REPORT OF COMMITTEE ON HIGHWAY TRANSPORTATION

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At the annual meeting of the Highway Research Board in Washington, D C, December 12th and 13th, 1929, a report was presented which outlined methods for computing the costs of highway transportation The complete text of the report will be found in the Proceedings of the 9th Annual Meeting of the Highway Research Board, page 360 It is the purpose of this year's report to illustrate the application of the method of computation set forth in the 1929 Proceedings, by actually computing the costs of transportation on two highways that differ greatly in their general physical characteristics and that are widely separated geographically

It is the belief of the Committee on Highway Transportation that those who have occasion to make estimates of the costs of highway transportation will be interested in the detailed calculations involved in typical problems of this type, and moreover, that the actual figures developed in the two cases presented herein will prove to be very interesting and illuminating.

The Committee is greatly indebted to the officials of the Iowa and Connecticut Highway Departments for the courtesies extended in connection with this investigation In both instances it was found that the records desired were surprisingly complete and accessible except in the case of some very old structures While this report is based on data obtained from official records, it must be understood that the officials of neither of the state highway departments have had an opportunity to make a critical study of this report, nor can they in any sense be held responsible for any of the conclusions that have been reached by the Committee

For convenience of reference, the method of computation applicable to any item is quoted at the beginning of the section of this report that deals with the computation of that item

The Engineering-News Record construction cost index has been used to bring costs to date and a graph of this index is shown in Figure 1.

PART I THE COMPUTATION OF ANNUAL COSTS OF UNITED STATES HIGHWAY NO 1 BETWEEN NEW HAVEN AND MILFORD, CONNECTICUT

This presents the computations necessary to determine the annual costs of a section of United States Highway No 1 lying between New

Haven, Connecticut and Milford, Connecticut, it being a portion of what is commonly known as the Boston Post Road This is one of the

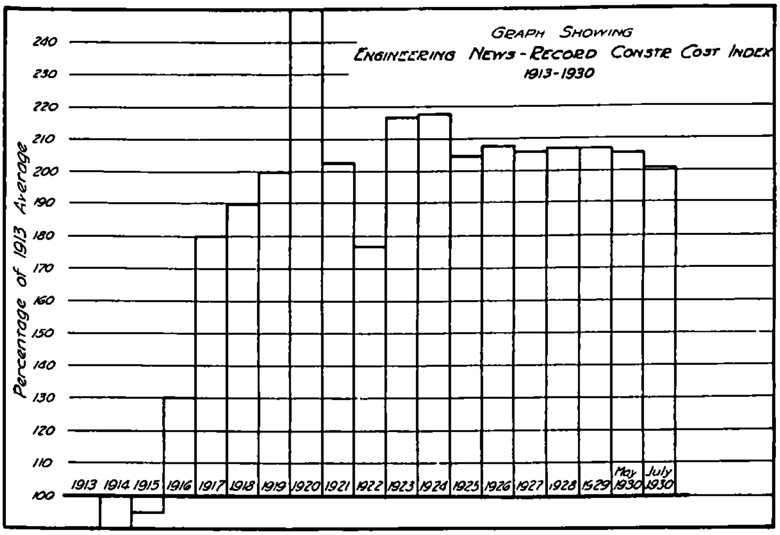

Figure 1

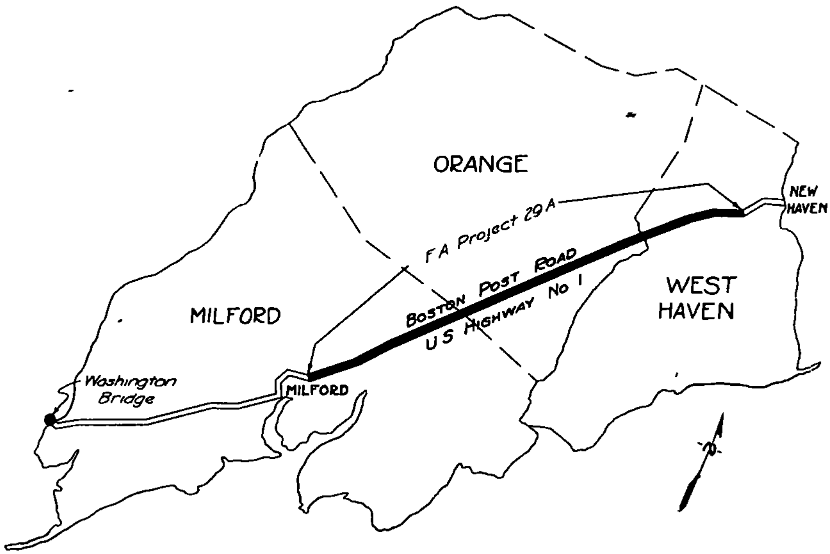

Figure 2 Map of U S. Highway No 1, between New Haven and Milford, Connecticut

oldest improved roads in New England as well as one of the most heavily traveled It is the most heavily traveled road in the State of Connecticut, as it is the link which connects New York City with such cities as Bridgeport, New Haven, New London, Providence and Boston

The section of highway selected for this investigation is 6 55 miles in length and is located just west of New Haven Its location is shown by the sketch map in Figure 2 The cross section of the road surface as it exists to-day is shown in Figure 3 The principal reason for selecting this particular highway is that it has passed through many stages of improvement By reference to Figures 3 and 4 it will be noted that this road was first surfaced with macadam of various widths and thicknesses These surfaces were completed at various times in the period between 1898 and 1910 Then in 1914 and 1915 these macadams were surfaced either with reinforced concrete or with bituminous macadam Finally, in 1926 and 1927 the road was again surfaced, this time with a reinforced concrete pavement 36 feet wide The drawings in Figures 3 and 4 do not represent the actual cross sections of the macadam as it was incorporated in the present road During the

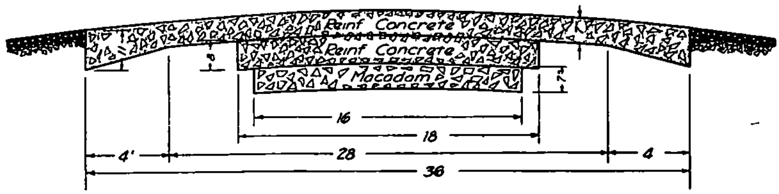

Figure 3 Typical Section, Showing Present and Prior Surfaces U. S Highway No 1, between New Haven and Milford, Conn.

resurfacing operations, the old macadam was scarified and spread to a certain extent in preparation for placing the new surface The sketches do show the relative thicknesses and lengths of the various pieces of work and portray the order in which they were laid

Section One Computation of Annual Road Cost

In the following analysis, the cost items have been assembled from the various contracts involved in each stage of the development of this road The sources of information from which the costs were obtained are indicated in the tabulation which is included with the report

Special attention is directed to the fact that property damage is included herein as a part of the costs of the right-of-way, to the influence of the use of a price index in bringing the costs of the several elements to a comparative basis, and to the difficulties involved in arriving at a fair estimate of the part of the costs of prior surfaces to charge against the present improvement While the Committee has exercised due diligence in arriving at the several items of cost, it should be recognized that this report is intended primarily to illustrate the

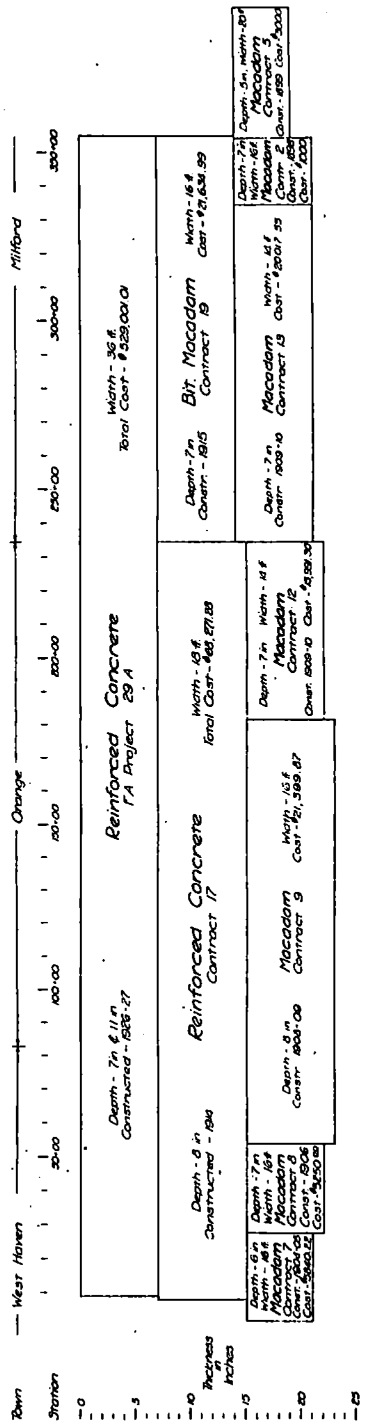

Figure 4. Longitudinal Section—Present and Prior Surfaces. Boston Post Road between New Haven and Milford, Conn.

method of attack rather than to present cost figures of a high degree of accuracy

1 *Right-of-way Cost, and Property Damage* "Assume the easement for the right-of-way to have a value equal to the value of the land for agricultural or other purposes at the present date" (Quoted from the report on Method of Computation)

It is generally recognized that it is not possible to use original cost as the basis for the comparison of right-of-way values In the case of an old established road, the original right-of-way consisted of easements for road purposes The title to this easement remains in the adjoining lands and, in the case of abandonment, the right-of-way will revert to the holders of the title Where right-of-way has been purchased, a fair price may or may not have been paid Whether or not the salvage value of this land will be higher or lower than the original cost is a matter of speculation, but it is almost certain that it will have a value equal to that of the adjacent land If the right-of-way has simply been taken from the adjacent lands, or has been donated for highway purposes, it does have value and that value is the value which the land now possesses In all cases, it is logical to assign to the easement for the right-of-way a value equal to the value of the adjoining lands

It will be noted that a charge for property damage has been included Strictly speaking, this charge is not a part of the right-of-way cost, it does seem more logical, however, to associate it with the right-of-way classification than with any other Property damage claims are the natural consequence of the widening of this road from a two-lane to a four-lane highway The payments for property damages have actually been incurred in the construction of the four-lane highway and without question its amount must be considered as a part of the cost of the highway

The determination of the right-of-way cost on this section of the Boston Post Road involves finding the area of the right-of-way and estimating the value of the adjoining lands Right-of-way plans were available at the Right-of-Way Division of the Connecticut State Highway Department These plans show that the right-of-way varies in width from 68 to 215 feet The various widths were scaled at equal intervals throughout the length of the road and an average width of 84 feet was obtained

