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IN THIS ISSUE

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U. S. DEPARTMENT OF COMMERCE
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BERTRAM D. TALLAMY, Administrator

Contents of this publication may be reprinted. Mention of source is requested.

A Survey of Air Pressures of Tires Mounted on Trucks Operating in the Everyday Traffic

BY THE DIVISION OF HIGHWAY TRANSPORT RESEARCH
BUREAU OF PUBLIC ROADS

Reported by CARL C. SAAL, Chief, Vehicle Operations Branch

This article discusses the results of a survey made in 1954 of tire pressures of trucks operating in the general traffic stream. Tire sizes included in the analysis ranged from 7.00 x 18, 8 ply, usually found on the lightweight single-unit trucks, to 11.00 x 24, 12 ply, used for the most part on the heaviest truck combinations. Inflation pressures and corresponding wheel loads were determined for about 8,000 vehicles and over 40,000 tires.

Over-the-road inflation pressures of dual tires of the smaller sizes were found to be about equal to or less than the cold inflation pressures recommended by the Tire and Rim Association, Inc., as revised on April 15, 1955. For tire sizes ranging from 9.00 x 20, 10 ply, and upward, the average hot inflation pressures were about 10 percent above the recommended pressures.

Air pressures of tires mounted on dual wheels did not vary significantly because of axle position or when mounted on the inside or outside of a dual-wheel assembly. Average inflation values for single tires on the front axle of vehicles were slightly less than the pressures of dual tires mounted on the other axles.

In most cases the average wheel load for dual tires was less than 70 percent of the loads recommended by the Tire and Rim Association, Inc., as revised on April 15, 1955. The increase in pressure was found to be very gradual over the entire load range, and in general amounted to slightly more than 10 percent from the lowest to the highest tire loads.

Ambient temperatures ranging from 60 to 95 degrees F. caused only small increases in the inflation pressures of tires checked on the highways. Above 95 degrees, rather sharp increases in tire pressures were found in some instances.

In recent years, there has been some tendency for truck operators to use high-pressure tires. These so-called "high-load" tires are constructed with all-nylon cord or with steel cord. Only a limited number of these tires were checked in this survey, but from the small sample it was found that hot inflation pressures averaged 9 pounds per square inch in excess of those for the comparable conventional tires.

A more recent survey of motor-carrier practices, concerning their tire inflation specifications for fleet operation, revealed that for three common tire sizes, the specifications exceeded the recommendations of the Tire and Rim Association, Inc., for cold inflation pressures by about 5 pounds per square inch.

THE inflation pressure of tires, as they run "hot" in service on trucks and truck combination units, was investigated for immediate use in planning and operating the AASHO Road Test Project at Ottawa, Ill. It is also expected that highway designers in general will be interested in the results.

The study was conducted in 37 States in conjunction with the annual summer loadometer surveys in 1954. In each of these States at least one station at which a large volume of truck traffic could be expected was selected and operated. The tire pressures and corresponding wheel loads were measured on the right-hand side of about 8,000 vehicles, involving some 40,000 tires.

The principal objectives of this study were to determine for given tire sizes the frequency of inflation pressures and the relation between wheel load and inflation pressure. In addition to the tire pressure results for vehicles in normal operation, the report describes some current practices of truck operators in inflating cold tires and investigates the trend in tire inflation practices to a limited extent by comparing the present results with those reported by Kansas in 1941.

Summary of Findings

1. In the case of dual tires, the "hot" inflation pressures on the average were either approximately equal to or less than the revised recommended "cold" inflation pressures of the Tire and Rim Association, Inc., for tire sizes of 8.25 x 20, 12 ply, and smaller. For tire sizes of 9.00 x 20, 10 ply, and larger, the average hot inflation pressures were about 10 percent above the recommended ones.

2. The average hot inflation pressures of dual tires lie between 80 and 85 pounds per square inch for tire sizes ranging from 10.00 x 20, 12 ply, to 11.00 x 24, 12 ply. The corresponding range of 85-percentile values was 90 to 95 p.s.i. The revised recommended cold pressure for this group of tire sizes was 75 p.s.i.

3. An analysis of average tire pressures for a given tire size and vehicle type indicated that it was only necessary to group the data by the first (front) axle and by the remaining axles with dual tires. The position of the dual tire with respect to axle configuration was determined not to be a factor.

4. The average pressure for single tires on the first axle was always slightly less than that for dual tires on the other axles. Also, on the average, the variation in pressure between the inside and outside tires mounted on dual wheels was found to be very small.

5. The average tire load for dual tires of a given size was generally less than 70 percent of the revised recommended load. Also, the 85-percentile values did not exceed the revised schedule of loads except for the 7.50 x 20, 10-ply and the two 8.25 x 20 tire sizes, and then only to a small degree.

6. The increase of average hot inflation pressures over the tire load range was very gradual and generally amounted to slightly over 10 percent from the lowest to the highest tire load. The increase was very insignificant for the range of load for a given tire size that would be considered in highway design.

7. The average hot inflation pressures did not vary materially with vehicle type or geographical region. On the basis of the results of this survey, it is reasonable to assume that the average values for the country as a whole and for all vehicle types may be applied universally.

8. For a given tire size, the average hot inflation pressure did not appear to increase appreciably with an increase in ambient temperature between 60° and 95° F. Above 95° there was a tendency for the pressure to increase sharply in some instances.

9. On the basis of very limited data, it appears that the so-called "high-load" tire might have average hot pressures of at least

Table 1.—Number of vehicles included in tire-pressure survey, classified by vehicle type and grouped by regions

Vehicle type [1]	Region 1 [2]			Region 2 [4]			Region 3			Region 4 [5]			All regions		
	Number of vehicles	Number of tires [3]	Number of tires checked	Number of vehicles	Number of tires [3]	Number of tires checked	Number of vehicles	Number of tires [3]	Number of tires checked	Number of vehicles	Number of tires [3]	Number of tires checked	Number of vehicles	Number of tires [3]	Number of tires checked
Single-unit trucks:															
2D	243	729	699	780	2,340	2,170	869	2,607	2,528	348	1,044	944	2,240	6,720	6,341
3	30	150	143	75	375	348	58	290	273	66	330	241	229	1,145	1,005
Tractor-semitrailer combinations:															
2-S1	350	1,750	1,694	871	4,355	4,139	711	3,555	3,366	120	600	521	2,052	10,260	9,720
2-S2	211	1,477	1,266	1,152	8,064	7,577	1,143	8,001	7,655	173	1,211	1,031	2,679	18,753	17,529
3-S2	2	18	18	7	63	58	255	2,295	2,112	252	2,268	1,848	516	4,644	4,036
Tractor-semitrailer and trailer combinations:															
2-S1-2	------	------	------	------	------	------	23	207	196	42	378	236	65	585	432
2-S2-2	------	------	------	------	------	------	17	187	171	1	11	6	18	198	177
Truck and trailer combinations:															
2-2	2	14	14	------	------	------	9	63	55	6	42	33	17	119	102
3-2	------	------	------	------	------	------	8	72	67	71	639	508	79	711	575
3-3	------	------	------	------	------	------	------	------	------	31	341	257	31	341	257
Total trucks and combinations	838	4,138	3,834	2,885	15,197	14,292	3,093	17,277	16,423	1,110	6,864	5,625	7,926	43,476	40,174

[1] For an explanation of the vehicle code, see text in right-hand column.
[2] No data for Maine, New Hampshire, New York, Rhode Island, Vermont, and District of Columbia.
[3] Only the tires on the right side of vehicles.
[4] No data for Florida, Tennessee, and West Virginia.
[5] No data for Montana, Texas, and Utah.

Table 2.—Frequency of tires by size and axle position

Tire size	Number of ply	Number of tires by position				
		First axle	Other axles with dual tires			Total tires, all axles
			Inside tires	Outside tires	Total tires	
7.00 x 18	8	61	53	59	112	173
7.00 x 20	8	72	50	54	104	176
7.00 x 20	10	41	28	33	61	102
7.50 x 20	8	479	194	221	415	894
7.50 x 20	10	359	252	276	528	887
8.25 x 20	10	1,327	1,645	1,911	3,556	4,883
8.25 x 20	12	59	107	137	244	303
9.00 x 20	10	857	1,432	1,622	3,054	3,911
10.00 x 20	12	2,577	6,683	7,567	14,250	16,827
10.00 x 22	12	700	1,906	2,350	4,256	4,956
11.00 x 20	12	261	675	776	1,451	1,712
11.00 x 22	12	326	787	952	1,739	2,065
11.00 x 24	12	10	18	18	36	46
Total tires	------	7,129	13,830	15,976	29,806	36,935

10 p. s. i. in excess of those found in comparable conventional sizes, but not to the extent of the pressure differential between the recommended cold inflation pressures.

10. The cold inflation pressures specified by motor carriers for their fleets were obtained in a recent survey of truck operation practices and were found for three common tire sizes to be about 5 p.s.i., on the average, above the recommended pressure.

11. The tire pressures measured on a similar survey made in Kansas about 1940 compared very closely with those obtained by the present survey for three tire sizes. For two smaller tire sizes (7.50 and 7.00), the 1954 values were appreciably higher.

12. Gaged by available reference data from controlled tests, the hot inflation pressure levels established by this survey appear to be well within the range that could be expected by following the recommended practice of inflating cold tires.

