Ohio Incremental Study: An Experiment in Vehicle-Tax Allocation

D. F. PANCOAST, *Ohio Department of Highways*

THE present paper, while based upon a solution for Ohio, emphasizes the use of new data and techniques which can be of general application. Methods of using data from road-use studies, loadometer surveys, and traffic classification counts are discussed.

Highways are divided into five groups according to types of pavement. These types are defined as those capable of carrying an indefinite number of repetitions of axle loads of 19,000 lb., 14,000 lb., 8,000 lb., and 4,000 lb. In each of these groups of highways, indices of incremental cost responsibility have been developed for pavements, structures, grading and drainage, and maintenance.

In the present study, a number of concepts were discarded and the analysis was based upon axle-miles. Costs of right of way and of the 30 percent of maintenance costs not assignable to definite highway sections (snow removal, traffic markings, etc.) were allocated on a vehicle-mile basis. Costs of the motor vehicle bureau (issuing licenses, etc.) and of the highway patrol were distributed equally among all vehicles.

It is believed that the new techniques described in this paper, while complicating the solution, represent a distinct advance in the attempt to make an equitable allocation of highway costs.

● AS far back as 1933, the Joint Committee of Railroads and Highway Users issued a report stating: "The basic cost of constructing, improving and maintaining a given highway should be determined from a highway designed for private passenger vehicles and other vehicles commensurate therewith. All vehicles using such highways should pay their proportionate share of that total as a base tax. The total additional cost of construction, improvements, and maintenance to make a road suitable for a type of vehicle requiring such additional cost should be shared by each vehicle of that type and each vehicle of greater size. Thus, each vehicle should share in the base cost plus all increments of cost up to and including cost required by it."

That still stands as a reasonably good definition of the "incremental," or "differential-cost," method of allocating the motor vehicle's share of highway costs among the several types of vehicles. Its use presupposes that the motor vehicle's fair share of highway costs as compared to the share to be borne by abutting property, the community, and other beneficiaries of highways, has already been determined.

The incremental method is not new. Probably the best known example of its use is in the report of the Federal Coördinator of Transportation.[1] Written at that same time was a report by Breed, Older, and Downs, for the Association of American Railroads.[2]

Among earlier studies using the incremental method were reports covering the highways of Oregon,[3] Illinois,[4] and Ontario.[5] The first of these is notable for the use of a short-cut method which uses only two increments; the basic highway and the standard highway. The former is a theoretical highway for basic vehicles of a gross weight of 4,000 lb. or less. The latter is a highway suitable for existing traffic.

A study of these and other incremental solutions, while rewarding as to methods, gives little help as to detailed figures. The paucity of data with which these authors had

[1] *Public Aids to Transportation*, Vol. IV, Government Printing Office (1940).

[2] C. B. Breed, Clifford Older, and W. S. Downs, *Highway Costs—A Study of Highway Costs and Motor Vehicle Payments in the United States* (1939).

[3] *Report of the Interim Committee for a Study of the Motor Transportation Act and the Fees and Taxes paid by the Road Users for the Highway Facilities Provided by the State of Oregon* (Jan. 1, 1937).

[4] V. L. Glover et al. *A Study of Highway Costs and Motor Vehicle Taxation in Illinois* (1938).

[5] C. B. Breed, Clifford Older, and W. S. Downs, *Report on Annual Highway Costs, Province of Ontario* (Feb. 21, 1938).

to work is appalling. Moreover, the costs and methods of construction and the characteristics of traffic have changed greatly in the last 10 or 15 yr. For example, the coördinator's report which the trucking industry refers to so nostalgicly, used 4 in. of concrete for the basic vehicles and only 6½ in. for the heaviest combinations. Now, 10 in. must be used. His heaviest combinations averaged 32,500 lb. gross weight and 28,000 mi. a year. Those figures are more than doubled today.

The incremental method can be used in analyzing historical costs, those of the immediate future, or (with a planner's customary hardihood) those of a long-range program of highway development.

The present study is in the last category. Its purpose was to determine a fair allocation of the motor-vehicle share of a 20-yr. program of highway improvement in Ohio.

A comprehensive needs study conducted under the direction of the Automotive Safety Foundation had resulted in suggested 10-, 15-, and 20-yr. programs.

A highway committee of the Ohio Program Commission had decided that the 20-yr. program was feasible and that the motorists' share of the cost should be about 82 percent.

This preliminary work gave a figure of approximately $220 million per year which was to be allocated among the various types of vehicles. The needs study also developed a mass of data which was invaluable in applying the incremental method. In fact, one should hesitate to recommend that any state attempt an incremental solution unless similar data were available.

Collecting and analyzing the data required for this type of study can conveniently be divided into three parts: 1) the highway, 2) the vehicle, and 3) the interaction between the two.

In considering highways, it was decided not to classify them according to jurisdiction such as rural primary, rural local, and city streets. Each of these classifications would have included pavements of the lowest as well as the highest types and many miles of highway which do not carry one heavy vehicle a month. A more realistic approach was deemed to be a classification based on type of pavement.

Luckily, such a classification was used in the needs study. Type A pavement was determined to be capable of sustaining large numbers of repetitions of 19,000-lb. axle loads, Type B of 14,000-lb. axle loads, Type C of 8,000-lb. axle loads, and Type D of 4,000-lb. axle loads. For each of these types the program costs had been divided into costs of 1) pavement, 2) structures, 3) grading and drainage, 4) right of way, and 5) maintenance.

In determining the incremental costs of pavements, the design engineers of the highway department reported that, due to climatic conditions in Ohio, a satisfactory road for large numbers of the lightest vehicles should be either 3 in. of asphaltic concrete on 5 in. of water-bound macadam, or 4 in. of portland-cement concrete, either of which would cost about $29,000 a mi. if 22 ft. wide. Such pavements will sustain indefinite numbers of repetitions of 4,000-lb. axle loads. For lesser numbers of light vehicles, this cost is reduced (see Table 2).

This determined our basic vehicles as those having axle loads of not over 4,000 lb.

To keep the necessary computations within reasonable bounds, it was decided to use only four increments of thickness, and hence four increments of cost, for Type A pavement. These were taken at thicknesses suitable for axle loads of 4,000, 8,000, 14,000, and 19,000 lb.

Costs for these increments were decided after studying all the contracts awarded during one year by the highway department, and consulting with state, county, and municipal engineers and contractors.

For the incremental costs of structures, the bridge department was asked to design a series of bridges for different weights of vehicles and for two different sites.

When it came to grading and drainage, the earlier studies were of little help. Are grades below 6 percent for the benefit of trucks, and are the tops of hills leveled to give passenger cars longer sight distance? Who benefits from easing horizontal curves?

Even if we knew the answers to such questions, no highway department keeps its accounts in such shape that the costs can be segregated.

One thing is known: trucks are wider than passenger cars. Commissioner McDonald has said[6] that trucks require an increase of 1 ft.