The total area of the right-of-way on this section of highway is 66 72 acres The fair value of this land has been estimated at $185 00 per acre The total value of the right-of-way, therefore, is $12,343 00 Property damages paid during widening was $20,992,35, bringing the total cost of right-of-way and property damage to $33,335 00, or approximately $5000 00 per mile

2 *Drainage Structures* "Use the actual cost of the drainage struc-

tures as of record, except for major stream crossings that serve traffic from additional miles of road The fair proportion of the cost of these major stream crossings is to be allocated to the road under analysis and the original cost reduced to a cost as of date by applying the Engineering News-Record price index or other reliable data "

Drainage structures are of three classes culverts, bridges, and tiling Under present conditions, a forecast of the probable life of drainage structures can hardly be made It is reasonable to assume that these structures, with proper repairs the cost of which is included in the annual maintenance charge, will last for a very long period of time With a "very long life" it is unnecessary to include any annual charge for future periodic reconstruction and consideration need only be given to the total value of the existing drainage structures

The actual cost of the drainage structures as of record should be brought to a cost as of date by application of the appropriate price index It would be unfair to assume that two bridges, exactly alike, serving the same purpose, in the same locality did not have the same value. Yet, it is possible that the construction records might show a variation as great as 280 per cent, depending, of course, upon the years in which each was constructed It is only by applying a price index to these costs and bringing them to a date, that the values can be placed upon a comparative basis

The committee recommended that the "fair proportion of the cost of major stream crossings that serve traffic from additional miles of road, shall be charged against the system under analysis " There are no bridges on this road which can be classified as "major" stream crossings It is proper therefore, to include the total cost of all drainage structures, as of July, 1930, in this determination of road value

As previously stated, drainage structures are of three classes—culverts, bridges, and tiling The bridges on the section of the Boston Post Road under analysis are old structures, whose cost must be estimated These bridges were usually of the concrete slab type with masonry abutments Neither their cost nor the date of construction is on record They have been widened as needed, but the costs of widening are a part of the construction records and are readily available The cost of the old structures was estimated from the record of cost of similar structures in Connecticut

The culverts on this section of road are of reinforced concrete pipe, varying in size from 15 to 30 inches The pipe, in most instances, were furnished by the State and laid by the contractor The cost of the pipe and the cost of laying them was determined from the construction records

The construction records do not show any drain tile on this section of highway

The determination of the cost of these drainage structures involved the use of the following records at the Connecticut Highway Department's offices Project maps, construction plans, Kardex files, final estimates, original contracts, and a bridge survey

Project maps are town (township) maps, which give the numbers of all of the construction projects executed on all of the roads in the town Having determined the projects relating to the construction of the road under analysis, it was found expedient to consult the construction plans It was thus possible to determine the number of bridges and culverts along with the size and location of each The Kardex file is, in reality, a condensed form of the final estimates, and it is from these that the actual construction costs were obtained

Consultation of the file of final estimates was made as a check on the information on the Kardex cards or to obtain information in more detailed form The original contracts and the bridge survey were consulted to secure information regarding the old bridges whose cost was not a part of the available records The descriptions secured through these sources were of use in making an estimate of the original cost of these old structures

The total cost of drainage structures on this highway, as of July, 1930 is fixed at $85,870 00, or approximately $13,600 00 per mile

3 *Earthwork and Prior Surfaces* "Charge the actual cost of grading and prior surfaces By prior surfaces is meant any wearing surface that has become an integral part of the existing wearing surface, as when a surface has been changed to a higher type "

Note In this report, the estimated *salvage* value of prior surfaces is added to the cost of the earthwork, instead of the actual *cost* of prior surfaces

a *Earthwork* The earthwork necessary to bring this road to its present grade probably represents the most permanent part of the total investment in the highway Regardless of whether it was done 5 years ago or 40 years ago, every grading operation on a certain section of road has helped to bring that section to its present condition The costs of these individual grading operations are a definite part of the total investment in the highway These costs were obtained from the office records and brought to a cost as of date by applying the price index The value of the earthwork on this section of highway is fixed at $159,500 00

b *Prior Surfaces* By prior surfaces is meant any superceded wearing surface that has become an integral part of the now existing wearing surface It is quite clear that the old bituminous macadam and concrete surfaces that were laid at various times on this section of highway, have become an integral part of the now existing roadway surface It is therefore necessary to determine the value of these as a part of the present road structure This may be arrived at by estimating the cost of construction of a roadway surface comparable in wearing properties and load carrying capacity with the one actually in use but constructed in a location where no prior surfaces existed In other words the desired information is arrived at by considering a substitute surface placed on an earth subgrade The value thus obtained for the prior surfaces may be checked against the estimated salvage value of those surfaces at the time they were resurfaced, but that salvage value must be considered from the standpoint of the value as pavement base, not as a wearing surface

TABLE I

PRIOR SURFACES

Boston Post Road, between New Haven and Milford, Connecticut

Contract	Type	Thickness	Width	Date of construction	Age at replacement	Condition	Pavement surface: Original cost	Pavement surface: Salvage value	Value as of July, 1930
		inches	*feet*		*years*	*per cent*			
17	Reinforced concrete	8	18	1914	12	35	$56,808 47	$19,880 00	$42,000 00
19	Bituminous macadam	7	16	1915	11	25	15,451 52	3,860 00	8,130 00
13	Macadam	7	14	1910	5	20	20,017 53	4,000 00	14,500 00
12	Macadam	7	14	1910	4	20	15,991 30	3,200 00	
9	Macadam	8	16	1909	5	20	20,920 17	4,180 00	8,400 00
8	Macadam	7	16	1906	8	20	5,250 00	1,050 00	2,120 00
7	Macadam	6	16	1905	9	20	5,840 22	1,170 00	2,350 00
2	Macadam	7	16	1898	17	20	1,000 00	200 00	400 00
							$141,279 21		$77,900 00

For purposes of comparison, the salvage value of the various prior surfaces at the date of resurfacing has been estimated as shown in Table I Since these prior surfaces had been well maintained, there was little difference in the condition of the several macadams, irrespective of their ages Since they could not be inspected (being covered by the more recent construction) the condition per cent had to be arrived at on a basis of judgment and experience The salvage value of approximately $80,000 is therefore in the nature of a carefully considered estimate The figure may or may not be of value but it affords an interesting comparison with the results obtained by the "substitute surface" method It is believed that such a substitute section would consist of two, two-lane concrete slabs each having a thickness of 11 inches at the edge and 8 inches in the middle 10 feet as shown in Figure 5 On the basis of the cost of the concrete in the existing road slab, this substitute surface would cost $526,500 The existing surface cost $435,700 (see Section 4) and the value of the prior surfaces would therefore be $90,800, on the basis of the relative costs of the existing and a substitute surface

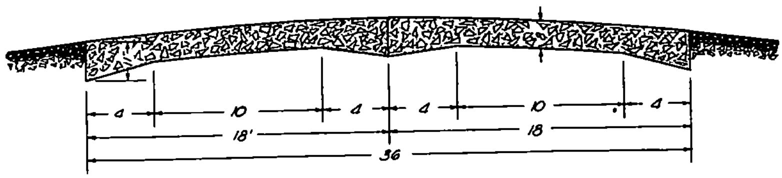

Figure 5. Cross Section of Substitute Surface. U. S. Highway No. 1, between New Haven and Milford, Conn.

On a basis of all of the information obtainable and the conditions outlined in the foregoing, it is concluded that the prior surfaces on this section of the Boston Post Road have a value of $84,000

4 *Road Surface* "Determine from the construction records the actual total cost of the road surface and reduce to a cost as of specific date by applying the Engineering News-Record price index, or other reliable data to the sections constructed during each year"

The determination of this cost involved only the consultation of the files at the Highway Commission offices The total construction cost

TABLE II

EXPENDITURES FOR ENGINEERING AND ADMINISTRATION, 1922–1928

State of Connecticut

Year	Engineering and administration expenditures	Total expenditures	Per cent
1928	$479,634	$11,994,317	4 00
1927	367,598	8,386,647	4 38
1926	204,298	6,649,712	3 07
1925	176,327	7,313,506	2 41
1924	157,247	2,476,100	6 36
1923	112,086	2,962,532	3 77

of the 6 55 miles of reinforced concrete pavement is $450,860 07, or $68,700 per mile The cost as of July, 1930, is $435,700, or $66,500 per mile

5 *Signs and Other Appurtenances* "Compute the total cost of signs, guard fence and similar appurtenances Crossing eliminations to be handled in the same manner as major stream crossings"

It has been found that the simplest way of obtaining a reasonably correct figure for this item consists in making a count of the number of signs and a measurement of the length of guard rail Through price lists, construction records, and other information it is then possible to compute the total cost of this item

The total cost of this item for the highway under consideration is $6800 00 or $104 00 per mile

6 *Engineering and administration* "The cost of engineering and administration is to be determined by applying to the total cost of all of the foregoing items the percentage which represents the total cost of this item in the jurisdiction (5 per cent may be used as a close approximation)"

Table II has been prepared from information contained in the Annual Report of the Highway Commissioner of the State of Connecticut for 1928 In this table, the column headed "Engineering and Administration Expenditures" does not include the amount expended for engineering and administration on maintenance Likewise, the column headed "Total Expenditure" excludes all expenditures for maintenance

The figures in Table II indicate that the engineering and administration expenditures are about 4 per cent of total construction costs Applying this percentage to the total cost of items 1 to 5 inclusive, the cost of engineering, administration and inspection on this section of highway is $32,754 50 or $5000 00 per mile

7 *Summary* "The grand total of items 1 to 6 constitutes the quantity A in formula 1" (on page 340)

Summary

Item 1	Right-of-Way and Property Damage	$33,335
2	Drainage Structure	85,870
3	Earthwork	159,500
4	Salvage Value of Prior Surfaces	84,000
5	Road Surface	435,700
6	Signs and Appurtenances	6,800
7	Engineering and Administration	32,755
	Total	$837,960

8 *Maintenance Cost* "The items of maintenance cost shall be determined from records of maintenance cost on the roads under consideration, supplemented by records of costs on like roads under equivalent traffic conditions in nearby areas where climatic conditions are similar Where the types of surface require routine maintenance supplemented by special periodic maintenance such as resurfacing, re-oiling, and the like, the annual maintenance cost shall be determined as prescribed in Section I The maintenance costs shall include the appropriate rental charge for equipment "

a Annual Maintenance Cost As might be expected, considerable difficulty was experienced in determining maintenance costs on the road under analysis However, it is possible to segregate these costs from an analysis of the daily time sheets, or weekly time books