Table 3.—Average air pressure for 10.00 x 20, 12-ply tires checked on truck-tractor-semitrailer combinations in region 3

Axle position	Number of tires and average pressure for 3 vehicle types					
	2-S1		2-S2		3-S2	
	Number of tires	Air pressure	Number of tires	Air pressure	Number of tires	Air pressure
		P. s. i.		*P. s. i.*		*P. s. i.*
First	191	73.1	848	73.7	103	77.6
Second	401	79.5	1,628	80.4	161	79.5
Third	486	79.4	1,702	80.7	163	80.2
Fourth	------	------	1,686	81.9	180	79.6
Fifth	------	------	------	------	175	79.5

Vehicle Type Code

In some instances vehicle types are represented by the general code in common use. Each digit of the code indicates the number of axles of a vehicle or of a unit of a vehicle combination. A single digit, or the first digit of a group symbol, represents a single-unit truck or, if followed by an "S," a truck-tractor. The "S" designation, of course, represents a semitrailer. A digit without an "S" in the second or third position of a group symbol represents a full trailer.

2D =2-axle single-unit truck with dual rear tires
3 =3-axle single-unit truck
2-S1 =2-axle truck-tractor with 1-axle semitrailer
2-S2 =2-axle truck-tractor with 2-axle semitrailer
3-S2 =3-axle truck-tractor with 2-axle semitrailer
2-2 =2-axle truck with 2-axle trailer
3-2 =3-axle truck with 2-axle trailer
3-3 =3-axle truck with 3-axle trailer
2-S1-2=2-axle truck-tractor with 1-axle semitrailer and 2-axle trailer
2-S2-2=2-axle truck-tractor with 2-axle semitrailer and 2-axle trailer

Procedure

The field data were recorded on a form which provided space for indicating vehicle type, tire size, tire pressure for each tire on the right-hand side of vehicles, and wheel or axle load depending on whether wheel loadometers or pit scales were used. Other information entered on the form included station number, the date, hour of operation, the ambient temperature, and the condition of the pavement surface (wet or dry).

Generally, two men in addition to the normal crew were required, one to obtain the tire sizes and inflation pressures, and another to record these data and to obtain the axle weight or wheel weights from the weighmaster. Tire pressures measured with an accurate truck-type tire gage were usually recorded to the nearest 5 pounds.

Vehicles were not delayed excessively for any reason. For instance, no attempt was made to gage the pressure if the valve stem was not readily accessible. A seemingly small

Table 4.—Summary of average air pressure of tires, according to size and position on vehicle

Tire size	Number of ply	Average tir pressure by position					Maximum recommended tire pressure [1]	
		First axle	Other xles with dual tires			All axles	Before Apr. 15, 1955	After Apr. 15, 1955
			Inside tires	Outside tires	All tires			
		P. s. i.	*P. s. i.*	*P. s. i.*	*P. s. i.*	*P. s. i.*	*P. s. i.*	*P. s. i.*
7.00 x 18	8	49	50	52	51	50	55	60
7.00 x 20	8	55	57	58	57	56	55	60
7.00 x 20	10	54	62	61	62	59	70	75
7.50 x 20	8	56	62	62	62	59	60	65
7.50 x 20	10	59	68	67	67	64	70	75
8.25 x 20	10	63	72	72	72	69	65	70
8.25 x 20	12	65	75	72	73	71	75	80
9.00 x 20	10	68	76	76	76	74	65	70
10.00 x 20	12	73	81	81	81	80	70	75
10.00 x 22	12	80	81	81	81	81	70	75
11.00 x 20	12	76	82	82	82	81	70	75
11.00 x 22	12	78	82	82	82	81	70	75
11.00 x 24	12	79	84	83	84	83	70	75

[1] Tire and Rim Association, Inc., Year Book.

Table 5.—Comparison of average observed air pressure of tires on first axle and other axles with maximum recommended air pressure

Tire size	Number of ply	Ratio of average observed tire pressure to maximum recommended pressure—			
		Before Apr. 15, 1955		After Apr. 15, 1955	
		First axle	Other axles	First axle	Other axles
7.00 x 18	8	0.89	0.93	0.82	0.85
7.00 x 20	8	1.00	1.04	.92	.95
7.00 x 20	10	.77	.88	.72	.83
7.50 x 20	8	.93	1.03	.86	.95
7.50 x 20	10	.84	.96	.79	.89
8.25 x 20	10	.97	1.11	.90	1.03
8.25 x 20	12	.86	.97	.81	.91
9.00 x 20	10	1.05	1.17	.97	1.09
10.00 x 20	12	1.04	1.16	.97	1.08
10.00 x 22	12	1.14	1.16	1.07	1.08
11.00 x 20	12	1.09	1.17	1.01	1.09
11.00 x 22	12	1.12	1.17	1.04	1.09

but very important item was the necessity to exercise extreme care in closing all valve cores. At least one State required the driver to sign a statement to the effect that the State was relieved from any responsibility in the case of subsequent tire failures.

The field data were first grouped by the four AASHO regions [1] and by vehicle types. A classification of the sample by region and vehicle type, including the number of tires involved, is shown in table 1. The size of the samples ranged from 54 vehicles in Idaho to 640 in Arkansas.

The next step was to group the data by tire size. The total sample, considering ply, included data for 103 tire sizes. The sizes found most frequently are shown in table 2. With the exception of the 11.00 x 24, 12-ply tire size, in which case the sample was very small, these are the sizes that are considered throughout the analysis. The average data for the 11.00 x 24, 12-ply tire size are included in the general results because of the interest in the operation of large tire sizes.

Another factor that had to be considered was the position of the tire with respect to axle configuration. An analysis of tire pressures for a given size indicated that it was necessary only to group the pressures by the first axle and by the remaining axles with dual tires. For example, the results of this analysis for 10.00 x 20, 12-ply tires in region 3 are summarized in table 3. It should be noted that the average pressures for the axles with dual tires are shown to be in close agreement for the three vehicle types. The distribution of the sample by tire size for the adopted axle grouping is shown in table 2.

Considering the fact that tire pressure is a function of load, miles operated without stops, speed, and surface type, as well as ambient and/or road surface temperature, and that control of all these variables was impractical if not impossible, it was not ex-

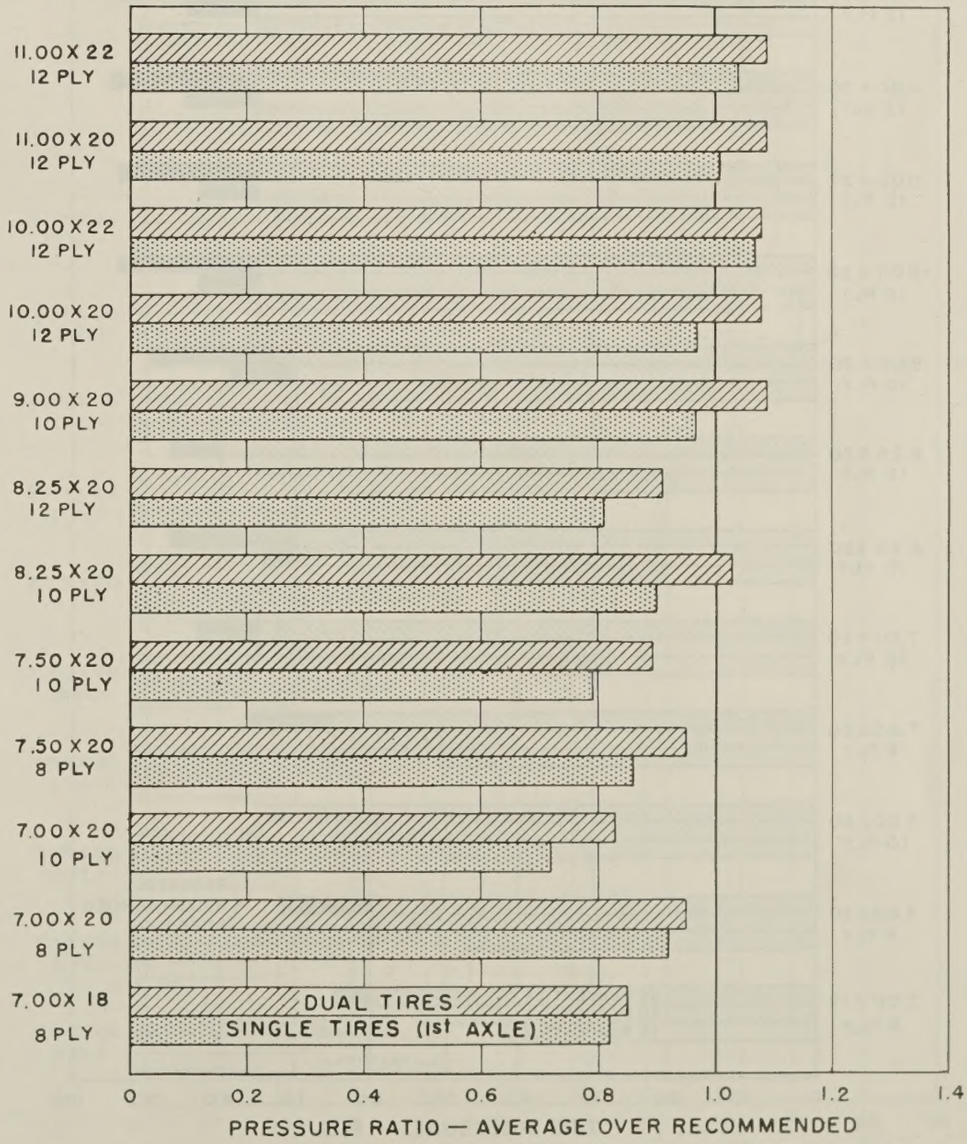

Figure 1.—Average observed tire pressure compared with pressure recommended by the Tire and Rim Association, Inc., after April 15, 1955.