[6] Hearings Before the subcommittee of the Senate Committee on Interstate and Foreign Commerce. Pursuant to Senate Resolution 50, Part II (June 1950).

in lane width over that satisfactory for passenger cars. It was decided that shoulders should be 2 ft. wider for trucks than if passenger cars only were considered. From these figures, typical cross sections were drawn (Fig. 1) and the percentage of grading and drainage costs chargeable to the larger vehicles computed.

Maintenance costs have been an equal bugaboo to earlier workers in this field. What is believed to be an entirely new approach has been used here. For each of the three pavement types, A, B, and C, the actual

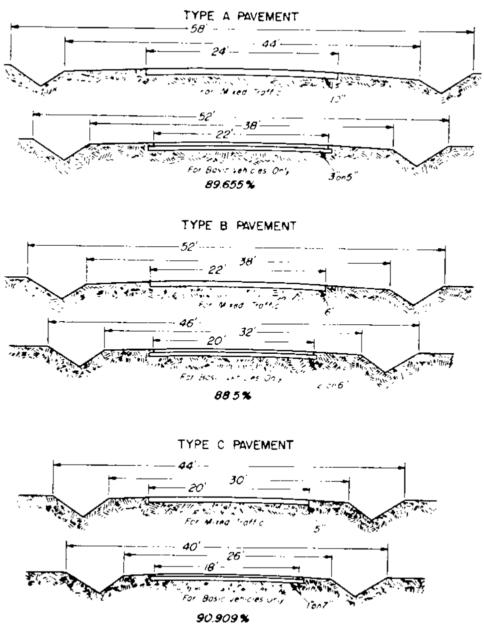

Figure 1. Typical cross-sections.

maintenance expenditures on a large number of highway sections over a 5½-yr. period was recorded. Only sections having the same width and which had not been constructed or reconstructed during the period were included. The total traffic and the heavy truck traffic on each of the sections was recorded.

A multiple-correlation analysis was made of the three factors: maintenance cost in dollars per mile per year; total traffic in vehicles per day; and heavy truck traffic in vehicles per day. The results are shown in Table 2.

It must be admitted, however, that an application of statistical tests of the significance of the multiple regressions shows that, if we use a 95-percent probability of correctness as a criterion, that the effect of numbers of heavy trucks on maintenance costs is significant in the cases of Type A pavements but not in the case of B and C pavements.

However, in order to complete the solution in time for this meeting (and as a probability of being correct attaches even to the results for B and C pavements) the figures for these were used. As time permits, additional data will be gathered and a new analysis made. It is not believed that appreciable changes in the final results will be necessary.

It should be emphasized that this treatment is applied only to the 76 percent of total maintenance costs which is directly allocable to specific highway sections. The remaining 24 percent, which included snow and ice control, traffic signs and marking, guard rail painting, and the like, is allocated on a vehicle-mile basis. Costs of right-of-way were also distributed on a vehicle-mile basis (see Table 3).

The costs of the motor-vehicle bureau and the highway patrol are paid from motor-vehicle revenues. These costs were considered to be justly allocable on a per-vehicle basis. Similarly, miscellaneous revenues such as fines and drivers' and dealers' license fees seemed to be derived mainly on a per-vehicle basis. Hence, such revenues were deducted from the cost of the bureau and patrol and the remaining cost allocated to all vehicles equally (see Table 3).

In considering vehicles, they were first divided by types into passenger cars, farm trucks, commercial trucks, trailers, tractor-trucks, semitrailers, and buses. Taxicabs were included in passenger cars and motorcycles were ignored. The subclassification by empty weight was necessitated by the fact that Ohio licenses its vehicles on that basis. Those states which license on a different basis should, of course, classify their vehicles accordingly.

Most of the earlier studies treated all the components of combinations together as one unit. This led to serious anomalies. We know, for example, that there are about twice as many semitrailers as there are tractors; hence, the former can have average annual mileages

TABLE 1
VEHICLE GROUP RESPONSIBILITY FOR COSTS OF TYPE C HIGHWAYS

(1) Axle Loads	(2) Type of Vehicle by Empty Weight Groups	(3) Annual Axle-miles (×1000)	(4) Cumulative Axle-miles (×1000)	(5) Cumulative Cost per Axle-mile (From Table 2)	(6) Cost per Vehicle Group (Column 3 × Column 5)
kips				¢	$
0-4	Passenger cars	3,149,384	3,923,160	0.75180	23,677,069
	Farm trucks				
	0-2000	484	773,776		3,639
	2001-3000	21,638	773,292		162,674
	3001-4000	62,833	751,654		472,378
	4001-5000	26,642	688,821		200,295
	5001-6000	23,328	662,179		175,380
	6001-7000	17,877	638,851		134,399
	7001-8000	10,888	620,974		81,856
	Commercial trucks				
	1001-2000	832	610,086		6,255
	2001-3000	38,076	609,254		286,255
	3001-4000	105,793	571,178		795,352
	4001-5000	42,296	465,385		317,981
	5001-6000	59,854	423,089		449,982
	6001-7000	33,243	363,235		249,921
	7001-8000	19,908	329,992		149,668
	8001-9000	14,898	310,084		112,003
	9001-10000	1,615	295,186		12,142
	10001-11000	730	293,571		5,488
	11001-12000	457	292,841		3,436
	Trailers				
	0-1000	29,998	292,384		225,525
	1001-2000	9,950	262,386		74,804
	2001-3000	6,201	252,436		46,619
	3001-4000	3,388	246,235		25,471
	4001-5000	6,072	242,847		45,649
	5001-6000	22,666	236,775		170,403
	6001-7000	5,392	214,109		40,537
	7001-8000	4,258	208,717		32,012
	8001-9000	2,827	204,459		21,253
	9001-10000	180	201,632		1,353
	Tractor trucks				
	2001-3000	1	201,452		8
	3001-4000	5	201,451		38
	4001-5000	12	201,446		90
	5001-6000	228	201,434		1,714
	6001-7000	234	201,206		1,759
	7001-8000	190	200,972		1,428
	8001-9000	77	200,782		579
	9001-10000	72	200,705		541
	Semitrailers				
	2001-3000	2	200,633		15
	3001-4000	1	200,631		8
	4001-5000	3	200,630		23
	5001-6000	9	200,627		68
	6001-7000	36	200,618		271
	7001-8000	40	200,582		301
	8001-9000	67	200,542		504
	9001-10000	21	200,475		158
	Buses				
	3001-4000	98	200,454		737
	4001-5000	239	200,356		1,797
	5001-6000	29	200,117		218
	6001-7000	8	200,088		60
Over 4	Farm trucks			5.09561	
	3001-4000	109	200,080		5,554
	4001-5000	490	199,971		24,968
	5001-6000	2,280	199,481		116,180
	6001-7000	1,637	197,201		83,415
	7001-8000	6,115	195,564		311,597
	Commercial trucks				
	3001-4000	2,713	189,449		138,244
	4001-5000	2,226	186,736		113,428
	5001-6000	5,498	184,510		280,157
	6001-7000	33,243	179,012		1,693,934
	7001-8000	18,572	145,768		946,357
	8001-9000	16,466	127,197		839,043
	9001-10000	11,739	110,731		598,174
	10001-11000	5,012	98,992		255,392
	11001-12000	2,365	93,980		120,511

