would be avoided if the subgrade and foundation work could be done and the road, with a temporary surface of gravel, turned over to traffic for one or two seasons before the final pavement is laid. Weak spots which develop only under traffic could be detected and corrected, and we would feel much more confident of ultimate success when the surface is placed. Furthermore, a cushion of gravel will lend strength and stability to any type of surface. The only objection is that the road must be closed to traffic for two seasons.

While we have all been disappointed at our accomplishments in actual road construction, I believe the fact that we have been unable to spend more money will prove to be a blessing in disguise. Delayed construction, in my judgment, will mean better and less expensive construction.

On account of the inability of the railroads to handle traffic offered, there has occurred a very heavy movement of commodities over the highways. If trucks had not been available for this traffic, many lines of business would have been forced to suspend operations entirely, both from want of raw material and from inability to deliver finished products to merchants and consumers. The results of this traffic many of you realize better than I do. In May last I saw a large collection of photographs taken in many States showing failures of all modern types of highways, many of which were constructed in 1919, presumably in accordance with the best practice then existing.

THE STUDY OF SUBGRADE PROBLEMS.

The direct result of these failures has been to bring about an intensive study of subgrade problems and a study of the amount and effect of highway traffic impact on pavements. Many road builders have apparently thought the construction of a road meant only the building to line and grade of a roadbed out of any material at hand, and the laying upon that of a pavement uniform as to its construction features from end to end of the job. More than likely the specifications for the pavement were taken from the advertising matter of some concern promoting the sale of a particular material. I do not mean to say that material interests are not of great assistance in working out problems of construction. Up to the present time most of the research work in pavement materials and machinery for constructing pavements has been carried on by manufacturers. The public does not seem to object to paying for this work if it can do so indirectly—that is to say, by giving the manufacturer an extra percentage of profit which he adds to his overhead and uses for research and investigation work for his own information and profit first and for the benefit of the public secondly. The real difficulty of this system lies in the fact that the public's representative in many cases is not competent to interpret results and consequently to make wise selection of materials or equipment for a particular piece of work.

PAUL D. SARGENT, PRESIDENT AMERICAN ASSOCIATION OF STATE HIGHWAY OFFICIALS.

In my judgment, each State highway department should have a thoroughly equipped laboratory for research and investigation of problems peculiar to the State. If this is not possible, a central laboratory should be maintained by a group of States whose road problems are similar.

I have referred to the intensive study of subgrade problems now in progress. This appeals to me as being one of the most important developments of the year in the field of highway work. We certainly all recognize as a fundamental principle of engineering that any structure will fail unless it has a proper foundation. No doubt we have all thought we were building proper foundations, but the failures just referred to indicate that we have much to learn about this branch of our work. With the customary promptness characteristic of its administration in recent years, the Bureau of Public Roads is attacking this problem in a vigorous way. Furthermore, committees whose personnel represents highway engineers, road users, and closely allied interests are lending their best thought to a thorough investigation of this problem in all its details. It is too much to hope for an immediate solution of all the questions now under investigation, but my belief is that before the beginning of another road-building season we shall have information at hand which will assist us to design more intelligently that part of our road structures. I will venture

the prediction that when investigations now under way are completed we shall come to the conclusion that lack of thorough drainage or neglect to provide suitable foundations where drainage conditions were bad have been the two underlying causes for most of the road failures. It is impossible to do a thorough job of road building without giving most careful study to and intelligent treatment of these two features.

IMPACT INVESTIGATIONS.

The outstanding development of the year is the investigation of the impact delivered to highway surfaces by the rear wheels of loaded motor trucks. This elaborate set of experiments which has been carried on by the Bureau of Public Roads sheds the first real light on the problem of rational design of road surfaces. If I interpret correctly the results so far obtained in this investigation, it seems to appear that highway impact, and consequently its destructive effect on highway surfaces, does not depend on gross weight of load and vehicle so much as on the actual wheel pressure on the road, which depends largely on the unsprung weight on the rear axle.

One of the compelling reasons for holding this meeting in the city of Washington was to afford opportunity for members of this association to become personally familiar with the experiments the bureau is conducting on the preparation of subgrades and on highway impact. Our program includes an inspection of the field experiments and a presentation of them by the men who have developed and carried them along.

The public should be apprised of the fact that its servants, the highway engineers, have undertaken the solution of these problems much more promptly than their brothers in the railroad profession undertook similar work, for it is only within a few years that railroad engineers have made a scientific study and determination of stresses in railroad track and roadbeds, although railroads have been the standard mode of transportation for three-quarters of a century.

TRUCK TRAFFIC AND ROAD FAILURES.

I have already stated that intensive trucking has proved disastrous to many miles of every kind of highway pavement. Road builders have long said that they should not be blamed for failures if they could not know in advance of construction what loads were to be brought upon the completed highway. The situation existing to-day, it seems to me, is analogous to the owning, constructing, and maintaining of a railroad by a company or corporation which will have nothing to say about the type, character, design, or weight of rolling stock and motive power that is to be allowed to operate over the road. We can all see that such a condition would quickly lead to chaos and ruin. Doesn't that fairly represent conditions on our highways? Roads built for the traffic of 5 or 10—yes; even 2 or 4—years ago, and which successfully carried the traffic then, are ruined to-day by the passage of a few heavily loaded trucks; sometimes one truck absolutely destroys a road so that the road is of no further service for that particular vehicle nor for any other. Moreover, the number of accidents on the highways, many of them fatal, in which motor trucks are involved is increasing.

The public is becoming incensed over this condition, and undoubtedly many of the State legislatures which meet this winter will attempt to pass regulatory measures. I fear that much of the legislation will be based on prejudice or personal spite rather than on real information concerning the subject. Truck owners and truck users may be properly blamed for a lot of the prejudice in the public mind against these vehicles. Overloading and overspeeding are the two underlying causes for most of the damage done to the highways and for most of the accidents in which trucks figure. The former puts too great a pressure upon the highway surface, and both overload and excessive speed put a burden upon trucks, and particularly upon brakes, which they were not designed to and can not handle. The driver of an overloaded truck understands this, and many times he will not leave the crown of the road for fear of getting over the edge of the pavement or of losing control of the machine. "Hogging" the road is the immediate cause of much of the popular clamor against trucks. Owners ought to regulate these matters themselves, but they probably won't. State highway departments should demand the passage and strict enforcement of laws or regulations relative to overloading and speed and should insist that all trucks carry mirrors so mounted on the driver's side that he can see what is behind his truck.

UNIFORM VEHICLE LAWS.

I know that weight and dimensions of trucks have been long discussed and that definite recommendations have been made covering these points. These recommendations have been enacted into law in some States. I wish we might have uniform traffic laws and regulations all over the country. One very real difficulty, it seems to me, in realizing this much-to-be-desired condition, is found in the States which for years have been building improved roads and now have a large mileage of roads not sufficiently strong to carry traffic of the extreme weight recommended. It is entirely possible, however, for a State to pass a law, and at the same time provide for exceptions to the law, even though in the nature of things the exceptions must be quite general. I am inclined to think that many of the States, if they adopted the uniform vehicle law, would have to except from its operation many of their principal through lines or else vest in some body the authority to so regulate traffic that during the critical periods in spring and fall only traffic of a certain weight would be allowed on these roads. Many roads which can not stand the strain at those seasons will

carry the maximum recommended load when subgrades are dry or frozen. While this would cause some confusion, it ultimately would lead to uniformity, for as the roads were worn out they would be rebuilt to the new standard.

On the other hand, many will claim that the regulation of traffic is more or less of a local question. I can hardly conceive of the legislators in my State agreeing that traffic between Portland, with a population of 70,000, and Bangor, with a population of 30,000, requires the same type of highway that is needed between New York and Philadelphia, for example; nor will they agree that our principal trunk line, some 445 miles in length, equal to the road mileage from Portsmouth, N. H., through six States to Baltimore, Md., and of which the Portland-Bangor section is a part, needs such a pavement. The business does not demand it.

Eighty-eight per cent of all motor vehicles registered in my State are passenger cars. Of the motor trucks it is a safe guess that 75 per cent are 3½ tons capacity or under, which will bring only 3 per cent of our total registration of motor vehicles over 3½ tons capacity. This figure checks fairly well with statistics given in Facts and Figures of the Automobile Industry, published by the National Automobile Chamber of Commerce, in which, on page 14 of the 1920 edition, it is shown that of all trucks produced in 1919 those of 5 tons capacity made up 2.9 per cent of the total. I should expect this proportion to hold fairly well in the sparsely settled and agricultural States. The argument will be advanced as to whether in these States it is to be expected that 97 per cent of the highway users should bear the added expense of construction to make a system of highways sufficient to accommodate traffic which is represented by only 3 to 5 per cent of the vehicles using the road.

Undoubtedly the tendency, as truck traffic develops, will be to go to larger units on account of their more economical operation. It has occurred to me that a considerable economy of operation over present methods of highway transportation can be secured by the use of trailers, which will not increase unit wheel or axle loads but will materially increase the usefulness or efficiency of any motor. Rail transportation would never have developed to its present state if each unit of load had been carried on an independent self-propelled vehicle. The railroads have taught us a great many things about road building. We may yet learn from them how to move traffic economically.

FEDERAL AID AND ROAD BUILDING.

Again, financial resources in many States will prevent the carrying out of a program of construction suited to sustain the heaviest types of trucks. Resolutions passed by this association in annual session last years calling for an increased percentage of Federal aid to certain States is sufficient evidence of this fact.

I do not need to remind you that the Secretary of Agriculture has promulgated the allotment of the last available appropriation for Federal aid. No other one thing could have been done which would have stimulated road building as this measure has. Every State now has an organized State highway department and many States have made liberal appropriations to match the money of the Federal Government. It is apparent from the size of many State highway bond issues authorized in the last three years that the voters have anticipated future Federal appropriations and have made financial provision so that there will be no cessation in the prosecution of road programs while waiting to secure State funds by the lengthy process of amending State constitutions.

Many States had a well established program of highway improvement prior to the passage of the Federal-aid act. These States and many others will undoubtedly continue these programs if the incentive of Federal aid is taken away. It is probable that many other States might give up the work now well started without the inducement of Federal assistance. Unless Congress shall make further appropriations, the extent and progress of the work will be much restricted.

I doubt if this association has changed its attitude as expressed a year ago in respect to a continuance of Federal aid. If this is a fact, we will undoubtedly have opportunity to personally interview our respective delegations on Capitol Hill and make our desires known. I might say that this feature was considered by the executive committee in selecting Washington as our meeting place.

FUTURE FEDERAL LEGISLATION.

I can not refrain from taking this opportunity to offer, not in an argumentative way but merely as a suggestion, my views as to the future course of Federal legislation with respect to road improvement.

It is said that history repeats itself; and I am wondering if this will be true in the case of Federal activity in road building. The history of this development has been similar in many of the States. I have taken pains to look up the course of improved road work in one State, together with the results obtained, and I can not bring my mind to any other conclusion than that this is a forecast of the successive steps in Federal legislation. The story briefly told is as follows:

Beginning in 1901 there were 7 years of State aid to towns, supervised as to location and kind of work by 16 boards of county commissioners, with 1,490 separate, distinct, and disconnected pieces of improved road, aggregating 362 miles, built at costs varying between $160 and $11,463 per mile, the average cost being $1,550. State aid continued for 5 more years, but directed by a State highway commissioner. During

this 12-year period there was no provision for laying out a connected system of State highways or trunk lines. The total result of the 12 years' work was 944 miles of roads rebuilt in 4,202 separate sections. If these locations were plotted on a map you would see at a glance where the municipal officers and local politicians lived, for practically every one had a piece of State road by his premises. You will agree with me that this was a record for "fixing roads," for that is just what was done. Bad spots from 100 feet to one-quarter of a mile in length were rebuilt. One could always tell when he was on a piece of State-aid road, but about the time he discovered the fact he had passed over the improved road and was once more on the old road. Several million dollars were spent in this way, but there were no good roads—that is to say, no continuous stretches of good road. Finally the legislators of that State decided it was time to have a real road program.

A commission of three men was created. They were instructed to lay out, construct, and maintain a system of State highways and a system of State-aid highways. Ample funds were provided for carrying out all of this work. For seven years the work has been in progress under the new scheme, and that State is now on the way to securing an adequate system of highways. The Federal aid which goes to that State is used solely on the State-highway system.

THE FINAL FORM OF FEDERAL AID.

I have recited this experience because, as already stated, I believe it represents the several steps we shall pass through as a Nation before we have the Federal-aid law in its final form. I believe there are States in which the Federal-aid funds are being used just as State aid was used in the early years in the example above cited—in constructing a series of disconnected stretches of improved road which begin nowhere and end nowhere, but which no doubt at the present time are the pride of some local politician. I believe there are States where mileage is desired rather than a thoroughly built, good road. In our example we had the prototype in the State-aid road at $160 per mile. State-aid roads, in the State to which I referred, many times did not connect between adjoining townships. Is it not also true that Federal-aid roads in adjoining States do not connect at the State lines?

It will not take 12 years, however, to get Federal-aid appropriations expended in a systematic way. With 8,000,000 motor vehicles using the highways, the public will soon see to it that principal arteries or trunk lines of travel are first reconstructed. If this result can not be obtained under the provisions of the law as it is now written, I believe we shall see a change or some amendment which will provide for the construction of the main arteries of travel in each State first.

My own thought is that, following the example of many of the States, we should have a system of Federal highways, supplemented by a system of Federal-aid highways, and that work on both systems should be carried on simultaneously. I well remember the dissension that occurred in this organization when this matter was under discussion two years ago. I should very much dislike to see a repetition of that. I do believe, however, that we who have such intimate association with this question should express our opinions on a matter of such importance to the Nation. Legislation, it seems to me, is an averaging of the views and opinions of those who know something about the subject matter and take interest enough to get their views before the legislators. It seems to me we can discuss this matter fairly without dealing in personalities, and if we can reach a common ground present our views to Congress. If we can not agree, we can at least agree to disagree and let the matter drop. I have always held that some improvement was better than none, and when I could not get towns to make improvement where I thought the public interest demanded it, I have never placed obstructions in the way of allowing them to proceed on the location they preferred.

I believe there has been much more actual highway construction under the Federal-aid law as it stands than would have been possible during the past three years if the work had been concentrated in the hands of a Federal department. If, however, the work expands in accordance with suggestions I have made, it seems to me that the responsibilities of administering the Federal appropriations will demand either the creation of a Cabinet position or a strong commission to look after this work. As I visualize this development, there will be far more responsibility attaching to it than now attaches to the work of any commission of the Government, not excepting the Interstate Commerce Commission.

Is it not remarkable that in an undertaking of the magnitude of the present road-building program of the country not even the suggestion of scandal or wrongdoing by anyone in executive authority has ever been raised. I believe the work can be kept on this same high plane, regardless of its magnitude, if its administration can be kept free from political influence and bias, as has been the case in the Federal bureau and in practically every State highway organization.

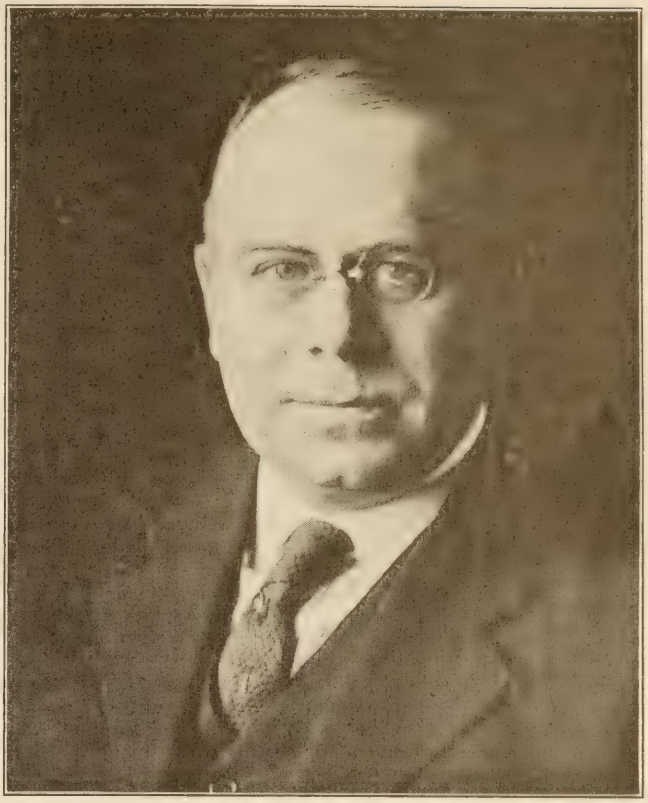
I am fully aware of the pressure that is brought to bear on substantially every highway department for the construction of roads not suited, in the judgment of the department, to the traffic which they will be called upon to carry. I believe it should be the aim of every department to build the best possible roads that the public sentiment of their respective States will allow, and if we can build just a little better, in a few years the public will give us credit rather than condemnation for what we have done. We should have our eyes on the future and not on the past. We are identified with a developing activity whose limits no one can foresee.