The present annual cost of maintaining this section of the Post Road is about $900 00 per mile This figure is substantiated by the fact that in 1928, the cost of maintaining the section of the Post Road in the town of Darion was $910 00 per mile That section of the highway is also 36 feet in width

Applying this figure, $900 00 per mile, to the 6 55 miles of road under analysis, an annual maintenance cost of $5987 70 is obtained

b *Periodic maintenance* In considering the expenditure for periodic maintenance, only the expenditure necessary for the maintenance of the present pavement surface has been included Signs, guard rail, and similar appurtenances are maintained and replaced as needed, these costs are included in the annual maintenance charge already computed Under present conditions, a forecast of the probable life of drainage structures can hardly be made As has been stated, it is reasonable to assume that with proper repairs, the cost of which is also included in the annual maintenance charge, these structures will last for a very long period of time With a "very long life" the annuity required to provide a fund for reconstruction at the end of the period is so small that it becomes negligible

In calculating the expenditure for periodic maintenance of the present wearing surface, it will be assumed that the existing pavement will be used as a base course for some type of bituminous surface as that is the usual practice in Connecticut As such this base course may be assumed to have a very long life, but at intervals (assumed herein at 20 years) this base course will require extensive reconstruction and strengthening

A survey of all resurfacing jobs in the State of Connecticut has brought out the interesting fact that the average age of concrete pavements at the time of resurfacing is 6 years and 7 months However the section under consideration is of recent construction and of high quality It is estimated that resurfacing will not be required under 10 years even under the severe traffic to which it is subjected At the end of that time it is assumed that the pavement will be resurfaced with asphaltic concrete Such a surface as now laid in Connecticut would probably last about 10 years, under the traffic it will be required to carry In other words, it must be assumed that such a surface would be replaced every ten years

A study of the Highway Department records of construction costs has shown that the average price for a 2½ inch asphaltic concrete surface is approximately $1 40 per square yard The cost, therefore, of resurfacing 6 55 miles of 36 foot pavement, or 138,400 square yards, is $193,600 00 It is this amount which must be spent every ten years for periodic maintenance

The probable cost of reconstruction of the pavement at the end of

20 years is largely a matter of conjecture because of the total lack of data on concrete roads of that age but it is assumed herein at $160,000 including engineering and administration

9 *Engineering and Administration on Maintenance* "This shall be determined by calculating the ratio of such overhead costs to the total expenditures for maintenance in the jurisdiction and applying that percentage to the total of Item 8"

This percentage has been obtained through figures obtained from the Annual Report of the Highway Commission of the State of Connecticut for 1928 They are shown in the Table III

The percentages given in Table III indicate that engineering and administration expenditures are approximately 5 5 per cent of the total expenditure for maintenance Applying this percentage to the annual maintenance cost, it is found that the total cost of engineering and administration on maintenance is $324 37

TABLE III

EXPENDITURES FOR ENGINEERING AND ADMINISTRATION ON MAINTENANCE, 1923–1928

State of Connecticut

Year	Expenditures for engineering and administration	Expenditures for maintenance	Per cent
1928	$199,184 00	$2,802,751 00	5 24
1927	195,018 07	3,467,120 00	5 62
1926	214,937 67	3,230,270 00	6 66
1925	174,800 25	2,960,737 00	5 90
1924	139,019 45	5,778,564 00	2 40
1923	112,054 92	3,614,097 00	3 10

10 *Annual Road Cost* "The annual cost of a road (not road value) may be expressed as the total average yearly expenditure that will construct, replace and maintain in perpetuity in standard serviceable condition any existing road under existing traffic and climatic conditions

This amount may be calculated by determining the amount of money which, if set aside today, will return in perpetuity, as interest, sums sufficient to pay annual interest charges on construction cost, to provide a sufficient annual maintenance charge, and to accumulate periodically necessary replacement costs, and by multiplying that amount by the rate of interest current in State financing

This may be put in terms of a formula as follows

$$C = \begin{matrix}\text{Average}\\ \text{Annual}\\ \text{Rd Cost}\end{matrix} = \begin{matrix}\text{Rate}\\ \text{of}\\ \text{Int}\end{matrix}\left[\begin{matrix}\text{Const}\\ \text{Cost}\end{matrix} + \frac{\text{Annual Maint}}{\text{Rate of Int}} + \frac{\text{Periodic Maint}}{(1 + \text{rate of int })^{n} - 1}\right]$$

$$C = r\left(A + \frac{B}{r} + \frac{E}{(1+r)^{n} - 1} + \frac{E'}{(1+r)^{n'} - 1} + (\text{etc})\right) \quad (1)$$

wherein

- C = average annual road cost
- A = cost to construct = $837,960
- B = Annual maintenance cost (every year) = $6222
- E = expenditure for periodic maintenance every n (= 10) years = $201,344
- E' = expenditure for reconstruction every n' (= 20) years = $160,000
- r = rate of interest prevailing in current State financing = 04

Substituting these values for Items 1 to 9 in Formula 1, (page 340), one arrives at a value for the annual road cost

TABLE IV

CALCULATION OF ANNUAL COST

Boston Post Road, between New Haven and Milford, Connecticut

Interest on Investment at 4 per cent	$33,518 00
Annual Maintenance Charge	5,898 00
Annuity for Periodic Maintenance and Reconstruction	22,150 00
Engineering and Administration on Maintenance	324 00
Total Annual Road Cost	$61,890 00
Annual Cost per Mile	9,445 00

The summary in Table IV shows that the annual cost of the section of the Boston Post Road between New Haven and Milford, Connecticut is approximately $9445 00 per mile

Section Two Estimate of Annual Traffic

This section of the report presents an estimate of the volume of traffic now carried by the section of the Boston Post Road between New Haven and Milford, Connecticut In making the estimate, consideration is given to the transportation survey of the State of Connecticut, to registration, population and gas tax figures, and to available traffic census figures for the section of road under analysis

A *The Transportation Survey* In 1922-23, the Connecticut State Highway Department and the U S Bureau of Public Roads conducted a survey of transportation on the roads of the State, the results being published in 1926[1] The survey was begun in September, 1922 and

[1] Report on the Survey of Transportation on the State Highway System of Connecticut, 1926, pp 84–85

continued for one year, during which time, traffic data were recorded at 57 survey stations One of these stations, No 11 was on the section of road under analysis and another, No 9 was adjacent

Station 11 was located on the Boston Post Road just a short distance west of New Haven on the section of road under analysis Station 9 is located a short distance west of Bridgeport, approximately at Washington Bridge These locations are shown on the map, Figure 2 A comparison of the traffic at Station 11 with that at Station 9 shows that there is a variation of approximately five per cent In other words, it is possible to assume that the density of traffic at any one point is the same as the density at any other point on this section of the Post Road The

TABLE V

REGISTRATION AND POPULATION FIGURES,* 1917–1930

Year	Registration		Estimated population	Persons per vehicle	
	Actual	Estimated		Actual	Estimated
1917	74,645	74,640	1,312,165	17 58	17 58
1918	86,067	86,759	1,339,552	15 56	15 44
1919	102,410	100,806	1,366,938	13 35	13 56
1920	119,134	117,072	1,394,324	11 70	11 91
1921	134,141	135,919	1,421,710	10 60	10 46
1922	152,977	157,682	1,449,097	9 47	9 19
1923	181,789	182,959	1,476,483	8 12	8 07
1924	217,227	212,111	1,503,869	6 92	7 09
1925	250,647	246,000	1,531,250	6 11	6 22
1926	263,235	285,000	1,558,640	5 92	5 47
1927	281,521	330,000	1,586,030	5 63	4 80
1928	309,792	382,000	1,643,410	5 31	4 22
1929	328,063	443,000	1,640,800	5 00	3 70
		513,000	1,688,180		3 25

* Report on the Survey of Transportation on the State Highway System of Connecticut, 1926, pp 84–85

final section of the Transportation Survey is given to an estimate of Connecticut highway traffic in 1930, which is summarized in Table V

The results of the 1922-23 survey show that the average motor vehicle traffic on this section of the Post Road was then 3230 vehicles per day Average motor truck traffic during this period, on the same section of highway, was 322 vehicles per day It is therefore assumed that 90 per cent of the total present traffic is made up of passenger vehicles, while 10 per cent is comprised of motor trucks

Since the completion of the statewide traffic survey, there have been a few traffic counts on this section of the Boston Post Road, and these indicated that the forecast of 1930 traffic which is shown in Table V was entirely too low

From a study of the state registration figures, the gas tax receipts and the traffic counts that have been made in recent years (these are summarized in Tables VI and VII), the Committee has reached the conclusion that the average daily traffic on this road during 1930 is approximtely 18,500 vehicles per day or 6,750,000 vehicles per year It is further concluded that about 10 per cent of the annual traffic is

TABLE VI

ANNUAL REGISTRATION AND GAS TAX RECEIPTS, 1923–1930

State of Connecticut

Year	Motor vehicle registration	Per cent of 1930 registration	Gas tax collections	Per cent of 1923 collections
1923	181,748	100	$1,531,878†	100
1924	217,236	120	1,956,566†	128
1925	250,669	138	2,444,606†	160
1926	263,235	145	2,689,372	176
1927	281,521	155	3,054,906	200
1928	309,792	171	3,511,675	230
1929	328,063	181	4,047,092	264
1930	350,000*	193	4,750,000*	310

* Estimates

† Equivalent 2¢ tax

TABLE VII

24-HOUR TRAFFIC COUNTS—WASHINGTON BRIDGE

Date	Day	Number of vehicles	Date	Day	Number of vehicles
4/25/27	Monday	16,794	8/29/28	Wednesday	19,069
4/26/27	Tuesday	7,781	9/ 2/28	Sunday	31,415
7/ 3/27	Sunday	25,732	11/29/28	Wednesday	14,799
7/ 4/27	Holiday	28,104	12/ 2/28	Sunday	18,372
9/ 4/27	Sunday	28,145	5/30/29	Holiday	27,552
9/ 5/27	Monday	32,255	6/ 2/29	Sunday	28,455
11/24/27	Thursday	10,554	9/ 1/29	Sunday	36,610
11/27/27	Sunday	13,981	9/ 2/29	Holiday	42,254

made up of commercial vehicles Hence the annual traffic on this highway consists of 675,000 commercial vehicles and 6,075,000 automobiles

Section Three Motor Vehicle Operating Cost

It was not within the province of this project to investigate the cost of motor vehicle operation Certain statistical studies of the cost of vehicle operation are available from which the committee obtained the information necessary for completing the calculation of highway transportation costs on the sections of road under analysis

1 *Automobile Operating Costs* The cost of operation of automobiles is taken from Bulletin 91 of the Iowa Engineering Experiment Station, "*Operating Cost Statistics of Automobiles and Trucks* " Data from that bulletin are included herewith as Table VIII

The annual traffic over each mile of the section of the Boston Post Road between New Haven and Milford, Connecticut is estimated at 6,750,000 vehicles, of which 6,075,000 are automobiles The total operating cost of this number of automobiles is, on the basis of Table VIII, $330,480 00.