TABLE 1—CONCLUDED

(1) Axle Loads	(2) Type of Vehicle by Empty Weight Groups	(3) Annual Axle-miles (×1000)	(4) Cumulative Axle-miles (×1000)	(5) Cumulative Cost per Axle-mile (From Table 2)	(6) Cost per Vehicle Group (Column 3 × Column 5)
kips				¢	$
	Trailers			5.09561	
	2001–3000	1,631	91,615		83,109
	3001–4000	6,162	89,984		313,991
	4001–5000	7,290	83,822		371,470
	5001–6000	22,664	76,532		1,154,869
	6001–7000	16,184	53,868		824,674
	7001–8000	6,768	37,684		344,871
	8001–9000	11,531	30,916		587,575
	9001–10000	4,488	19,385		228,691
	10001–11000	2,512	14,897		128,002
	11001–12000	538	12,385		27,414
	Tractor trucks				
	2001–3000	1	11,847		51
	3001–4000	27	11,846		1,376
	4001–5000	138	11,819		7,032
	5001–6000	1,038	11,681		52,892
	6001–7000	1,042	10,643		53,096
	7001–8000	1,362	9,601		69,402
	8001–9000	1,181	8,239		60,179
	9001–10000	758	7,058		38,625
	10001–11000	242	6,300		12,331
	Semitrailers				
	2001–3000	2	6,058		102
	3001–4000	4	6,056		204
	4001–5000	16	6,052		815
	5001–6000	219	6,036		11,159
	6001–7000	683	5,817		34,803
	7001–8000	1,124	5,134		57,275
	8001–9000	902	4,010		45,962
	9001–10000	516	3,108		26,293
	10001–11000	192	2,592		9,784
	Buses				
	4001–5000	7	2,400		357
	5001–6000	7	2,393		357
	6001–7000	42	2,386		2,140
	7001–8000	80	2,344		4,076
	8001–9000	294	2,264		14,981
	9001–10000	408	1,970		20,790
	10001–11000	1,074	1,562		54,727
	11001–12000	196	488		9,987
	12001–13000	240	292		12,229
	14001–15000	34	52		1,733
	15001–16000	18	18		917

of only about half those of tractors. Moreover, the two vehicles are often under different ownership. They are licensed separately. A tractor may haul a one-axle semitrailer today and a two-axle one tomorrow. The case of trucks and trailers is similar. The components of vehicle trains must be treated individually.

As this study was made to allocate the costs of a proposed 20-yr. program, it was necessary to project vehicle registrations to the mid-year of the program. The same was true of average annual mileages. In this connection, the spectacularly increasing traffic on our highways makes it imperative that the very latest available data be used.

In considering the interaction between vehicle and pavement, a complete break was made from the earlier work in this field. Where gross ton-miles or vehicle-miles classified by the heaviest axle on the vehicle or combination have been used, the present study was based on axle-miles.

By this method, a two-axle truck having a front-axle weight of 3,000 lb. and a rear-axle weight of 6,000 lb. would be charged with two axles in the basic cost increment but for only one in the second increment. A three-axle truck with a front axle of 3,000 lb. and two rear axles of 6,000 lb. each would be charged for three axles in the basic increment and for two axles in the second increment.

The loadometer surveys and traffic classification counts furnished the information

TABLE 2

INCREMENTS OF COSTS WHICH VARY WITH VEHICLE WEIGHT OR SIZE

		Pavement				Structures				Grading and Drainage			Maintenance (76%)			Totals		
(1) Axle Load (Kips)	(2) Cumulative Axle-miles (× 1000)	(3) Cost Per Mile (Dollars)	(4) Index of Cost (From Col. 3)	(5) Increments of Index	(6) Increments of Cost (Dollars)	(7) Cost Per Lineal Feet (Dollars)	(8) Index of Cost (From Col. 7)	(9) Increments of Index	(10) Increments of Cost (Dollars)	(11) Index of Cost	(12) Increments of Index	(13) Increments of Cost (Dollars)	(14) Index of Cost	(15) Increments of Index	(16) Increments of Cost (Dollars)	(17) Increments of Cost (Cols. 6 + 10 + 13 + 16)	(18) Cost Per Axle-mile (Col. 17 ÷ Col. 2) (Cents)	(19) Cumulative Cost Per Axle-mile
Type A Highways																		
	From Table 1(a)*																	
0–4	50,346,005	29,041	43.423	43.423	15,108,651[a]	259	72.752	72.752	11,120,492[d]	89.655	89.555	23,083,292[g]	40.000	40.000	6,338,049[j]	55,650,484	0.11054	0.11054
4–8	4,385,883	46,464	69.474	26.051	9,064,216	301	84.551	11.799	1,803,534	100.000	10.345	2,663,506	56.000	16.000	2,535,219	16,066,475	0.36632	0.47686
8–14	2,108,755	59,840	89.474	20.000	6,958,824	342	96.097	11.516	1,760,276	100.000	0	0	80.000	24.000	3,802,829	12,521,929	0.59381	1.07067
14–19	822,932	66,880	100.000	10.526	3,662,429	356	100.000	3.933	601,178	100.000	0	0	100.000	20.000	3,169,024	7,432,631	0.90319	1.97386
Type B Highways																		
	From Table 1(b)																	
0–4	11,993,960	17,600	36.755	36.755	3,102,861[b]	234	74.522	74.522	3,931,787[e]	88.500	88.500	6,458,349[h]	60.000	60.000	5,388,726[k]	18,881,723	0.15743	0.15743
4–8	1,168,121	33,042	69.003	32.248	2,722,379	276	87.898	13.376	705,719	100.000	11.500	839,220	76.000	16.000	1,436,994	5,704,312	0.48833	0.64576
8–14	547,760	47,885	100.000	30.997	2,616,770	314	100.000	12.102	638,502	100.000	0	0	100.000	24.000	2,155,490	5,410,762	0.98780	1.63356
Type C Highways																		
	From Table 1(c)																	
0–4	3,923,160	12,672	48.002	48.002	4,357,930[c]	212	84.462	84.462	5,633,604[f]	90.909	90.909	6,639,013[i]	85.000	85.000	12,863,948[l]	29,491,495	0.75180	0.75180
4–8	200.080	26,399	100.000	51.998	4,720,712	251	100.000	15.538	1,036,383	100.000	9.091	663,909	100.000	15.000	2,270,109	8,691,113	4.34381	5.09561
Type D Highways																		
	From Table 1(d)																	
0–4	624,731		100.000	100.000	1,286,501		100.000	100.000	915,774	100.000	100.000	1,914,083	100.000	100.000	7,513,411	11,629,769	1.86156	1.86156

* Tables 1(a), 1(b), and 1(d) have been deleted from this final report. Table 1 of this paper is Table 1(c) of the original report.