Federal-Aid Accomplishments.

THOS. H. MacDONALD, Chief Bureau of Public Roads.

TO MANY here has come to-day the great opportunity to contrast the present highway situation with that existing at the time of the annual meeting of this association at Chicago in 1915—just five years ago. At that time the proposed Federal-aid measure was presented by the executive committee and received the final approval of the association. Many of the States were facing a reactionary wave against modern highway improvement, threatening the authority, even the very existence, of the organizations themselves. A few months later the Federal-aid act had become a law, and even while in one State petitions were being circulated calling on the general assembly to refuse cooperation with the Federal Government, the future of road building in this country was definitely established.

Sharply contrasted with the road-improvement program under the charge of officials in that convention is the immense program going forward under the direction of the officials in this convention. Here are gathered more of the men who are responsible for the development of highway policies than will come together again until this body meets after another 12 months. Highway history is in the making. Our progress in the future is dependent upon a correct analysis of the underlying principles developed by our experience so far and an intelligent forward-looking policy based upon this study.



THOS. H. MACDONALD, CHIEF, BUREAU OF PUBLIC ROADS.

PROGRESS UNDER FEDERAL AID.

Although since 1916 the State and Federal highway departments and road-building agencies have been continuously handicapped, disorganized, and rebuilt, still great progress has been made. The year just ending has been filled with many discouragements and restrictions, and yet surprisingly large and excellent results have been produced. Certainly not all the results which have accrued have been the direct product of Federal aid, but it has seemed desirable to extend the topic to include the broad developments of the last five years, of which the Federal-aid measure has been one of the major factors. Further, it has seemed desirable to treat the progress already made as an index of the possible rate at which highway improvements may be carried on in the future rather than to be content with a summary of the more or less lifeless figures which go to make up the totals. This opportunity can not be satisfied with a bare recital of statistical facts.

Any standard of measurement that will actually indicate what has been accomplished under Federal aid, or, more properly, during the period that Federal aid has been effective, is not the standard of dollars made available or expended for highway purposes or the mileage of highways which has been built. Any conception which seeks to measure progress by these factors is wrong. Any State highway department which fails to sense a different problem than these is missing the main reason for its existence.

THE MOTOR VEHICLE AND THE HIGHWAYS.

During the six-year period since 1914 an astonishing development of the motor vehicle has given us potentially the means for a great increase in our transportation facilities, but the availability of the motor vehicle for this purpose is contingent upon serviceable highways, not of any particular type or character of material, but highways over which, with the maximum public and private economy, motor vehicles in sufficient numbers to supply the highway transportation necessities of the Nation may operate. This, in general, means continuous service, but not continuous service under maximum or peak loads. The extent to which such service is being and will be supplied is the true standard of measurement which should be applied to the past results and the future proposed programs. The motor vehicle in combination with the improved highway has added such a powerful influence to our civilization that we do not yet sense its potentialities. The increase in transportation facilities for the local and short haul afforded by this combination is destined to bring great changes in the conduct

of the activities which go to make up the life of the whole Nation, and will have a far-reaching effect upon its development along every line. The results which have been so far accomplished in a relative sense are unimportant. The important thing is, rather, the way which they point toward the realization of great mileages of adequate highways, and by this test the outstanding development of this period is the sum total of modern highway legislation produced.

ADVANCED ROAD LEGISLATION.

Legislation is the only vehicle through which the public can set in motion activities for its own use and advancement, and no great constructive policy can go forward without adequate authority from the public itself. Here the influence of the Federal-aid act has been potent, and in the great amount of new legislation which has been set up as the law governing highway activities is the greatest result which has come largely as a direct consequence of the Federal-aid act. It is conceivable that such legislation would have come in time, but the same amount of advanced legislation would not have resulted within a decade without this measure to stimulate and guide. Not only is the amount large but there is a uniformity, which will mean larger results than had there been no standard, in the principles in which the State legislatures have shown confidence, and with which new legislation has conformed. In this five-year period there have been new laws providing State participation, State revenues, State highway systems, and State supervision. Entirely new highway departments were established in 5 States, and in about 20 others the highway departments were reorganized and greatly strengthened to carry on the program set in motion by the Federal-aid appropriation. Thus in over half of the States new highway departments were added or those existing were greatly strengthened, and in practically all the others some new legislation was enacted increasing the authority and available funds of the departments. Ten States by a State-wide vote have provided either for constitutional amendments or for State bond issues removing prohibitions and enabling these States to engage in highway improvement. By the passage of the Federal-aid act the Federal Government, after a lapse of nearly 80 years, again assumed responsibility for highway construction, provided funds ample to carry on a large highway improvement program, and provided for general supervision through a Federal department that is a constant force for elevating standards of engineering and construction in the work undertaken.

DEVELOPMENT OF ORGANIZATION.

Next in order of importance to the legislation provided for highway improvement is the development of the organizations necessary to carry on the work. The placing of large, new responsibilities upon the State departments and the Bureau of Public Roads has been followed not only by a growth of the central organizations, but by a systematic expansion of the departments extending down to the men responsible in these organizations who are in immediate charge of all road work carried on through the cooperative funds. Activities of both the State and the Federal departments have been decentralized to facilitate procedure and to place the responsibility upon the men in actual supervision of the work so far as our experience had dictated advisable. The construction work proper has attracted many of the companies and individuals formerly engaged in other lines of construction activities, has brought into the highway building field a large number of men who are experienced in handling large work, and has made available a large amount of capital as well as equipment to carry on the work. It is quite true that these new contractors have come into the field at a very difficult time, and the experience of many has been discouraging, yet the past season has proved to many of them that the highway-contracting field can and will be in the future a profitable field in which to be engaged. Many manufacturing companies have extended their lines of equipment and are engaged in the development of new devices which will prove effective in quantity production.

During the past few years much attention has been given to the development of labor-saving devices because of conditions existing. Producers of road materials have established new plants, enlarged existing plants, and prepared themselves to furnish a larger output of material for this purpose. An effort has been made by a very considerable number of these producers to standardize their product and to produce the sizes and quality of material which the highway engineers are demanding. In addition to the contractors' organizations and equipment which have been made available, every State has profited largely from the distribution of surplus war materials and equipment, and there is now available sufficient equipment in each one to carry on road-building operations of a major character.

Summing up this period, the greatest results are undoubtedly shown by the amount of constructive legislation and the development of the engineering, construction, manufacturing, and producing organizations, and the making available of a large amount of State-owned equipment for both construction and maintenance purposes.

FEDERAL AID TO DATE.

All of this progress has been time consuming and has been carried through at a most difficult period, but there has been produced a situation out of which during the next few years will come a larger production of roads than has yet been considered possible. There is not an indication which fails to confirm this view of the future, yet during this same period the actual

operations under the Federal-aid act have been large. From the engineering and administrative standpoint the following table indicates the progress by years of the project statements approved by the Secretary of Agriculture:

Project statements approved by fiscal years.

Fiscal year.	Number.	Federal aid.	Estimated States' share.	Total estimated cost.
1917	23	$846,152	$999,282	$1,845,432
1918	557	15,478,090	25,575,111	41,053,201
1919	736	38,664,397	52,831,401	91,495,798
1920	1,670	109,830,366	142,699,817	252,530,183
To Oct. 31, 1920	501	24,198,610	40,599,480	64,798,090
Total	3,487	189,017,615	262,705,091	451,722,706

Because of the fact that the project agreements are not executed until after the preliminary engineering work has been completed, the projects financed and ready for taking bids, the following statement of project agreements executed is more indicative of the producing ability of the highway organizations.

Project agreements executed by fiscal years.

Fiscal year.	Number.	Federal aid.	Estimated States' share.	Total estimated cost.
1917	6	$224,717	$322,375	$547,092
1918	218	5,658,458	8,581,481	14,239,939
1919	454	18,048,442	23,583,290	41,631,732
1920	1,286	85,906,556	111,665,070	197,571,626
To Oct. 31, 1920	393	23,745,415	33,324,573	57,069,988
Total	2,357	133,583,588	177,476,789	311,060,377

The extent of the development of the State and Federal highway organizations is well shown by contrasting the engineering output as indicated by the project agreements executed between the fiscal years 1917 and 1920. In 1917 six project agreements were executed, in 1920 1,286, more than 200 times as many. Project agreements in 1917 called for a total expenditure of $547,092, of which $224,717 was Federal aid. In 1920 the total estimated cost of projects was nearly $200,000,000, of which $86,000,000 was Federal aid, an increase of nearly 400 times the amount requested in 1917.

THE RECORD OF CONSTRUCTION.

The construction record also is good. Prior to the fiscal year 1920 only 59 projects, comprising 293 miles and involving Federal aid in the amount of $1,284,806, had been completed.

The fiscal year 1920 added to the list of completed projects 233 more, or nearly four times as many as had been completed up to the beginning of the year. These 233 projects involved 1,384 miles and $7,635,547 of Federal aid, so that the record of entirely completed projects at the end of the year was as follows:

Number of projects completed	292
Mileage of completed projects	1,677
Federal aid allotted to complete projects	$8,920,353
Estimated total cost of completed projects	$20,878,484

The above refers only to entirely completed projects. In addition to these there were at the end of the fiscal year (June 30, 1920) 1,835 more projects under construction, involving 14,940 miles, and Federal aid to the amount of $103,925,094, the estimated total cost of these projects being $241,977,217.

As these projects were reported at the end of the year as being 30 per cent complete in the aggregate, it follows that the work done on these uncompleted projects up to the end of the year would call for approximately 30 per cent of the Federal aid allotted to them, or $31,174,732. This, added to the Federal aid expended on completed projects ($8,920,353) gives a total equivalent expenditure of Federal aid up to the end of the fiscal year of $40,095,085. At the end of the fiscal year 1919, the amount allotted for completed work was only $4,658,749, so that the Federal aid allotted to work completed during the year was $35,436,336.

But until the 1st of July, 1920, we had not yet caught our stride in construction work. In the face of the most serious shortage of rail transportation, between June 30 and October 31, 329 additional projects were completed, or 37 more than had been completed in the four years preceding, making the total completed projects on October 31, 621.

The Federal aid and mileage, of course, were correspondingly increased, and in order to show the amount of the increase the several items are listed below for the two dates.

	June 30, 1920.	Oct. 31, 1920.
Number of projects completed	292	621
Mileage of completed projects	1,677	3,191
Federal aid allotted to completed projects	$8,920,353	$20,900,014
Estimated total cost of completed projects	$20,878,484	$46,740,472

Notwithstanding the great increase in these items for completed projects, the corresponding items for the projects under construction on October 31 were not decreased, but largely increased. On that date there were 17,369 miles under construction, to which had been allotted $121,322,198 of Federal aid. These projects were reported as 43 per cent complete in the aggregate, and the equivalent Federal-aid expenditure upon them as $51,844,586. This amount added to the Federal aid expended on completed projects gives a total of $72,744,600 as the equivalent of the Federal aid expended for completed work up to October 31.

Thus the work completed on October 31, 1920, has consumed, practically speaking, the whole amount of Federal aid appropriated up to February 28, 1919.

STATE CONDITIONS VARY WIDELY.

It will be noted that during the previous four-month period construction was completed requiring approximately $32,000,000 from Federal-aid funds, or $8,000,000 per month. The acceleration of the rate of con-

struction will be large when highway building is operating under more favorable circumstances. It is now apparent, however, that conditions will vary widely between the States. As closely as can be approximated at this time, it appears that if freed from influences which have so hindered construction during the past season, particularly the lack of rail transportation, the rate of expenditure will be greatly increased, and by the end of the calendar year 1921, 8 States will have expended the full amount of their Federal-aid apportionments, 20 more States will have expended or placed under contract all of their funds, 5 will have placed their funds under contract by the middle of the following year, 15 will have placed all of their work under contract by the end of the year 1922. The number of States in each of the above classes may vary somewhat, but the figures here given are based on the best evidence obtainable.

This situation should be clearly understood, because between 30 and 40 of the State legislatures which meet biennially will be in session this winter, at which time questions affecting the future road-building programs should be settled. More than one year should be allowed to get the funds in the State treasuries after the legislation is enacted, and the highway organizations should know the amount of available funds for several years in advance to enable them to carry out the preliminary engineering and administrative work necessary for the inauguration of road-building projects.

While we are seriously suffering from a lack of improved roads, and our production of new roads up to the present year since 1916 has been small, it has been fortunate for the future stability of the road-building program that because of the limitations imposed there has been sufficient time to get the necessary engineering work done much more thoroughly than would have been possible had we gone hastily into a heavy construction program. So it would seem that conditions have worked out well in spite of the discouragements. We have come to see the immense task ahead and the organizations which have succeeded in driving through actual construction in spite of the handicaps can not fail to produce road mileage at an accelerated rate.

WEAK PHASES OF STATE LEGISLATION.

But the big work, considering the general situation, is ahead, and as we go into the heavy construction program in all of the States we must face the immense physical task of transforming the funds which are provided into adequately built roads. There are certain phases in which our present legislation is weak. These weak points have already shown up and should be eliminated in future legislation. It has become very apparent that those States which have provided State funds with which to meet the Federal-aid apportionments have less difficulty in exercising proper engineering control of the design and construction than those States in which the funds are largely provided by the counties or districts. In a number of States it has been necessary to remove constitutional limitations before State funds could be appropriated for this purpose. There is no reason why local funds should not be used with State and Federal funds, but these should be made to augment the other funds.

Referring again to the standard of measurement by which results must be gauged—that is, the extent to which transportation is facilitated by highway improvement—the results of our observation as to the deterioration of roads and the intensive studies which have been carried on during the past year have demonstrated as never before the absolute necessity of adequate maintenance. In about 30 States the Federal-aid projects are maintained under the direct supervision of the State highway departments or the highway departments have funds to maintain the projects if the local authorities fail. In about 18 States the maintenance is under supervision of the local authorities. Probably the majority of those represented here will not question that a principal of any future Federal aid provided should be that the States as States should have control of the maintenance of the roads built under the cooperative funds. More than 40 of the States have established a system of main roads. These systems vary from a restricted mileage up to more than 10 per cent of the total mileage within the State. The aggregate mileage of the main systems is approximately 8 per cent of the total mileage of rural roads within the United States. Further classification of many of these systems is necessary in order that the construction of those roads of the greatest importance should be expedited. In order that there may be a systematic improvement of the highways this classification should be carried forward, and the sequence of the improvement of the roads should be justified, within reason, by the relative uses which they serve. Only by properly laying out highway systems can the task of road improvement be completed within any reasonable period to an extent necessary to give the public adequate highway service.

BETTER STANDARDS ARE NEEDED.

There are other important features which the experience already acquired has pointed out. In many States better standards should be adopted for the basic improvements such as widths of graded roadway, alignment, grade crossing elimination, and building of permanent drainage structures. The comprehensive studies of the relation of soils to road design, particularly the studies which have coordinated surface failures with certain types of soils, have proved beyond doubt the great prominence which should be given soil studies in road designing. In general, more ample surface widths should be provided, and greater attention given to the construction of shoulders. All of these are fea-

tures which make for permanency of design and the first cost, while greater, will be more than compensated by lesser expenditures for maintenance and reconstruction as our traffic grows heavier. Sufficient attention is not yet being given to the control of materials. The results which really count are the finished product. The materials used must be more adequately controlled through laboratory and field tests. To accomplish these results it seems highly desirable that there be more intimate contact between the Federal and State forces. Up to the present time the Bureau of Public Roads has not succeeded in carrying out the amount of inspection originally planned because of difficulty in maintaining a sufficient organization. It seems probable that a larger number of engineers will be available during the coming year, and so far as possible the bureau proposes to render greater assistance to the States in carrying on a large construction program

This whole road movement has been conceived with the idea of providing adequate roadways for the movement of the highway traffic of the Nation. We have not reached a stabilized character of traffic, particularly with reference to the limiting weights of the larger vehicles, and we should not plan the higher types of construction without allowing a considerable safety factor. Our scientific knowledge of the duty imposed upon highways has been largely increased during the past year, and in the face of facts secured it is evident that our highways in the vicinity of the larger centers of population must be more amply designed and more carefully constructed. No matter how true this is, we must not lose sight of the big fact that there are large areas where transportation over the highways is of the greatest importance to our producing population and where roads of the less costly type, particularly well-built gravel roads, will amply serve the purposes if properly maintained.