TABLE VIII

COST OF OPERATION OF AN "AVERAGE" AUTOMOBILE ON HIGH TYPE ROADS

Item of cost	Cents per mile
Gasoline	1 09
Oil	0 22
Tires and Tubes	0 29
Maintenance	1 43
Depreciation	1 26
License	0 14
Garage at $4 00 per month	0 44
Interest at 6 per cent	0 36
Insurance	0 21
Total Cost	5 44

TABLE IX

COST OF OPERATING AN "AVERAGE" COMMERCIAL VEHICLE

Cost of Operation Includes Maintenance and Depreciation	15 15¢ per mile
Average Miles per Gallon of Gas	11 22 miles
Average Miles per Quart of Oil	99 25 miles
Average Pay Load	42 25 pounds

2. *Commercial Vehicles* The cost of operation for commercial vehicles is taken from a *National Motor Truck Analysis* made by the General Motors Corporation[2] in 1929 The data contained in this report lead to average costs of commerical vehicle operation as shown in Table IX

The number of commercial vehicles which annually use each mile of this section of highway is estimated at 675,000 At 15 15 cents per mile, the annual cost of operating this number of commercial vehicles is $102,262 50 per mile

[2] National Motor Truck Analysis, General Motors Truck Corporation, 1929, p 7-8

3 *Contributions to Road Funds* Contributions of owners of motor vehicles to road funds are obtained from two sources the gas tax and the registration fee In the state of Connecticut, a two cent tax is levied upon every gallon of gasoline sold The whole of the collections from the gas tax and the whole of the collections from the registration fee are available for use by the State Highway Department for highway work

a *Automobiles* As shown in Table VIII, 1 09 cents of the total operating cost of the "average" automobile is attributed to the cost of gasoline With gasoline at 20 cents per gallon (as used in Bulletin 91) and knowing that the whole of the 2 cent tax is available for road purposes, the amount which each vehicle contributes to the road funds through the gas tax is $\frac{2\ 00}{20\ 00} \times 1\ 09$ or 0 109 cent per mile of travel Applying this amount to the 6,075,000 automobiles which annually use each mile of the section of road under analysis, it is found that the annual contribution of this traffic to the road funds through the gas tax is $6,621 75 per mile of road

In the same way, Table VIII shows that 0 14 cent of the total operating cost of the "average" automobile is attributed to the cost of the registration fee Since the whole of these collections is used for road purposes, the contribution of each vehicle through the registration fee is 0 14 cent per mile of travel With an annual traffic of 6,075,000 automobiles per mile of highway, as previously stated, the total contribution to the road funds through the license fee is $8,505 00 per mile of road

The total contributions to the road funds through the gas tax and the registration fee of the 6,075,000 automobiles which annually use each mile of the section of the Boston Post Road between New Haven and Milford, Connecticut is $6,621 75 + $8,505 00 or $15,126 75 per mile of road

b *Commercial Vehicles* The *General Motors National Motor Truck Analysis* has indicated that the average motor truck will travel 11 25 miles per gallon of gasoline With gasoline at 20 cents per gallon, the cost of gasoline for the average truck is $\frac{20\ 00}{11\ 25}$ or 1 78 cents per mile of travel With a 2 cent gasoline tax, all of which reverts to the road funds, each vehicle contributes $\frac{2\ 00}{20\ 00} \times 1\ 78$ or 0 178 cent per mile Since it is estimated that the annual truck traffic is 675,000 vehicles per mile, the amount which this traffic contributes annually to road funds through the gas tax is $1,201 50 per mile of road.

In the determination of the contributions through the registration fee, several assumptions are necessary. The average pay load of the "average" truck is 4225 pounds[3] It is not illogical to assume, therefore, that the "average" truck is a two ton truck The license fee for such a truck, in the State of Connecticut, is \$50 00 Assuming an annual mileage of 10,000 miles, the cost of the registration fee is $\frac{50\ 00}{10{,}000}$ or 0 5 cent per mile With the whole of the registration fee reverting to the road funds, the contribution of 675,000 commercial vehicles would be \$3,375 00 per mile of road

The total contributions to the road funds through the gas tax and the registration fee, therefore, of the 675,000 commercial vehicles which annually use each mile of the section of the Boston Post Road between New Haven and Milford, Connecticut is \$1,201 50 + \$3,375 00 or \$4,576 50 per mile of road

Section Four Cost of Highway Transportation

Since the cost of highway transportation is to be determined for both automobiles and commerical vehicles, it will be necessary to split the annual road cost between these two classes It seems that this division should be made upon the basis of annual tonnage, rather than on total numbers

Assuming that the automobile vehicle weighs $1\frac{1}{4}$ tons and the average weight of a 2 ton truck is 4 tons, the total annual tonnage carried by every mile of the section of U S Highway No 1 between New Haven and Milford, Connecticut is 10,293,750 tons Of this amount, 7,593,750 tons may be attributed to automobiles and 2,700,000 tons to commercial vehicles Apportioning the annual road cost on this basis, the amount which must be born by automobiles is \$6968 00 while the amount to be carried by commercial vehicles is \$2477 00 per mile

After substitution of the values for the annual road costs, the annual operating costs, the annual contributions to the road funds, and the annual traffic, the following costs of highway transportation are obtained

For automobiles,

Theoretical Cost of Highway Transportation

$$= \frac{\$6968\ 00 + (\$330{,}480\ 00 - \$15{,}126\ 75)}{6{,}075{,}000}$$

$= 5\ 31$ cents per vehicle per mile

For commercial vehicles,

Theoretical Cost of Highway Transportation

$$= \frac{\$2477\ 00 + (\$102{,}262\ 50 - \$4576\ 50)}{675{,}000}$$

$= 14\ 84$ cents per vehicle per mile

[3] National Motor Truck Analysis, General Motors Truck Corporation, 1929, p 7–8

PART II HIGHWAY TRANSPORTATION COSTS ON U S HIGHWAY 65 BETWEEN DES MOINES AND AMES, IOWA

This part of the report presents the computations necessary to determine the annual cost of the Jefferson Highway, U S 65, between Ames, Iowa and Des Moines, Iowa This portion of the Jefferson Highway is one of the heaviest traveled roads in the State of Iowa It is the link which connects Des Moines with the Lincoln Highway at Ames, is one of the principal north and south traffic arteries of the state, and is also an important part of the transcontinental highway which connects Winnipeg, Canada and New Orleans, Louisiana and the Gulf States

Des Moines is the capital of the State of Iowa, has a population of 142,469, and is the largest city in the state Ames is approximately 30 miles north of Des Moines, has a population of 10,261, and is the largest city in Story County The main offices of the Iowa State Highway Commission are located at Ames as is also the Iowa State College of Agriculture and Mechanic Arts

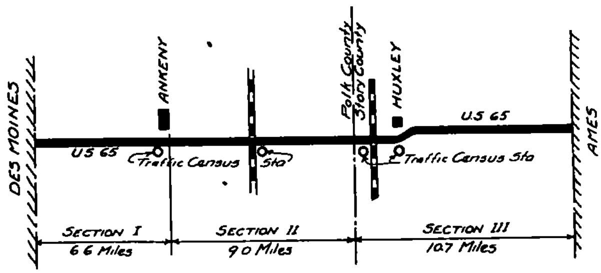

Figure 6 U S. Highway No 65, between Ames and Des Moines, Iowa

The two cities are connected by a concrete highway approximately 26 3 miles in length, the annual cost of which has been calculated

For purposes of convenience, this highway has been divided into three sections as shown in Figure 6 Section I comprises that portion of the road between the city limits of Des Moines and the village of Ankeny, Section II, between Ankeny and the Story-Polk County line, and Section III, between the Story-Polk County line and the city limits of Ames

Section I, 6 6 miles in length, was paved in 1920 under Federal Aid Project 104 Quoting the Iowa State Highway Commission, "no road in the State has been so much 'cussed' and 'discussed' as this section of heavily traveled roadway It is one of the oldest roads leading into the State capital It has passed through every stage of highway improvement It has been plowed and scrapered, dragged, wheel-scrapered, blade-graded, steam-rollered and all the rest of it It has been ox-teamed, horse-teamed, steam-engined and gas-tractored It has been a prairie trail, an earth road, a coal mine slag road, oiled slag road, gravel, oiled gravel and dirt road again, time after time Now it is a 20-foot concrete highway "

Section II, 9 0 miles in length, was paved in 1923 under Federal Aid Project 187, and was practically an entirely new right-of-way due to relocation of this section of the route

Section III, 10 7 miles in length, was paved in 1929 under Federal Aid Project 311, originally an earth road, this section was later surfaced with gravel and finally with concrete paving in 1929

Section One Computation of Annual Road Cost

In the following analysis, the costs have been grouped in accordance with the classification given in the preceding paragraphs Each item has been headed with the instructions for its determination as outlined in the Committee report The sources of information for each item have been shown and a tabulation of the complete cost figures for each item will be found The committee has endeavored throughout this report, to follow a logical sequence and arrange the material in a way that can be readily followed by anyone attempting to find the annual cost of any given highway

1. *Right-of-Way* "Assume the easement for the right-of-way to have a value equal to the value of the land for agricultural or other purposes at the present date "

In the determination of the right-of-way value, the construction plans for the various sections of road were found to be of use These were readily obtainable at the Iowa State Highway Commission offices Right-of-way lines are usually indicated on the road plans and the length and various widths of right-of-way are easily scaled After determining the total area it is quite simple to apply a unit value and calculate the total value of the right-of-way This unit value will vary to a considerable extent, being more or less dependent upon local conditions It should, as stated above, be equal to the value of the land for agricultural or other purposes at the present date

In determining the total worth of right-of-way, the fair value of the land for agricultural purposes has been estimated at $175 00 per acre Applying this figure to 217 5 acres, a total value of approximately $38,000 00 was obtained

2 *Drainage Structures* "Use the actual cost of the drainage structures as of record except for major stream crossings that serve traffic from additional miles of road The fair proportion of the cost of these major stream crossings is to be reduced to a cost as of specific date by applying the Engineering News Record price index or other reliable data "