[a] Column 5 × $34,794,121.
[b] Column 5 × $8,442,010.
[c] Column 5 × $9,078,642.
[d] Column 9 × $15,285,480.
[e] Column 9 × $5,276,008.
[f] Column 9 × $6,669,987.
[g] Column 12 × $25,746,798.
[h] Column 12 × $7,297,569.
[i] Column 12 × $7,302,922.
[j] Column 15 × $15,845,122.
[k] Column 15 × $8,981,210.
[l] Column 15 × $15,134,057.

TABLE 3
COSTS WHICH DO NOT VARY WITH VEHICLE SIZE OR WEIGHT

(1) Type of Vehicle by Empty Weight Groups	(2) Estimated 1962 Registration	(3) Costs of Highway Patrol and Motor Vehicle Bureau Col. 2 × $5,167,000 / 3,542,943	Type A Highway (4) Vehicle-Miles (× 1,000)	Type A Highway (5) R/W and 24% Maint. Col. 4 × $18,666,611 / 25,160,643	Type B Highway (6) Vehicle-Miles (× 1,000)	Type B Highway (7) R/W and 24% Maint. Col. 6 × $3,850,557 / 6,138,098	Type C Highway (8) Vehicle-Miles (× 1,000)	Type C Highway (9) R/W and 24% Maint. Col. 8 × $5,145,612 / 2,296,063	Type D Highway (10) Vehicle-Miles (× 1,000)	Type D Highway (11) R/W and 24% Maint. Col. 10 × $2,445,014 / 352,588	(12) Totals (Cols. 3 + 5 + 7 + 9 + 11)
											$
Passenger cars	2,848,000	4,153,500	20,042,436	14,869,427	4,436,979	2,783,410	1,574,692	3,528,977	245,893	1,705,140	27,040,454
Farm trucks											
0–2,000	523	763	1,582	1,174	485	304	242	542	45	312	3,095
2,001–3,000	16,800	24,501	60,682	45,020	20,321	12,748	10,819	24,246	2,258	15,658	122,173
3,001–4,000	35,400	51,627	153,140	113,614	56,251	35,287	31,471	70,528	6,938	48,111	319,167
4,001–5,000	12,000	17,501	61,098	45,328	24,072	15,101	13,566	30,402	3,264	22,634	130,966
5,001–6,000	9,120	13,300	56,056	41,588	22,858	14,339	12,804	28,695	3,130	21,705	119,627
6,001–7,000	5,920	8,634	43,181	32,036	17,621	11,054	9,757	21,866	2,257	15,651	89,241
7,001–8,000	4,100	5,979	36,954	27,416	14,442	9,060	7,706	17,270	1,578	10,943	70,668
	83,863	122,305	412,693	306,176	156,050	97,893	86,365	193,549	19,470	135,014	854,937
Commercial trucks											
1,001– 2,000	1,498	2,185	7,636	5,665	2,314	1,452	1,157	2,593	128	888	12,783
2,001– 3,000	48,075	70,112	283,222	210,122	93,462	58,630	49,760	111,515	6,231	43,209	493,588
3,001– 4,000	101,407	147,891	682,717	506,506	246,307	154,514	137,802	308,822	18,229	126,409	1,244,142
4,001– 5,000	32,979	48,096	252,207	187,111	97,288	61,031	54,828	122,873	7,915	54,886	473,997
5,001– 6,000	39,426	57,499	352,550	261,556	140,625	88,217	78,773	176,535	11,557	80,142	663,949
6,001– 7,000	32,495	47,390	359,389	266,629	143,661	90,122	79,548	178,272	11,042	76,570	658,983
7,001– 8,000	20,671	30,146	267,602	198,533	102,825	64,504	54,869	122,965	6,740	46,738	462,886
8,001– 9,000	13,268	19,350	207,581	154,004	72,010	45,173	36,805	82,483	3,649	25,304	326,314
9,001–10,000	6,200	9,042	113,959	84,546	33,681	21,129	15,773	35,348	887	6,151	156,216
10,001–11,000	3,055	4,455	70,350	52,193	16,306	10,229	6,522	14,616	0	0	81,493
11,001–12,000	2,121	3,093	58,612	43,484	10,007	6,278	2,859	6,407	0	0	59,262
12,001–14,000	1,337	1,950	44,572	33,068	5,065	3,177	1,013	2,270	0	0	40,465
14,001–16,000	368	537	15,133	11,227	805	505	161	361	0	0	12,630
16,001–20,000	207	302	10,069	7,470	207	129	52	116	0	0	8,017
Over 20,000	34	50	1,698	1,260	189	119	0	0	0	0	1,429
	303,141	442,098	2,727,297	2,023,374	964,752	605,209	519,922	1,165,176	66,378	460,297	4,696,154
Trailers											
0–1,000	201,597	294,007	224,821	166,794	63,221	39,660	29,998	67,227	4,515	31,309	598,997
1,001– 2,000	12,880	18,784	64,915	48,160	19,900	12,484	9,950	22,299	1,835	12,725	114,452
2,001– 3,000	4,386	6,397	31,119	23,086	10,421	6,537	5,548	12,433	1,158	8,030	56,483
3,001– 4,000	2,772	4,042	23,983	17,793	8,809	5,526	4,929	11,046	1,087	7,538	45,945
4,001– 5,000	3,120	4,550	30,089	22,322	11,855	7,437	6,681	14,973	1,607	11,144	60,426
5,001– 6,000	9,432	13,756	99,223	73,613	40,461	25,382	22,665	50,794	5,541	38,424	201,969
6,001– 7,000	4,150	6,052	47,742	35,420	19,483	12,222	10,788	24,176	2,497	17,315	95,185
7,001– 8,000	2,087	3,044	26,437	19,613	10,332	6,481	5,513	12,355	1,128	7,822	49,315
8,001– 9,000	2,890	4,215	40,014	29,686	14,045	8,811	7,179	16,088	1,186	8,224	67,024
9,001–10,000	1,076	1,569	16,776	12,446	4,985	3,127	2,334	5,231	223	1,547	23,920
10,001–11,000	767	1,119	13,551	10,053	3,146	1,974	1,256	2,815	0	0	15,961
11,001–12,000	278	405	5,517	4,093	942	591	269	603	0	0	5,692
12,001–14,000	60	87	1,351	1,002	150	94	0	0	0	0	1,183
14,001–16,000	57	83	1,527	1,133	0	0	0	0	0	0	1,216
16,001–20,000	61	89	1,693	1,256	0	0	0	0	0	0	1,345
Over 20,000	44	64	1,298	963	0	0	0	0	0	0	1,027
	245,657	358,263	630,051	467,433	207,750	130,326	107,110	240,040	20,777	144,078	1,340,140