TYPES OF FEDERAL-AID ROADS.

The building of highways is the means to an end, that of carrying most economically the traffic developed in the communities served. This principle is being carried out in the projects which have been agreed upon between the Federal and State highway departments, as evidenced by the mileage of the various types of road improvement for which the plans and specifications had been approved up to June 30, 1920. Grouping these types by classes, we have:

Type.	Mileage.	Per cent of mileage.	Total cost.	Per cent of total cost.
CLASS 1.				
Earth	3,701	21.5	$21,763,989	7.7
Sand-clay	1,721	10.0	9,854,570	3.5
Shell	27	.2	296,801	.1
Gravel	5,583	32.5	47,151,795	16.8
Gravel (surface treated)	355	2.1	4,136,533	1.5
Total	11,387	66.3	83,203,688	29.6
CLASS 2.				
Water-bound macadam	342	2.0	5,258,779	1.9
Water-bound macadam (surface-treated)	97	.6	1,433,499	.5
Bituminous macadam	714	4.1	16,669,782	5.9
Total	1,153	6.7	23,362,060	8.3
CLASS 3.				
Rock asphalt	51	.3	1,978,293	.7
Bituminous concrete	496	2.9	15,064,756	5.3
Concrete	3,308	19.2	120,629,308	42.9
Brick	351	2.0	15,725,494	5.6
Sheet asphalt	48	.3	1,572,472	.6
Total	4,254	24.7	154,970,323	55.1
CLASS 4.				
Undetermined	392	2.3	19,796,607	7.0

It is unimportant whether all engineers would agree to this classification in regard to all the types. The relative percentages would be little changed between the classes. One big important fact stands out, that all types of roads must be used, and if the traffic demands are to be supplied large mileages of the lower cost roads must be built. The time factor alone will permit no other course, but there are the other conditions of funds available, continued public support, and economical handling of the public's business which can not be met otherwise. The other important fact is that the big percentage of the funds, particularly where the population served is relatively dense, is going into the more durable types of construction.

In closing, as conditions have tended more toward the normal, and limitations have been removed upon the activities of both the State and Federal departments, the spirit of cooperation has steadily improved, and it is needless to say that as the organization of the Bureau looks forward to the biggest year for construction of highways in the history of the United States, it is with the most friendly attitude toward the State organizations and with a desire to produce large results which will reflect credit upon both organizations, and with the sincere hope that at the end of another year the efforts made will have produced greater results than has been possible heretofore.

The Traffic Census.

A. N. Johnson, Dean, Engineering College, University of Maryland.

THERE is a general agreement among all conversant with highway conditions as to the immediate necessity for thorough and systematic work in highway research, and there are already under way well-organized efforts toward this end. Even a brief study of the problems of highway research shows that many of them of the most fundamental character require for their solution a comprehensive knowledge as to the traffic which moves over the highways. It is therefore of the utmost importance that traffic census work be undertaken and this information collected as rapidly as possible. It will be the purpose of this paper to present some of the features that should govern a traffic census.

WHAT HAS BEEN DONE.

There have been collected, from all of the State highway departments, reports as to the traffic enumerations that have been taken, and such other details as could be secured. From these reports there has been compiled as an appendix to this paper a complete summary of the information received, and in addition a brief outline of the traffic census as taken in France during the present year, in Belgium during 1908 (for which the reports have just been received), and the traffic census now underway in England. It is thought that it would be useful to have information of this character collected for ready reference.

For the most part, the traffic records made in this country have been of spasmodic character, and with one or two exceptions have not been taken with any very definite purpose in view other than to record some information which might prove interesting to examine.

The first traffic census taken in this country for any extended period was made in Illinois, 1906–7, where the traffic was counted at some seventy-odd stations continously during a two-year period on an average of four times a month. The data collected, however, are chiefly valuable from an historical standpoint.

The only State reporting that systematic traffic records have been made within the past few years is Maryland, where, since 1912, one-day counts each month have been maintained on all of the State highways. In 1912 there were about 50 stations, to which additional stations have been added as new sections of State highways were built, until at present there are 191. These traffic records have been used to a certain extent to study maintenance costs and have been very valuable indeed in this connection.

THE BASIS OF A TRAFFIC CENSUS.

Let us now examine some of the considerations upon which to base a traffic census and, from the requirements to be met, deduce as much of the detail as possible as to the manner of making such a census.

The great disparity between the amounts of traffic that use a road prior to its improvement and subsequently is to be noted everywhere. This fact makes a general traffic census over a system of roads which have not been improved of little value, although there will probably be certain points on all such systems of roads prior to their improvement where a traffic count would be of assistance to determine something both as to character and amount of traffic that such particular sections of road might be expected to carry after improvement.

A general traffic census, such as has been taken in a number of foreign countries, particularly in England, France, and Belgium, can not have the same application here, except in those localities or States where the roads have been generally improved and where, as a consequence, highway traffic has developed and the principal routes of travel have been defined. Also as a result of the general improvement of the highways the amount of traffic to be noted may be expected to give a fairly accurate indication of the total use to which those communities find it at present profitable and convenient to use the highways.

There are few States in which the highways have been thus generally improved where a traffic census should be of value in this sense. In such a list are to be included Massachusetts, New Hampshire, Connecticut, Rhode Island, New York, New Jersey, Delaware, and Maryland. To this list may, perhaps, be added Ohio, Wisconsin, Minnesota, portions of Pennsylvania, and California. Outside these States there are a number of localities centering around large cities where the roads for a considerable distance have been materially improved, in particular about Chicago, Detroit, Kansas City, St. Louis, Portland, and Seattle. The improved roads about these cities, extending for 15 or 20 miles, are generally confined to the neighboring county.

PURPOSE OF A TRAFFIC CENSUS.

From the summary of traffic censuses that have been made in other countries and various States, which is appended to this paper, it will be noted that there is a wide variation as to the details. Before these can be discussed it is necessary to analyze the purpose of a traffic census and then to adopt such a method of taking the census as will give the data necessary to serve the purpose sought. It is evident that more than this entails unnecessary expense, while less makes the expense incurred of little or no value.

Some of the purposes of a traffic census may be outlined as follows:

(*a*) For the economic evaluation of a highway, i. e., to determine its worth as an investment, or how much may be safely invested in highway improvement.
(*b*) To find the seasonal variation in the use of a highway.
(*c*) For the proper design of a highway.
(*d*) For a rational allocation of reconstruction and maintenance funds.
(*e*) To obtain the cost of operating traffic over the highways.
(*f*) To furnish data for the formulation of regulations governing vehicles and the manner of their use of the highways.

Let us examine what will be required to furnish the data necessary for the purposes above outlined. First, to evaluate the economic worth of a highway it is necessary that both the amount and character of traffic using the highways be known, not only on a few sections of road but for a large mileage constituting a system of highways. We should also have some knowledge of the amount of traffic on the auxiliary roads to such a system.

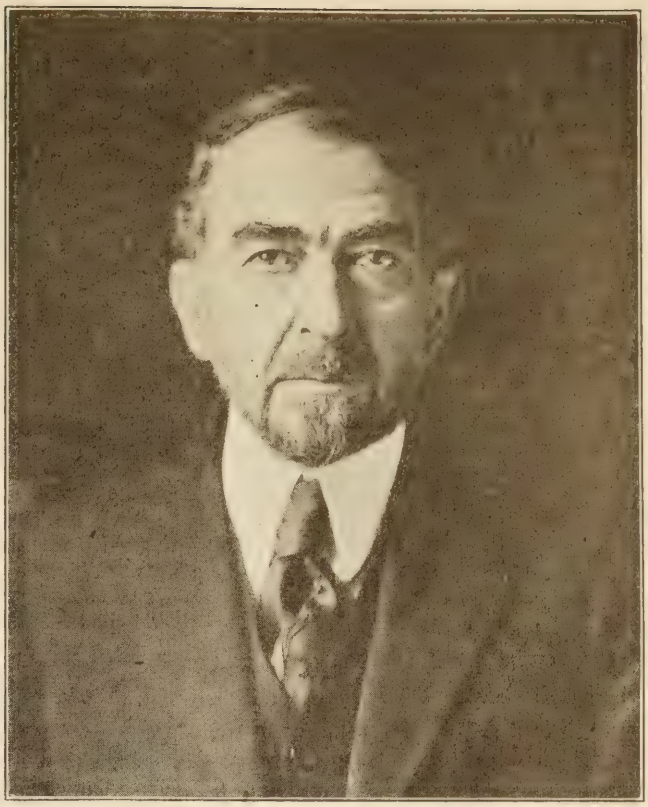
To determine the total amount of traffic it is necessary that we know the total number of vehicles of all kinds. We should also know what proportion of these vehicles are for freight and what for passengers. We should want to know the number of passengers as well as the net tonnage transported during the whole year and at different seasons of the year, together with some indication of the nature of the products, as agricultural products, both raw and manufactured, manufactured goods, products of mines and quarries, etc.

To allocate the maintenance funds the amount of traffic and its character should be known over all sections of the highways. This same information would also be used to determine the maintenance cost per unit of traffic.

To determine the wear due to traffic on different highways of similar construction, it should be possible to compare the relative amount of different kinds of traffic, the proportion of light and heavy vehicles and of horse-drawn and motor vehicles.

For the proper design of a pavement we should know the heaviest loads to be carried and their frequency, to aid in designing the thickness, for which there will be required also much data from other sources. To determine the width of pavement, the maximum amount of traffic to be carried in each direction for a given period during the day, and whether the bulk of the traffic changes direction according to the time of day, would be the governing factors in deciding whether a pavement should be widened to a three-track or four-track way.

The cost of operating traffic over the highways is one of the most significant factors concerned with the economics of highway building and maintenance.



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Until the cost of highway transportation and the elements that affect it are known and applied, true economy in the construction and maintenance of roads can not be attained. The fundamental requirement for data for such a purpose is a reliable traffic census. Not that the census in itself will answer our problems, for there are many experimental data necessary, which are to be secured only by patient and exhaustive study. But these data will be of no practical application until we know the traffic over our highways. For this purpose we shall require to know the total numbers of each class of vehicle using the road and the total tonnage.

To formulate regulations to control traffic, general divisions, as horse-drawn and motor-driven traffic, are evidently essential as well as the number of passenger and freight motor vehicles. The relative frequency of heavy and light loads will be useful to determine the necessity of traffic segregation, while the total amount of traffic using a highway will help to develop rationally other limitations that may be necessary to impose upon those using the highway for transportation.

From what has been said as to the purposes that are to be served by a traffic census, we may now turn to a discussion of the elements of a traffic census which will give the required information.

We have to answer three principal questions: First, as to where traffic enumerations shall be made; second, as to how often—that is, their frequency and duration; and third, as to what shall be enumerated.

LOCATION OF TRAFFIC STATIONS.

Traffic-census stations should be established close enough so that the traffic over a given section of road may be determined with reasonable accuracy. They should not be so close to cities or villages as to include merely local traffic that extends but a mile or less beyond the observation point. As important byroads join the main road, other traffic stations should be established. Some idea of the total number that may be necessary may be gained from the work in Maryland, where on the average there is a traffic station every 7 miles on the State highway system. Additional stations would be required if the traffic carried by the more important side roads is to be known. In England it is not thought necessary to have counting stations in the open country closer than every 10 miles, but they are nearer together in the vicinity of cities. Where traffic is not heavy, counts could be made at crossroads, one observer taking traffic on both roads.

FREQUENCY AND DURATION OF TRAFFIC COUNTS.

Already reference has been made to the conditions under which a general census may profitably be made; that is, a census taken over a widely spread system of roads. Unless such a system has been improved so that traffic uses the roads of the system in preference to the other near-by routes, there is little value to be gained from a widely extended count of present traffic throughout the year. If the roads of the system are not generally improved, it is recommended that counts be confined to two weeks during the summer and fall, a week at a time, counting the traffic for seven consecutive days.

Traffic records throughout the year may be made on certain roads of an unimproved system near larger cities, to which may be applied a traffic factor obtained from observed traffic in other localities of similar environment, but where the roads have been generally improved.

With the data thus collected it would be possible to form an estimate of the expected traffic over a proposed system of State roads yet to be improved, that should closely approximate the relative amounts of traffic the different highways would carry, while giving a reasonable estimate as to actual amounts of traffic that may shortly be expected to develop. Such studies would furnish a sound basis for the determination of the routes and sections of routes most needed for immediate improvement.

Where a traffic census is to be taken over an entire State system of roads, the enumerations should be taken with sufficient frequency to establish the seasonal, weekly and hourly variations. For these purposes it is recommended that the counts should be made on an average of four times a month, each count falling on a different day of the week, the intervals between the counts being as nearly equal as it is practicable to make them. The observations should be made from 12 to 14 hours continuously, the longer time during the summer months.

Night traffic for the majority of the roads which are not near the large centers of population, can be sufficiently well averaged by taking a few typical counts, which need not exceed four or five a year, taken at different seasons of the year. But in the vicinity of all large cities, particularly on those roads where the public makes considerable use of them for riding during summer evenings, the counts should continue far enough into the night to insure that the bulk of this traffic will be included in the summary.

After one or two years' data have been accumulated, the frequency of the counts may be reduced; from one-third to one-half the number will doubtless be found sufficient.

WHAT SHALL BE ENUMERATED.

It is desirable that the classification of traffic be made according to two distinct methods; (1) according to type of vehicle, and (2) according to the destination of traffic, i. e., whether its direction is toward or away from a given center, whether it is farm-to-town or town-to-town traffic, intertown, or traffic through the State. These distinctions as to destination of traffic can usually be discerned by the observer from his general knowledge of the locality and the character of the vehicle and its load, the bulk of through traffic being indicated closely enough by noting those vehicles bearing license numbers of other States or that manifestly carry tourists.

The tally sheets should therefore be divided into two parts, one according to types of vehicles and the other according to destination of traffic, the observer making two marks, one under each of the general divisions, as each vehicle passes, which will be in itself, to some extent, a check upon his work.

The classification of vehicles should be such that the tonnage, both gross and net, as well as the number of passengers can be estimated for any given unit of time. This will require that the tally sheets shall show the traffic for each hour or two-hour period throughout the day, the hourly period being the one recommended. In addition to the total tonnage, the frequency and number of the heavier units should also be shown, for it is these heavier units which determine the critical loads that the road is to carry, and the frequency known will make possible some determination as to how much relative value this portion of the traffic has, and therefore to what extent the engineer is justified in increasing the strength of the road for these heavier units over that required for the average loads which use the road.

To determine the number of passengers and the tonnage it is not necessary for the enumerator to make very nice distinction; probably two classes of passenger vehicles would be sufficient, or not more than three, to

include passenger busses. A few days' count, showing the actual number of passengers and the number for each classification of vehicles, would give a factor by which the enumeration, made as already suggested, could be reduced so as to give with reasonable accuracy the total number of passengers carried over the road for a given period. To estimate the gross tonnage or net tonnage the enumerator need not keep more than three classifications, one for motor trucks of 5-ton capacity and over; one for trucks of 2 to 5 ton capacity; and one for trucks under 2 tons.

A few days' records noting carefully the type and weight of all motor vehicles according to the classification now used in Maryland, for example (see Appendix), will give reliable factors for reduction to secure the gross tonnage. Likewise records in detail of the net loads carried should be made for a few days on some much-traveled road, until several thousand vehicles have been recorded, from which the net tonnage factors may readily be deduced.

These net tonnage factors would vary somewhat for different localities and possibly for the same locality at different seasons of the year, but need not cause any change in the classification to be used on the tally sheets for the general enumerations. They do, however, bring out the necessity for an experienced observer to study the conditions of traffic in different localities in order that the most intelligent and rational application possible may be made in reducing the traffic to a tonnage and passenger basis.

