October 20, 1920.
Springfield, Mass.

HIGHWAY ENGINEERING RESEARCH

Meeting of Land Grant
College Association.

As a background for these observations, it may be germane to say that my own earliest experiences in highway work were in connection with research and investigational studies undertaken by direction of the General Assembly by the Land Grant College of the State of Iowa, and for which a small appropriation was provided for "good roads experimentation." The conduct of this work laid the foundations for a basic road law establishing a State highway department and providing many of the general principles which are common to modern highway legislation. Even after a State highway department was established under a different Board than that of the educational institution under which the work was first started, contact in all lines of research and investigation was closely maintained between the State Highway Commission and the College. It is my personal belief that this contact has proven a stimulus and a source of strength to both the educational institution and the highway department, and it is on the basis of a firm belief in such relationships that these thoughts are presented.

The entrance of the Federal Government into the field of highway improvement through the Federal Aid Road Act has added a third agency, and has established a new point of contact between the Federal and State Governments, which can and should prove most useful in furthering this great public undertaking -- the improvement of the public highways.

Without dwelling too long on the statistics involved, it is perhaps not out of place to refresh your minds with some of the figures with reference to the growth of the motor vehicle. In 1906 the total registrations were approximately 48,000 cars. Thirteen years later there was a registration of 7,565,446 motor cars, including commercial vehicles, and 241,000 motor-cycles. It was not until 1914, however, that the total registration reached 1,700,000, so that the rapid increase in the use of motor vehicles has been in the last five years. The most significant factor, however, has been the growth in commercial vehicles, particularly motor trucks. It has been estimated that at the end of this year there will be not less than 1,000,000 commercial vehicles in operation on the public highways, and this development has practically all taken place in less than five years.

A very similar story is told by the expenditures for road and bridge construction. In 1906 only about $10,000,000 were expended. By 1914 this had grown to $250,000,000. In 1919 the approximate expenditure was $400,000,000. In 1916 the Federal Government appropriated $75,000,000 as Federal aid extending over the succeeding 5-year period. In 1919 an additional appropriation of $200,000,000 was made. The expenditure of these funds was so delayed by the war period that at the beginning of this year it was estimated that more than $600,000,000 were available from all sources for highway improvement.

There is a common expression that the use of the highways has increased tremendously, and this is evidenced by the concrete facts of motor

vehicles in use and the expenditure of public funds for highway improvement. Analyzing this general fact we find, among others, the following specific conditions:

1. A very large increase in the total number of vehicle-miles per year in each State. For a distinctly agricultural State it is estimated that 500% increase is conservative, while in the more densely populated districts the increase will be at least 1,000%, and in specific cases much higher.

2. An increase in the unit weight of vehicles carried. An investigation covering a large number of farm-owned trucks in the Eastern and Corn-belt States has shown that the farmers as a class are adhering to trucks with a carrying capacity not much greater than the loads customarily hauled by horse-drawn vehicles, but that the commercial truck user is demanding upwards of 15 tons gross weight of vehicle and load, with a net load capacity of about $7\frac{1}{2}$ tons, but because of the tendency to over-loading the gross loads in some instances far exceed this figure. We have authentic records of loads as heavy as $18\frac{1}{2}$ tons.

Another highly important weight factor is the concentrated axle and wheel loads. Up to the present time too little attention has been given the adaptation of the design of the load carrying vehicle to the track over which it must run.

3. The speed has greatly increased. A good driving team might travel 8 miles per hour, and a farmer's draft team draving a reasonable load perhaps 3 to 4 miles per hour. Passenger vehicles are now expected to run 25 to 35 miles per hour, the latter figure being a legal limit in some States, while the commercial vehicles are demanding a speed of 15 to 25 miles per hour.

4. Radius of travel has lengthened, demanding longer continuous routes.

5. The number of hours per day in which there is considerable traffic on the road has increased.

6. Continuity of highway service is demanded throughout the year.

All of these factors have brought about not an evolution in highway improvement practices, but because of the short time involved, what may be termed a revolution. At the present time the situation is aggravated by other factors such as the much higher cost of highway materials and labor, the increased interest rates for money, and the advancing cost of operating motor vehicles.

Since the present highway building program was set in motion there have been most serious handicaps from lack of rail transportaion for materials. It is not to be doubted that had sufficient rail transportation been available, other economic limitations would have appeared successively, and among these the lack of sufficient engineers to properly supervise the carrying on of such a large program. From a national point of view, therefore, two major problems have developed, the first of which is educational and the second investigational.