[1] *Region 1.*—Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, Vermont, and District of Columbia. *Region 2.*—Alabama, Arkansas, Florida, Georgia, Kentucky, Louisiana, Mississippi, North Carolina, South Carolina, Tennessee, Virginia, and West Virginia. *Region 3.*—Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska, North Dakota, Ohio, Oklahoma, South Dakota, and Wisconsin. *Region 4.*—Arizona, California, Colorado, Idaho, Montana, Nevada, New Mexico, Oregon, Texas, Utah, Washington, and Wyoming.

Table 6.—Comparison of 15-, 50-, and 85-percentile tire pressures of dual tires with maximum recommended pressure

Tire size	Number of ply	Ratio of observed tire pressure to maximum recommended pressure—					
		Before Apr. 15, 1955			After Apr. 15, 1955		
		15 percentile	50 percentile	85 percentile	15 percentile	50 percentile	85 percentile
7.00 x 18	8	0.76	0.98	1.13	0.70	0.88	1.08
7.00 x 20	8	.86	1.09	1.31	.79	1.00	1.20
7.00 x 20	10	.76	.92	1.06	.71	.86	.99
7.50 x 20	8	.85	1.08	1.28	.78	1.00	1.18
7.50 x 20	10	.80	1.01	1.19	.75	.94	1.11
8.25 x 20	10	.95	1.15	1.34	.88	1.06	1.24
8.25 x 20	12	.85	1.03	1.16	.80	.96	1.09
9.00 x 20	10	1.02	1.20	1.38	.95	1.13	1.28
10.00 x 20	12	1.04	1.19	1.34	.97	1.11	1.25
10.00 x 22	12	1.04	1.19	1.34	.97	1.11	1.25
11.00 x 20	12	1.05	1.21	1.36	.98	1.13	1.27
11.00 x 22	12	1.07	1.21	1.36	1.00	1.13	1.27

pected that the survey would clearly define the effect of ambient temperature on tire-pressure levels. However, examples are given later in the report to indicate how pressure varied with ambient temperature.

The average temperatures for the four regions in numerical order were 79, 84, 80, and 72 degrees, respectively. These averages were obtained by averaging the hourly temperatures for the period of study. It is evident that the survey was conducted during the more critical period of the year with respect to tire inflation pressures. The temperatures ranged from a minimum of 40 degrees in Nevada to a maximum of 108 degrees in Missouri.

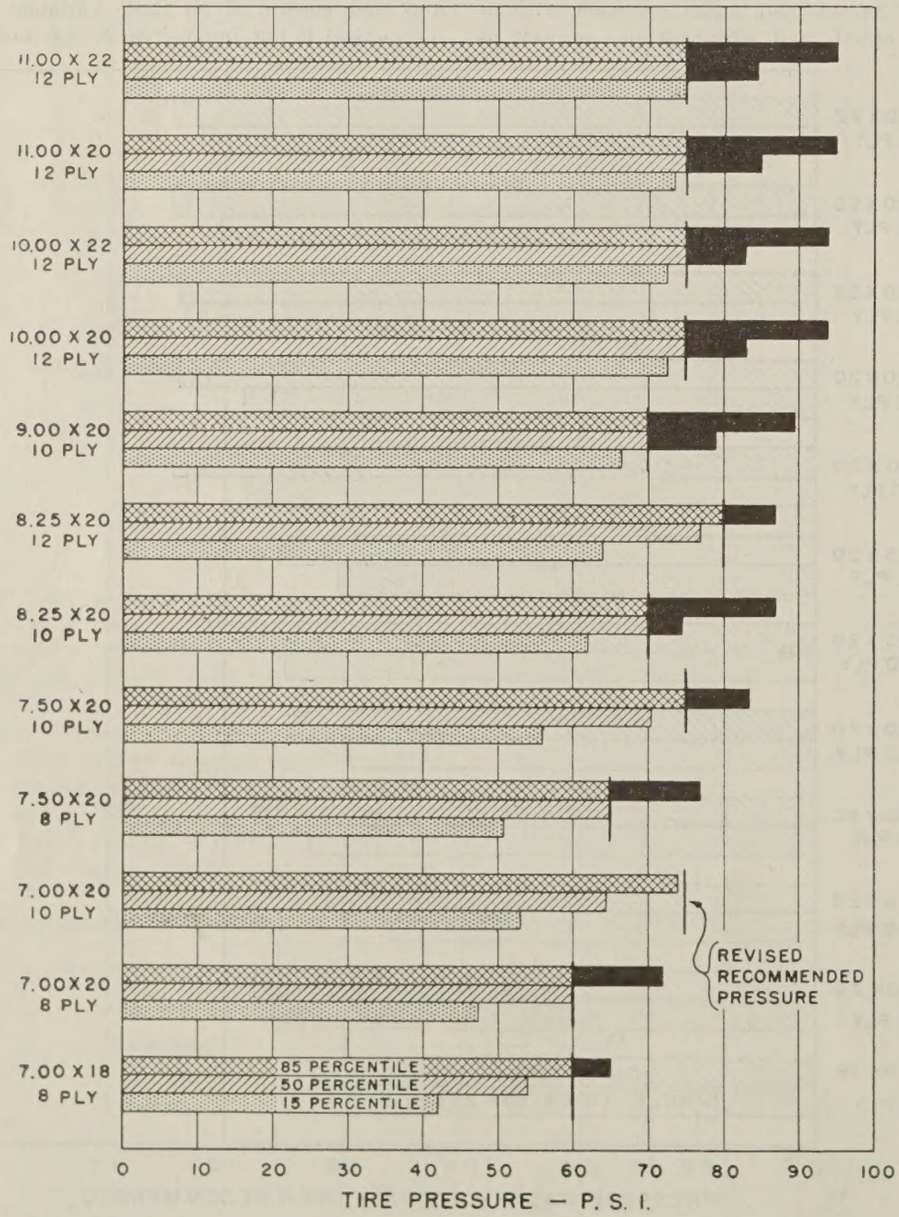

Figure 2.—Comparison of 15-, 50-, and 85-percentile values of tire pressures for dual tires.

Tire-Pressure Observations

The average results of the tire-pressure survey are summarized for the common tire sizes in table 4. In this table are shown the maximum recommended tire pressures of the Tire and Rim Association, Inc., and the average tire pressures observed for selected axle and wheel configurations. The average pressure for the tires on the first axle was always slightly less than that for the other axles with dual tires. Another point of interest is the small variation in average pressure between the inside and outside tires mounted on dual wheels. Average hot inflation pressures for the dual tires ranged between 80 and 85 p.s.i. for tire sizes of 10.00 x 20, 12 ply and greater.

Two schedules of recommended pressures are shown in table 4. This was necessary since the Tire and Rim Association, Inc., revised their recommendations on April 15, 1955, after the period of the tire survey. The increase in the recommended values is not believed to have altered materially the practice of inflating tires, because the new schedule only endorsed what had been the rule. The effect, if any, would be to raise the level of tire pressures established by the 1954 survey. In some of the later presentations of data, both schedules are used as bases for comparisons.

The extent to which the average pressure varies from that recommended for a given tire size is indicated by the pressure ratios in table 5. For example, if the ratio of observed pressure to recommended pressure was 1.08, then the observed value was about 8 percent greater than the recommended value. The ratios computed on the basis of the new schedule of recommended pressures are shown in figure 1. It is seen that dual tires (other axles) had an average pressure greater than the recommended pressure for the 8.25 x 20, 10-ply size and for the 9.00 x 20, 10-ply and greater sizes. In contrast, the single tires on the first axle had an average pressure greater than the recommended pressure only for the three largest tire sizes. In the case of dual tires, the 9.00 x 20, 10-ply and greater tire sizes were inflated on the average almost 10 percent above the new schedule, and more than 15 percent above the old schedule of recommended pressures.

The frequency distribution of tire pressures for a given tire size is indicated partially in figure 2. It is thought that the 85-percentile values are the most pertinent from the viewpoint of highway design. Those values range from 65 p.s.i. for 7.00 x 18 tires to 95 p.s.i. for the two 11.00 size tires. For tire sizes of 8.2

Table 7.—Summary of average tire loads by tire size and position on vehicle

Tire size	Number of ply	Average tire load by position			Maximum recommended tire load [2]	
		First axle	Other axles [1]	All axles	Before Apr. 15, 1955	After Apr. 15, 1955
		Lbs.	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*
7.00 x 18	8	1,510	1,280	1,380	1,850	2,140
7.00 x 20	8	1,690	1,550	1,600	2,000	2,310
7.00 x 20	10	1,760	1,645	1,690	2,250	2,630
7.50 x 20	8	1,775	1,765	1,770	2,375	2,740
7.50 x 20	10	1,760	1,650	1,690	2,700	2,980
8.25 x 20	10	2,070	2,415	2,320	2,900	3,330
8.25 x 20	12	2,425	2,300	2,325	3,150	3,600
9.00 x 20	10	2,540	2,705	2,670	3,450	3,960
10.00 x 20	12	3,095	2,870	2,910	4,000	4,580
10.00 x 22	12	3,430	2,805	2,965	4,275	4,880
11.00 x 20	12	3,530	3,115	3,180	4,500	5,150
11.00 x 22	12	3,955	3,170	3,295	4,750	5,480

[1] To determine load on a single tire of a dual assembly, the wheel load was divided by 2, or the axle load was divided by 4.
[2] Tire and Rim Association, Inc., Year Book.

and greater the 85-percentile pressures are above 85 p.s.i. The spread between the 15- and 85-percentile values is confined within the range of 20 to 27 p.s.i. Figure 2 shows that tire inflation pressures of 90 p.s.i. are rather common for commercial vehicles operating in the general traffic.