_____ STATE HIGHWAY DEPAPTMENT

TRAFFIC CENSUS

STATION AT _____ DATE _____

NORTH SOUTH / EAST WEST BOUND TRAFFIC

WEATHER _____

OBSERVER _____

HOURS	HORSE DRAWN VEHICLES			MOTOR VEHICLES							
		FREIGHT		PASSENGER				TRUCKS			
	PASSENGER	ONE HORSE	TWO HORSES	MOTOR CYCLES	2 PASSENGER.	5-7 PASSENGER	BUSSES	2 TON AND LESS	OVER 2 TO 5 TONS	5 TONS AND OVER	TRAILERS STATE CAPACITY TONS
AM 6-7											
7-8											
8-9											
9-10											
10-11											
11-12											
PM 12-1											
1-2											
2-3											
3-4											
4-5											
5-6											
6-7											
TOTALS											

FARM TO TOWN	INTER-TOWN	THROUGH OR TOURIST	REMARKS

SUGGESTED TALLY SHEET FOR TAKING TRAFFIC CENSUS.

THE TALLY SHEET.

One practical consideration to be kept in mind in the make-up of the tally sheet is the fact that the enumerators will probably be patrolmen or persons of similar limited abilities, so that it is desirable that the tally sheets upon which the actual counts are to be recorded should be made as simple as possible.

The classification recommended to be shown on the tally sheets is as follows:

Horse-drawn vehicles:
- Passenger.
- Freight—
  - One-horse.
  - Two-horse.
  - —— horse.

Motor vehicles:
- Passenger—
  - Motorcycles.
  - Two-passenger.
  - Five or seven passenger.
  - Busses.
- Freight—
  - Two tons or less.
  - Two to five tons.
  - Over five tons.
  - Trailers (giving approximate weight in tons.

The tally sheets are also to show traffic classified as:
- Farm-to-town.
- Intertown.
- Through or tourist.

The tally sheet (see cut) should show the number of vehicles in each direction. For this purpose two tally sheets may be used simultaneously, one for the north or east bound traffic and the other for that bound south or west.

Each sheet is to be divided into hourly spaces 14 hours on a sheet, using additional sheets for night counts.

In addition each tally sheet should show the date of the enumeration, location of the station, weather conditions, the name of the observer, and whether the count was taken on a day of unusual traffic conditions because of some special event happening in the vicinity.

It is evidently desirable that the traffic census taken in one locality should be readily comparable with that

in another, and this will be brought about most effectively if the general purposes of a traffic census are first well understood and developed and the details of making the enumerations made as nearly uniform as practicable. Possibly the suggestions here furnished will help toward such an end.

APPENDIX.

The following summaries of traffic enumerations that have been made in the various States were compiled from information recently furnished the writer by the various State highway departments. Special mention has been made of the classification of traffic that has been used in the different States as well as the duration and frequency of the counts.

For the present purpose it was not thought necessary to give any detailed results of the various enumerations, though in some instances certain general conclusions that had been made have been mentioned.

Acknowledgment is gratefully made to the State engineers who have so generously placed at the writer's command such complete information upon a very short notice.

Alabama.—No traffic counts have been taken by the State highway department except on sections of roads that are to be taken immediately under construction, the census being used as a basis to estimate the annual tonnage to be carried by the road in question.

The report states, however, that Jefferson County, in which is located the city of Birmingham, undertook a traffic census as part of the plan made for a $5,000,000 bond issue. Traffic was observed on practically all of the roads of the county for two days each week for three consecutive months, the observers being stationed at the intersection of two or more roads.

The observers were furnished with blank forms divided into hourly periods. The traffic was classified as follows:

Large trucks.
Small trucks.
Five or seven passenger cars.
Two-passenger cars.
Two-horse wagons.
Single-horse wagons.
Buggies.
Motor cycles or bicycles.
Miscellaneous.

Trucks were noted as being loaded or empty. The average speed was also noted.

The count was made for 14 hours a day. The observers were first stationed approximately 5 miles from the city limits and each week were moved 5 miles farther out on the same road. The census was used to study the classes of traffic using the roads, to estimate the importance of various roads, and to determine the class of surfacing material best adapted for given situations.

The result of the traffic census showed that 80 per cent of the traffic of the county was carried on 20 per cent of the roads, and that 75 per cent of the traffic was motor drawn; also that 75 per cent of the traffic did not pass beyond the 15-mile zone from the center of Birmingham.

Arkansas.—Reported no traffic counts have been made.

California.—No traffic census has been undertaken by the State highway department. During 1920 traffic counts extending over a single day were made by the United States Bureau of Public Roads at stations scattered over the State highway system, but the results of this census are not yet available.

Colorado.—Traffic counts were made in 1917 and 1918 daily during August, from 6 a. m. to 8 p. m., covering many of the State highways. This work was done in cooperation with the county commissioners.

The observation stations were located close to large centers, but outside of the zone of local traffic.

The classification of vehicles on the tally sheets is as follows:

Automobiles:
- Colorado cars.
- Foreign cars.
- Motor trucks.
- Motorcycles.
- Tractors and other engines.

Horse-drawn vehicles:
- One-horse.
- Two-horse.
- Three-horse.
- Four-horse.

A column is included for live stock (horses, cattle, and sheep). The amount of traffic each hour was recorded.

A very instructive description of the results obtained in Colorado was made by Mr. J. E. Maloney, chief engineer of the State highway department, in the Colorado Highway Bulletin for October and December, 1918, and January, 1919. A map of the State highways is shown, with the total tonnage carried by each.

Connecticut.—Traffic counts extending over three days during August for the full 24-hour period were taken at the bridge over the Housatonic River between the towns of Milford and Stratford.

The enumeration was made with the aid of counting machines, the only classification being that between pleasure vehicles and trucks.

Delaware.—Soon after the organization of the State highway department in 1917 a traffic census was taken at 26 points to determine which roads at that time were carrying the greatest amount of traffic. No general traffic census has been taken since then, but counts have been made at certain points to compare with the results obtained by the original census. The traffic counts extended over a period of two months at intervals of eight days from 7 a. m. to 12 midnight.

A comparison of the traffic for 1920 with the records of 1917 shows that in 1920 there is an increase of 72 per cent in the number of vehicles and 34 per cent increase in tonnage, it being noted that the increase in the traffic coincides with the motor registration for the same period.

For purposes of classification the traffic was divided and weighted as follows:

	Tons.
Horse-drawn vehicles:	
1-horse passenger vehicles	0.350
2-horse passenger vehicles	0.500
1-horse freight vehicles	1.000
2-horse freight vehicles	2.500
3-or-more-horse freight	3.500
Automobiles:	
Motor cycles	0.225
Runabouts	1.000
Light touring cars	1.125
Heavy touring cars	2.250
Light motor trucks	2.250
Heavy motor trucks	7.500

The average weights are used to reduce traffic to a tonnage basis.

Florida.—Except in a few isolated cases no traffic counts have been made.

Georgia.—Except in a few isolated cases no traffic counts have been made.

Idaho.—Three traffic counts have been taken during 1920—one in March, one in June, and one in September, respectively. The observation stations were located on the State highways, chiefly at important intersections. No compilation of the results has been published.

The classification divides the vehicles as follows:

One-horse passenger.	Motor cycles.
One-horse freight.	Tractors.
Two-horse passenger.	Bicycles.
Two-horse freight.	Farm machinery.
—— horse passenger.	Saddle horse.
—— horse freight.	Pedestrian.
Roadster.	Loaded freight.
Touring cars.	Number of passengers.
Motor trucks.	

The traffic was also classified as:

Farm-town.	Intercounty.
Interurban.	Interstate.

Traffic counts were taken from 7 a. m. to 9 p. m. for nine consecutive days. It was expected that observers would be obliged to stop vehicles in order to get the information necessary to classify them.

Indiana.—No traffic counts have been undertaken.

Illinois.—During 1906 the State highway department began a traffic census which extended continuously over a period of two years. There were first established 37 traffic stations at different points on the main roads throughout the State, but this number was soon increased to 71. The counts were taken on an average of four days a month, no two successive counts being on the same day of the week. The record of traffic showed the total number of vehicles moving in each direction at a given point hourly from 6 a. m. to 6 p. m. The vehicles were recorded as loaded and unloaded. Horse-drawn traffic was indicated by the observer, showing the number of horses. Motor traffic, of which there was a very small amount, was indicated by the letter "A," thus giving the total number of motor vehicles.

The observations were made by people residing near the roads, usually by women. It is interesting to note that at some of the stations no automobiles were recorded during the entire two-year period.

Traffic counts have also been made during 1910–1912 at many of the stations established in 1906 and 1907. Full details regarding this traffic census are found in the reports of the Illinois highway commission for 1906, page 22, for 1907, page 23, and the report of 1910–1912, page 269.

As the majority of the stations selected are now located upon the new State highway system, much interest will attach to these older records in comparison to those that will be taken on completion of the State highways.

Iowa.—Traffic counts were made at 47 stations on Federal-aid projects in 1917, and 1918 at 87 stations, 40 of which were located on Federal-aid projects, an average of 3 stations per project. The counts were taken for a period of seven consecutive days from 7 a. m. to 9 p. m.

In 1917 the traffic was classified according to motive power, as horse-drawn and motor-driven, and was also classified according to destination, as farm, interurban, tourist, and town traffic. It is noted that 28.6 per cent of the traffic was farm traffic, 46.9 per cent interurban, 6.5 per cent tourist, and 18 per cent town traffic.

Farm traffic includes traffic between farm and town; interurban, from one town to another; tourist, traffic originating outside of the State or within the State and bound for the outside; town, as traffic originating in the town and going into the country and returning to town.

It is noted that the individual enumerators did not classify on the same basis and there resulted considerable variation in the results from the different stations.

The averages for 47 stations show that 86 per cent of the traffic was motor-driven; the average traffic per day, 339 vehicles and 996 passengers. In 1919 the traffic census at 87 stations showed an average daily traffic on the intercounty road system of 300 vehicles per day; motor traffic, 82.6 per cent; horse drawn, 17.4 per cent; farm-to-town, 47.1 per cent; interurban, 46.1 per cent; interstate, 6.7 per cent. These stations were located in 36 counties.

The 40 stations located on Federal-aid projects show a daily average of 260 vehicles; motor-driven, 78.5 per cent, and horse-drawn, 21.5 per cent.

The classification of traffic in 1918 was different from that used in 1917. In 1918 farm-to-town traffic included the two classifications, "farm" and "town," while the interurban classification was divided in 1918 into "interurban" and "intercounty." The 1918 classification "interstate" is the same as the 1917 classification "tourist."

The tally sheets classify vehicles as follows:

One-horse passenger.	Motor trucks.
One-horse freight.	Motor cycles.
Two-horse passenger.	Tractors.
Two-horse freight.	Bicycles.
——horse passenger.	Farm machinery.
——horse freight.	Saddle horse.
Roadsters.	Pedestrian.
Touring cars.	Loaded freight.

The number of passengers was also recorded.

Classification of traffic: Farm-town, interurban, intercounty, interstate.

In 1919 traffic counts were made at 107 stations, the following tabulation being a comparison of traffic for 1917, 1918, and 1919.

	1917	1918	1919
Average daily traffic	339	260	337
Motor-driven.....per cent..	86.1	78.5	90.3
Horse-drawn.....do....	13.9	21.5	9.7
Local traffic.....do....	93.5	78.1	76.6
Through traffic.....do....	6.5	21.9	23.4

The details of these traffic data are found in the State highway reports for 1917, 1918, and 1919 (1919 not yet published).

Kansas.—Except in one instance in cooperation with county officials, no traffic census has been taken.

Kentucky.—No systematic census has been undertaken. A few traffic counts have been made, but no uniform set of instructions or classifications was used.

Maryland.—A systematic traffic census has been taken at various points on the State roads system since 1912. At that time there were about 50 traffic stations; since then stations have been added as additional sections of the State highways have been completed until in 1920 there were 191 stations covering about 1,600 miles of highways. The counts have been taken once every month for one-day periods, usually from 12 to 14 hours according to the time of the year.

As soon as a new State highway section is opened, traffic counts are secured. The enumerations are taken by the patrolmen, the point of observation being selected so as to represent as nearly as possible the traffic on that particular section of the road.

The classification and weight in tons of vehicles as shown on the tally sheets is as follows:

Vehicles.	Tons.
1-horse:	
Runabouts, open and top-buggies	0.362
Open spring wagons and covered delivery wagons	1.000
2-horse:	
Family carriages and hacks	.562
Delivery wagons, vans, farm wagons, and dump wagons	2.500
Farm wagons, drays, and vans	3.500
4-horse, farm wagons and drays	3.750
6-horse, farm wagons and vans	4.250
1-horse carts	.800
Ox carts	1.000
Motorcycles	.225
2-passenger automobiles:	
Light-weight machines	.900
Medium and heavy weight machines	1.750
5-passenger automobiles, light-weight machines	1.125
5 and 7 passenger automobiles, medium and heavy weight machines	2.250
3 and 4 passenger automobiles, inclosed (like taxicabs)	2.000
Store delivery automobiles, medium and heavy weight, with tops	2.250
¾, 1, 1½, and 2 ton hauling trucks	3.200
3, 4, and 5 ton hauling trucks	7.500
Passenger auto busses, light-weight machines	1.150
Passenger auto busses, medium-weight machines	3.000
Passenger auto busses, heavy-weight machines	4.250

The traffic census for a given station for one year is transferred at the central office to cards, the results being reduced to a tonnage basis. These summary cards show the monthly tonnage for each class of vehicle and the total tonnage of all classes for the month.

Maine.—Traffic counts have been taken from 1916 to date. In 1916, 1917, and 1918 there were 18 stations at which the traffic was recorded but at present there are 44 stations located at various points on the State highway system.

The traffic counts are taken for one week, the last week in August or the first week in September, extending each day from 7 a. m. to 7 p. m.

The tally sheets show two-hour periods, and a classification as follows:

Loaded one-horse wagon.	Rubber-tired horse vehicle.
Unloaded one-horse wagon.	Saddle horse.
Loaded two-horse wagon.	Motor cycle.
Unloaded two-horse wagon.	Excessively heavy vehicle.
Loaded four-horse wagon.	Motor runabout.
Unloaded four-horse wagon.	Motor touring car.
One-horse pleasure vehicle.	Loaded motor truck.
Two-horse pleasure vehicle.	Unloaded motor truck.

A distinction was made between vehicles going in opposite directions. The counts were taken by persons with whom the State highway department had an agreement to do the work.

The average percentage of horse-drawn vehicles as noted at six stations in 1916, 1917, and 1918 is shown in the following table. The daily average of the total number of vehicles at seven stations in 1916 varied from 1,207 to 200 and in 1920 from 2,667 to 197, the average being 514 in 1916 and 797 in 1920.

	Horse-drawn vehicles.	Motor vehicles.
	Per cent.	*Per cent.*
1916	15	85
1917	12	88
1918	10	90

Massachusetts.—Four traffic counts have been made in 1909, 1912, 1915, and 1918, respectively. The counts were taken from 7 a. m. to 9 p. m. The observation stations were on the main through roads and so selected as to be away from the influence of merely local village traffic.

In 1909 the census was taken at 238 stations, in 1912 at 156 stations, in 1915 at 192 stations, and in 1918 at 57 stations. The counts were made for seven consecutive days in August and again in October. At a few important points the count was made at night, covering the entire 24 hours.

The classification of vehicles was as follows:

One-horse vehicle, light.
One-horse vehicle, heavy.
Two or more horses, heavy.
Motor truck or bus, small.
Motor truck or bus, 1 ton or more.
Automobile.

A summary of the traffic enumerations made at different times is found in the report of the Massachusetts highway commission of 1918, pages 50–57, also Appendix J.

Based upon average counts at 44 stations on main lines, the increase in motor traffic from 1909 to 1918 was 661 per cent, with a total decrease of horse-drawn vehicles of 62½ per cent and a net total gain of all vehicles of 243 per cent. It is noted that in 1909 there were practically no trucks, in 1912 there were 17, in 1915 the number was 45, and in 1918 there was an average of 75 recorded daily. In 1909 horse-drawn vehicles constituted 57 per cent of all the traffic and in 1918, 6 per cent of the traffic. During the three years 1916–19 it is noted that motor traffic had increased at the rate of 22 per cent a year.

No reduction of the results to a tonage basis is indicated.

Minnesota.—Traffic counts were made between 1912 and 1917 at 10 different points. They were taken during the summer months extending over a period of three to eight consecutive days.

The classifications made were as follows: Automobiles, trucks, wagons, buggies.

The number of State and foreign cars was also noted, together with the number of passengers per car at some of the stations. During 1918–19 traffic counts were extended to some 56 stations, the counts being made during the summer months, usually for a period of six days. The classification was the same as used in the earlier counts, except that practically all stations reported the number of passengers per car.