The first of these - the educational problem - while perhaps not properly a part of this subject, should be in such a gathering at least touched upon to a sufficient extent to bring to the attention of engineering educators the situation as it exists. In May of this year, at a conference called by the Commissioner of Education to dis-

cuss highway engineering and highway transport education, the fact was brought out, resulting from a survey of the organizations employed by the State and Federal Governments on highway work, that all of the civil engineering graduates of the institutions could be absorbed in this one field of engineering, while, as a matter of fact, it was probable that only a very small percentage of these graduates would find their way into this field. The fact was also developed that a very large number of competent mechanics and drivers should be trained each year, probably through extension agencies and in short courses conducted by the educational institutions. As a result of this conference a permanent committee was formed, of which the Commissioner of Education is Chairman, and on which the Bureau of Publib Roads, the War Department, the Society for the Promotion of Engineering Education, and the motor vehicle and accessories industries all have representation. It is the function of this committee to assist in bringing about a very much more intensive educational program, and to establish cooperative contacts with educational institutions for the purpose of bringing the great importance of these questions into prominence.

The need for educational development along highway lines lies not alone in the training of highway engineers and automotive engineers, or in the development of extension and short courses, but it extends to the education of the public generally in the proper use of highways, in the broad economic principles involved, and in the proper observance of necessary safety rules and regulations. It is proposed to make this movement a national cooperative one among all interested agencies, and it is hoped that because of the large public interests involved this program will receive the sympathetic cooperation of the land grant colleges.

Turning to the other major problem, - that of research and investigation along highway engineering and highway transport lines, - it has been recognized that a great national program is needed if the public interests are to be served by properly built and maintained highways, and if the construction of these highways is to be put upon an economically sound financial basis, so that the funds expended will prove investments returning the highest possible percentage of dividends in the service rendered. For the next quarter of a century improvement of public highways will be the greatest single public activity, and will require such enormous sums of money that these expenditures should and must rest upon the soundest principles of engineering and economics.

There are many agencies interested in these problems, and whose efforts should be correlated into one comprehensive program. It is highly important that while this program should be pre-conceived as a whole, and each undertaking formed as a component part, the actual working out of the problems go forward in such a manner that individual initiative will be encouraged and local conditions will be met. It must be recognized that while the improvement of highways in the aggregate is of national concern and has been so recognized by the Federal Government in making available large sums for encouraging road building, the important problems of research and investigation are more or less local. The underlying principles of sound construction or maintenance, or of economics, while remaining the same, are subject to an infinite number of variations dependent upon local conditions of topography, geological formations, population densities, development of

industries and such modifying circumstances, as to render the proper solution of these problems necessary through a decentralized organization. To bring such a movement into being on a national basis, it seems properly to be a function of the National Research Council. Broadly speaking, the program can be divided into the following main undertakings:

1. The problems relating to the construction and maintenance of highways.
2. Those relating to their operation.
3. Their economic value.

Under one of these headings it would seem that any problem with reference to our highways could be properly fitted.

Perhaps there is one master problem which should first be solved as a foundation for all others. We would be on a very considerably sounder basis now with reference to highway legislation, appropriations and organizations, were this investigation complete. This problem is that of highway traffic. It is of such importance alone to demand a study, comprehensive and accurate, in every State, and one which first of all might well engage the attention of those agencies which are interested in the fundamentals of knowledge necessary for the carrying out of large public undertakings. It may be said in passing that this problem has become acute in other countries as well, and is now engaging the attention of both the English and French national departments of highways to the extent that detailed and accurate studies are being undertaken of highway traffic in both of these countries.

The National Research Council is a correlating body, and under this plan the Federal Bureaus concerned or those which, in exercising their proper functions, could lend aid to the solution of these problems, the State highway departments of the individual States, and the educational institutions, could institute cooperative research activities. As an example, there has just been put into effect a cooperative agreement between the University of Maryland, the State Highway Department and the Bureau of Public Roads, by which certain problems of highway research will be taken up at once. It is probable that the first of these cooperative problems will be a comprehensive study of highway traffic, and the work will be done under the immediate direction of the Dean of Engineering of the University.

The program proposed under the National Research Council is already under way, and committees have been appointed on the Structural Design of Highways, the Study of Properties of Road Materials and Their Combinations, and the Economic Theory of Highway Improvement. These committees are functioning, and valuable results have already been obtained. For the purpose of broadening this program to the extent of enlisting all the interested agencies, the National Research Council proposes to hold a conference in November. It will be the purpose of this conference to outline a broad program of research and investigations along highway lines, in which every agency possible will be enlisted for the purpose of obtaining some fundamental data which can be directly applied in the large investments which we are making and will continue to make for highway improvement. In such a program some of the individual land grant colleges have already expressed the greatest interest, and at least one such institution has made available both research funds and personnel.

The land grant colleges have been great beneficiaries from the Federal Aid principle so long ago adopted by the Federal Government. The great increase in the number of technical schools which were established immediately following the passage of the Morrill Land Grant Act in 1862 has had a counterpart in the great increase in the funds which have been made available for highway improvement and the construction programs undertaken since the passage of the Federal Aid Road Act in 1916. The facilities of these colleges which have been developed through the years since 1862, and the trained personnel, are now needed in the program of highway research and investigation which is necessary to insure the proper expenditure of the funds for highway improvement. It is my earnest hope that cooperative activities may be established in many of these institutions along these general lines to the end that a great national highway research investigational program may be instituted and carried forward without delay.