Tractor trucks											
2,001- 3,000	5	7	115	85	36	23	1	2	0	0	117
3,001- 4,000	82	120	2,037	1,511	669	420	16	36	0	0	2,087
4,001- 5,000	330	481	8,649	6,417	2,991	1,876	75	168	0	0	8,942
5,001- 6,000	2,618	3,818	71,945	53,376	25,597	16,058	633	1,419	0	0	74,671
6,001- 7,000	2,642	3,853	75,813	56,245	27,115	17,010	638	1,430	0	0	78,538
7,001- 8,000	3,283	4,788	100,388	74,478	35,081	22,007	776	1,739	0	0	103,012
8,001- 9,000	3,085	4,449	99,735	73,993	32,291	20,257	629	1,410	0	0	100,159
9,001-10,000	2,725	3,974	94,166	69,861	21,955	13,773	415	930	0	0	88,538
10,001-11,000	1,846	2,692	69,167	51,315	16,182	10,151	121	271	0	0	64,429
11,001-12,000	551	803	22,395	16,615	3,998	2,508	0	0	0	0	19,926
12,001-14,000	414	604	18,387	13,641	2,231	1,400	0	0	0	0	15,645
14,001-16,000	121	176	5,960	4,422	341	213	0	0	0	0	4,811
16,001-20,000	13	19	688	510	23	14	0	0	0	0	543
Over 20,000	3	4	168	125	2	1	0	0	0	0	130
	17,718	25,838	569,613	422,594	168,512	105,711	3,304	7,405	0	0	561,548
Semitrailers											
2,001- 3,000	58	85	564	418	157	98	4	9	0	0	610
3,001- 4,000	58	85	634	470	186	117	5	11	0	0	683
4,001- 5,000	176	257	2,099	1,557	654	410	19	42	0	0	2,266
5,001- 6,000	1,876	2,736	24,272	18,008	7,776	4,878	219	491	0	0	26,113
6,001- 7,000	5,343	7,792	74,684	55,408	24,050	15,088	646	1,448	0	0	79,736
7,001- 8,000	9,099	13,270	137,577	102,068	42,502	26,662	1,072	2,402	0	0	144,402
8,001- 9,000	7,663	11,176	109,872	81,514	53,296	33,433	820	1,838	0	0	127,961
9,001-10,000	4,762	6,945	85,548	63,468	22,160	13,902	389	872	0	0	85,187
10,001-11,000	3,053	4,452	59,836	44,393	12,716	7,977	109	244	0	0	57,066
11,001-12,000	1,528	2,229	32,458	24,080	5,284	3,315	0	0	0	0	29,624
12,001-14,000	1,339	1,953	31,472	23,249	3,497	2,194	0	0	0	0	27,496
14,001-16,000	266	387	6,964	5,167	367	230	0	0	0	0	5,784
16,001-20,000	36	52	1,017	754	31	20	0	0	0	0	826
Over 20,000	86	125	2,618	1,942	26	16	0	0	0	0	2,083
	35,343	51,544	569,615	422,596	172,702	108,340	3,283	7,357	0	0	589,837
Buses											
3,001- 4,000	15	22	241	179	96	60	49	110	16	111	482
4,001- 5,000	71	104	1,319	979	468	294	123	276	50	347	2,000
5,001- 6,000	15	22	318	236	88	55	18	40	4	28	381
6,001- 7,000	43	63	1,035	768	234	147	25	56	0	0	1,034
7,001- 8,000	57	83	1,465	1,087	330	207	40	90	0	0	1,467
8,001- 9,000	215	314	6,017	4,464	1,361	854	147	329	0	0	5,961
9,001-10,000	272	397	8,000	5,935	2,050	1,286	204	457	0	0	8,075
10,001-11,000	730	1,065	24,213	17,964	4,815	3,021	537	1,203	0	0	23,253
11,001-12,000	258	376	8,918	6,616	2,181	1,368	98	220	0	0	8,580
12,001-13,000	330	481	12,898	9,569	2,162	1,356	120	269	0	0	11,675
13,001-14,000	285	416	11,723	8,697	2,071	1,299	0	0	0	0	10,412
14,001-15,000	344	502	14,571	10,810	2,646	1,660	17	38	0	0	13,010
15,001-16,000	330	481	15,243	11,309	1,776	1,114	9	20	0	0	12,924
16,001-17,000	487	710	23,229	17,234	2,582	1,620	0	0	0	0	19,564
17,001-18,000	616	898	30,595	22,698	2,669	1,674	0	0	0	0	25,270
18,001-19,000	301	439	15,398	11,424	1,157	726	0	0	0	0	12,589
19,001-20,000	545	795	29,076	21,571	1,444	906	0	0	0	0	23,272
Over 20,000	86	125	4,679	3,471	223	140	0	0	0	0	3,736
	5,000	7,293	208,938	155,011	28,353	17,787	1,387	3,108	70	486	183,685