In 1918 at some of the stations over 30 per cent of the automobiles passing were foreign cars, averaging from 10 to 15 per cent. In 1919 the percentage of foreign cars was slightly decreased, although a number of stations reported in excess of 25 per cent. In 1919 it was noted on one of the heavy-traffic roads that motor vehicles were 80 per cent of the total; in 1919, 99 per cent. From the average of all traffic counts made, it was found that in 1918 motor vehicles were 89 per cent of the total; in 1919, 92 per cent.

The traffic census has been used to gain some idea of the volume of traffic carried by the roads and to make a comparison of the traffic on the various roads.

The report of the State highway commission of 1918 and 1919, issued March 1, 1920, contains a tabular statement of the traffic counts.

Mississippi.—Except in one or two instances to get the approximate number of vehicles on a given piece of road per day, no traffic counts have been made.

Missouri.—Except in a few isolated cases no traffic counts have been made.

Montana.—A few traffic counts have been made. The instructions state that counts are to be taken on four days from 8 a. m. to 4 p. m. and four days from 4 p. m. to 12 midnight.

Three general classifications are made: Automobiles, light and heavy; trucks, light and heavy; wagons, light and heavy.

A column is also provided to note the number of motor cycles and number of head of stock.

Nebraska.—No traffic census has been undertaken by the State highway department.

Nevada.—Three traffic counts covering a period of one week each have been made, during the latter part of October and the first part of November in 1917 and 1920. Two counts were made at two stations in 1917 and at one station in 1920 at the same point on the road south of Reno where counts were taken in 1917.

Enumerations were made from 7 a. m. to 9 p. m., the tally sheets showing the following classifications:

Horse drawn vehicles:
- One-horse, light vehicle.
- One-horse, heavy vehicle.
- Two or more horses, light vehicle.
- Two or more horses, heavy vehicle.

Automobiles:
- Runabout.
- Touring car.
- Motor truck.
- Motor cycle.

Miscellaneous.

The average daily traffic on the road south of Reno is given as follows:

	Horse-drawn.	Automobiles.	Truck.
1917	70	355	20
1920	42	647	45

New Hampshire.—A traffic census was taken during 1918 at 57 observation stations on trunk-line roads. The counts were made for seven consecutive days during June, July, August, and September.

The classification used was as follows:

Horse-drawn traffic:
- Horse without vehicle.
- One-horse vehicle, light.
- One-horse vehicle, heavy.
- Two-horse vehicle, light.
- Two-horse vehicle, heavy.
- Three-horse vehicle, heavy.
- Four-horse vehicle, heavy.

Motor traffic:
- Motorcycle—
  - New Hampshire.
  - Foreign.
- Two-passenger car—
  - New Hampshire.
  - Foreign.

Motor traffic—Continued.
- Three-passenger car—
  - New Hampshire.
  - Foreign.
- Four-passenger car—
  - New Hampshire.
  - Foreign.
- Five-passenger car—
  - New Hampshire.
  - Foreign.
- Seven-passenger car—
  - New Hampshire.
  - Foreign.
- Freight trucks, omnibusses, etc.

At most of the stations it is to be noted that the foreign cars are considerably in excess of the cars registered locally. On some of the roads the foreign cars were five times as numerous, averaging between two and three times as many.

The results of the census are shown by diagrams in the State highway report of 1917–18.

New York.—Some traffic counts were made on the State highways in 1909, 1914, and 1916. A four-day census from 8 a. m. to 8 p. m. was taken about the 1st of September in these years on practically all of the important highways of the State and instructions were

issued August 2, 1920, for a similar census extending over a 12-hour period on one Saturday and one Sunday during August.

A total increase of traffic from 1916 to 1919 of 115 per cent was recorded.

The traffic of 1919 compared with 1909 shows a twentyfold increase, although the horse-drawn traffic of 1919 was but 36 per cent of that recorded in 1909. The increase in motor traffic from 1916 to 1919 was 148 per cent, while the increase in the number of motor licenses during this same period was 77 per cent. The conclusion drawn is that each car was making a greater road mileage.

The classification used was as follows: Automobiles, New York State, other States; light delivery trucks; all other trucks; one-horse vehicles; two-horse vehicles. No reduction of results to obtain the tonnage is indicated.

Oklahoma.—No traffic counts have been undertaken except one or two days' observation on a particular stretch of road to determine whether the traffic was too heavy to justify a certain type of construction.

The classification of the traffic was made as follows: Heavy and light horse-drawn vehicles; pleasure motor vehicles and trucks. No special forms on which to record the traffic were used.

Ohio.—Except in a few isolated cases no traffic counts have been made.

Oregon.—Except in a few isolated cases no traffic counts have been made by the State highway department. In the few instances where traffic has been counted, the classification made was as follows: Automobiles licensed in the State, licensed outside of the State; trucks, divided according to capacity as nearly as could be judged; and horse-drawn vehicles.

Observation stations were at points about midway between important towns in order to eliminate local traffic. The counts made extended from 8 a. m. to 6 p. m., but the report recommends that they should be made throughout the 24 hours.

Pennsylvania.—The only report at hand is for a traffic count made by the State highway department on the Lincoln Highway, taken for a 14-day period, hourly from 7 a. m. to 7 p. m., during the autumn of 1920.

The classification used was as follows:

One-ton truck.
Two-ton truck.
Three-ton truck.
Four-ton truck.
Five-ton truck.
Touring car.
Motor cycle.
One-horse vehicle.
Two-horse vehicle.

Rhode Island.—Traffic counts were taken by the State highway department in 1907, 1908, 1913, 1915, and 1920. The earlier tally sheets used contained a much larger number of classifications than the forms used at present.

An attempt was made to have the observers record the weight of vehicles, but it was found difficult to arrive at accurate figures by this method. The tabulation shows results of counts during August of different years.

The classification now in use divides vehicles into: Automobiles, motor cycles, motor trucks, heavy wagons, light wagons.

Observations were made at 19 stations on different roads throughout the State, so selected that the results would not be influenced by purely local traffic.

The traffic census has been used as a basis for designing roads and planning expenses. The count is made from 6 a. m. to midnight. The tabulation at hand shows the census was taken on seven consecutive days, from August 1, during 1913, 1915, and 1920, but there is no indication as to the time of previous counts.

It is noted that the increase of all traffic in 1920 over that of previous years varies from 52 to 378 per cent, but at all points remarkably uniform decrease in wagon traffic is recorded, varying from 54 to 89 per cent. The average daily number of trucks has increased enormously, being as high as 1113 per cent on one road and on none is it reported as less than 156 per cent.

South Dakota.—Except in a few isolated cases no traffic counts have been made.

Tennessee.—No general traffic counts have been made but fairly accurate counts of traffic on special road projects are attempted.

Texas.—No traffic counts have been taken by the State highway department. The data that have been collected have been secured through the county engineers, the counts extending from 7 a. m. to 7 p. m.

The classification of vehicles is as follows: One-horse, loaded, unloaded; two-horse, loaded, unloaded; two-or-more-horse, loaded, unloaded; runabout; touring car; motor truck. Also the record provides for information regarding the type of road, weight of load, principle commodities hauled, approximate weight and kind of heaviest loads, and the width of tires of such vehicles.

Utah.—Except in a few isolated cases no traffic counts have been made.

Vermont.—Except in a few isolated cases no traffic counts have been made.

Washington.—The State highway department has requested the county engineers or the maintenance engineer to report the daily volume of traffic on each section of primary highways. Single day's traffic is to be counted during the period of greatest highway travel. Traffic stations are to be located at junctions making a count upon two roads at once. The counts are to extend for one day for the full 24 hours.

The classification of vehicles is as follows:

1. Motor vehicles:
   - (*a*) Motor cycles.
   - (*b*) Touring cars.
   - (*c*) Trucks (up to 2 tons).
   - (*d*) Trucks (over 2 tons); tractors, etc. (over 5 tons).
2. Horse-drawn vehicles:
   - (*a*) Carriages and light wagons.
   - (*b*) Stages and freight wagons.

N. B.—Tonnage stated refers to truck only, regardless of load.

West Virginia.—Except in a few isolated cases no traffic counts have been made.

Wisconsin.—Traffic counts have been taken at 100 stations throughout the State for the past three years (1918, 1919, 1920). The traffic record is divided between Wisconsin cars and foreign cars, trucks, motor cycles, and horse-drawn vehicles.

The counts began at 6 a. m. and continued until 11 p. m., and were made through cooperation with county organizations. The tally sheets show the hourly variations in the traffic. The observation points were selected by the State highway department near cities on the heavier-traveled roads within a county. During 1919 counts were made four times a month on different days of the week; in 1920 counts have been made twice a month.

The purpose of the census was primarily to determine the traffic that various types of roads were carrying and the cost of keeping these roads up to a certain standard.

It is noted that although one man could make the enumerations at certain stations, two men were required at others, and at a few stations four men were necessary.

Wyoming.—Except in a few isolated cases no traffic counts have been made.

FRANCE.

Under date of May 20, 1920, there was issued by the bureau of national roads of the ministry of public works, a circular of instruction regarding a traffic census to be taken on the national roads in 1920 and 1921, the enumeration to begin August 30 and to continue for a year at intervals of 13 days. The observation stations, as laid out on a chart by the chief engineer, are located in general as nearly as possible at the same points where traffic was counted in 1913. It is noted that changes may be necessary on account of new conditions, due to the establishment of factories, railroad stations, or thoroughfares since the last census.

During the summer months, April to September, traffic counts are made from 5 a. m. to 9 p. m., during the remainder of the year from 6 a. m. to 9 p. m. Traffic counts at night are to be taken as fixed by the chief engineer as frequently as he may decide to be necessary to secure a correct average for night traffic. The classification is the same as for previous counts and is generally comprised in three catagories:

1. Vehicles loaded with produce or merchandise (carts, wagons, drays, trucks, farm wagons, etc.).
2. Public conveyances for travelers, full or empty (omnibusses, diligences, mail carts).
3. Private carriages for travelers (barouches, tilbury carts, etc.), and empty wagons of all kinds except those of the second category.

Animals not pulling vehicles are classed in two categories:

1. Beasts not in harness (horses, oxen, mules, asses).
2. Small cattle (calves, sheep, hogs, goats).

Among the beasts not in harness, those mounted by riders or loaded with packs are distinguished from those not mounted or loaded.

There are besides to be separately enumerated:

1. Automobiles for carrying goods (lorries, vans, delivery cars).
2. Autobusses (automobiles doing a public service in carrying passengers).
3. Private automobiles.
4. Motorcycles.
5. Velocipedes or cycles.

No account is taken of the passage of pedestrians.

Vehicles running on rails will be the subject of a special census for which later instructions will be given.

The circular gives very minute instructions as to the pay of the observers who are cantonniers or road men and receive for this service in general one-half of their pay per day, while for night counts they receive pay for a day and a half.

Observers must pay their own expenses for light, heat, and shelter, unless the position of the observation post is remote from settlement and a special watch house has to be built. There are many other interesting details as to rates of pay in the circular which is signed by the minister of public works.

The tally sheets are divided under column headings into small squares, in each of which, according to the character of vehicles, the observer makes a pinhole. All observations are reduced to "collars," according to the following reduction table:

	Collars.
Conveyances loaded with produce or merchandise	1
Public conveyances for passengers, full or empty	1
Private conveyances and empty vehicles of all kinds except those of the second category	$\frac{1}{2}$
Animals not in harness (horses, cattle, mules, asses)	$\frac{1}{2}$
Small cattle (calves, sheep, hogs, goats)	$\frac{1}{10}$
Private automobiles	5
Velocipedes or cycles	0.05
Motor cycles	0.5
Automobiles for merchandise (lorries, vans, delivery motors)	1.2 P [1]
Autobusses (automobiles doing public service in carrying passengers)	2 P [1]

The results are prepared by the engineers to show the total weight of traffic over each road for which the loads are given, and this total divided by the length furnishes the average load for the road or tonnage per kilometer.

The instructions for reducing the observations as made on the tally sheets are minutely detailed. The average tonnage carried by various roads is shown on maps, the width of the line representing the road being proportioned to the tonnage carried; thus, main roads are shown as broad colored line, while the less traveled roads are indicated by much narrower lines.

BELGIUM.

The report on the census of traffic on the State roads in 1908 was made by the administration of bridges and

[1] P is the weight expressed in tons, established throughout the department.

roads of the ministry of public works and published at Brussels in 1920.

The object of the census was to enable the administration of bridges and roads to classify the roads into three classes, as follows:

1. Roads which by reason of their main direction, their width, and the intensity of their traffic seem to have an importance of the highest order.

2. Roads which in the above respects are of much less importance, ranking comparatively with ordinary county roads.

3. Roads intermediate between the preceding in importance.

As no traffic census had been made since 1879, it was evident a new census would have to be made.

The traffic census was also to be used to note the industrial and commercial progress of the Kingdom, and, "Above all, of the coming of the new mode of locomotion; we mean automobile traffic." The information was used as an authentic and official basis for correct apportionment of maintenance and for further improvement of different roads according to their importance.

The report states that the research justified the expense and that in general it was found that traffic had trebled since 1879.

A traffic census was taken in 1879 during a period of a little over six months, from May to November, counts being made at intervals of 10 days.

The 1908 census extended from March 10 to December 18. The traffic was counted on 24 days distributed so as to come on different days of the week and to include each day of the week. Each day's count continued for 24 hours, the observers being the road men or laborers who were under the direction of inspectors of the department. The observer, as each vehicle passed made a note of the mode of propulsion, the number of wheels, and the kind of transport, while the checker marked the number of passengers and the weight of the load. The report states that only the more intelligent cantonniers and laborers were chosen, upon whose initiative dependence could be placed.

It is noted that while maintenance cost per kilometer has risen 42 per cent it was far from being proportionate to the traffic increase, and that the " running down " of the roads and the expense of maintenance are by no means proportionate to the tonnage transported. On the average it was found that the expense of maintenance for every ton transported in 1918 was 0.014 franc per kilometer compared with 0.031 franc in 1879.

A rather significant statement was made to the effect that the census is not considered to give sufficient data to permit the division of the roads into the three classes as described. The following general remark taken directly from the report makes some important suggestions:

It seems to be opportune to call attention to the question of city traffic. Without going into the question of the necessity of a census of the traffic in the cities we will only say that the census of 1908 gives no indication concerning the internal traffic of Brussels, Ghent, Liege, and the majority of the populous centers.

This may be considered an omission, and with a view to a subsequent census the number and location of the stations adopted for 1908 might, if thought necessary, be revised with the object of reaching this urban traffic and treating it like the rural traffic.

It would be well to have the provincial service set forth * * * the time the last improvement of reconstruction of the road represented by the station * * *.

A supplemental note to this report, dated February 1, 1920, is so suggestive of conditions in Belgium that it is thought worth while to reproduce it here in full:

In the first period of the enemy occupation the employees of the administration of bridges and roads found themselves interdicted without any notice from access to the bureau in the Rue de Louvain, these having to serve as quarters for German soldiers.

The first occupants showed no respect for the records of the administration; they piled a great part of the bundles of papers that they found in the desks of the editors in the central court and burned them, and rain completed the destruction.

Among these records were the principal final documents relative to the results of the traffic census on the State roads in 1908.

Still it has been possible for us to reconstruct them, thanks to what has been preserved of Tables B and C, described in the preceding note; the reconstructed final documents are annexed to the said notes in the form of D tables, except for the Province of Namur, for which no document has been recovered. All that is left of the results for the Province of Namur is found set down in Tables I, II, III, and IV, which were prepared in 1914 and the minutes of which have been recovered.

As regards the diagrammatic maps that were discussed in the note, they have disappeared likewise.

The administration does not deem it worth while to make new ones, since they have no immediate present interest. The new conditions of road traffic are indeed very different from those of 1908; as a consequence of the war there has been an enormous extension of traffic with motor vehicles, and the results of 1908, therefore, do not correspond any more to the actual traffic.

A new census would in principle be demanded, but in our opinion it would be better to wait before proceeding to that until the situation in the interior of the country as regards transport has become normal, until the railroads and country roads have been restored to what they were, with the same intensive service as before the war, until the requisitioned horses and vehicles have been replaced, until the roads, particularly in the devastated regions, have been put back into a state of repair comparable to that of 1914, until the bridges that were destroyed have at last been erected again, until industry has regained its old importance—in short, until the whole country has been raised again from its calamities and ruins.

ENGLAND.

