point, and has an extra foot in front of the initial point which is graduated in tenths outward from this point to ten tenths or one foot. This is very convenient in setting off the fractional parts of a foot.

In land surveying we prefer a tape graduated in links, each of which is 7.92 inches or .66 foot long. The chain, as you know, has 100 links, and is 66 feet long. With many, this type of chain is a back number. Yet I prefer its use to the 100 foot tape in land surveys as this is the way I have been schooled and as the calculations are much more simplified. For example, we have a tract of land 20 chains square to find the number of acres. All we need to do with the Gunter's Chain is to multiply 20 by 20, which gives a result of 400 square chains, or moving the decimal point one place to the left we have 40 acres in the tract. By the use of the 100-foot tape you would have 1,320 to be multiplied by 1,320 and the product to be divided by 43,560 square feet in an acre. Also where we have tracts with many sides requiring the method of finding areas by latitude and departure using traverse tables given in chains, the calculations are much simplified by the use of the Gunter's chain.

HIGHWAYS IN TERMS OF TRANSPORTATION

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The past 20 years have seen the reemergence of highway transportation from a position of comparative unimportance to a place of first rank in our national scheme of transportation. The registration of approximately 23,500,000 motor vehicles in 1927 compared with approximately 5,000,000 in 1917 is a remarkable illustration of the rapid growth in motor vehicle ownership and the need for improved systems of roads to furnish economical highway transportation of people and goods.

In Ohio, the state highway system, 13.0 per cent of the total rural mileage, provided highway service for a traffic of 2,160,435,000 vehicle miles, equal to 57.7 per cent of the total traffic on rural roads in the state in 1925; the county highways, which include 27.1 per cent of the rural mileage, provided service for 1,108,870,000 vehicle miles, 29.6 per cent of the total traffic; and the township highways, which constitute 59.9 per cent of rural mileage provided only 12.7 per cent of total rural traffic. The daily traffic on the state system

in Ohio averages over nine times that upon the county and township roads. The same relationship exists in Pennsylvania, and other states where traffic and highway planning surveys have been conducted.

Of the 11,000 miles of Ohio state highways 1.2 per cent carried 2,500 or more motor vehicles per day, 7.8 per cent carried 1,500 or more, 29.4 per cent carried 600 or more and 70.6 per cent carried less than 600 vehicles per day in 1925. Based on the forecast of traffic for 1935, approximately half the system will carry 600 or more vehicles per day.

In Ohio during 1925, the average daily density per mile on the state system was 538 vehicles, 132 on county highways and 26 on township roads.

Motor Truck Traffic

Motor truck traffic is an important part of total traffic on state highway systems. In Ohio in 1925, 13.1 per cent, 1,442 miles of state roads carried 100 or more trucks per day and 27.5 per cent, 3,019 miles carried 60 or more per day. Based on the forecast of truck traffic it is expected that by 1935 over 1,300 miles of Ohio state highways will carry 200 or more trucks per day.

It is clearly shown that the principal routes of a state system comprising what are known as the federal aid and main market or primary systems, are, with few exceptions, the most important traffic routes of a state. These facts show the necessity of alloting a sufficient portion of total highway revenues to complete first the improvement of the primary highways of a state.

Large capacity motor trucks and heavy loads comprise a comparatively small part of total truck traffic on the state highways of all the states. In Ohio nine-tenths of the trucks operating on the state system are small units, 2½ tons capacity or less. The 20,000 pound gross load limit in Ohio is partly responsible for this situation. In Pennsylvania, however, during 1924 only 90 miles, 2.3 per cent of the primary highway system, carried 20 or more loaded 5-7½ ton trucks per day and this mileage is in the immediate vicinity of Philadelphia, and Pittsburgh. Only 358 miles, less than 10 per cent of the primary mileage, carried 10 or more loaded 5-7½ ton trucks per day. This mileage is adjacent to the important industrial cities of the state.

The federal aid systems of the several states carry the largest part of the total traffic using the state highway systems. In Ohio, in 1925, the federal aid systems, slightly more than half the state mileage, carried 70.6 per cent of the daily traffic on the state system. In New Hampshire in 1926 the federal aid system, 68 per cent of the trunk-line mileage, carried 80.8 per cent of the total trunk-line traffic. In Ver-

mont during 1926, the federal aid system carried approximately half the traffic on all rural roads.

Origin of Traffic

Foreign traffic comprises but a small part of total traffic except on a few main through-traffic routes. In Ohio during 1925, 10.2 per cent of the daily passenger car miles on state routes were produced by foreign traffic, although on one of the principal interstate routes, U. S. 40, 23.6 per cent of the passenger car traffic was of foreign registration. Approximately the same proportions are true for states similar in traffic to Ohio. In states like Vermont and New Hampshire a large part of the traffic on state highways is of foreign registration. In Vermont 35.6 per cent and in New Hampshire approximately half the traffic was of foreign registration.