The tire-pressure ratios, similar to those shown in table 5 for average inflation pressures, are given in table 6 for the 15-, 50-, and 85-percentile tire pressures plotted in figure 2. For the larger tire sizes, the 85-percentile inflation pressures exceed the new schedule of recommended pressures by about 25 percent.

Tire-Load Observations

An analysis of tire loads was made in the same manner as that just described for tire pressures. It is not intended that the results should be used for design or other purposes, as much more quantitative data are available from the more comprehensive regular loadometer surveys. The purpose is merely to give a general picture of the range of tire loads found in the tire-pressure survey.

Table 8.—Comparison of average observed tire loads on first axle and other axles with maximum recommended load

Tire size	Number of ply	Ratio of average observed load to maximum recommended load—			
		Before Apr. 15, 1955		After Apr. 15, 1955	
		First axle	Other axles	First axle	Other axles
7.00 x 18	8	0.82	0.69	0.71	0.60
7.00 x 20	8	.84	.77	.73	.67
7.00 x 20	10	.78	.73	.67	.63
7.50 x 20	8	.75	.74	.65	.65
7.50 x 20	10	.65	.61	.59	.56
8.25 x 20	10	.71	.83	.62	.72
8.25 x 20	12	.77	.73	.67	.64
9.00 x 20	10	.74	.78	.64	.68
10.00 x 20	12	.77	.72	.67	.63
10.00 x 22	12	.80	.66	.70	.57
11.00 x 20	12	.78	.69	.68	.60
11.00 x 22	12	.83	.67	.72	.58

Table 7 summarizes the average tire loads for each tire size by axle configuration. Also included in the table for reference purposes are the two schedules of recommended tire loads which are compatible with the recommended tire pressures. It is evident that the average tire loads are well below those recommended by the Tire and Rim Association, Inc. The extent of this variation is shown in table 8 which contains the ratios of observed to recommended loads. It is seen that tires on the front axle were loaded heavier than those on the other axles in all except two instances. The average tire load was generally less than 70 percent of the new load schedule.

The 15-, 50-, and 85-percentile tire loads for the dual-tired wheels (other axles) are plotted in figure 3 for the several tire sizes. There was a wide range of tire loads for a given tire size especially for the larger sizes. Also, the 85-percentile values did not exceed the new schedule of loads except for the 7.50 x 20, 10-ply and the two 8.25 x 20 tire sizes, and then only to a small degree.

The ratios of the tire loads shown in figure 3 to both the old and new schedules are listed in table 9 for the respective tire sizes. A study of the ratios in table 9 definitely reveals that present operating practices result in tire

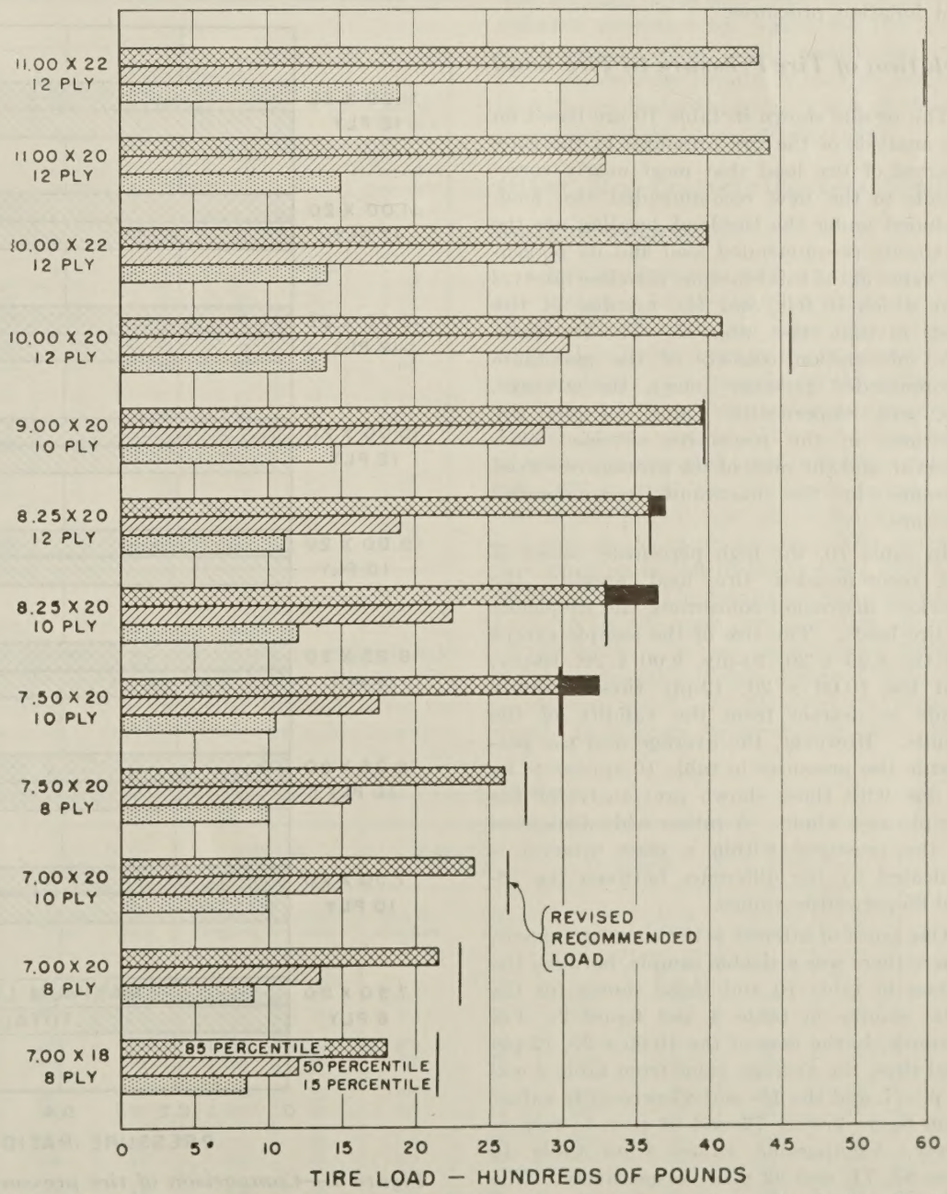

Figure 3.—Comparison of 15-, 50-, and 85-percentile values of tire loads for dual tires.

Table 9.—Comparison of 15-, 50-, and 85-percentile tire loads of dual tires with maximum recommended load

Tire size	Number of ply	Ratio of observed tire load to maximum recommended load—					
		Before Apr. 15, 1955			After Apr. 15, 1955		
		15 percentile	50 percentile	85 percentile	15 percentile	50 percentile	85 percentile
7.00 x 18	8	0.46	0.65	0.98	0.40	0.56	0.84
7.00 x 20	8	.45	.68	1.08	.39	.58	.93
7.00 x 20	10	.45	.67	1.07	.38	.57	.92
7.50 x 20	8	.42	.65	1.10	.37	.57	.95
7.50 x 20	10	.39	.65	1.20	.35	.59	1.09
8.25 x 20	10	.41	.78	1.26	.36	.67	1.10
8.25 x 20	12	.35	.60	1.17	.30	.53	1.03
9.00 x 20	10	.42	.83	1.14	.37	.72	1.00
10.00 x 20	12	.35	.76	1.03	.30	.66	.89
10.00 x 22	12	.33	.69	.94	.29	.60	.82
11.00 x 20	12	.33	.73	.98	.29	.64	.86
11.00 x 22	12	.40	.68	.92	.35	.59	.79

loads that are generally well within the recommended ones. This was in decided contrast to what was indicated by the ratios in table 6. In that instance, hot tire pressures were shown to be considerably above the recommended cold inflation pressures.

Relation of Tire Pressure to Tire Load

The results shown in table 10 are based on the analysis of the tire pressures in the class interval of tire load that most nearly corresponds to the new recommended tire load. Included under the tire-load heading are the maximum recommended load and its percentile value in the total sample, the class interval into which it fell, and the number of tire loads in that class interval. The tire pressure information consists of the maximum recommended pressure (new), the average, 15-, and 85-percentile values of the tire pressures in the respective tire-load class interval, and the ratio of the average observed pressure to the maximum recommended pressure.