A traffic census has been undertaken this past year in England by the roads department of the ministry of transport. The object of this census is to classify the roads for the purpose of allocating Parliamentary grants toward construction and maintenance.

The census is taken by local highway authorities under the general instruction of the director general of roads. The number of observation points is determined according to the character of the road, but in general on rural roads it is considered sufficient if the count is taken once in every 10 miles, the census stations to be on the open roads, not in villages or at junctions or cross roads.

Approval of the location of the traffic stations together with the dates when the census is to be taken is given by the director general of roads. The forms for taking the census indicate a total period of seven days.

The classification of vehicles is made as follows:

	Tons
Ordinary cycles	0.09
Motor cars (including any motor vehicles not otherwise specified)	1.60
Motor cycles	.13
Motor vans (covered)	2.50
Motor omnibusses	6.00
Motor lorries (rubber tires)	5.00
Trailers to motor lorries	5.00
Motor lorries (steel tires)	10.00
Trailers to motor lorries	5.00
Light tractors	5.00
Trailers to light tractors	5.00
Tractor engines	12.00
Trailers to tractor engines	8.00
Light vehicles (one horse)	.40
Light vehicles (two or more horses)	.60
Heavy vehicles (one horse)	1.25
Heavy vehicles (two or more horses)	2.50
Omnibusses (two or more horses)	3.00
Tramcars	——
Horse (led or ridden)	.50
Cattle	.50
Sheep or pigs	.10
Handcarts, etc	——
Horses drawing vehicles	.50

These traffic enumerations are a part of a report submitted to the director general to permit classification of roads as: First class, to which 50 per cent of the maintenance cost is to be paid; second class, to which 25 per cent is to be paid; and third class, which receive no contribution.

DISCUSSION OF MR. JOHNSON'S PAPER.

A. W. Dean, chief engineer, Massachusetts: Mr. Johnson's paper shows that in this country traffic census is in its embryo stage, and that thus far the results obtained are really of value only locally, and I should say principally of use in cases of argument. For example, in Massachusetts a traffic census has been taken once in three years since 1908. The principal use of that traffic census has been by the commissioners in conference with parties interested in the construction of a particular road. Such a road, though it may be of great benefit to some individual, is frequently shown by the traffic census to be of little value to the traveling public as a whole. On the other hand, though no particular individual might be interested, the traffic census might show a large use of another road, and thus bring that road to the consideration of the authorities who have the power to place the funds where the funds in their opinion should be placed. As I read Mr. Johnson's paper, Maryland appeared to be the only State that really had a systematic method of taking the traffic census and a systematic tabulation converting the observations into tonnage. Such a conversion makes the census useful, not only for the determination of the amount of use of the road but it is also, to a certain extent, a determination of the magnitude of the loading the road has to carry. The truck weights recorded in the census probably influence the determination of the character of the surface and foundation that should be constructed to a greater extent than the other data recorded, and yet the weights of trucks can not be taken into account alone without taking into consideration also the other factors which affect the choice of surface.

The average vehicular weights in use in Maryland appear to be well chosen, but their proper application would appear to be dependent upon skill and intelligence in the observer. Judging by my experience, I should say it would be impossible to find an observer who could accurately segregate into the 21 different classifications provided on the record sheet all vehicles as they pass, sometimes at the rate of 20 or 30 vehicles a minute, and be sure to get his marks in the right columns. In Massachusetts we use about seven different classes, and even with this simple classification we know the observer does not always put down the count in the right column. In one or two instances trucks have been shown on roads where trucks were prohibited and the road patrolled by a traffic officer, who would stop any truck he saw. My idea is that in arranging for the traffic census we should try to simplify the work of the observer as much as possible and not expect him to do as much as this plan calls for. I do not wish to be understood as criticizing Maryland, because I think the more elaborate classification would be an excellent thing if it could be accurately done. However, I believe that the most that can be done with a reasonable degree of accuracy is to divide the traffic into about five classes, such as light horse-drawn, heavy horse-drawn, light motor vehicles, and, if desirable, have perhaps two classes of heavy motor vehicles under which you would place the small grocery delivery trucks in a class separate from the heavier vehicles, such as heavy trucks carrying stone, sand, steel, etc.

NO CENSUS OF ACTUAL LOADING.

In connection with this matter I have not seen any report of a traffic census that has been taken anywhere showing the actual loading. So far as I have been able to observe the weights recorded have always been estimated. Now, the average enumerator can not tell when he sees the truck going by whether it is a 2-ton or a 5-ton truck. Some of the 2-ton trucks look as large as the 5-ton trucks and some actually have as heavy loads as the 5-ton trucks should carry. In Massachusetts this year the commissioner of public works caused a census to be taken of the actual weights of motor vehicles using the principal through routes in the State. A loadometer was used for the purpose of weighing the machines. This loadometer, if you are not familiar with it, is a small implement that can be carried in any automobile. It operates on the same

principle as an automobile jack, and set under the axle of a truck it weighs as it lifts. Generally the weights of the rear and front axle are taken separately. There is a great value in having the two weights separated because, in many instances, the rear end of the truck is heavily overloaded by as much as 250 per cent. Trucks of a nominal capacity of three-fourths ton were found to be carrying as much as 3 tons, and 5-ton trucks carrying 9 tons were very frequent. Therefore I come back to the statement that assumed weights for the loads that are using the highways are useful but they do not indicate, even approximately, the actual weight of traffic. A chauffeur does not know what his load weighs. If the observer stops the truck and asks the chauffeur how much the truck weighs he does not know unless he is carrying by the ton; then he has a slip showing the weight.

It strikes me, therefore, that we shall come much closer to a representative record of the weight of traffic using our highways by abandoning the attempt to obtain an elaborate classification, and resorting instead to a simplified classification, which can be made by a person of average intelligence, and applying to this classification more accurate average weights determined by actual measurement. The measurements could be made with the loadometer by stationing observers at various points from time to time, without giving warning as to where they are going to be at any time.

I do not think, however, that it is possible at this time to determine definitely what type of surface should be used, basing the determination upon any traffic census. Other conditions will enter into that matter, and enter into it to a very large extent. We might determine to what classes of vehicles certain types of surface would be suitable, but we can not so closely relate the type to the traffic, that, for example, a person in Pennsylvania can tell a man in Virginia what type to use, simply from a description of the traffic.

WEIGHING LOADS FOR REAL CENSUS.

A. B. Fletcher, chief engineer, California: We, in California, have not had any traffic census until very recently, except in a few sporadic cases. Under Mr. MacDonald's direction quite an extensive census has been taken this last fall. The figures, I believe, are not yet available. We are proposing quite an extensive campaign all over the State, using the loadometer, and while I am here I hope to get some information about that device. We have attempted to calibrate two of them ourselves with the testing machine, and we have also had the State department of weights and measures to test them, and we have found them in error by as much as 400 pounds, so that at present I am a little in doubt about the wisdom of using them. There is one dream I have had for several years, which is somewhat in line with the plan Mr. Dean described. Carrying his thought a little further, I think it may be possible to devise an automatic weighing and counting device. Mr. Johnson does not agree with me. He thinks the device would be too complicated and too expensive, but I think it should be looked into more carefully, and I believe it possible in that way to obtain a real traffic census, and I see no other real solution.

REORGANIZATION OF NEW JERSEY STATE HIGHWAY DEPARTMENT.

Effective December 1, 1920, the State highway department of New Jersey has been reorganized as follows:

State highway engineer.....T. J. Wasser.

ADMINISTRATION DIVISION.

A. LEE GROVER, chief clerk, in responsible charge, including the following subdivisions.

Auditing and accounting.....M. L. Howell.
Departmental personnel and clerical.....Chas. Fishberg.
Purchasing.....R. W. Wildblood.
Filing.....Miss Grace Williamson.

CONSTRUCTION DIVISION.

C. F. BEDWELL, engineer in charge of construction, in responsible charge, including the following subdivisions.

Right-of-way engineer.....R. A. Meeker.
Bridge engineer.....C. A. Mead.
Supervisor of State labor.....C. A. Burn.
Division construction engineers.....Roy Mullins. H. D. Robbins. J. A. Williams.

MAINTENANCE, EQUIPMENT, FEDERAL, COUNTY, AND TOWNSHIP PROJECTS DIVISION.

EDWARD E. REED, assistant State highway engineer, in responsible charge, including the following subdivisions.

Maintenance of State highways and bridges.....A. W. Muir.
Superintendent of equipment.....N. C. Applegate.
Federal, county, and township projects.....A. D. Bullock.
Assistant engineer, in charge of special assignments.....H. C. Shinn.

TESTING LABORATORY.

R. B. GAGE, in responsible charge.

NEW CENSUS OF ROAD MILEAGE IN NEW MEXICO.

The State highway department of New Mexico has recently completed a census of road mileage in the counties of the State. The census shows that there are 47,677 miles of rural roads in the State at the present time, as compared with 43,091 miles in 1914, a gain of 4,586 miles in six years.

The mileage of road reported by counties is as follows:

Bernalillo	573	Quay	3,383
Chaves	1,921	Rio Arriba	2,328
Colfax	1,619	Roosevelt	2,067
Curry	2,197	Sandoval	1,299
De Baca	1,851	San Juan	1,078
Dona Ana	1,010	San Miguel	1,620
Eddy	1,181	Santa Fe	940
Grant	1,189	Sierra	634
Guadalupe	3,361	Socorro	3,682
Hidalgo	756	Taos	664
Lea	878	Torrance	1,041
Lincoln	1,046	Union	3,078
Luna	894	Valencia	2,434
McKinley	1,827		
Mora	1,732	Total	47,677
Otero	1,394		

UNIVERSITY OF MICHIGAN AWARDS FELLOWSHIPS IN HIGHWAY AND HIGHWAY TRANSPORT ENGINEERING

FIVE fellowships have been awarded to the following highway engineers and highway transport specialists by the board of regents of the University of Michigan. These men are in residence during the winter period from December to March, inclusive, and are candidates for the degree of master of science in highway engineering or highway transport. The titles of their investigations are included in the statements covering their educational and engineering training.

Roy D. Chapin fellow in highway transport: Herschel C. Smith, Oklahoma City, Okla.; A. B., 1913, University of Michigan; B. C. E., 1915, University of Michigan. Mr. Smith has been continuously engaged in highway work since 1915, having occupied the position of deputy chief engineer of the Oklahoma State highway department, and has been practicing as a consulting engineer, specializing in highway work. Investigation: Highway transport economics.

Roy D. Chapin fellow in highway engineering: Richard R. Fauver, Lorain, Ohio; A. B., 1917, Oberlin College; graduate student in highway engineering, University of Michigan, December, 1919, to March, 1920. Since 1917 engaged in highway construction work with the Ohio Engineering Co. Investigation: Economic aggregates for cement concrete pavements and structures.

Detroit Edison fellow in highway engineering: E. R. Olbrich, assistant professor of highway engineering, Oklahoma Agricultural and Mechanical College; C. E., 1915, Pennsylvania State College. From June, 1915, to November, 1920, Prof. Olbrich was engaged in highway engineering work with the bureau of highways of Philadelphia and the Barrett Manufacturing Co., and in railroad work with the Southern Railway Co. Investigation: Dust preventatives and surface preservatives for gravel roads.

Detroit Edison fellow in highway engineering: Chia T. Yeh, B. Sc. in C. E., 1916, Government Institute of Technology, Shanghai, China; M. C. E., June, 1920, Cornell University. In 1917 Mr. Yeh was appointed by the government of Kwangtung Province to make a survey of 30 miles of military road at Waichow. During 1917 he was also connected with the maintenance of way department of the Kwangtung Samshiu Railroad. In 1918 he was sent to the United States by the Chinese Government to study American practice in highway engineering and highway transport in order to make use of this knowledge in connection with the future development of transportation and highways in China. Investigation: Binding value of Michigan gravels.

National Steel Fabric Co. fellowship in highway engineering: Harold Tuttle Corson; B. S. in C. E., June, 1918, University of Michigan; 1918–19, teaching assistant in charge of sanitary experiment station; and 1919–20, graduate student in civil engineering and instructor in surveying, University of Michigan; June, 1920, to September, 1920, instructor in surveying, Camp Davis; September, 1920, to date, engineer in appraisal office, Ann Arbor. Investigation: Design of cement concrete pavements and foundations as structures.

GRADUATE SHORT COURSE.

Each graduate short period course is given in a period of two weeks and consists of 30 lecture hours in afternoon periods, while the mornings are devoted to library research work in the Davis Library of Highway Engineering and Highway Transport, which is the most complete collection of literature on these subjects in existence. In connection with some courses, the fully equipped highway engineering and automotive laboratories are used for research work. Any man over 21 years of age is admitted to these courses while men holding bachelor's degrees may become candidates for the master of science degree. A man may take one course or a group of courses depending on the duration of his leave of absence from the department or company with which he is connected. The schedule of the courses to be given during January, February, and March, 1921, follows:

January 10 to 21, 1921: C. E. 72, Earth, Sand-Clay, Gravel and Broken Stone Roads, Prof. Bateman; C. E. 81, American and English Highway Transport Methods, Prof. Blanchard.

January 24 to February 4, 1921: C. E. 68, Bituminous Surfaces and Bituminous Pavements, Prof. Blanchard. C. E. 74, Bituminous materials, Prof. Bateman. C. E. 80, Interrelationship of Highway, Railway, and Waterway Transport, Prof. Riggs.

February 7 to 18, 1821: M. E. 40, Mechanism, Operation, and Maintenance of Motor Trucks, Tractors, and Trailers, Prof. Lay. C. E. 69, Highway Laboratory Research, Prof. Bateman. C. E. 70, Highway Structures, Prof. Gram. C. E. 79, American and English Highway Traffic Legislation and Regulations, Prof. Blanchard.

February 21 to 25, 1921: Seventh Annual Michigan Conference on Highway Engineering and Highway Transport.

February 28 to March 11, 1921: C. E. 73, Brick, Cement-Concrete, Stone Block and Wood Block Pavements, Prof. Bateman. C. E. 75, Highway Engineering Seminar, Prof. Blanchard. C. E. 82, Highway Transport Management, Costs and Record Systems, Prof. Blanchard.

March 14 to 25, 1921: C. E. 77, Highway Engineering Financing, Administration, and Organizations, Prof. Blanchard; C. E. 83, Highway Transport Seminar, Prof. Blanchard.

In addition to the members of the faculty of the University of Michigan, between 10 and 15 nonresident lecturers, experts in highway transport, will deliver lectures in the several courses.

The men who registered during December include engineers, contractors, and highway transport specialists, varying in age from 24 to 25 years and coming from the States of Washington, Texas, Oklahoma, Mississippi, Wisconsin, Michigan, Ohio, West Virginia, Pennsylvania, New York, New Jersey, and the Provinces of Quebec and Saskatchewan, and two engineers sent by the Chinese Government to specialize in highway transport.

FEDERAL-AID ALLOWANCES.

PROJECT STATEMENTS APPROVED IN NOVEMBER, 1920.