TABLE 4
SUMMARY OF PROGRAM COST RESPONSIBILITY OF MOTOR VEHICLES

(1) Type of Vehicle by Empty Weight Groups	(2) Estimated 1962 Registration	Motor-Vehicle Share of Program Cost (3) From Table 1(a)*	(4) From Table 1(b)	(5) From Table 1(c)	(6) From Table 1(d)	(7) From Table 3	(8) Total	(9) Cost Responsibility per Vehicle Column 8 ÷ Column 2	(10) Gas Tax Credit at 5¢ per gal.	(11) To be Collected by License or Other Fees	(12) Column 11 Smoothed
		$	$	$	$	$	$	$	$	$	$
Passenger cars	2,848,000	44,309,818	13,970,272	23,677,069	9,154,891	27,040,454	118,152,504	41.49	30.78	10.71	10.71
Farm trucks											
1,001-2,000	523	3,497	1,527	3,639	1,675	3,095	13,433	25.68	11.03	14.65	11.74
2,001-3,000	16,800	134,156	63,983	162,674	84,068	122,173	567,054	33.75	13.72	20.03	25.23
3,001-4,000	35,400	340,503	178,064	477,932	258,310	319,167	1,573,976	44.46	17.18	27.28	29.60
4,001-5,000	12,000	143,168	80,046	225,263	121,523	130,966	700,966	58.41	21.23	37.18	34.61
5,001-6,000	9,120	160,498	91,851	291,560	116,534	119,627	780,070	85.53	21.64	63.89	50.03
6,001-7,000	5,920	130,609	75,754	217,815	84,031	89,241	597,450	100.92	33.38	67.55	85.63
7,001-8,000	4,100	226,042	119,853	393,453	58,751	70,668	868,767	211.89	54.63	157.26	151.13
Commercial trucks											
1,001- 2,000	1,498	18,779	7,144	6,255	2,085	12,783	47,046	31.41	18.38	13.03	25.76
2,001- 3,000	48,075	701,157	294,262	286,255	129,490	493,588	1,904,752	39.62	22.05	17.57	10.95
3,001- 4,000	101,407	1,854,668	835,660	933,596	363,600	1,244,142	5,231,666	51.59	26.92	24.67	15.17
4,001- 5,000	32,979	741,545	356,826	431,409	153,504	473,997	2,157,281	65.41	32.26	33.15	36.77
5,001- 6,000	39,426	1,120,931	565,783	730,139	217,319	663,949	3,298,121	83.65	39.56	44.09	74.15
6,001- 7,000	32,495	2,656,970	1,306,487	1,993,855	176,848	658,983	6,733,143	207.21	71.11	136.10	125.67
7,001- 8,000	20,671	2,452,121	1,239,279	1,096,025	53,092	462,886	5,303,403	256.56	97.11	159.45	189.70
8,001- 9,000	13,268	2,193,749	1,307,282	951,046		326,314	5,778,391	435.51	129.30	306.21	264.63
9,001-10,000	6,200	2,354,258	713,024	610,316		156,216	3,833,814	618.36	167.48	450.88	348.80
10,001-11,000	3,055	1,655,920	337,318	260,880		81,493	2,335,611	764.52	205.34	559.18	440.60
11,001-12,000	2,121	999,597	181,621	123,947		59,262	1,364,427	643.29	207.11	436.18	538.42
12,001-14,000	1,337	744,955	87,656			40,465	873,076	653.01	242.55	410.46	692.82
14,001-16,000	368	508,502				12,630	521,132	1,416.11	376.24	1,039.87	904.50
16,001-20,000	197	332,045				8,017	340,062	1,726.20	453.42	1,272.78	1,208.01
Over 20,000	34	66,439				1,429	67,868	1,996.11	505.62	1,490.49	1,518.13
Trailers											
0- 1,000	201,597	248,517	99,529	225,525	84,049	598,997	1,256,617	6.23	0.75	5.48	16.00
1,001- 2,000	12,880	71,757	31,329	74,804	34,160	114,452	326,502	25.35	3.53	21.82	20.00
2,001- 3,000	4,386	82,103	38,129	129,728	30,437	56,483	336,880	76.81	11.80	65.01	88.00
3,001- 4,000	2,772	161,219	80,655	339,462	39,204	45,945	666,485	240.43	26.21	214.22	160.00
4,001- 5,000	3,120	219,342	121,823	417,119	59,831	60,426	978,541	281.58	34.38	247.20	243.00
5,001- 6,000	9,432	716,621	413,777	1,325,272	206,298	201,969	2,863,937	303.64	38.65	264.99	335.00
6,001- 7,000	4,150	651,418	396,546	865,211	92,966	95,185	2,101,326	500.34	57.85	448.49	413.00
7,001- 8,000	2,087	410,480	196,565	376,889	41,997	49,315	1,075,246	515.21	60.89	454.32	488.00
8,001- 9,000	2,890	906,527	293,196	608,828	44,156	67,024	1,919,731	664.27	72.14	592.13	550.00
9,001-10,000	1,076	406,392	111,734	230,044	8,303	23,920	830,393	771.74	76.81	694.93	600.00
10,001-11,000	767	332,382	71,643	128,002	10,015	15,961	558,003	727.51	79.67	647.84	648.00
11,001-12,000	278	135,222	21,471	27,414		5,692	189,799	682.73	82.36	600.37	687.00
12,001-14,000	60	38,205	3,913			1,183	43,301	721.68	95.46	626.22	721.00
14,001-16,000	57	51,250				1,216	52,466	920.46	121.79	798.67	763.00
16,001-20,000	61	55,798				1,345	57,143	936.77	125.45	811.32	810.00
Over 20,000	44	43,257				1,027	44,284	1,006.45	133.81	872.64	860.00

Tractor trucks										
2,001- 3,000	5	888	377	59		117	1,441	288.20	130.57	157.63	187.25
3,001- 4,000	82	20,973	9,754	1,414		2,087	34,228	417.41	161.23	256.18	244.03
4,001- 5,000	330	115,224	54,568	7,122		8,942	185,856	563.20	194.43	368.77	304.47
5,001- 6,000	2,618	1,005,348	439,961	54,606		74,671	1,574,586	601.45	204.32	397.13	368.55
6,001- 7,000	2,642	1,119,264	471,482	54,855		78,538	1,724,139	652.60	209.66	442.94	436.29
7,001- 8,000	3,283	1,698,196	439,780	70,830		103,012	2,311,818	704.18	245.86	458.32	507.67
8,001- 9,000	3,085	1,870,665	653,558	60,758		100,159	2,685,140	870.39	268.59	601.80	582.67
9,001-10,000	2,725	1,663,359	437,076	39,166		88,538	2,228,139	817.67	270.53	547.14	661.29
10,001-11,000	1,846	1,425,372	362,822	12,331		64,429	1,864,954	1,010.26	303.51	706.75	743.52
11,001-12,000	551	457,822	105,563			19,926	583,311	1,058.64	323.21	735.43	928.36
12,001-14,000	414	529,862	74,928			15,645	620,435	1,498.63	290.93	1,207.70	964.86
14,001-16,000	121	155,314	10,218			4,811	170,343	1,407.79	260.65	1,147.14	1,158.03
16,001-20,000	13	20,814	840			543	22,197	1,707.46	261.72	1,445.74	1,474.51
Over 20,000	3	6,632	88			130	6,850	2,283.33	343.56	1,939.77	1,945.97
Semitrailers										
2,001- 3,000	58	1,657	721	117		610	3,105	53.53	12.56	40.97	82.52
3,001- 4,000	58	3,395	1,441	212		683	5,731	98.81	19.63	79.18	80.08
4,001- 5,000	176	19,664	6,564	838		2,266	29,332	166.66	28.58	138.08	94.73
5,001- 6,000	1,876	246,297	84,151	11,227		26,113	367,788	196.05	33.86	162.19	124.52
6,001- 7,000	5,343	853,228	295,320	35,074		79,736	1,263,358	236.45	39.93	196.52	167.49
7,001- 8,000	9,099	1,514,048	553,997	57,576		144,402	2,270,014	249.48	42.34	207.14	221.73
8,001- 9,000	7,663	1,485,285	779,242	46,466		127,961	2,438,954	318.28	50.94	267.34	285.25
9,001-10,000	4,762	1,369,999	403,125	26,451		85,187	1,884,762	395.79	62.17	333.62	356.14
10,001-11,000	3,053	1,194,783	285,213	9,784		57,066	1,546,846	506.66	82.71	423.95	432.41
11,001-12,000	1,528	690,570	118,751			29,624	838,945	549.05	85.51	463.54	512.12
12,001-14,000	1,339	782,452	88,351			27,496	898,299	670.87	102.05	568.82	633.94
14,001-16,000	266	274,919	11,990			5,784	292,693	1,100.34	143.04	957.30	790.26
16,001-20,000	36	36,516	964			826	38,306	1,064.05	144.96	919.09	980.03
Over 20,000	86	103,351	425			2,083	105,859	1,230.91	159.56	1,071.35	1,067.84
Buses										
3,001- 4,000	15	533	302	737	596	60	2,228	148.53	65.67	82.86	111.24
4,001- 5,000	71	3,806	1,738	2,154	1,861	294	9,853	138.77	73.24	65.53	101.00
5,001- 6,000	15	1,523	541	575	149	55	2,843	189.53	94.80	94.73	107.22
6,001- 7,000	43	8,724	4,262	2,200		147	13,747	319.70	135.60	184.10	128.06
7,001- 8,000	57	13,972	2,676	4,076		207	22,517	395.04	155.49	239.55	161.65
8,001- 9,000	215	57,385	17,578	14,981		854	90,798	422.32	169.05	253.27	206.13
9,001-10,000	272	76,298	26,476	20,790		1,286	124,850	459.01	182.08	276.93	259.63
10,001-11,000	730	243,567	67,204	54,727		3,021	368,519	504.82	199.81	305.01	320.30
11,001-12,000	258	91,650	30,904	9,987		1,368	133,909	519.03	215.86	303.17	386.25
12,001-13,000	330	153,747	36,774	12,229		1,356	204,106	618.50	272.68	345.82	455.64
13,001-14,000	285	191,446	50,128			1,299	242,873	852.19	297.13	555.06	526.62
14,001-15,000	344	232,949	64,894	1,733		1,660	301,236	875.69	333.15	542.54	597.30
15,001-16,000	330	297,326	51,011	917		1,114	350,368	1,061.72	344.15	717.57	665.83
16,001-17,000	487	462,858	77,966			1,620	542,444	1,113.85	358.59	755.26	730.36
17,001-18,000	616	655,143	87,199			1,674	744,016	1,207.82	379.35	828.47	788.99
18,001-19,000	301	329,188	37,801			726	367,715	1,221.64	386.38	835.26	839.89
19,001-20,000	545	672,698	47,177			906	720,781	1,322.53	403.97	918.56	881.19
Over 20,000	86	104,312	7,286			140	111,738	1,299.28	405.93	893.35	930.23