In table 10, the high percentile values of the recommended tire load amplify the previous discussion concerning the frequency of tire loads. The size of the sample except for the 8.25 x 20, 10-ply, 9.00 x 20, 10-ply, and the 10.00 x 20, 12-ply tires certainly tends to detract from the validity of the results. However, the average and the percentile tire pressures in table 10 appear to be in line with those shown previously for the sample as a whole. A rather wide dispersion of the pressures within a class interval is indicated by the difference between the 15- and 85-percentile values.

One point of interest is the close agreement, where there was a sizable sample, between the values in table 10 and those shown for the total sample in table 4 and figure 2. For example, in the case of the 10.00 x 20, 12-ply dual tires, the average value from table 4 was 81 p. s. i. and the 15- and 85-percentile values from figure 2 were 72 and 94 p. s. i., respectively. Comparable values from table 10 were 83, 71, and 92 p.s.i., respectively. The inference is that tire pressure did not increase materially with tire load. This point is further illustrated by the comparison in figure 4 of the average pressure ratios listed in tables 5 and 10. It is indicated that the ratio for the maximum load interval usually is only slightly greater than the one for total sample.

Table 11 contains results similar to those in table 10 for conditions of tire load and pressure recommended prior to April 15, 1955. The main reason for including this table is to present another set of values for a specific tire-load group that are based on a larger sample. From table 10, the average, 15-, and 85-percentile values are 84, 75, and 90 p.s.i., respectively, for 23 11.00 x 20, 12-ply tires. The respective values from table 11 are 84, 71, and 92 p.s.i. for 181 tires of the same size. The tire-load class interval in the first instance is 5,000 to 5,249 pounds, and it is 4,250 to 4,749 pounds in the latter instance. The results in table 11 tend to substantiate those presented in table 10.

A further evaluation of the variation of tire pressure with tire load for dual tires is made in table 12 and figure 5. The average pressure and number of observations by 500-pound class intervals of tire load are given in table 12 for 6 of the more common truck tires. The increase in pressure is very gradual over the load range and generally amounts to slightly over 10 percent from the lowest to the highest tire load. The rate of pressure increase with

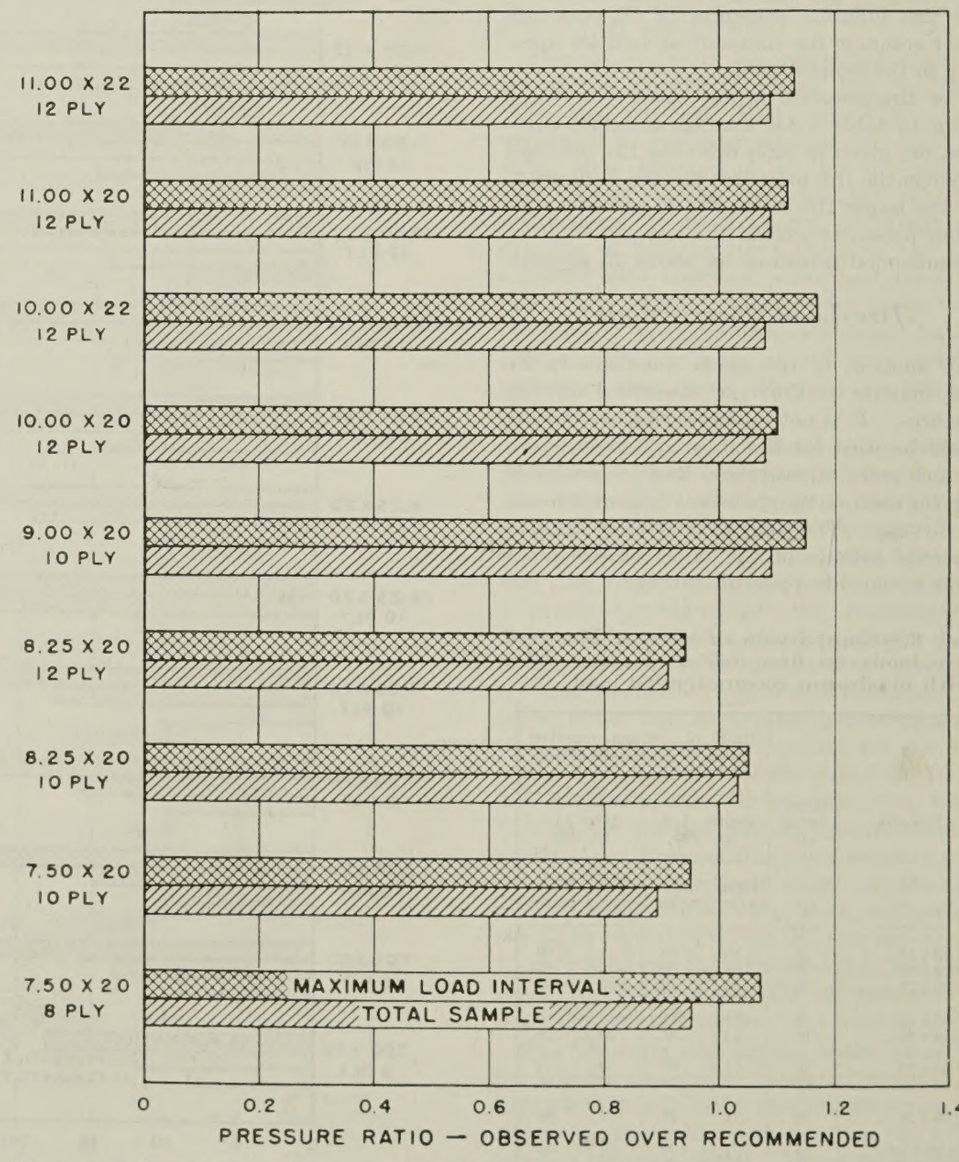

Figure 4.—Comparison of tire pressure ratios for total vehicle sample and for class interval of tire load containing maximum load recommended by the Tire and Rim Association, Inc., after April 15, 1955.

Table 10.—Average, 15-, and 85-percentile values of tire pressure of dual-tired wheels for class interval of tire load corresponding to maximum recommended load after Apr. 15, 1955

Tire size	Number of ply	Tire load				Tire pressure				Ratio of observed to maximum recommended pressure
		Maximum recommended load		Class interval		Maximum recommended pressure	Average observed pressure	15 percentile	85 percentile	
		Pounds	Percentile	Pounds	Number of tires					
						P. s. i.	*P. s. i.*	*P. s. i.*	*P. s. i.*	
7.00 x 18	8	2,140	95	2,000–2,249	6	60	53	[1] 40	[2] 60	0.88
7.00 x 20	8	2,310	90	2,250–2,499	2	60	68	[1] 65	[2] 70	1.13
7.00 x 20	10	2,630	92	2,500–2,749	2	75	74	[1] 72	[2] 75	.99
7.50 x 20	8	2,740	88	2,500–2,749	20	65	70	60	75	1.07
7.50 x 20	10	2,980	77	2,750–2,999	24	75	71	60	85	.95
8.25 x 20	10	3,330	75	3,250–3,499	307	70	74	60	83	1.05
8.25 x 20	12	3,600	83	3,500–3,749	16	80	75	61	86	.94
9.00 x 20	10	3,960	85	3,750–3,999	198	70	81	66	89	1.15
10.00 x 20	12	4,580	95	4,500–4,749	466	75	83	71	92	1.10
10.00 x 22	12	4,880	99	4,750–4,999	39	75	88	75	100	1.17
11.00 x 20	12	5,150	96	5,000–5,249	23	75	84	75	90	1.12
11.00 x 22	12	5,480	97	5,250–5,499	18	75	85	80	90	1.13

[1] Minimum value. [2] Maximum value.

Table 11.—Average, 15-, and 85-percentile values of tire pressure of dual-tired wheels for class interval of tire load corresponding to maximum recommended load before Apr. 15, 1955

Tire size	Number of ply	Tire load				Tire pressure				Ratio of observed to maximum recommended pressure
		Maximum recommended load		Class interval		Maximum recommended pressure	Average observed pressure	15 percentile	85 percentile	
		Pounds	Percentile	Pounds	Number of tires					
						P. s. i.	*P. s. i.*	*P. s. i.*	*P. s. i.*	
7.00 x 18	8	1,850	87	1,750–1,999	10	55	60	40	68	1.09
7.00 x 20	8	2,000	79	1,750–2,249	21	55	62	45	73	1.12
7.00 x 20	10	2,250	75	2,000–2,499	11	70	64	53	72	.91
7.50 x 20	8	2,375	81	2,250–2,499	17	60	64	60	70	1.07
7.50 x 20	10	2,700	72	2,500–2,749	23	70	66	58	80	.94
8.25 x 20	10	2,900	63	2,750–2,999	167	65	72	59	82	1.11
8.25 x 20	12	3,150	70	3,000–3,249	8	75	68	60	75	.91
9.00 x 20	10	3,450	71	3,250–3,499	221	65	77	62	86	1.18
10.00 x 20	12	4,000	82	3,750–4,249	2,274	70	84	71	90	1.20
10.00 x 22	12	4,275	91	4,000–4,499	440	70	85	73	92	1.21
11.00 x 20	12	4,500	88	4,250–4,749	181	70	84	71	92	1.20
11.00 x 22	12	4,750	93	4,500–4,999	117	70	86	76	92	1.23

load is shown in figure 5 for the smallest and largest tire sizes included in table 12.