It was found that the determination of the cost of drainage structures, along with that of earthwork has presented the greatest difficulty, and the following method of procedure for this determination was evolved

The costs of those drainage structures built under the jurisdiction of the Iowa State Highway Commission were found through the use of project maps, road plans, records of contracts, and the paid voucher files at the offices of the Highway Commission The costs of those structures built prior to that time were found through plans and reports at the County Engineers' offices

Reference to the opening paragraph of this section indicates that "the fair proportion of the cost of major stream crossings that serve traffic from additional miles of road shall be charged against the system under analysis"

There are no crossings which one might be justified in calling "major" stream crossings on this section of highway A study of the traffic using this highway indicates that a small percentage is interstate traffic and that the major portion is inter-county or local traffic It is logical, therefore, to use the total cost of drainage structures as of May, 1930

The total cost of the drainage structures as of May, 1930, is $132,950 00, or approximately $5,050 00 per mile

3 *Earthwork and Prior Surfaces* "Charge the actual cost of grading and prior surfaces By prior surfaces is meant any wearing surface that has become an integral part of the existing wearing surface as when a surface has been changed to a higher type"

As stated above, by prior surfaces is meant any wearing surface that has become an integral part of the existing wearing surface The gravel and other surfacing materials used on the highway under consideration can, in no way, be considered as an integral part of the present concrete surface, having been no more than maintenance construction, the cost of prior. surfaces, therefore, need not be considered It is necessary to obtain only the costs of the earth-work involved in bringing the road to its present grade

The determination of the cost of earthwork on prior surfaces follows the method of procedure outlined in the determination of the cost of drainage structures For earthwork of recent date, the use of the project maps, records of contracts and paid voucher files at the Highway Commission offices is again necessary Similarly, that work performed before the organization of the Highway Commission can be obtained, with a more or less degree of accuracy, at the office of the County Engineers Again a certain amount of estimation is necessary as these old records are far from complete The cost figures for each year are then reduced to a cost as of date by application of the Engineering News Record price index

The total expenditures for earth-work as of May, 1930 were $204,000 00, an average of approximately $7,750 00 per mile

4 *Road Surface* "Determine from the construction records the actual total cost of the road surface and reduce to a cost as of specific date by applying the Engineering News Record price index, or other reliable data, to the sections constructed during each year"

This cost determination is simple as it is necessary to refer only to the paid voucher files at the Highway Commission offices to secure the construction costs of the various sections These costs are reduced to costs as of present date by application of the Engineering News Record Construction Cost Index (Figure 1)

The total construction cost of the three sections comprising U S 65 between Ames and Des Moines was $844,017 89, or approximately $32,000 00 per mile Reduced to a cost as of present date, this total cost is $771,000 00 or $29,300 00 per mile

5 *Signs and Other Appurtenances* "Compute the total cost of signs, guard fence and similar appurtenances Crossing eliminations to be handled in the same manner as major stream crossings"

The simplest and surest way to obtain a reasonably correct figure for this item consists of making an actual count of the number of signs and an actual measurement of the length of guard rail Through price lists and other information available at the offices of the Highway Commission, it is then possible to compute the total cost of this item

The total cost of this item for the highway under consideration is $4200 00 or $160 00 per mile

6 *Engineering and Administration* "The cost of engineering and administration is to be determined by applying to the total cost of all of the foregoing items the percentage which represents the actual cost of this item in the jurisdiction (5 per cent may be used as a close approximation)"

Consultation of the 15th Annual Report of the Iowa State Highway Commission shows that this percentage, for Iowa, is 6 13 Applying this percentage to $1,150,150 00 the total cost of items 1 to 5 inclusive, it is found that the cost of engineering, inspection and administration on this road is $70,500 00, or $2,680 00 per mile

7 *Summary* "The grand total of items 1 to 6 inclusive constitutes the quantity A in formula 1

Using the values found in the preceding sections, the total construction cost of U S 65 between Ames and Des Moines as of May, 1930, is $1,220,650 00 or $46,600 00 per mile The following summary gives the value of each of the items making up the construction cost

Summary

Right-of-way	$38,000 00
Drainage Structures	132,950 00
Earthwork on Prior Surfaces	204,000 00
Road Surface	771,000 00
Signs and Other Appurtenances	4,200 00
Engineering and Administration	70,500 00
Total Construction Cost	$1,220,650 00

8 *Maintenance Cost* "The items of maintenace cost shall be determined from records of maintenance cost on the roads under consideration, supplemented by records of costs on like roads under equivalent traffic conditions in nearby areas where climatic conditions are similar Where the type of surface requires routine maintenance supplemented by periodic special maintenace such as resurfacing, re-oiling and the like, the annual maintenance cost shall be determined as prescribed in Section I The maintenance costs shall include the appropriate rental charge for equipment "

a *Annual Maintenance Cost* The annual reports of the Iowa State Highway Commission are used as a basis for the determination of the annual maintenance costs on the system under analysis In these reports, maintenance costs are grouped according to various "units " Unit 1 is composed of 65 1 miles of concrete pavement in Polk County, 15 7 miles of which are made up of Section I and II of U S 65 between Ames and Des Moines

The total maintenance costs on the 65 1 miles of Unit 1 for the years 1927, 1928, and 1929 were, respectively, \$26,516 97, \$22,330 93, and \$24,293 15 The average for these three years is \$24,380 35 or \$375 00 per mile Applying this figure to the 26 3 miles of the highway being studied, an annual maintenance cost of \$9,850 00 is obtained

b *Periodic Maintenance* In considering the expenditure for periodic maintenance, only the expenditure necessary for the replacement of the pavement surface has been considered Signs, guard rail and similar appurtenances are maintained and replaced as needed, these costs are included in the maintenance charge already computed Under present conditions, a forecast of the probable life of drainage structures can hardly be made It is reasonable to assume that with proper repairs, the cost of which is also included in the annual maintenance cost, these structures will last for a very long period of time Furthermore, with a "very long life," the annual charge predicated on reconstruction at the end of the period is so very small that it becomes irrelevant

In calculating the expenditure for periodic maintenance or replacement of the pavement surface, it is assumed that the pavement, at the end of its economic life, which is assumed to be 25 years in view of the amount and character of the traffic, can be used as a base course for some type of surfacing Based upon this assumption, the present surfacing will have a salvage value of \$1 50 per square yard, or a total value of \$463,500 00 Subtracting this value from \$771,000 00, the construction cost as of April, 1930, it is found that the replacement cost is \$308,500 00

The amount of money which must be set aside each year to accumulate one dollar at the end of a certain number of years is given by the formula

$$s = \frac{r}{(1 + r)^n - 1}$$

Where

s = the sum

r = rate of interest

n = number of years

If we wish to accumulate the replacement value of the pavement surface at the end of its economic life, the above expression becomes

$$s = \frac{rE}{(1 + r)^n - 1}$$

Where

s = the annual charge for periodic mantenance

E = expenditure for periodic maintenance every n years

r = rate of interest prevailing in current State financing

With r = 0 0425, E = $308,500 00, and n = 25 years, the annual expenditure for periodic maintenance is $7,160 00

TABLE X

CALCULATION OF ANNUAL ROAD COST

U S 65 between Des Moines and Ames, Iowa

Interest on Investment @ 4½ per cent	$51,877 00
Annual Maintenance Charge	9,850 00
Annual Expenditure for Engineering and Administration	43 00
Periodic Maintenance	7,160 00
Annual Road Cost	68,830 00
Annual Cost per Mile	2,620 00

9 *Engineering and Administration on Maintenance* "This shall be determined by calculating the ratio of such overhead costs to the total expenditures for maintenance in the jurisdiction, and applying that percentage to the total of item 8"

The 15th Annual Report of the Iowa State Highway Commission indicates that engineering and administration is 0 433 per cent of the total maintenance cost This percentage represents the part of the total engineering and administration figures which it is possible to definitely classify as being applicable to maintenance Applying this percentage to $9,850 00, it is found that the total cost of engineering and administration on maintenance is $42 65

10 *Annual Cost of U S 65 Between Ames and Des Moines* Substituting the values found in Items 1 to 9 in formula 1, one arrives at a value for the annual road cost This formula states that the annual cost of a given highway is equal to the interest on the investment (A), plus the annual maintenance charges, plus the annual expenditure for periodic maintenance

Table X shows that the annual cost of U S 65 between Ames and Des Moines is $68,830 00 or approximately $2,620 00 per mile

Section Two Traffic Survey

A *General Considerations* An actual census was taken at various intervals through the spring and summer of 1930, of the number of vehicles using the highway and this was used as the basis of estimating the probable annual traffic on U S 65, between Ames and Des Moines

The census indicates that the average week day traffic is approximately 2,125 vehicles per day and the average week-end (Saturday and Sunday) traffic is approximately 3,370 vehicles per day The variation of traffic over the average week day and week-end day is shown in Figure 7

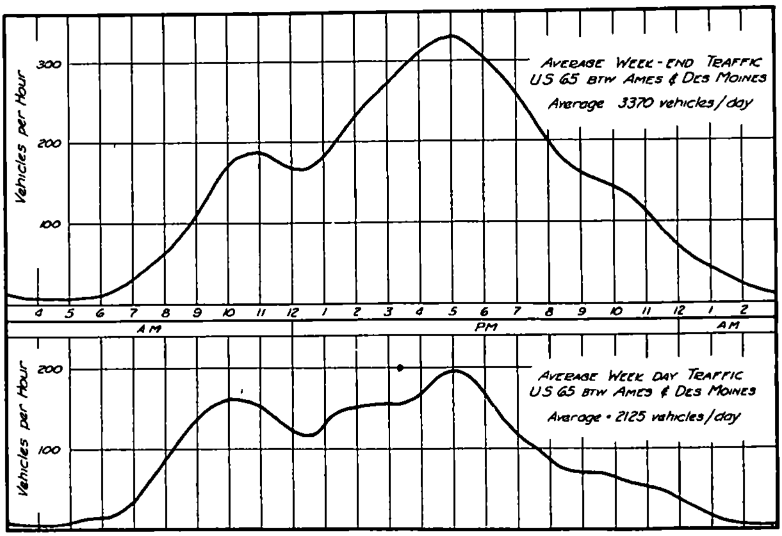

Figure 7 Variation in Week Day and Week-end Traffic in U S Highway No 65 between Ames and Des Moines, Iowa

A study of the data leads to the conclusion that the averge weekly traffic is approximtaely 17,500 vehicles, the average monthly traffic, between 78,000 and 80,000 vehicles and the annual traffic, between 900,000 and 1,000,000 The total annual traffic may be estimated at 1,000,000 vehicles of which commercial vehicles are so small a percentage as to be negligible