In states where a considerable part of the traffic is of foreign registration, the cost of constructing and maintaining the highways is materially increased by this class of traffic, and it should, therefore, produce at least a part of this additional cost of highway improvement.

The several surveys completed by the Bureau of Public Roads clearly show that the traffic using our state highway systems is predominantly city owned passenger car and motor truck traffic, farm owned motor vehicles comprising only a small part of total traffic. In Ohio in 1925 farm owned passenger cars and motor trucks made up only 12.4 and 15.5 per cent respectively of the total traffic.

In Vermont during 1926 farm owned passenger cars comprised one-tenth and city owned passenger care nine-tenths of the total passenger car traffic on the state aid system.

The distribution of population, and consequently of motor vehicle ownership, is an important factor in planning highway improvements. The volume of traffic in any given area is principally produced by the population residing within a radius of thirty miles, since less than 30 per cent of the truck traffic and 40 per cent of the passenger car traffic travels more than thirty miles per trip. In Ohio, for example, 80 per cent of the area of the state has a population of less than 80 persons per square mile and less than approximately 18 motor vehicles per square mile, while 9.4 per cent of the area of the state has a population of 160 or more persons per square mile and this area includes approximately 70.0 per cent of the state's population and motor vehicles.

These variations in Ohio, and similarly in other states, indicate marked differences in the requirements for highway improvements in the several areas of a state. In the densely populated areas the highway system should be planned to serve large volumes of traffic between the principal centers of population, with tributary feeder routes connecting minor

population centers with the primary traffic routes. These routes should be of sufficient width and improved with surfaces adequate to carry the large daily volume of traffic, as directly as possible. Obstructions to the free movement of traffic, such as railway crossings at grade, sharp curves, heavy grades and congested traffic sections should be eliminated, and by-pass routes should be constructed to avoid the congestion which occurs when a main route passes through the business center of small villages and cities.

In the sparsely settled areas of a state the volume of traffic is smaller and its sources more scattered. A connected system of main routes comprising a smaller mileage, improved with gravel or the lower types of paved surfaces where traffic warrants such improvements, should satisfactorily meet traffic requirements in these areas, except on the main through routes traversing them. The removal of obstacles to the easy movement of traffic is not an important problem in areas of low population and traffic, particularly when the expectancy of future traffic increase is small.

Scientific Planning and Improvement

The development of highways in the United States from an administrative standpoint can be grouped in three stages. First, the early period of local control, with its inevitable evils of waste, inefficiency and the failure to develop connected systems of improved highways. Second, the period of state control, characterized by efficient engineering standards and methods of improvement and resulting in the emergence of connected systems of improved state and national highways over which move an enormous daily volume of people and commodities. I believe we have already entered the third stage in the development of our highway systems where lie the most difficult problems that will require solution in the near future, that is the scientific planning and improvement of state and county highways in the areas about congested centers of population and traffic.

The territory surrounding cities like New York, Chicago, Philadelphia, Cleveland, Cincinnati and Indianapolis present complicated problems of highway location and improvement; width; grade separations, both rail and highway; double deck roadways; parking areas; reservation of adequate right of way for future highway use; structures and traffic control problems that challenge the modern highway engineer. I wonder if we are adequately preparing for the future in areas of this kind. Adequate highway development in such areas demands cooperative planning by state highway engineers, county highway engineers and frequently by municipal highway administrators.

I believe that a careful analysis of traffic demands and a scientific plan of improvement for the highway system is imperative for state highway systems, and for the combined state and county highway systems in the areas surrounding congested centers of population and traffic. Such plans should be prepared for at least five to ten years in the future and the establishment of a yearly budget of expenditures based on required improvements should be an integral part of this plan. The preparation of such plans is the function of the state highway engineers for the state highway system and the cooperative function of the state and county highway administrators in metropolitan areas.

There is no fundamental difference in principle between the public business of developing systems of highways, and private enterprises engaged in producing commodities. For example, light and power, gas and telephone utilities and other industries are all engaged in the production of commodities or services for public use. The history of their modern development is based upon a careful analysis of the demand for their product by present and expected future consumers in any given area.

The same basic economic and engineering principles of management that exert such a controlling influence in the field of private business should govern the public business of highway improvement. Our highways, to insure their proper development, should be improved in accordance with economic and engineering facts and should not be influenced by political considerations.

The first basic principle of highway management is that the various sections of state and county highway systems selected for improvement and the class of improvement chosen for each section should be based upon present and expected future traffic demands, modified by the various physical and economic characteristics which affect the choice of specific construction types to be built on the various parts of our highway systems.