It seems rather conclusive that tire load is not too significant in the study of tire pressures measured at random from the general traffic stream. Similar investigations for a particular vehicle type and State or region have yielded approximately the same trends. The tendency for a particular tire size is for the pressure to increase with tire load; however, in the range of loads that would normally be considered in highway design, the increase is rather insignificant.

Effect of Vehicle Type and Geographical Area on Tire Pressure

The average tire pressures for the more predominant vehicle types are summarized in table 13 by tire size. For a given tire size the variation of pressure with vehicle type is not material if the less common vehicle combinations are excepted. This is clearly indicated by figure 6, which compares the average pressures for two tire sizes. Excluding truck-tractor-semitrailer and full-trailer combinations (2–S1–2 and 2–S2–2), the range in average pressure was from 74 to 81 p.s.i. for the 10.00 x 20, 12-ply tires.

As indicated earlier in the report, an analysis was made to determine whether there was any regional variation of inflation pressures. This was accomplished by grouping the data by the four AASHO regions. Sample results of the analyses for 10.00 x 20, 12-ply tires, irrespective of vehicle type, are shown in table 14. Also included in the same table are the average inflation pressures by region for the 2-axle truck-tractors with 2-axle semitrailers. On the basis of these results, it may be assumed that the results for the country as a whole may be applied safely to any given region.

Other Tire-Pressure Factors Studied

Ambient temperature

A trial analysis was made on the samples of tire pressures for the 10.00 x 20, 12-ply tires checked in Missouri and Iowa to investigate the relation between ambient temperature and tire pressure. The sample for Missouri was the largest of any State and was observed at 15 widely separated stations. Ambient temperatures for day and night operations ranged from 62° to 108° F. The Iowa sample was one of the largest and all of the tires were checked at the same station. The range in temperatures in this instance was a little less, 62° to 98° F. The results are summarized in table 15 for the more common class intervals of tire loads. As was expected, considering the uncontrollable factors involved, there was no definite trend. In Missouri the pressure tended to increase rather sharply after about

Table 12.—Variation of tire pressure with tire load for dual tires

Tire-load interval	8.25 x 20, 10-ply tires		9.00 x 20, 10-ply tires		10.00 x 20, 12-ply tires		10.00 x 22, 12-ply tires		11.00 x 20, 12-ply tires		11.00 x 22, 12-ply tires	
	Number checked	Pressure	Number checked	Pressure	Number checked	Pressure	Number checked	Pressure	Number checked	Pressure	Number checked	Pressure
Pounds		*P. s. i.*		*P. s. i.*		*P. s. i.*		*P. s. i.*		*P. s. i.*		*P. s. i.*
1,000–1,499	626	69	425	73	2,043	77	635	76	183	78	143	77
1,500–1,999	697	69	495	72	1,603	77	473	78	166	79	164	78
2,000–2,499	412	69	349	73	1,258	80	420	79	121	80	139	81
2,500–2,999	321	72	364	76	1,516	80	572	79	143	80	234	81
3,000–3,499	563	75	488	76	2,110	82	709	83	159	84	313	83
3,500–3,999	388	77	408	80	2,679	83	709	85	235	84	327	82
4,000–4,499	222	81	291	81	1,752	85	440	85	230	84	189	83
4,500–4,999	61	77	109	82	642	84	137	85	110	86	117	86
5,000–5,499	6	63	21	81	116	85	29	86	47	84	33	86
5,500–5,999	2	90	2	70	37	84	10	86	17	86	23	88

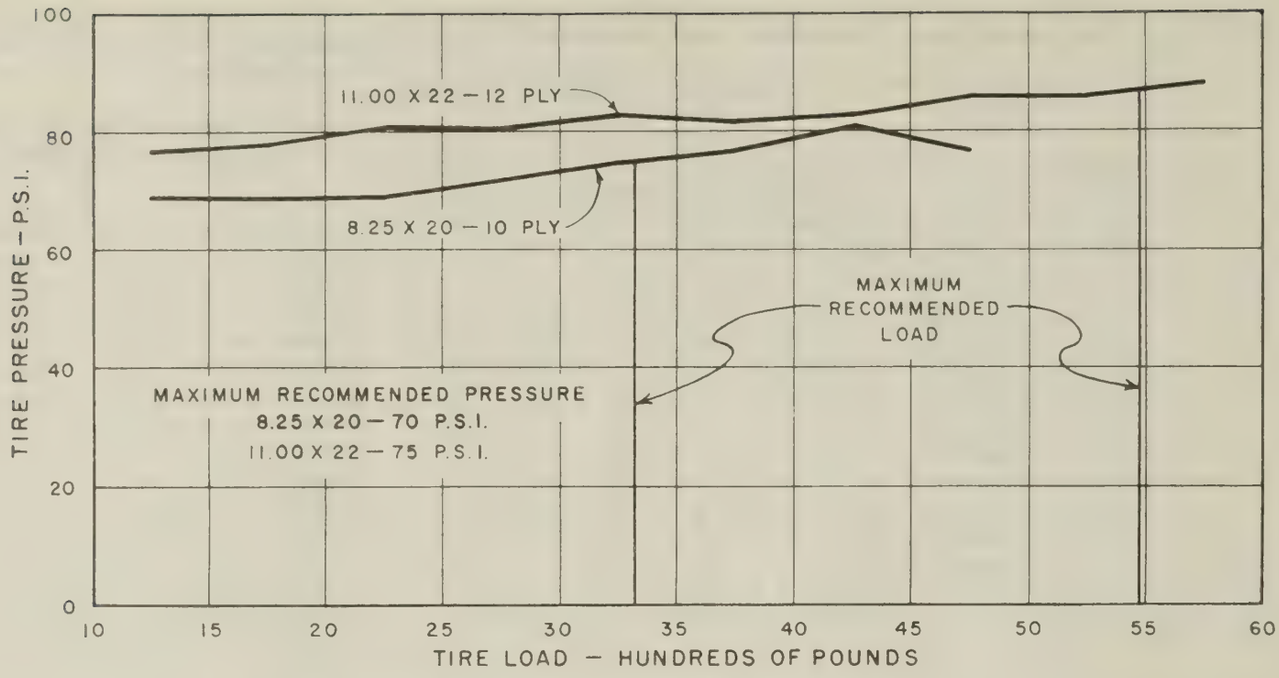

Figure 5.—Variation of tire pressure with load for dual tires of two common sizes.

95° F. It appeared from other investigations of the data that pressures during the daytime period of higher temperatures would seldom be more than 5 p.s.i. above the average of the combined night and day operating pressures.

Motor-carrier tire inflation practices

One of the items recorded on a recent investigation of truck-operation practices was the initial (cold) inflation pressure specified by a motor carrier for his fleet. The frequency of specified pressures and the average values are shown in table 16 for carriers interviewed during 1955 and 1956 in 32 States. Also included for comparison are the recommended pressures, and the 50- and 85-percentile values of pressure read from figure 2 for the given tire size. It is very evident that there is a sizable variation in carrier practice. Tire pressures reported by the average carrier are about 5 p.s.i. above the recommended pressure.

The 50- and 85-percentile values obtained by the tire-pressure survey and reported in table 16 are about 5 and 15 p.s.i., respectively, above the values for the average carrier. In this respect, one tire manufacturer has reported that normal inflation increases would probably be from a recommended value of 75 to 90 or 95 p.s.i. Other available references seem to support such a pressure differential. It would appear that the results of the tire survey are within the expected limits.

Use of high-pressure tires

In the past few years there has been a trend toward the use of higher pressure tires. This has been characterized by the introduction of a "high-load" tire with all-nylon cord in this country and the importing of steel cord tires from Europe. Neither of these types were prominent in the sample collected in 1954. Nevertheless, the trend has been viewed with alarm by some highway engineers.

Since 1954 the use of the high-load tire undoubtedly has increased substantially. It is used by operators who want maximum vertical cargo space in their trailer units. The popular size is the 10.3 x 20, 14-ply (nylon cord equivalent) tire with a maximum recommended load of 4,750 pounds and inflation pressure of 95 p.s.i. when mounted on dual wheels. Seven vehicles equipped with tires of this size were checked in the 1954 survey. The average pressure was 90 p.s.i. which was 9 p.s.i. above the average found for the much larger sample of the comparable conventional tire size. The range in pressure was from 70 to 110 p.s.i.

There have been persistent rumors that some carriers are operating high-load tires at pressures less than the recommended because of alleged operating advantages. One of the largest west coast operators specifies an initial inflation pressure of 85 p.s.i. on the single tires (front axle) and 80 on the dual tires. Another fleet in Illinois inflates to 90 p.s.i. From the limited data, it would appear that pressures of at least 10 p.s.i. in excess of those found for the comparable conventional size may be expected, but probably not to the extent of the difference in recommended inflation pressures which is 20 p.s.i.