State.	Project No.	County.	Length in miles.	Type of construction.	Project statement approved.	Estimated cost.	Federal aid.
Alabama	91	Coffee	26.200	Sand-clay	Nov. 4	$242,106.70	$121,053.35
	93	Monroe	20.602	Gravel	Nov. 29	155,415.70	77,707.85
Arizona	20	Navajo	0.946	Bituminous	Nov. 16	62,773.20	22,003.53
	35	Conconino	3.000	Earth	Nov. 4	29,491.00	14,745.50
	37	do	2.000	Gravel	Nov. 20	29,942.00	14,971.00
	38	Chochise	26.400	do	Nov. 9	157,140.50	78,570.25
	39	Mohave	23.000	Earth	Nov. 27	175,862.90	87,931.45
Arkansas	98	Woodruff	5.450	Gravel	Nov. 20	106,211.05	20,800.00
	99	Howard	8.470	do	Nov. 29	57,345.64	26,000.00
	110	Chicot	2.000	Concrete	Nov. 20	37,041.98	4,200.00
	122	Sevier	8.200	Gravel	Nov. 29	27,321.25	12,700.00
California	62	Sutter	5.950	Concrete	Nov. 1	189,541.00	94,770.50
	63	Kings	12.400	do	do	505,780.00	252,890.00
Connecticut	6	Litchfield	9.440	Bituminous surface	Nov. 13	419,100.00	188,800.00
Florida	26	Columbia	10.606	Macadam	Nov. 5	451,187.11	212,120.00
Georgia	188	Randolph	5.000	Sand-clay	Nov. 1	34,686.74	15,000.00
	199	Quitman	5.000	do	do	35,698.42	17,849.21
	196	Early	6.000	Top soil	Nov. 4	35,943.60	17,971.80
	200	Webster		Bridge	Nov. 1	9,622.27	4,811.13
	202	Wilcox	1.130	Gravel	Nov. 4	22,282.37	11,000.00
	204	Lowndes and Echols	5.650	Top soil	Nov. 29	33,301.01	16,650.50
Illinois	40	DeKalb, Gwinnett	[1] 6.446	Concrete	Nov. 24	[1] 169,560.88	[1] 47,500.00
	18	Sangamon, Macon, Pratt and Champaign.	8.650	Earth	Nov. 4	317,604.10	79,401.02
	19	Stephenson	2.650	do	do	95,071.90	23,767.97
	20	Henry and Bureau	20.000	do	do	312,028.02	78,007.00
	21	Warren	.920	do	do	55,394.20	13,848.55
	22	Kankakee	.320	do	do	7,516.34	1,879.08
	23	Effingham, Clay and Wayne	16.680	do	do	774,899.97	193,724.99
Kansas	57	Marshall	[1] 30.500	Concrete	Nov. 18	[1] 1,472,927.50	[1] 147,500.00
Kentucky	45	Breathitt	2.800	Earth	Nov. 1	76,780.00	38,390.00
	46	Hancock	22.200	do	Nov. 5	359,480.00	179,740.00
Louisiana	67	Tendas	4.320	Sand-clay and gravel	Nov. 1	74,806.29	37,403.14
	76	St. Tammany	39.890	do	do	453,896.26	226,948.13
	85	Claiborne	35.010	Gravel	Nov. 4	550,629.75	200,000.00
	83	Caldwell	14.900	do	Nov. 27	195,749.84	88,000.00
Maryland	40	Baltimore	2.500	Asphalt	Nov. 1	101,730.97	50,000.00
	42	Anne Arundel	2.140	Concrete	Nov. 20	84,727.50	42,363.75
Michigan	39	Clinton	7.250	Concrete or bituminous	Nov. 1	323,785.00	145,000.00
Mississippi	67	Alcorn	8.080	Gravel	Nov. 6	165,429.00	80,000.00
	94	De Soto	11.900	do	Nov. 4	104,508.80	52,254.40
	108	Holmes	5.000	do	Nov. 1	67,688.79	25,000.00
Missouri	171	Clark	8.810	do	Nov. 29	81,260.96	40,630.48
	174	Bollinger	22.000	do	Nov. 13	154,455.40	77,227.70
Montana	108	Musselshell	[2] 5.300	Earth	Nov. 4	[2] 57,549.80	[2] 28,774.90
	124	do	7.150	do	Nov. 1	33,339.40	16,669.70
	147	Glacier		Bridge	Nov. 23	23,584.00	11,792.00
	149	Cascade	1.500	Gravel	Nov. 18	27,830.00	13,915.00
Nebraska	158	Holt	19.000	Gravel and earth	Nov. 29	92,950.00	46,475.00
	169	Adams		Bridge	Nov. 20	10,846.00	5,423.00
Nevada	37	Clark	13.310	Earth	Nov. 12	80,589.74	40,294.87
New Mexico	57	Chaves	12.750	do	Nov. 4	89,100.00	44,550.00
	58	Union	55.700	do	Nov. 9	119,627.20	59,813.60
	59	do	54.000	do	do	131,841.60	65,920.80
	61	Bernalillo	5.500	Concrete	Nov. 4	162,002.50	81,001.25
	62	Dona Anna	4.300	do	Nov. 16	118,635.00	59,317.50
	64	Luna	12.100	Crushed stone	Nov. 29	92,035.13	46,017.56
	53	Torrance	36.000	Earth	Nov. 5	92,763.00	6,381.50
New York	72	Nassau	1.370	Concrete	Nov. 16	68,500.00	23,975.00
	86	Greene	3.600	do	Nov. 5	205,200.00	71,820.00
	87	Westchester	6.500	do	Nov. 4	370,500.00	129,675.00
	88	Chenango and Cortland	2.300	do	Nov. 20	92,000.00	46,000.00
	89	do	7.700	do	do	438,900.00	153,615.00
	90	Herkimer	8.500	Macadam	Nov. 24	340,000.00	170,000.00
	92	Oswego	2.400	do	Nov. 30	120,000.00	42,000.00
	94	Wayne and Seneca	4.200	Concrete	do	168,000.00	84,000.00
	97	Ontario	.900	do	do	51,300.00	17,955.00
	99	Wyoming	6.200	Bitumin or concrete	do	353,400.00	123,690.00
North Carolina	32	Edgecombe	[1] 3.100	Sand-clay and gravel	Nov. 10	[1] 14,080.70	[1] 7,000.00
	106	Alamance	[1] 18.000	Bituminous macadam	Nov. 3	[1] 230,639.64	[1] 115,319.82
	113	Caswell	[1] 17.600	Top soil	do	[1] 136,433.00	[1] 68,216.50
Oregon	47	Jackson	14,350	Gravel	Nov. 12	593,521.50	222,570.56
Rhode Island	12	Washington	6.640	Concrete	Nov. 20	287,485.44	87,676.67
South Carolina	38	Oconee	[3] 11.197	Top soil	do	[3] 143,948.16	[3] 28,125.18
	88	Anderson	6.777	do	Nov. 23	48,548.50	20,000.00
	102	Dorchester	12.917	Sand-clay	Nov. 30	144,098.32	45,448.62
	103	York	3.824	Top soil	Nov. 4	33,798.52	13,000.00
Tennessee	41	Knox	15.608	Macadam, concrete, or rock asphalt	Nov. 5	524,190.72	262,095.36
Texas	210	Val Verde	4.540	Gravel	Nov. 1	35,000.00	17,500.00
	213	do	11.590	do	Nov. 5	85,000.00	42,500.00
	216	Hemphill		Bridge	Nov. 1	9,958.01	4,979.00
	217	Bexer	5.100	Gravel surface treated	Nov. 4	61,198.54	26,502.24
	218	San Augustine	20.900	Gravel	Nov. 12	296,539.79	100,000.00
	220	Morris	2.694	do	do	41,476.00	15,000.00
	221	Colorado	4.570	do	do	50,001.49	25,000.00
	223	McCullock	1.500	do	Nov. 30	10,015.50	5,007.75
	71	Grayson	[1] 1.770	do	Nov. 6	[1] 14,326.95	[1] 7,163.48
Utah	26	Bearer	9.560	do	Nov. 12	125,449.50	62,724.75
Virginia	84	Campbell	5.000	Macadam	Nov. 24	162,405.10	81,202.55
	86	Pittsylvania	3.945	do	Nov. 1	93,060.00	46,530.00
West Virginia	106	Jackson	0.738	Concrete	Nov. 27	23,020.00	11,510.0
	107	Morgan	5.000	Earth	do	44,309.50	22,154.75
	108	Braxton	5.000	Earth and bridge	do	69,760.00	34,880.00
	109	Doddridge	1.000	Concrete	do	38,240.00	18,240.00
Wyoming	64	Carbon	[1] 7.424	Crushed rock	Nov. 26	[1] 73,040.00	[1] 36,520.00
	104	Niobrara		Bridge	Nov. 24	41,360.00	20,680.00
	107	Converse		do	Nov. 12	33,660.00	16,830.00

[1] Canceled.
[2] Revised statements. Amounts given are increases over those in the original statement.
[3] Revised statements. Amounts given are decreases from those in the original statement.

PROJECT AGREEMENTS EXECUTED IN NOVEMBER, 1920.

State.	Project No.	County.	Length in miles.	Type of construction.	Project agreement signed.	Estimated cost.	Federal aid.
Alabama	79	Dallas	3.144	Gravel	Nov. 15	$53,622.85	$26,811.42
	42	Talladega		Earth	do	[1] 29,064.53	[1] 14,532.27
Arizona	28	Pinal	7.522	do	Nov. 16	188,899.84	90,000.00
	33	Maricopa	7.060	Concrete	do	249,998.88	124,999.43
Arkansas	92	Grant	4.760	Gravel	Nov. 10	30,553.82	14,400.00
Colorado	7B	Montrose	4.027	Earth	Nov. 1	49,525.02	24,762.51
	123	Eagle and Garfield	6.941	do	Nov. 10	99,548.57	49,774.28
Georgia	4	Oconee and Walton		Top soil	Nov. 23	[2] 12,127.95	[2] 6,063.98
	23	Candler		Sand-clay	Nov. 24	[2] 5,413.22	[2] 2,706.61
	40	Gwinnett	[3] 6.520	Concrete	do	[3] 179,790.98	[3] 47,500.00
	51	Colquitt	1.360	Asphalt	Nov. 23	47,038.66	23,519.33
	69	Franklin	3.845	Top soil	do	17,532.50	8,000.00
	93	Taylor and Upton	2.881	do	Nov. 20	103,551.69	49,194.62
	95A	Mitchell	9.970	Sand-clay	Nov. 23	145,633.20	68,476.60
	106	Sumter	2.000	Concrete, bituminous macadam	do	[1] 88,305.56	[1] 64,500.00
	115	Chattooga		Top soil	Nov. 20	28,700.87	14,350.43
	120	Carroll	8.546	do	do	92,319.81	39,420.53
	128	Barrow	6.842	Sand-clay	Nov. 23	57,683.72	28,841.86
	130	Baldwin-Putnam		do	Nov. 20	48,653.80	24,326.90
	133	Troup		Bridge	Nov. 24	158,210.25	50,000.00
	138	Warren	8.840	Sand-clay	Nov. 20	75,943.69	25,000.00
	140	Hancock	10.535	do	Nov. 23	48,660.20	22,000.00
	141	Richmond	12.680	do	do	52,692.01	24,000.00
	142A	Thomas		Bridge	Nov. 20	40,672.87	16,202.50
	145	Montgomery	12.370	Sand-clay	Nov. 23	79,049.79	31,619.91
	151	Floyd	7.300	Top soil	Nov. 24	76,369.72	38,184.86
	155	Elbert	8.105	do	Nov. 23	50,069.85	25,034.92
	156	Mitchell		Earth	Nov. 20	39,276.90	15,578.45
	160	Houston		Bridge	do	41,950.55	20,975.27
	161	Richmond	2.710	Sand-clay	do	79,280.26	35,516.00
	166	Dougherty	2.500	Bituminous concrete	do	87,471.26	15,900.00
	167	Fulton	2.470	Concrete	do	80,868.97	37,500.00
	168	Jefferson	8.660	Sand-clay	Nov. 23	34,672.07	17,000.00
	170	McDuffie	4.554	do	do	21,975.22	9,000.00
	172	Baldwin	.071	Bridge	do	42,363.62	12,000.00
	173	Schley	2.348	Sand-clay	Nov. 24	25,122.06	10,000.00
	175	Wilkinson	2.980	do	Nov. 23	23,578.03	10,000.00
	176	Lincoln	4.877	do	Nov. 20	31,251.02	12,000.00
Idaho	15	Bannock	8.175	Crushed rock	Nov. 8	112,392.50	56,196.25
	29	Kootenai	11.820	Gravel	Nov. 6	197,990.11	98,995.05
	34	Oneida	6.250	do	Nov. 16	49,997.62	24,998.60
	35	Caribou	3.876	Earth and gravel	Nov. 8	47,967.56	23,967.90
	36	Franklin	17.415	Gravel	Nov. 16	159,999.70	79,999.85
	38	Butte	15.398	Earth and gravel	Nov. 8	90,000.00	30,000.00
	39	Lewis	4.260	Crushed rock	Nov. 6	75,051.73	20,000.00
Illinois	2L	Iroquois	.999	Concrete	Nov. 19	39,757.07	19,878.53
	2–4	Will, Kankakee, Iroquois, Lake	.473	do	do	[1] 72,670.16	[1] 36,335.08
	7B to T	Marshall, Putnam, La Salle, Grundy Bureau	.065	do	do	[1] 20,712.85	[1] 9,057.89
	12A, B, C, D, E, F.	Egdar Creek	28.863	Concrete and brick	Nov. 15	1,270,045.74	602,749.40
	14–24 to 33, inc.	Fayette, Marion, Washington	10.546	Earth	Nov. 19	399,249.47	99,812.33
Iowa	15	Mills	13.100	do	Nov. 20	125,931.96	17,455.35
	51A	Guthrie	12.498	do	do	117,820.45	50,000.00
	55A, B	Scott	15.620	do	do	82,911.07	30,000.00
	58	Benton	17.890	Earth and concrete	do	505,256.01	190,400.00
	60	Van Buren	10.790	Earth	do	82,566.11	27,000.00
	63A, C, D.	Lucas	11.710	do	do	125,799.13	60,000.00
	65B	Boone	10.570	Gravel	do	78,589.94	30,000.00
	67	Hamilton	20.730	Earth	do	72,113.30	35,200.00
	80	Ida	18.990	do	do	110,848.21	26,500.00
	99	Carroll	8.960	do	do	83,175.34	41,400.00
	105	Franklin	9.840	Gravel	do	75,445.37	34,000.00
	110	Lyon	22.810	Earth	do	82,976.63	34,900.00
	116	Cherokee	14.030	do	do	60,861.24	21,900.00
Kansas	32A, B	Dickinson	4.543	Brick or concrete	Nov. 15	304,279.49	68,145.00
Maine	6	Aroostook	5.870	Gravel	Nov. 4	93,950.45	46,975.22
	26	Cumberland		Bituminous macadam	do	[1] 25,048.67	[1] 12,524.34
	25	Aroostook	6.120	Gravel	do	131,898.74	65,949.37
	27	Cumberland	8.640	Bituminous macadam	do	247,349.50	123,674.75
	34	Oxford	4.570	Concrete	do	234,716.59	91,400.00
Mississippi	36	Walthall		Clay, gravel	Nov. 6	[1] 45,759.29	[1] 23,756.89
Missouri	20A	Cass	19.024	Earth	Nov. 22	140,775.88	70,387.94
	33	Polk	13.864	Gravel	Nov. 9	90,496.35	45,248.17
	35	Pemiscot	5.930	do	do	104,089.00	52,044.50
	40	New Madrid	19.810	do	do	279,900.12	139,950.00
	45	Hickory	7.400	do	do	46,211.15	23,105.57
	46	do	4.490	do	do	28,703.08	14,351.54
	52	Cape Girardeau		Concrete	do	[1] 5,549.09	[1] 2,774.55
	53	Lawrence		Gravel	do	[1] 23,347.69	[1] 11,673.85
	63	Ralls	3.350	do	do	17,207.96	8,603.98
	64A	do	4.110	do	do	25,223.40	12,611.70
	65A	do	4.580	do	do	23,566.26	11,783.13
	72	Hickory	[1] 8.100	do	do	56,136.39	28,068.19
	49	Buchanan	20.020	Concrete or bituminous concrete	do	1,107,276.90	418,107.69
	66A	Ralls	5.380	Gravel	do	52,674.03	26,337.01
	95	Howard	1.000	do	do	11,797.45	5,898.72
	122	Pettis	4.760	Bituminous macadam	do	62,996.64	31,498.32
	123	Andrew	.517	do	do	11,601.21	5,800.60
	132	Henry	5.950	Gravel	do	59,720.04	29,860.02
Montana	3	Vernon		Flint screenings	Nov. 3	[1] 8,613.76	[1] 4,306.88
	7A	Mississippi		Gravel	Nov. 16	[1] 3,001.92	[1] 1,500.96
	13	Buchanan		Asphalt concrete	Nov. 8	[1] 13,166.51	[1] 6,583.25
	23	Pettis		Bituminous macadam	Nov. 10	[1] 3,483.53	[1] 1,741.76
	27	Fergus	10.890	Earth	Nov. 12	70,195.36	35,097.68
	60A	Park	5.500	Gravel	Nov. 10	50,020.76	25,010.38
	62	Toole	27.480	do	do	155,311.73	77,655.86
	84B, D, G, J.	Roosevelt	21.474	do	do	169,415.85	84,707.91
	91	Musselshell	1.369	Bitumin on concrete	do	67,102.06	27,380.00
	94	Meagher	14.070	Earth	Nov. 16	96,514.77	48,257.38
	102	Flathead	2.420	Gravel	Nov. 10	21,292.02	10,646.01
	103A, B	Fergus	15.407	Concrete, earth, and gravel	Nov. 10	199,963.08	93,566.85
	107	Carbon	9.080	Gravel	do	88,951.98	44,475.99
	108B	Musselshell	6.527	Earth	Nov. 26	57,346.45	28,673.22
	114	Rosebud	10.910	Gravel	Nov. 3	68,502.77	34,251.38
	64	Ralls		do	Nov. 16	[1] 9,490.80	[1] 2,847.25

[1] Modified agreements. Amounts given are increases over those in the original agreement. [2] Modified agreements. Second revision. Increase. [3] Canceled.