* Tables 1(a), 1(b) and 1(d) have been deleted from this final report. Table 1 of this paper is Table 1(c) of the original report.

required for this breakdown, except for buses. Ohio loadometer crews have not weighed buses for several years. However, the Washington Highway Department furnished photostats of the field sheets of a bus study made in connection with James C. Nelson's report[7] for that state.

and of the federal-aid secondary system (as well as numerous local studies) were available. From these it was possible to make a distribution of the annual axle-miles by axle weights of each type of vehicle to the several highway systems and finally to the pavement types.

TABLE 5
VEHICLE-MILES BY AXLE COMBINATIONS AND BY PAVEMENT TYPES
COMMERCIAL TRUCKS

Empty Weight	Axle Loadings	Total	Vehicle-Miles (times 1,000)			
			On Type A	On Type B	On Type C	On Type D
kips	*kips*					
1–2	(0–4) (0–4)	11,235	8,494	2,269	416	56
2–3	(0–4) (0–4)	432,675	317,151	93,458	19,038	3,028
3–4	(0–4) (0–4)	1,030,803	735,993	233,992	51,540	9,278
	(0–4) (4–8)	54,252	38,736	12,315	2,713	488
4–5	(0–4) (0–4)	371,014	258,968	88,301	20,035	3,710
	(0–4) (4–8)	41,224	28,774	9,811	2,226	413
5–6	(0–4) (0–4)	485,322	335,357	117,933	27,178	4,854
	(0–4) (4–8)	97,000	67,027	23,571	5,432	970
	(0–4) (8–14)	1,183	817	287	66	13
6–7	(0–4) (4–8)	534,276	369,719	130,363	29,919	4,275
	(0–4) (8–14)	59,364	41,080	14,485	3,324	475
7–8	(0–4) (4–8)	151,450	106,469	36,197	8,178	606
	(0–4) (8–14)	217,226	152,710	51,917	11,730	869
	(4–8) (4–8)	38,016	26,725	9,086	2,053	152
	(4–8) (8–14)	25,344	17,817	6,057	1,368	102
8–9	(0–4) (8–14)	242,029	175,713	54,456	11,860	0
	(0–4) (Over 14)	62,008	45,018	13,952	3,038	0
	(4–8) (8–14)	16,008	11,622	3,602	784	0
9–10	(0–4) (Over 14)	24,619	18,661	4,973	985	0
	(4–8) (8–14)	79,633	60,362	16,086	3,185	0
	(4–8) (Over 14)	54,800	41,538	11,070	2,192	0
	(0–4) ((0–4) (0–4)	5,247	3,977	1,060	210	0
10–11	(4–8) (Over 14)	81,527	65,140	14,023	2,364	0
	(0–4) (0–4) (0–4)	1,860	1,486	320	54	0
	(0–4) (0–4) (4–8)	9,790	7,822	1,684	284	0
11–12	(4–8) (Over 14)	26,252	22,262	3,596	394	0
	(0–4) (0–4) (4–8)	6,639	5,630	909	100	0
	(0–4) (4–8) (4–8)	17,187	14,575	2,355	257	0
	(4–8) (4–8) (4–8)	21,400	18,147	2,932	321	0
12–14	(0–4) (4–8) (4–8)	9,987	9,218	769	0	0
	(0–4) (4–8) (8–14)	6,408	5,915	493	0	0
	(4–8) (4–8) (4–8)	20,792	19,191	1,601	0	0
	(4–8) (4–8) (8–14)	9,324	8,606	718	0	0
	(4–8) (8–14) (8–14)	4,139	3,820	319	0	0
14–16	(0–4) (4–8) (8–14)	2,805	2,805	0	0	0
	(4–8) (8–14) (8–14)	680	680	0	0	0
	(4–8) (8–14) (Over 14)	12,614	12,614	0	0	0
16–20	(8–14) (Over 14)	500	500	0	0	0
	(0–4) (4–8) (8–14)	1,634	1,634	0	0	0
	(4–8) (8–14) (Over 14)	7,994	7,994	0	0	0
	(8–14) (8–14) (8–14)	100	100	0	0	0
	(8–14) (Over 14) (Over 14)	100	100	0	0	0
Over 20	(4–8) (8–14) (Over 14)	1,887	1,887	0	0	0

In studying the combined factors of vehicle and highway, and the influence of each upon the other, those states which have recent road use surveys are to be envied. In Ohio, the road use study was made in 1936 and driving habits have changed since then. However, recent comprehensive traffic surveys of the state highway system, both rural and urban,

The results in vehicle-miles are shown in Table 3. Table 5 illustrates how the loadometer data were used to break these vehicle-miles down into axle-miles.