The steel cord tire has 2 to 4 plies which replace the usual 10 to 18 of the textile type. It is believed to be in very limited use in this country at the present time. In the 1954

Table 13.—Average observed air pressure for dual tires by tire size and vehicle type

Tire size	Number of ply	Average observed air pressure of dual tires, by vehicle types										All vehicles	
		2D	3	2-S1	2-S2	3-S2	2-S1-2	2-S2-2	2-2	3-2	3-3	Number of tires	Average air pressure
		P. s. i.	*P. s. i.*	*P. s. i.*	*P. s. i.*	*P. s. i.*	*P. s. i.*	*P. s. i.*	*P. s. i.*	*P. s. i.*	*P. s. i.*		*P. s. i.*
7.00 x 18	8	51	------	------	------	------	------	------	------	------	------	112	51
7.00 x 20	8	57	------	------	------	------	------	------	------	------	------	104	57
7.00 x 20	10	62	------	------	------	------	------	------	------	------	------	61	62
7.50 x 20	8	62	------	68	------	------	------	------	------	------	------	415	62
7.50 x 20	10	64	------	78	------	------	------	------	------	------	------	528	67
8.25 x 20	10	69	75	74	78	------	------	------	------	------	------	3,556	72
8.25 x 20	12	71	78	74	------	------	------	------	------	------	------	244	73
9.00 x 20	10	73	78	75	79	75	------	------	------	------	------	3,054	76
10.00 x 20	12	77	74	80	81	79	89	89	------	81	74	14,250	81
10.00 x 22	12	------	------	83	83	78	83	94	86	80	75	4,256	81
11.00 x 20	12	76	------	80	83	82	87	94	------	82	------	1,451	82
11.00 x 22	12	78	------	83	82	79	86	------	------	78	------	1,739	82
11.00 x 24	12	90	------	80	86	------	------	------	------	------	------	36	84

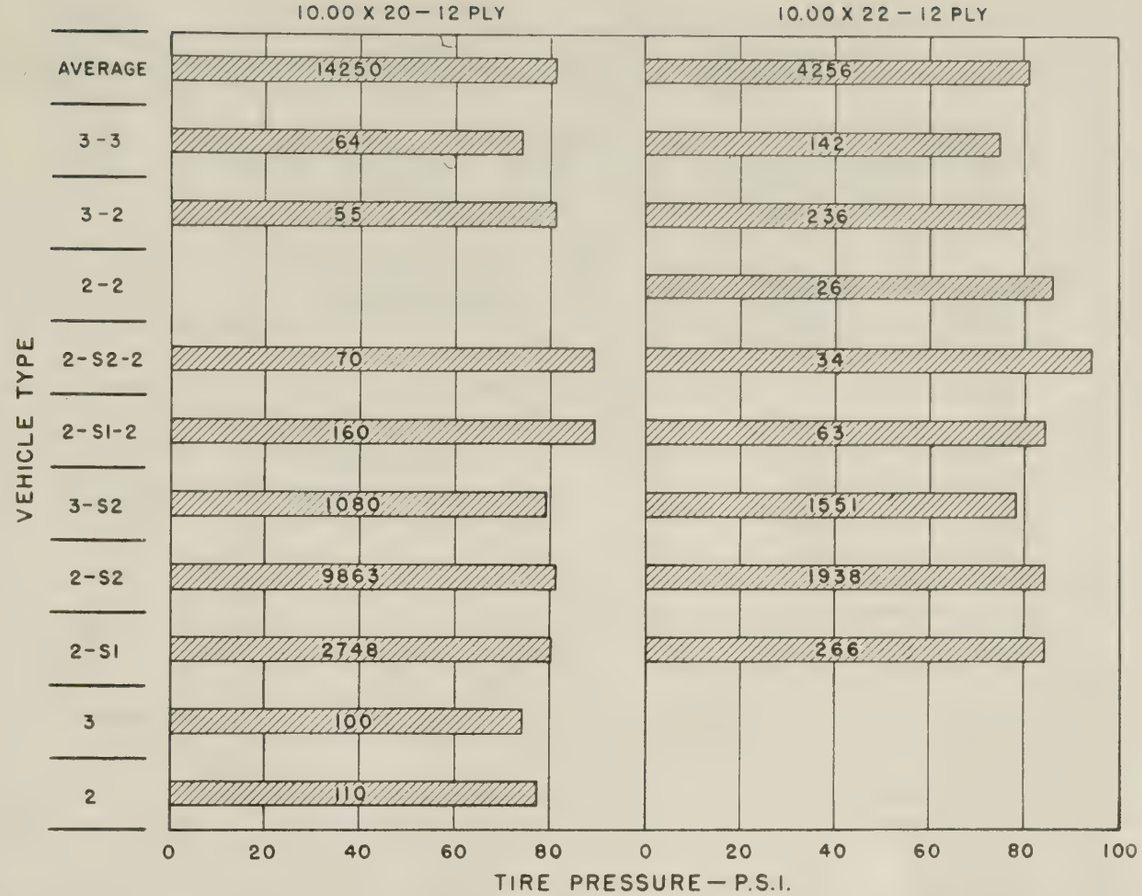

Figure 6* (above).—*Variation of tire pressure with vehicle type for dual tires of two sizes.

survey one combination was found with this type of tire. The average pressure for the tires checked was 116 p.s.i. The size encountered has a maximum load rating of 6,500 pounds per tire when inflated to 110 p.s.i. and used as duals. The rating is 5,400 pounds if inflated to 100 p.s.i. which compares closely with a rating of 5,480 pounds for a conventional 11.22 x 20, 12-ply tire inflated to 75 p.s.i. The steel cord tire has the same operating advantage over the conventional tire as the high-load tire. That is, it is possible to carry the same wheel load on a smaller diameter tire.

Table 14.—Variation of tire pressure for 10.00 x 20, 12-ply dual tires, by regions

Tire-load interval (pounds)	Average tire pressure for all vehicle types observed in—					Average tire pressure for 2-axle truck-tractors with 2-axle semitrailers (2-S2) observed in—				
	Region 1	Region 2	Region 3	Region 4	All regions	Region 1	Region 2	Region 3	Region 4	All regions
	P. s. i.	*P. s. i.*	*P. s. i.*	*P. s. i.*	*P. s. i.*	*P. s. i.*	*P. s. i.*	*P. s. i.*	*P. s. i.*	*P. s. i.*
1,000–1,499	78	78	77	74	77	77	78	78	76	78
1,500–1,999	78	76	77	76	77	79	78	78	78	78
2,000–2,499	79	81	79	78	80	81	84	79	77	81
2,500–2,999	80	80	80	77	80	81	78	80	78	80
3,000–3,499	83	83	81	80	82	84	83	82	82	82
3,500–3,999	83	83	83	81	83	84	83	87	84	85
4,000–4,499	84	83	87	82	85	85	83	87	84	85
4,500–4,999	83	82	86	84	84	87	81	84	83	83
5,000–5,499	87	83	86	84	85	90	83	90	82	85
5,500–5,999	84	----	----	85	84	79	----	----	85	80
Average air pressure	81	81	81	79	81	82	81	81	80	81

Table 15.—Variation of tire pressure with ambient temperature for 10.00 x 20, 12-ply dual tires

Tire-load interval (pounds)	Number of tires	Average tire pressure for temperatures (° F.) ranging from—									Average pressure
		60–64 degrees	65–69 degrees	70–74 degrees	75–79 degrees	80–84 degrees	85–89 degrees	90–94 degrees	95–100 degrees	100–104 degrees	
MISSOURI											
		P. s. i.	*P. s. i.*	*P. s. i.*	*P. s. i.*	*P. s. i.*	*P. s. i.*	*P. s. i.*	*P. s. i.*	*P. s. i.*	*P. s. i.*
2,500–2,999	213	------	75	82	81	80	83	80	81	------	81
3,000–3,499	263	81	75	81	80	80	87	83	88	91	82
3,500–3,999	464	80	81	77	78	85	84	83	84	87	82
4,000–4,499	242	82	82	82	83	84	84	80	89	87	84
Average air pressure	1,182	81	79	80	80	83	84	82	85	88	82
IOWA											
2,500–2,999	171	79	79	76	79	------	------	86	77	------	78
3,000–3,499	195	78	80	79	80	------	80	83	85	------	81
3,500–3,999	241	81	81	80	82	------	87	90	78	------	82
4,000–4,499	134	81	89	79	82	------	81	80	80	------	81
Average air pressure	741	80	82	79	81	------	83	85	80	------	81

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Table 16.—Initial (cold) inflation pressures reported by selected carriers compared with results of the present survey made on the highways

Tire size	Number of carriers	Tire pressure				Percentage of carriers reporting initial (cold) inflation pressure of—							
		Maximum recommended pressure	Average pressure reported by carriers	Observed pressure		60 p. s. i.	65 p. s. i.	70 p. s. i.	75 p. s. i.	80 p. s. i.	85 p. s. i.	90 p. s. i.	95 p. s. i. and over
				50 percentile	85 percentile								
		P. s. i.	*P. s. i.*	*P. s. i.*	*P. s. i.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*
9.00	71	70	76	79	90	------	16.9	19.7	26.8	16.9	11.3	8.4	------
10.00	418	75	79	83	94	1.2	2.6	17.7	21.5	30.4	16.0	8.9	1.7
11.00	85	75	80	85	95	1.2	2.3	14.1	21.2	27.1	15.3	17.6	1.2

Results of 1940 and 1954 Surveys Compared

The results of a tire-pressure survey published in 1941 by the Kansas State Highway Commission are compared with the results of the present survey in table 17. The 50- and 85-percentile values for the 1954 survey are read from figure 2. There is little difference in the values for the three larger tire sizes; however, the 1954 values are appreciably higher in the case of the 7.00 and 7.50 sizes.

The significant variation between the results of the two surveys was in the percentage of the tire loads for a given tire size that exceeded the maximum recommended load. For example, in the earlier study 41 percent of the tire loads for 9.00 x 20, 10-ply tires were in excess of the recommended value. In 1954, the comparable percentage was 29 percent for the old schedule and 15 percent for the new schedule of recommended tire loads.