Section Three Highway Transportation Costs

In any study of highway transportation costs, there are two factors that must always be considered These are, first, the apportionment of the annual road cost to the vehicles using the road; and second, the annual operating cost of these vehicles The following formula, proposed by the Committee in its report, gives the basis for determining the cost of highway transportation per vehicle mile

$$\left.\begin{matrix}\text{Highway}\\ \text{Transportation}\\ \text{Cost per}\\ \text{Vehicle Mile}\end{matrix}\right\} = \frac{\left\{\begin{matrix}\text{Annual Cost of}\\ \text{Roads per Mile}\end{matrix}\right\} + \left\{\begin{matrix}\text{Annual Operating Cost per Mile}\\ \text{of Annual Traffic Less Contribu-}\\ \text{tions to Road Funds}\end{matrix}\right\}}{\text{Annual Traffic}}$$

This formula has been used in determining the cost of highway transportation on U S 65 between Ames and Des Moines

1 *Road Costs* The annual road cost is made up of (1) the interest on the original investment, (2) the annual maintenance charges, and (3) the annual charge for periodic maintenance Table X shows that this annual cost for the highway under analysis is $2,620 00 per mile

2 *Vehicle Operating Costs* For the purposes of this problem, vehicle operating costs have been taken from Bulletin 91 of the Iowa Engineering Experiment Station This bulletin estimates that it costs 5 44 cents to operate an "average" automobile over one mile of concrete pavement With an annual traffic of 1,000,000 vehicles per mile, it is evident that the annual operating cost of this traffic is $54,400 00 per mile

3 *Contributions to Road Funds* Contributions to road funds in Iowa are obtained from two sources the gas tax and the license fee Quite naturally, several assumptions are necessary in calculating these contributions from a relatively small volume of traffic operating over one mile of road It is with this in mind that the following computations are offered

In the State of Iowa, a 3 cent tax is levied upon every gallon of gasoline sold According to the latest revision, the law states that five-ninths of the 3 cent tax, or $1\frac{2}{3}$ cents, shall be apportioned to the state for use on the primary road system. The remaining $1\frac{1}{3}$ cents is apportioned to the various counties of the state for use on county and township roads

As shown in Table VIII, 1 09 cent of the total operating cost of the average automobile is attributed to the cost of gasoline

With gasoline at 20 cents per gallon (as used in Bulletin 91) and knowing that $1\frac{2}{3}$ cents of the 3 cents gas tax reverts to the primary road funds, the amount which each vehicle contributes to the road funds through the gas tax is $\frac{1\ 667}{20} \times 1\ 09$ or 0 091 cents per mile of travel

Applying this amount to the one million vehicles using each mile of U S 65 between Ames and Des Moines, the total contribution of this traffic to the road funds through the gas tax is $910 00

In the same way, Table VIII shows that 0 14 cent of the total operating cost of the "average" automobile is attributed to the cost of license fees In the State of Iowa, however, only 95 per cent of this amount reverts to the primary road funds The contribution, therefore, of each vehicle to the road funds through the license fee is 0 133 cents per mile With an annual traffic of one million vehicles per mile, the contribution of this traffic to the road funds through the license fees is $1,330 00

4 *Highway Transportation Cost on U S 65 between Ames and Des Moines* By substitution of the values for the annual road costs, the annual operating costs, the annual contritutions, to road funds and the annual traffic, highway transportation cost is computed as follows

$$\left.\begin{array}{c}\text{Theoretical Cost of}\\ \text{Highway Transportation}\\ \text{for Automobiles}\end{array}\right\} = \frac{2620 + (54{,}400 - 2240)}{1{,}000{,}000}$$

$$= 5\ 47 \text{ cents per vehicle mile}$$

DISCUSSION

ON

HIGHWAY TRANSPORTATION

Professor C B Breed, *Massachusetts Institute of Technology* In the above analysis of the Transportation Costs on the Boston Post Road, the passenger vehicle operating cost per mile is taken as 5 44 cents (from Bulletin 91 of the Iowa Experiment Station) The Road Cost per passenger vehicle mile will be the total road cost per mile $6968 divided by the number of passenger vehicles, which equals 0 11 cents Adding these two figures gives 5 55 cents as the total Transportation Cost per passenger vehicle mile.

Similarly the Transportation Cost per commercial vehicle mile on the Boston Post Road is 15 15 cents vehicle operating costs plus 0 31 cents allocated road cost per commercial vehicle mile, or 15 46 cents per commercial vehicle mile

In the case of the total passenger vehicle mile cost of 5 55 cents, it is obvious that the cost of vehicle operation, 5 44 cents, entirely masks the road cost per vehicle mile It has only cost 0 11 cents per passenger vehicle mile to build that road and to maintain it in serviceable condition in perpetuity, whereas the passenger cars contributed 0 11 cents gas tax plus 0 14 cents registration fee, or 0 25 cents per vehicle mile toward the road costs Putting it in another form, the passenger vehicle traffic on the Boston Post Road paid in gas tax alone sufficient to pay for all road costs, and in addition paid 0 14 cents per vehicle mile in the form of registration fees

It is true of course that this particular four-lane road is carrying a very large volume of traffic which comes to the Boston Post Road and departs from it over roads of very much lighter traffic where an analysis like the above would show a different picture

The Ames-Des Moines Road, No 65, which has also been analyzed by the method proposed by the Committee shows that the total transportation cost per passenger vehicle mile is 5 44 (vehicle operating cost) plus 0 26 (road cost per vehicle mile) = 5 70 cents per passenger vehicle mile The commercial vehicles on this road were negligible in number

This total cost 5 70 cents on the Ames-Des Moines Road is not unlike the total cost 5 55 cents on the Boston Post Road—because the vehicle operating cost is such a large proportion of the entire cost Yet the road cost per vehicle mile on the Iowa road with 1,000,000 vehicles was (0 26 cent) more than double the road cost (0 11 cent) on the Connecticut road with 6,000,000 miles per year

On the Iowa road the passenger vehicles contributed for each mile a gas tax of 0 09 cent and also 0 13 cent through registration fees, or a total contribution of 0 22 cent per vehicle mile trust road funds

On this Iowa road, with 1,000,000 vehicles per year on a two-lane highway, the contribution of the vehicle drivers in gas tax and registration fees does not quite pay all road costs

The above analyses lead one to conclude that on roads of heavy traffic, 1,000,000 passenger vehicles and above per year, the passenger cars are, with respect to that particular road only, probably paying the full road cost at the prevailing gas tax and registration fees, but this by no means is true for the thousands of miles of highways that feed these heavily traveled thoroughfares

MR A J BROSSEAU, *Mack Trucks, Inc* Professor Breed gave an analysis of the extent to which the passenger cars pay their way, but no reference was made to the truck I am wondering if you have any information which would tell us whether the truck comes as near to paying its way as the passenger car

PROFESSOR BREED The commercial vehicles on the Boston Post Road amounted to about 10 per cent of the total number of vehicles, or 675,000 trucks In the analysis made it was assumed that the operating cost per mile of an "average" commercial vehicle is 15 15 cents and that the road cost is 0 31 cent per vehicle mile, or a total Transportation Cost per commercial vehicle mile of 15 46 cents The commercial vehicles contributed to road costs per mile in the form of gas tax 0 18 cent and in the form of registration fees 0 50 cent, or a total of 0 68 cent; as against a road cost per mile of 0 31 cent So it will be seen that the commercial vehicle on the Boston Post Road contributed toward road cost (0 68 to 0 31) in about the same ratio as the passenger automobiles did (0 25 to 0 11)

Mr E W James, *Bureau of Public Roads* When the first report by Professor Agg was under consideration last year by the Research Committee of the Bureau of Public Roads, I raised the question whether the use of a sample section of the whole system for determining figures of this sort should be relied upon as sufficiently accurate from which to draw conclusions I now feel that there is more involved in the matter than accuracy, and that it is really dangerous to use this sampling of a road section for drawing such conclusions If we should accept the condition as applying to U S No 1 in Connecticut, we should have an indication that the automobile and the truck are unquestionably paying a great deal more than they should be called upon to pay

In the discussion last year, I said that I thought the best way to attack this problem, instead of taking A, the cost of the road for the section in particular, would be to take A as the total cost of the road system in a State and M as the annual maintenance charge of the State for its road system, and similarly for the other items For the reasons shown in the report the traffic on U S No 1 in Connecticut is heavy enough to give the stated result, but the traffic on miles and miles of the road system in Connecticut probably will show a deficit when you allot to the automobile traffic on these sections the cost attributable to the vehicle The heavy vehicle costs on the heavily traveled sections may be absorbed by that traffic perhaps twice, whereas the light traffic on other sections will not absorb the vehicle cost through the gasoline taxes and the vehicle fees that may be paid

The only way in which you can arrive at a conclusion that is sound is to take the whole system and find out if the costs of the entire system are being met by the contribution of the traffic on the entire system, because, as I say, you will find some pieces so heavily traveled that the automobile will seem to be contributing more than any one car should contribute On the other hand there is so little traffic on some of the other built sections that there the automobiles will not be contributing enough, and to reach a sound conclusion we have to secure all of the costs of the entire system and then get all the traffic on the entire system for your other unit

Dr L I Hewes, *Bureau of Public Roads* I would like to speak a moment on this question Mr James has the habit of taking away my speeches from me! I want to support in general what he said but in a slightly different way You can all see from the discussion this afternoon of two of the papers that we are really approaching a question of *rate making* The cooperative endeavor between the Bureau and the University of Wisconsin will result in a report which will furnish basic facts for such procedure We will eventually have before us the question of the rate of taxation for gasoline Now this formula, I think, should be subject to very careful scrutiny It is an example of one method of approach, of painstaking anaylsis of the sample cost

We write the formula in four terms involving six variables,—all of these variables involve some question First, how many years are you going to count that interest? And is N^1 greater than N and what is E That thought of formal presentation is absolutely necessary but don't let us assure ourselves too much Since we have written the formula, I would like to inquire whether it would not be possible to apply what Mr James suggests? Take a State and see whether the miles in that State multiplied by "C" would check against the total cost

Furthermore, what is the traffic capacity of a road? Should we not consider what these costs are when the road is operating at normal capacity? We have here two samples—in Connecticut and Iowa, samples of different kinds of traffic but we have nothing to state as to the capacity of either road Now, of course, that involves some more variables and so we go on But we have better mass data now for checking the mass figures by taking not a road but a system of roads For one I do not believe that the road building program for the past quarter of a century has evidenced much over-building I have watched it since 1897 We have never over-built—I would say in general we have under-built

I think we should inquire whether or not those figures check with the gasoline revenue Furthermore what cost are we computing, the cost to the community, to the owner or the operator, or the combined cost?