PROJECT AGREEMENTS EXECUTED IN NOVEMBER, 1920—Continued.

State.	Project No.	County.	Length in miles.	Type of construction.	Project agreement signed.	Estimated cost.	Federal aid.
Nebraska	2	Richardson, Nemaha, Otoe		Gravel and earth	Nov. 3	[1] $66,643.66	[1] $33,321.83
	4	Cedar, Wayne		Earth	Nov. 5	[2] 15,183.03	[2] 7,591.52
	18	Gage, Lancaster		do	do	[1] 9,391.21	[1] 4,695.61
	14	Holt	19.922	do	do	123,201.85	61,600.92
	23	Burt, Washington		do	Nov. 3	[1] 14,831.06	[1] 7,415.53
	27	Saunders, Dodge		do	do	[2] 56,194.79	[2] 28,095.50
	33	Knox		do	Nov. 5	[2] 9,602.90	[2] 4,801.45
	49B	Burt	4.015	do	Nov. 3	26,174.19	13,087.09
	57A	Dixon	3.928	do	do	30,633.98	15,316.99
	78	Douglas		do	Nov. 5	[2] 7,538.34	[2] 3,769.17
	98A	Lancaster	11.960	do	do	75,802.25	37,901.12
	100	Douglas		do	do	[2] 6,393.70	[2] 3,196.85
	138	Sarpey	8.460	do	do	58,331.46	29,165.73
	151	Lancaster	.596	Brick	do	42,289.97	10,977.34
Nevada	3	Churchill		Sand-clay	Nov. 3	[1] 23,640.94	[1] 11,820.47
	9	Washoe		Concrete	Nov. 15	[2] 33,637.53	[2] 16,818.75
	12	Lyon	2.270	Earth and gravel	Nov. 25	25,609.28	12,804.64
	14	Douglas		Gravel	Nov. 3	[1] 3,445.20	[1] 1,722.60
	22	Eureka	6.280	do	do	108,823.99	54,411.99
	28	Douglas	1.800	Concrete	do	79,753.74	36,000.00
New Jersey	22	Mercer	.928	do	Nov. 5	75,120.04	18,560.00
	24	Cape May	5.180	do	do	245,199.54	103,600.00
New Mexico	18	Eddy	32.411	Local material	Nov. 10	86,898.29	43,449.14
New York	24	Herkimer		Concrete, bituminous macadam	Nov. 16	[2] 15,530.00	[2] 1,375.00
	27	Cattarangus	7.060	Reinforced concrete	Nov. 27	282,400.00	141,200.00
	28	Wyoming	8.080	do	Nov. 6	323,200.00	161,600.00
	30	Cattaraugus	[7] .410	Concrete	Nov. 24	[1] 107,561.45	[1] 11,930.72
	52	Dutchess	3.490	Reinforced concrete	Nov. 15	166,100.00	58,135.00
	56	do	4.890	do	Nov. 18	279,200.00	97,720.00
	64	Suffolk	9.070	do	Nov. 16	362,200.00	174,050.00
	68	Otsego	2.820	do	do	147,000.00	51,450.00
North Carolina	12	Wayne		Sand-clay, gravel	Nov. 11	[6] 18,335.95	
	27A	Orange	[7] 9.727	Top soil	Nov. 10	[1] 19,813.66	[1] 14,972.86
	34	Wayne		Bridge	Nov. 11	[1] 10,815.27	[1] 15,399.00
	39	Union		Bituminous macadam and top soil	do		[6] 12,421.25
	49	Lenoir		Concrete	Nov. 10	[1] 7,159.77	[8] 36,356.21
	50	Guilford		Bituminous concrete	Nov. 16	[2] 23,922.14	[2] 11,961.07
	53	Lenoir		Concrete	Nov. 10	[8] 7,950.92	[8] 32,394.56
	60	do		do	do	[8] 25,280.10	[1] 68,750.77
	38B	Caswell	6.680	Top soil	do	50,907.23	25,453.61
	58	Johnston	6.018	do	do	67,927.25	33,963.62
	75	Columbus	7.031	do	do	66,605.38	33,302.69
	98A	Moore	20.534	do	do	162,943.88	81,471.94
	94A	Mitchell		Gravel	Nov. 11	[1] 28,627.06	[1] 14,313.53
	103	Duplin	11.322	Top soil	Nov. 10	85,550.68	42,775.34
	105	Hoke	9.808	do	do	54,571.55	27,285.77
	111	Forsyth		do	Nov. 11	[1] 29,168.65	[1] 14,584.33
	114	Rowan	.438	Bituminous or concrete	do	[8] 23,706.15	[8] 9,066.49
	116	Stanly and Montgomery		Bridge	Nov. 10	199,218.80	99,609.40
	32	Edgecomb	3.100	Sand-clay, gravel	do	[2] 14,088.65	[3] 7,000.00
North Dakota	6	Eddy		Grading, part gravel	Nov. 9	[2] 11,030.34	[2] 5,515.17
	8	do		Grading and gravel	Nov. 12	[2] 36,873.80	[2] 18,436.90
	22	Towner		Grading	Nov. 9	[1] 6,829.41	[1] 3,414.71
	25	Ward	.277	Gravel	do	[2] 3,601.08	[2] 1,800.54
	28B	Ransom	9.108	Earth	do	58,237.00	29,118.50
	33	McIntosh	18.069	do	do	78,376.61	39,188.30
	38	Hettinger		do	do	[1] 4,174.96	[1] 2,087.48
	43	Bottineau		Gravel	do	[1] 8,990.07	[1] 4,495.03
	45	Foster		Earth	do	[1] 16,021.89	[1] 8,010.94
	46	Traill		do	do	[1] 24,087.32	[1] 12,043.66
	48A	Pierce		Earth	Nov. 30	25,319.89	12,659.94
	51	Grand Forks	1.005	Reinforced concrete	Nov. 9	61,198.00	20,100.00
	65	Stark		Gravel	do	8,658.38	4,329.19
	107	Grand Forks	6.020	do	do	38,541.52	19,270.76
	70	Nelson	5.266	Earth	Nov. 30	29,579.23	14,789.61
	58	Sargent	18.950	do	do	103,613.99	51,806.99
Oklahoma	13	Pushmataha		Steel truss bridge	Nov. 22	[1] 4,342.56	[1] 2,171.28
	16	Hughes		Bridge	do	[1] 5,544.15	[1] 2,772.07
Pennsylvania	86	Potter	.953	Reinforced concrete	Nov. 16	54,526.78	19,060.00
	87	do	1.495	do	do	114,175.50	29,900.00
	89	do	4.103	do	do	244,995.82	82,060.00
	90	Greene	2.611	do	do	175,988.83	52,220.00
	93	Butler	4.939	Sheet asphalt	do	356,535.53	98,780.00
	96	Cambria	4.627	Reinforced concrete and brick	do	393,045.77	92,540.00
South Carolina	55	Greenwood	9.868	Concrete and sand-clay	Nov. 27	134,098.87	57,711.59
Utah	34	Utah		Reinforced concrete	Nov. 11	[1] 7,230.03	[1] 3,615.01
Virginia	47B	Hanover	5.076	Top soil	Nov. 1	20,748.92	10,374.46
	47D	Louisa	7.900	do	do	50,203.07	25,101.53
	47AC	Hanover and Louisa	5.345	do	Nov. 5	29,805.16	14,902.58
Wisconsin	22	Polk		Grading and draining	Nov. 13	[1] 8,929.45	[1] 8,351.18
	46	Waushara		Grading and draining, part sand-clay	do	[1] 12,095.10	[1] 6,282.97
	49	Waupaca	[7] 1.960	Gravel, macadam	do	86,379.30	[8] 662.03
	59	Jefferson		do	do	[1] 55,511.62	[1] 19,283.79
	70	Waupaca	5.450	Concrete	do	205,861.86	69,000.00
	86	Lafayette	[7] 2.175	Earth	do	[8] 7,414.07	[8] 1,587.48
	108	Juneau		do	do	[1] 15,159.68	[1] 5,008.65
	114	Oconto	4.580	Gravel	do	45,975.44	15,000.00
	116	Winnebago	6.270	Concrete	do	206,923.10	70,500.00
	117	Shawano	5.020	Gravel	do	68,572.60	22,857.53
	120	Trempealeau	7.190	do	do	135,992.13	47,996.07
	122A	Pierce	7.600	do	Nov. 24	77,301.43	23,650.71
	130	Price	5.500	Earth	Nov. 13	54,544.03	19,272.02
	131	Adams	4.498	Top soil	Nov. 24	45,671.81	15,335.90
	132	Marquette	5.995	Gravel	Nov. 13	51,790.22	18,250.00
	144	Chippewa	3.580	Earth	Nov. 24	41,474.29	20,000.00
	145	Clark	3.700	Disintegrated granite	Nov. 13	33,139.29	12,000.00
	147	do	5.587	Gravel and disintegrated granite	do	49,782.05	18,891.03
	148	Waushara	4.380	Gravel	do	46,383.78	15,691.90
	154	Fond du Lac	3.590	Concrete	do	123,562.65	42,781.33
	163	Kewaunee	2.970	Gravel	do	43,450.07	16,225.04
	167	Lincoln	5.520	do	do	49,804.84	17,302.42
	172	Richland	3.500	Earth	do	49,395.43	18,000.00
	179	Waukesha	5.860	Concrete	do	290,932.38	91,716.19

[1] Modified agreements. Amounts given are increases over those in the original agreement.
[2] Modified agreements. Second revision. Increase.
[3] Canceled.
[4] Modified agreements. Third revision. Decrease.
[5] Modified agreements. Third revision. Increase.
[6] Modified agreements. Second revision. Decrease.
[7] Decrease in mileage.
[8] Modified agreements. First revision. Decrease.

ROAD PUBLICATIONS OF BUREAU OF PUBLIC ROADS.

Applicants are urgently requested to ask only for those publications in which they are particularly interested. The Department can not undertake to supply complete sets, nor to send free more than one copy of any publication to any one person. The editions of some of the publications are necessarily limited, and when the Department's free supply is exhausted and no funds are available for procuring additional copies, applicants are referred to the Superintendent of Documents, Government Printing Office, this city, who has them for sale at a nominal price, under the law of January 12, 1895. Those publications in this list, the Department supply of which is exhausted, can only be secured by purchase from the Superintendent of Documents, who is not authorized to furnish publications free.

REPORTS.

Report of the Director of the Bureau of Public Roads for 1918.
Report of the Chief of the Bureau of Public Roads for 1919.

DEPARTMENT BULLETINS.

Dept. Bul. *105. Progress Report of Experiments in Dust Prevention and Road Preservation, 1913. 5c.
*136. Highway Bonds. 25c.
220. Road Models.
230. Oil Mixed Portland Cement Concrete.
*249. Portland Cement Concrete Pavements for Country Roads. 15c.
257. Progress Report of Experiments in Dust Prevention and Road Preservation, 1914.
314. Methods for the Examination of Bituminous Road Materials.
347. Methods for the Determination of the Physical Properties of Road-Building Rock.
*348. Relation of Mineral Composition and Rock Structure to the Physical Properties of Road Materials. 10c.
*370. The Results of Physical Tests of Road-Building Rock. 15c.
*373. Brick Roads. 15c.
386. Public Road Mileage and Revenues in the Middle Atlantic States, 1914.
387. Public Road Mileage and Revenues in the Southern States, 1914.
388. Public Road Mileage and Revenues in the New England States, 1914.
*389. Public Road Mileage and Revenues in the Central, Mountain, and Pacific States, 1914. 15c.
390. Public Road Mileage in the United States, 1914. A Summary.
*393. Economic Surveys of County Highway Improvement. 15c.
407. Progress Reports of Experiments in Dust Prevention and Road Preservation, 1915.
414. Convict Labor for Road Work.
*463. Earth, Sand-Clay, and Gravel Roads. 15c.
532. The Expansion and Contraction of Concrete and Concrete Roads.
*537. The Results of Physical Tests of Road-Building Rock in 1916, including all Compression Tests. 5c.
555. Standard Forms for Specifications, Tests, Reports, and Methods of Sampling for Road Materials.
583. Reports on Experimental Convict Road Camp, Fulton County, Ga.
586. Progress Reports of Experiments in Dust Prevention and Road Preservation, 1916.
660. Highway Cost Keeping.
670. The Results of Physical Tests of Road-Building Rock in 1916 and 1917.
*691. Typical Specifications for Bituminous Road Materials. 15c.
704. Typical Specifications for Nonbituminous Road Materials.
724. Drainage Methods and Foundations for County Roads.
*Public Roads, Vol. I, No. 11. Tests of Road-Building Rock in 1918. 15c.
*Public Roads, Vol. II, No. 23. Tests of Road-Building Rock in 1919. 15c.

DEPARTMENT CIRCULAR.

No. 94. TNT as a Blasting Explosive.

FARMERS' BULLETINS.

F. B. 338. Macadam Roads
505. Benefits of Improved Roads.
597. The Road Drag.

* Department supply exhausted.

SEPARATE REPRINTS FROM THE YEARBOOK.

B. Y. Sept. 727. Design of Public Roads.
B. Y. Sept. 739. Federal Aid to Highways, 1917.

OFFICE OF PUBLIC ROADS BULLETINS.

Bul. *45. Data for Use in Designing Culverts and Short-span Bridges. (1913.) 15c.

OFFICE OF PUBLIC ROADS CIRCULARS.

Cir. *89. Progress Report of Experiments with Dust Preventatives, 1907. 5c.
*90. Progress Report of Experiments in Dust Prevention, Road Preservation, and Road Construction, 1908. 5c.
*92. Progress Report of Experiments in Dust Prevention and Road Preservation, 1909. 5c.
*94. Progress Reports of Experiments in Dust Prevention and Road Preservation, 1910. 5c.
*99. Progress Reports of Experiments in Dust Prevention and Road Preservation, 1912. 5c.
*100. Typical Specifications for Fabrication and Erection of Steel Highway Bridges. (1913.) 5c.

OFFICE OF THE SECRETARY CIRCULARS.

Sec. Cir. 49. Motor Vehicle Registrations and Revenues, 1914.
*52. State Highway Mileage and Expenditures to January 1, 1915. 5c.
59. Automobile Registrations, Licenses, and Revenues in the United States, 1915.
63. State Highway Mileage and Expenditures to January 1, 1916.
*65. Rules and Regulations of the Secretary of Agriculture for Carrying out the Federal Aid Road Act. 5c.
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74. State Highway Mileage and Expenditures for the Calendar Year 1916.
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Public Roads Vol. I, No. 1. Automobile Registrations, Licenses, and Revenues in the United States, 1917.
Vol. I, No. 3. State Highway Mileage and Expenditures in the United States, 1917.
*Vol. I, No. 11. Automobile Registrations, Licenses, and Revenues in the United States, 1918. 15c.
*Vol. II, No. 15. State Highway Mileage and Expenditures in the United States, 1918. 15c.
Public Roads Vol. III, No. 25. Automobile Registrations, Licenses, and Revenues in the U. S. 1919.
Public Roads Vol. III, No. 29. State Highway mileage 1919.

REPRINTS FROM THE JOURNAL OF AGRICULTURAL RESEARCH.

Vol. 5, No. 17, D–2. Effect of Controllable Variables Upon the Penetration Test for Asphalts and Asphalt Cements.
Vol. 5, No. 19, D–3. Relation Between Properties of Hardness and Toughness of Road-Building Rock.
Vol. 5, No. 20, D–4. Apparatus for Measuring the Wear of Concrete Roads.
Vol. 5, No. 24, D–6. A New Penetration Needle for Use in Testing Bituminous Materials.
Vol. 6, No. 6, D–8. Tests of Three Large-Sized Reinforced-Concrete Slabs under Concentrated Loading.
Vol. 10, No. 7, D–13. Toughness of Bituminous Aggregates.
Vol. 11, No. 10, D–15. Tests of a Large-Sized Reinforced-Concrete Slab Subjected to Eccentric Concentrated Loads.
Vol. 17, No. 4, D–16. Ultra-Microscopic Examination of Disperse Colloids Present in Bituminous Road Materials.

* Department supply exhausted.