The second basic principle is the familiar one of the budget, upon which all financially sound industries operate. Applied to the highway business it involves: (1) the determination of the yearly amount of funds necessary for the five or ten year improvement plan; (2) the apportionment of the cost among those who benefit from the improvements; (3) provision through legislation for raising the required revenue to stabilize highway income over the period of the improvement plan.

This management must insure the expenditure of the money in accordance with a predetermined plan of improvement in which each route and section of a route is to be improved to the degree required by traffic and to no greater or less degree.

A plan of state highway improvement may materially alter the economic and social development of a people as a whole or any section thereof. The location and improvement or lack of improvement of a given route is of vital importance not only to the traffic of the immediate locality but also to the traffic of larger areas. The planning and construction of a connected system of state and county highways deal in fact with the destiny of localities and states, their agriculture, their industries, the growth of suburban areas adjacent to centers of population and the economic and social activities of a people. This is a tremendous social responsibility resting upon our state and county highway engineers.

The major problem involved is not one of the particular type of improvement or materials to be used in the construction of a highway, but rather whether to build or not, and how much highway service can be economically justified in a given area. Upon the proper solution of these problems depends the well-being and progress of a people. Considering the improvement of highways from this point of view, there can be no question concerning the necessity of developing scientific plans for highway improvement over a period of years in the several states and counties, and of providing the necessary funds to carry out economically the proposed plan of improvement.

Outline of Procedure

What is the procedure and what are the basic facts necessary to lay out a scientific plan of state or county highway improvements?

1. The first step is the measurement of the present and the prediction of the future volume and character of traffic on state and county highway systems. The principal traffic factors involved in determining the relative traffic importance of the various parts of a highway system are average daily and maximum total traffic, average daily and maximum total truck traffic and the number of daily loaded large, 5-7½ ton capacities, medium, 3-4 ton capacities and light, ½-2½ ton capacities using and expected to use each section of highway. Population density and distribution is of material assistance in preparing this analysis. This material is best summarized as a traffic classification of each section of state and county highways, showing those sections now carrying or expected to carry 1,500 or more daily vehicles during a 5 or 10 year period; those sections carrying or expected to carry between 500 and 1,500, and those sections carrying or expected to carry 500 or fewer vehicles per day. Approximately these three classifications of traffic sections of a highway system determine the general classes of improvement necessary on each section of the system, gravel or similar improvements

for the 500 or fewer class; paved surfaces of the lower type for the 500 to 1,500 class, and the superior types of paved surfaces for the class of 1,500 or more vehicles.

2. The second stage of highway planning analysis is the determination of new highway locations or connections, relocation of present highways, and the elimination of the obstacles to the free movement to traffic based on the traffic classification data prepared as the first step in developing the plan of improvement.

3. The third stage of a scientific analysis of a highway system is the evaluation of the present highway improvements on the system to determine in the light of traffic data and the physical problems involved in improving the various sections of a system, whether the present surface is adequate for 5 or 10 years, has a salvage value for base material or is of no value as a part of the plan of improvement to be developed. The district superintendents and division engineers should first log each section of highway in their respective jurisdictions as to type, surface width, and highway right of way width. Then the present surfaces on each section of a route should be classified, based on the traffic classification for each section as follows: first class, adequate for 10 years; second class, adequate for 5 years and indicating reconstruction during the succeeding 5 year period; third class having salvage value as base material and requiring reconstruction; fourth class, having no salvage value and requiring new construction. This data should be carefully prepared since it forms the basis for the reconstruction program.

4. The fourth step is the determination of surface width for each section of highway based on traffic density and time rate analysis. It is obvious that sections of the state and county systems having less than a modern 2-lane surface should be included as a part of the plan of widening such surfaces. Those sections of the system carrying large daily volumes of traffic should be planned for additional width as a part of the widening program. It is doubtful if any considerable mileage of state or county highways will require more than 2-lane surfaces and it is also doubtful if any such highways should be planned for more than four lanes of traffic.

5. The next step is the determination of the new construction necessary, based on the traffic classification.

6. The next stage is the analysis of present structures and the planning of new bridge and grade separation requirements during each of the 5-year periods.

7. The next step is the summary of the plan of highway improvement including new construction, reconstruction, widening, and structures.

8. The final stage is the establishment of the budget requirements for the 10-year period based upon careful estimates of construction costs for each part of the improvement plan and the determination of the yearly construction, maintenance and administrative funds necessary to carry out a scientific, and orderly plan of improvement based upon facts.

When the above plan is completed it is essential that the public be made familiar with all the essential facts involved in the plan of improving their system of transportation. I am confident that when you have completed a thorough economic and engineering analysis of your system of highways, prepared your plan and budget based on facts and acquainted your public with the facts, that sufficient revenue will be made available to carry out successfully the plan of improvement.