The first formula for C was, I take it, intended to represent the cost to the community Now we bring in 5 44 cents which is the cost to the operator It is more or less true that the operating unit is the public, but that is not sufficiently clear We also get into the twilight zone there (regarding whose cost is involved) in connection with subtracting this payment under the gas and license fee

I attempted some years ago in California to bring out this question of rate making on particular routes, and large mileages, and to find out whether the number of recorded passing vehicles really paid in gas and plate taxes for the maintenance of those roads We found later some difficult hurdles to jump We could not, for example, segregate the movement of the vehicles in the municipalities where we had no traffic data I think one of the things these studies teach us to do as a research group is to determine next what is the split between urban and rural movement How is the gas used? Establish a check on the traffic census count with the gas and then apply this formula for C to the mass data that can be easily segregated.

It seems to me that it is otherwise very dangerous to set up this formula because this body is a body of extreme authority and when we put out a formula those of less authority worship by that formula I do not know what value is used for N Your sinking fund involves the same rate as used for the interest on your investment (cost) A How long should we pay interest? We could not pay now for interest on the total public construction There isn't enough money in the world to pay it We are not in the habit of amortizing loans actually by the annuity formula We have examples of those loans financed by the gas tax, that procedure is of another form that has to be worked out I do not know whether the truck costs there indicated involve any time of operator I suppose that is in another place. It is a curious fact that we can frequently find trucks to transport material for as low as 17 cents per ton mile but the cost here is 15 46 cents without a driver, is it not?

Professor Agg The committee approves quite fully most of the points raised by Dr Hewes and by Mr James, and I think our position may be said to be this That we are approaching a time when a correct analysis of this problem is entirely desirable from many points of view We have attempted to take a sample or to take two samples, and to show how the methods set up by the committee can be applied The results thus obtained have no value beyond showing the actual situation on these two highways Had it not been for the fact that this report was being presented to a body like this, men of scientific turn of mind, men who are really seeking after research data, I certainly would never have felt like presenting a report of this type I do believe, however, that there is food for thought in the results that are presented in this report I also believe the method of attack should commend itself and doubtless as the committee continues its studies, and as the matter is discussed, we will arrive at a reasonable and satisfactory basis if we are not already there I would like to make one point clear This is not a report for general publicity, nor a report intended to be a final answer to any particular question, but it is intended to show how the engineer should approach a problem of this type and to give him a problem completely worked out so that if he wishes to make a similar analysis on one mile of road or on a whole system of roads, he will have a basis for procedure

With reference to the formula about which Dr Hewes commented, I think it will be found to be economically sound The question that we must decide and which is the troublesome question at the present moment is the point upon which he raised the question as to what value to insert under E and what value to insert under maintenance We will never know what values to insert for any of these until the life history of some of these roads unfolds itself before us so we will know what has happened At the present time we can only judge the future by what has happened in the past and our past prognostication may be considerably in error We have sensed that situation and have done the best we could in that direction We want to make the explanation in the case of both of these highways, that the past is a matter of record It is exactly the same problem that confronts the valuation engineer in connection with an industrial valuation problem He must make assumptions as to future service life and other factors of that type and his valuation is only as accurate as is his estimate of what will happen in the future

Mr H K Craig, *Pennsylvania Department of Highways* The Iowa road as I understand it, carries an average of 3,000 and the Connecticut road, 6,000 vehicles a day Would that average daily traffic in Iowa justify the same type of road that the average daily traffic in Connecticut would justify?

Professor Agg I am not sure that I got the drift of your question The question as to whether you would be justified in building a road under traffic conditions is not involved in this project The point that you perhaps thought of in this connection is that the Iowa road does not quite pay for itself, that is to say, the traffic does not at present quite pay for the perpetual maintenance of that road while the Connecticut road pays something in excess These are not particularly typical roads in each system We did not go into that question and do not presume to say that this analysis tells you when you ought to build a high type road and when not to build That is another question entirely

Mr Craig The purpose of my inquiry was to have it made clear that the two sections of road under discussion were not selected as average or representative sections It evidently was not intended that general conclusions be drawn from this report as to trucks and buses or other vehicles paying their share or more than their share of road costs, and the report will not sustain such general conclusions

Professor Breed I agree thoroughly with what Professor Agg says and I would go a step further—I would not want to use an average figure for an entire state, as suggested by Mr James, for there is often greater danger in the use of average figures than in the use of values for specific cases I believe that the application of the above analysis to a number of specific typical roads will present valuable data from which conclusions can be intelligently drawn provided all of the essential facts can be obtained The aim of the Committee is to present a method of analysis that is sound It has given two illustrations where the facts were fairly reliable It hopes to present other applications in later reports If the method is right, the conclusions drawn from the results of these specific applications can safely be left to the intelligence of the profession

Dr Hewes· I do not wish to give a wrong impression—I think this type of investigation is extremely valuable as a reconnaissance It seems to me, however, that Mr James' idea has merit Understanding that sound averages are used, I believe we can set up categories to test out a formula like this We have here two sets of ideas confronting us, one is the theoretical formula, the other is what we derive from actual practice The cost of the vehicle is not so theoretical That certainly is made up of averages Would it be possible for instance to take a State like Iowa and check the operation of this formula against the several categories of road service? How does it apply for so many miles of say 18 foot concrete, so many miles of other kinds And if the formula has practicable application, the figures of the check would be illuminating

Now that formula is highly theoretical—for example, the amount needed to amortize assumes that money is set aside Presumably that may take the form of buying back the bonds in a State I do not know of many States that successfully and continuously operate a sinking fund for the purposes indicated by the last two terms at the right hand side of the equation for "C" Those two terms are highly theoretical The first term of the right hand member "A", the cost of the road, is certainly determined from averages and so is "M" determined from averages and probably with ample reason There are average methods used even in this formula so I do not see that we are denying the use of averages in checking its application

Dean Marston. As far as theoretical derivation of the question is concerned, I think it is perfectly sound

Mr J A Sourwine, *U S Bureau of Public Roads* As I have listened to this report and to its discussion, it has seemed to me that possibly some confusion has arisen The original basic presentation in the report would seem to consist in the computation of a theoretical perpetual cost of highway, based on certain assumptions of types of construction and cost, and of future needs In the special studies presented by Professor Breed, and in the later discussion by Mr Brosseau, Professor Breed, Mr Craig and Professor Agg, another entirely different problem has been discussed, being the determination of a unit of value for any given highway, to be used as a rate basis for the fixing of the proper tax which traffic shall pay

I wish to discuss briefly the general principles involved in the computation of a theoretical perpetual cost of highway, with particular reference to the use of such a unit of value, as supplementary data, to serve as a check on rate basis for tax on motor vehicles

I wish, also, to call attention, and I will discuss first, one item of unit value, presented by Professor Agg, which, if I understand correctly the method of computation used, appears to me an unsound value and one from which fallacious conclusions may be drawn I will ask a question, if I may, in order to be sure that I am clear as to the method used by the Committee in the computation of this item of unit value We have figures here for the average cost of operation of a motor vehicle Professor Agg, is the figure 5 44 cents for average passenger vehicle and 15 16 cents for average truck vehicle, computed for the State of Connecticut, or for the given highway which we are discussing in the State of Connecticut, or how is that cost computed?

PROFESSOR AGG It is an average cost of automobile operation from reports submitted to us, by owners from all over the United States

MR SOURWINE Referring to Bulletin 91 of the Engineering Experiment Station, Iowa State College, on "Operating Cost Statistics of Automobiles and Trucks," we find computed a relative cost of operating an imaginary average automobile and an imaginary average truck vehicle Two criticisms offer, in connection with this estimate

1 Is the average motor vehicle, truck or passenger, carrying traffic on roads of the two extremes of type, actually the same, or may the average type be widely different for these widely different conditions? In other words, is the average motor vehicle, truck or passenger, which represents typical traffic on the low type road, the same average motor vehicle, truck or passenger, which represents typical traffic on the high type main highway?

2 Does the average motor vehicle, truck or passenger, vary in different areas of the United States In other words, putting the above two criticisms in the form of one question, the question becomes "Can cost data based on an imaginary average motor vehicle, truck or passenger, determined from the study of a relatively small number of vehicles, located in scattered areas throughout the United States, be applied to determine the imaginary average motor vehicle, truck or passenger, operating over a given through highway, in a particular State, being in our one study, the Boston Post Road in the State of Connecticut

With regard to passenger vehicles, data for comparison appears to be lacking With regard to truck vehicles, the following comparative study is submitted, based partially on Iowa Bulletin 91, and partly on Connecticut "Survey of Transportation"

For Vehicles Studied in Bulletin 91, Iowa State College

(1) L D = 11 6 × 0 579 = 6 72
M D = 17 1 × 0 315 = 5 39
H D = 28 8 × 0 106 = 3 05
} Based on 46,017 trucks throughout United States

Total 15 16 cents per mile

Revised Cost (Computed for average conditions, State of Connecticut)

(2) L D = 0 658 × 11 6 = 7 63
M D = 0 151 × 17 1 = 2 58
} Based on 82,738 trucks in Connecticut
H D = 0 191 × 28 8 = 5 50

Total 15 71 cents per mile

Second Revised Cost (Computed for vehicle count on Boston Post Road, west of New Haven)

(3) L D = 0 481 × 11 6 = 5 58
M D = 0 197 × 17 1 = 3 37
H D = 0 322 × 28 8 = 9 27

Total 18 22 cents per mile

It is interesting to note that the average cost of operation as determined in Bulletin 91, for an average truck, throughout the United States, —and the average cost of operation for all trucks in the State of Connecticut, as determined by the Connecticut survey, are quite closely similar, differing only by about 5 per cent It is also of interest to note that the average truck vehicle, operating on the Boston Post Road, is quite different from the average truck vehicle operating throughout the State of Iowa, or the average truck vehicle operating throughout the State of Connecticut,—the average truck vehicle operating on the Boston-Post Road being considerably heavier and costing about 20 per cent more to operate, than the average truck vehicle throughout the State of Connecticut, or throughout the State of Iowa