Table 1 shows how the axle-miles for each class of vehicle on Type C highways are combined for each of the two increments into which this type of highway was divided.

Table 4 completes the incremental solution. The breakdown of the computations into

[7] James C. Nelson, *Taxing Washington's Motor Vehicle. Equitably for Highway Services* (Sept. 23, 1950).

TABLE 6
AXLE-MILES BY AXLE LOADINGS AND BY PAVEMENT TYPES, COMMERCIAL TRUCKS

Empty Weight	Axle Loadings	Axle-Miles (times 1,000)			
		On Type A	On Type B	On Type C	On Type D
kips	*kips*				
1–2	0–4	16,988	4,538	832	112
2–3	0–4	634,302	186,916	38,076	6,056
3–4	0–4	1,510,722	480,299	105,793	19,044
	4–8	38,736	12,315	2,713	488
4–5	0–4	546,710	186,413	42,296	7,833
	4–8	28,774	9,811	2,226	413
5–6	0–4	738,558	259,724	59,854	10,691
	4–8	62,027	23,571	5,432	970
	8–14	817	287	66	13
6–7	0–4	410,799	144,848	33,243	4,750
	4–8	369,719	130,363	29,919	4,275
	8–14	41,080	14,485	3,324	475
7–8	0–4	259,179	88,114	19,908	1,475
	4–8	71,267	24,229	5,474	406
	8–14	170,527	57,974	13,098	971
8–9	0–4	220,731	68,408	14,898	0
	4–8	11,622	3,602	784	0
	8–14	187,335	58,058	12,644	0
	Over 14	45,018	13,952	3,038	0
9–10	0–4	30,592	8,153	1,615	0
	4–8	101,900	27,156	5,377	0
	8–14	60,362	16,086	3,185	0
	Over 14	60,199	16,043	3,177	0
10–11	0–4	20,102	4,328	730	0
	4–8	72,962	15,707	2,648	0
	Over 14	65,140	14,023	2,364	0
11–12	0–4	25,835	4,173	457	0
	4–8	111,483	18,011	1,971	0
	Over 14	22,262	3,596	394	0
12–14	0–4	15,133	1,262	0	0
	4–8	102,956	8,589	0	0
	8–14	22,161	1,849	0	0
14–16	0–4	2,805	0	0	0
	4–8	16,099	0	0	0
	8–14	16,779	0	0	0
	Over 14	12,614	0	0	0
16–20	0–4	1,634	0	0	0
	4–8	9,628	0	0	0
	8–14	10,528	0	0	0
	Over 14	8,694	0	0	0
Over 20	4–8	1,887	0	0	0
	8–14	1,887	0	0	0
	Over 14	1,887	0	0	0

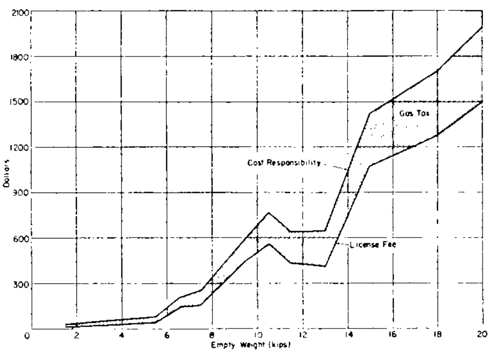

Figure 2. Trucks.

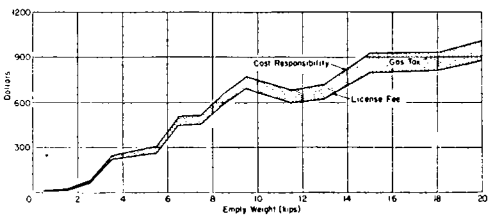

Figure 3. Trailers.

many tables and the cross referencing back and forth between them is regretted, but the limitations of reproduction and legibility compelled it. The classical methods of the incremental solution have been followed, and it is believed that the readers of this paper are sufficiently familiar with those computations to follow those shown in these tables.

Actually, the incremental solution ends with the ninth column of Table 4, where the annual cost responsibility of each type and weight of vehicle is shown. However, to put this information to practical use it is necessary to

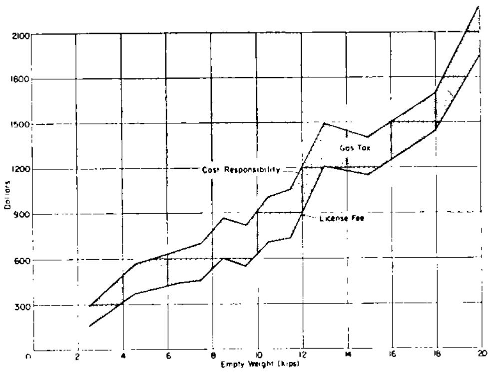

Figure 4. Tractor-trucks.

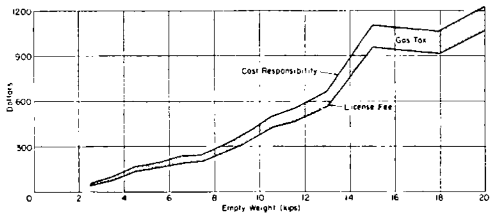

Figure 5. Semitrailers.

determine how much of this responsibility is taken care of by gasoline tax payments, and how much is left to be covered by license fees or other forms of taxation.

The gallons-per-mile gasoline consumption for passenger cars and buses were taken from the Simpson[8] report. For the other vehicle types, it was based upon data from HRB's *Research Report 9–A*. Specifically, the formula $G = .0208W^{0.618}$ was used. Here G is gallons per mile and W the gross weight of the vehicle or combination. The fuel consumption of trailers and semitrailers was computed by subtracting from the weighted average fuel consumption of the combinations in which a

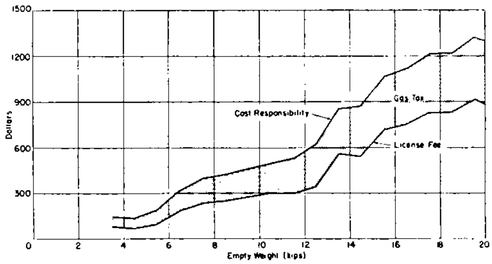

Figure 6. Busses.

given trailer is found, the weighted average fuel consumption of the motive units.

Figures 2 and 6, inclusive, are presented to give a quick visualization of the results of the Ohio study.

It is hoped that this description of the use of modern data and new techniques will encourage others to use and further improve the incremental method which is believed the soundest yet proposed for the equitable allocation of highway costs among highway users.

[8] Herbert D. Simpson, *Highway Finance, A Study Prepared for the Ohio Program Commission* (Sept. 1951).