The determination of a unit cost of motor vehicle operation, to be used as a basis for computing traffic tax, is a complex problem To select one arbitrary stretch of highway, to ignore all branch highways leading into that highway, and to ignore both the sources and destinations between which vehicles move,—seems comparable to the cutting off of a man's feet at his ankles, his hands at the wrists, and his head at the neck, and still count him as a living organism, and proceed to figure the operating efficiency of the parts remaining, which constitutes the portion normally connecting the feet with the hands, and both feet and hands with head Under such an assumed condition, the working organism will be dead There will be no use in figuring out a theoretical value for the parts remaining The activity of the organism will have ceased and so will its value—and the value of each of its parts We can not but see the analogy of an actively operating highway system to a human organism The highway system also is a living organism Its body, consisting of main traffic highways, is an important part of the system as a whole,—but to be a living, active, effective organism, it requires also hands and feet and head The persons and material transported over it have in each case a source and a destination

I offer three criticisms of the present study

1. The unit selected as a basis for study is not a representative highway unit, and does not offer a direct basis either (a) for comparative study of highway cost versus motor vehicle operation cost, or (b) for use as a guide in fixing rates of gas tax or motor vehicle license

2 A comparative study of highway cost versus motor vehicle operation cost, without consideration of the industrial phase of the highway problem, or of the industrial and agricultural service, made possible by improved highways,—does not offer a complete study of the problem, or give a true picture of existing facts

3 The use of general values over the United States, for cost of motor vehicle operation, without consideration of the actual condition of motor vehicle operation in the area or on the route being studied, does not give a true basis for comparative study

Other minor criticisms suggest themselves One is that all gas tax and motor vehicle license tax, for vehicles operating on a given highway, is not necessarily paid within the same State, as instance the assumption in this paper for the Boston Post Road in the State of Connecticut, where statistics show that for freight vehicles approximately one-third of the total ton mileage is carried by vehicles having a license outside the State of Connecticut, and operating under "through traffic" conditions, such that it seems likely a considerable portion of their fuel is also purchased outside of the state

Another minor item, is that the freight haul of a given main highway can not be measured by the number of vehicles in operation The average load varies greatly, depending upon the material hauled and depending upon the character and condition of the branch highways leading into the main highway

Another item is, that the average freight haul over the United States can not be accurately assumed as identical with the average freight haul of any given State, nor can the average haul either for the United States, or for the given State, be accurately assumed as identical with the average haul of a given through highway, in that State

Let me illustrate, I used to own an 80-acre farm It was located a mile and a half from a main traffic highway Beginning at the point on the main traffic highway nearest to my farm it was a distance of four miles to town, over a good high grade pavement But the portion of the one and one-half miles of branch road connecting my farm with the main traffic highway was not a travelable road So I went by a different road to town and over a poorer road, and my trucks carried lighter loads and it cost me at least 20 per cent more money per ton mile because I did not have access to that main traffic highway, and I had several neighbors in similar situation to mine For a period of several years after the completion of contruction on that main traffic highway, none of us were able to obtain practical use of it Finally, we succeeded in getting that one and one-half miles of connecting branch road improved Then we also became users of the main traffic highway into town, and by so doing we changed two things (1) we saved money by obtaining cheaper unit cost of transportation, (2) we rendered that main highway more efficient because we added to its amount of profitable traffic

Do I make clear what I mean? The main highway is of value only when it has profitable feeder lines—it is the body, through which movement passes The feeder lines are the feet and hands and head, without which effective bodily movement would cease All movement, either of human body or of highway traffic, must have a source and a destination Without these two prerequisites, movement there will be none, and if we assume conditions such that there is no life, or activity, or movement, why then go through the form of computing a theoretical value? Because practically, we know, without taking any time to present computed figures, that under such conditions, actual value there is none In general, the traffic use and relative efficiency of any main through highway, depends largely upon, and varies with, the conditions and capacity of the branch feeder roads leading into the main highway

We start to compute the value of a highway What is the first reqquisite on which we base value? "Traffic!"—comes the answer Why is a main highway of greater relative value per unit of length? Because it serves more traffic, per unit of length! But can it—will it—serve this traffic—without feeder lines, carrying that traffic from its many sources and to its many places of destination? I submit that it will not—it can not And therein, in this close relation of source and of destination, of relationship of main lines with feeder lines, lies the practical problem of highway transportation, which requires to be met, and which we must meet The factors are there, the main lines and the feeder lines are closely related each to the other and interdependent each upon the other, and when we endeavor to determine unit cost of operation based on the consideration only of one isolated stretch of highway, we are proceeding without sufficient facts, and the results we obtain are likely to be unsound, and to lead to conclusions which are not dependable

I submit, that in order to have a sound basis, for the determination of the cost of operation of highway vehicles per unit highway, and for the determination of data, which may be suitable for use if desired, for checking the rate basis or motor vehicle tax, we must use care in selecting a representative, typical unit of highway system Just what may be the best size of typical unit to be studied, remains a matter for determination and discussion The suggestion is made, however, that the unit studied should be a relatively complete, representative, and typical unit of the highway system It should be a section or area including one or more main highways, with several secondary cross roads and with branch roads or feeder roads, leading to points of destination and to sources of supply

Summarizing, I submit the following

1 The value of any highway is based on traffic

2 The amount of traffic transported and the value of traffic transported are important items which must be studied, as well as the number of traffic vehicles

3 The industrial value of traffic is an important factor which can not be neglected either in planning a highway system or in calculating its value

4 In considering the planning of the design, construction, or maintenance of a unit of highway system, or in computing the value of such a unit, the consideration of source and destination of persons and of material transported, can not be neglected

5 In planning highway layout, or in computing highway value, an important essential is, that the study shall cover and include a representative typical unit of the highway system

PROF D KRYNINE, *Research Associate in Soil Mechanics, Yale University* Any technical research work passes through the following stages (1) A theoretical idea, formula, or rule is conceived by the investigator Generally, it results from his practice, his knowledge, some preliminary experiments, and sometimes from intuition (2) Then the formula or the rule is checked in the field or in a laboratory, after which (3) a new step in the research work starts, namely, the modification of the original idea as corrected by the investigator himself, or by the people who work with him, or who follow the development of his ideas, or who are interested in them in any manner Finally, (4) the idea acquires its definite shape We are assisting now in the second step of the research work of the Committee on Highway Transportation, namely, the checking of the ideas discussed in the report of 1929

It is obvious that no investigator is in a position to check his idea on all the matters touched by it The writer wishes to quote an analogy from the field of Soil Mechanics, in which he has been working several years Suppose you are studying a certain property of soils, cohesion, let us say, or any other You cannot bring all the soils of the world to your laboratory in order to test them, the task would be thankless and unprofitable But if you are able to chose a few characteristic samples and to study them with proper intelligence, you may be sure that the results of your investigation will be satisfactory enough The same is true of the research work of the Transportation Committee Certainly, all the roads, even within the limits of one State, can not be studied That would entail an enormous and useless expenditure of time and energy Fair results may be obtained, however, by checking the formula on a few roads and highways intelligently chosen. Two such tests, indeed, are not too many, but it is to be hoped that the report of 1930 is but the beginning of a series of interesting reports, provided Professor Agg and the Committee will be able to find good statistical data with respect to different cost items

As to the details of the report, the present writer would make the following observations

1 One of the most interesting items of transportation cost is "Maintenance," annual and periodical It is important to know how the maintenance cost increases with the age of the pavement, and how often periodical maintenance is necessary If even a rough approximation might be found, the Committee formula would give values of C, increasing with the age of the pavement, even if the amount of traffic is constant In reality, this amount is subject to change, and if it increases, the increase of the maintnance cost would be accentuated

The average value of maintenance as introduced in formula (1) may give fair results for high types of roads But in dealing with lower types, more accurate values of C are needed Actually, it is interesting to know the proper time at which a low type of road should be changed to a higher one Suppose the annual value of a low type road increases from C_1 to C_2, then to C_3, afterward to C_4 and so on, reaching at last such a value, C_n, as is equal to or greater than the corresponding value of a higher type, then this is the proper time to change the type. These considerations are no more than a presentation, perhaps in different words, of the theory of "economical life" of a pavement so clearly developed by Professor Agg in his book on Roads and Pavements It is to be regretted that the idea of "economical life" has not been applied in the report of the Committee Incidentally, the theories of Professor Agg are known in different countries, and the present writer had the opportunity of discussing them in his own text-book on Highway Engineering [1]

2 In the report of the Committee, of December, 1929, section III, item 4, requires the subtraction of the amount of the gasoline tax from

[1] In Russian, 3rd ed , p 828

the transportation cost, because of the apportioning of that amount for use on roads This requirement is quite logical, because in the contrary case the amount of the gasoline tax would appear twice in the computation of the transportation cost, (a) charging the amount in question against the road under consideration, and (b) charging it against the road to which the said amount has been or will be invested Therefore the considerations of the Committee when dealing with the gasoline tax in Iowa may be considered, in the judgment of the writer, as not quite correct Actually, according to the report of the Committee, the Iowa law states 'that five-ninths of the three cent tax, or one and two-thirds cents, shall be apportioned to the state for use on the primary road system The remaining one and one-third cents is apportioned to the various counties for use on county and township roads' Therefore, the one and two-third cents devoted to the primary road funds is considered as a contribution to road funds and is subtracted from the cost of transportation; meanwhile the one and one-third cents assigned to the county and township roads appears twice, (a) being charged against U S Highway 65, and (b) being charged against any county or township road Thus a situation has been created in which the single system of road transportation has been divided in two different sections, one of which belongs to the State as such, and the other does not Following such a principle to its logical end, one should divide the state highways also into two sections (a) roads, such as U S Highway 65, which contribute to the construction and maintenance of the primary roads, and (b) the primary roads which obtain such help from their elder brothers, and this would be evidently a mistake

If the population of a state is to be considered as a whole, the system of roads being also a whole, it should be recognized that the amount of three cents should be deducted from the cost of transportation on U S Highway 65

3 The amount of "Engineering and Administration" on construction work has been estimated as 4 per cent in Connecticut, and as 6 13 per cent in Iowa Probably this difference may be explained by the greater distances in Iowa, and the loss of time and energy necessitated in attending works scattered in different parts of the State Taking into account this difference, the writer thinks that even within the limits of the same state large and concentrated works necessitate a smaller amount of "Engineering and Administration" expenses than smaller jobs Therefore all primary roads probably require a greater percentage of "Engineering and Administration" than highways of modern types

4 The report quotes the following figures on the total maintenance costs of 65 1 miles in Polk County, Iowa including 15 7 miles of the road, covered by the committee report for the years 1927, 1928, and 1929,

respectively $26,516, $22,330, $24,293 In cases of such fluctuations, it is interesting to analyze their cause before taking the average

With these slight observations, the writer thinks that the work of Professor Agg and of the Committee of Highway Transportation is a splendid achievement, and represents a noteworthy step in the development of Road Economics