Table 17.—Results of 1940 survey in Kansas compared with the present survey

Tire size	Number of ply	Tire pressure					
		Maximum recommended pressure		Observed pressure, 50 percentile		Observed pressure, 85 percentile	
		1940	1954 [1]	1940	1954	1940	1954
		P. s. i.	*P. s. i.*	*P. s. i.*	*P. s. i.*	*P. s. i.*	*P. s. i.*
7.00 x 20	8	55	55	52	60	63	72
7.50 x 20	8	55	60	57	65	72	77
8.25 x 20	10	60	65	72	74	89	87
9.00 x 20	10	65	65	76	79	90	89
9.75 x 20	12	70	[2] 70	81	[2] 83	94	[2] 94

[1] Recommended air pressure prior to Apr. 15, 1955.
[2] 10.00 x 20, 12-ply tires.

State Highway-User Taxes Paid in 1954 and 1955 on Vehicles of Various Type and Weight Groups

BY THE DIVISION OF FINANCIAL AND ADMINISTRATIVE RESEARCH
BUREAU OF PUBLIC ROADS

Reported [1] by ELIZABETH SAMSON, Transportation Economist

This study of highway-user taxes contributed by vehicles of different type and weight groups is primarily concerned with revenues received by the States in 1954, although preliminary data for 1955 are also included.

State highway-user taxes collected by the States during 1954 amounted to $3,623 million, of which 63.6 percent came from motor-fuel taxes, 29.4 percent from registration fees, 2.3 percent from motor-carrier taxes, 1.9 percent from operator's and chauffeur's licenses, and 2.8 percent from miscellaneous fees and taxes. Revenues from the same sources amounted to $4,008 million in 1955, a 10.6-percent increase over the previous year.

In 1954, passenger cars contributed 64.7 percent of the total State highway-user taxes; trucks and truck combinations, 32.9 percent; buses, 1.8 percent; and motorcycles and light trailers, 0.6 percent.

Excluding motorcycles and light trailers from consideration, passenger cars accounted for 83.5 percent of the registrations, 81.0 percent of the mileage traveled, and 65.1 percent of the user-tax payments; trucks and truck combinations represented 16.3 percent of the registrations, 18.3 percent of the travel, and 33.1 percent of the tax payments; and buses accounted for 0.2 percent of the registrations, 0.7 percent of the travel, and 1.8 percent of the tax payments.

When 2-axle, 4-tire single-unit trucks are combined with passenger cars and compared with medium and heavy trucks, the percentages of registration, travel, and tax payments were as follows: light vehicles, 93.7, 90.6, and 74.3 percent; and medium and heavy trucks, 6.1, 8.8, 23.9 percent, respectively.

Average payments of highway-user taxes in 1954 were made at the following rates per vehicle, per vehicle-mile, and per ton-mile: passenger cars $48, 0.52 cent, and 0.26 cent; trucks and truck combinations $127, 1.17 cents, and 0.17 cent; and buses $462, 1.83 cents, and 0.17 cent, respectively. For truck combinations alone, the corresponding amounts were $850, 2.20 cents, and 0.12 cent.

In 1955, average user-tax payments per vehicle, per vehicle-mile, and per ton-mile were $50, 0.54 cent, and 0.27 cent for passenger cars; $131, 1.21 cents, and 0.18 cent for trucks and truck combinations; and $470, 1.85 cents, and 0.20 cent for buses. Truck combinations alone contributed $881, 2.25 cents, and 0.12 cent, respectively.

IN 1954 the Bureau of Public Roads published estimates of State highway-user taxes paid during 1952 on vehicles in different type and weight groups.[2] Since better and more up-to-date information is now available, it has been deemed desirable to undertake similar computations for the calendar year 1954. A complete analysis could not be made for 1955, but some preliminary estimates for that year are included.

The estimates given in this article cover the continental United States and include only payments that are generally regarded as State highway-user taxes, as follows: motor-vehicle registration fees; motor-carrier taxes; operator's and chauffeur's licenses; motor-fuel taxes, including imposts levied on special fuels; and miscellaneous fees and charges, such as certificate-of-title fees, special titling taxes, and service charges. State-imposed sales and excise taxes, fines and penalties, and toll charges are omitted, as are all imposts levied directly against motor vehicles and their use by the Federal Government, counties, cities, special authorities, and other local units.

State highway-user taxes totaled $3,623 million for 1954 and $4,008 million for 1955. These amounts exclude $17 million and $18 million, respectively, of fines and penalties, which are not considered to be road-user revenues even though they are miscellaneous receipts of the highway departments in some States. No estimate has been made of income from sales and use taxes on motor vehicles and parts, but the sums received from other imposts on highway users that are not covered by this analysis are given in table 1.

The classification of vehicles which was selected as having the most meaning for this study is essentially the one by which vehicles are recognized on the highways and by which traffic data are usually collected and presented. The principal modification in this visual classification was made to subclassify buses so that the distribution of highway-user taxes would reflect differences in the taxes required for buses in three different types of operation—school bus service and commercial intercity and transit service.

Findings

Of the total of $3,623 million received by the States from highway-user taxes in 1954, 63.6 percent or $2,306 million came from motor-fuel taxes, 29.4 percent or $1,064 million from registration fees, 2.3 percent or

Table 1.—Revenue from highway-user imposts not included in this analysis

Type of impost	Amounts paid in—	
	1954	1955
	Million dollars	*Million dollars*
Federal motor-fuel, lubricating oil, and excise taxes [1]	2,204	2,736
State-imposed toll charges	167	211
County and local imposts on motor-vehicle users	54	58
County and local toll charges	58	60
Total	2,483	3,065

[1] These amounts are the portions of the Federal imposts estimated to have been paid by highway users. The gross collections were $2,334 million in 1954 and $2,867 million in 1955.

[1] Estimates of the distribution of vehicles by types and their corresponding travel were prepared by Nathan Lieder, statistician, Bureau of Public Roads.

[2] *Estimate of user taxes paid by vehicles in different type and weight groups*, by Edwin M. Cope, John T. Lynch, and Clarence A. Steele. PUBLIC ROADS, vol. 28, No. 2, June 1954, pp. 17–26. The same article was published in a somewhat revised and expanded form but without change in the basic data in *Highway-User Taxation*, Bulletin 92, Highway Research Board, pp. 15–34.

Table 2.—Estimate of State highway-user taxes paid in 1954, by major types of vehicles

Vehicle type	Registration fees	Motor-carrier taxes	Operator's and chauffeur's license fees	Miscellaneous fees	Motor-fuel taxes	Total	
						Amount	Distribution
	1,000 dollars	*1,000 dollars*	*1,000 dollars*	*1,000 dollars*	*1,000 dollars*	*1,000 dollars*	*Percent*
Passenger cars	603,446	-------	55,821	81,487	1,602,572	2,343,326	64.7
Motorcycles	1,840	-------	135	513	5,027	7,515	.2
Camp and other light trailers	15,633	-------	-------	-------	-------	15,633	.4
School and miscellaneous buses	1,735	-------	247	125	2,283	4,390	.1
Commercial buses:							
Intercity	4,050	9,360	100	51	9,891	23,452	.6
Transit	6,791	(1)	260	132	29,629	36,812	1.1
All commercial buses	10,841	9,360	360	183	39,520	60,264	1.7
All buses	12,576	9,360	607	308	41,803	64,654	1.8
Single-unit trucks:							
2-axle, 4-tire	110,267	-------	6,278	8,200	207,034	331,779	9.1
2-axle, 6-tire	168,415	3,396	3,105	6,253	174,777	355,946	9.8
3-axle	33,597	331	337	1,230	28,084	63,579	1.8
All single-unit trucks	312,279	3,727	9,720	15,683	409,895	751,304	20.7
Vehicle combinations:							
Tractor-semitrailer	105,529	64,025	1,080	4,100	216,787	391,521	10.9
Truck-trailer	12,922	5,715	135	410	29,675	48,857	1.3
All combinations	118,451	69,740	1,215	4,510	246,462	440,378	12.2
All trucks and combinations	430,730	73,467	10,935	20,193	656,357	1,191,682	32.9
All vehicles	1,064,225	82,827	67,498	102,501	2,305,759	3,622,810	100.0

[1] In many States intracity buses are exempt from most, if not all, State carrier taxes, and it was not possible to segregate the amount that would be paid on these vehicles.

$83 million from motor-carrier taxes, and 1.9 percent or $67 million from operator's and chauffeur's license fees. The remaining 2.8 percent or $103 million came from a variety of miscellaneous sources, the most productive of which were certificate-of-title fees and special titling taxes.

In 1955 State highway-user taxes amounted to $4,008 million, 10.6 percent more than they produced the year before. Although contributions to the increase varied from one type of tax to another, no significant change occurred in the percentage distribution of total user taxes among their principal sources. Registration fees, motor-carrier taxes, and motor-fuel taxes, each of which rose in the neighborhood of 10 percent, amounted to $1,162 million, $91 million, and $2,543 million, respectively, in 1955. Operator's and chauffeur's license fees increased 30 percent to $87 million, and miscellaneous fees and taxes amounted to $124 million, an increase of 21 percent.

The findings of this study are presented first for 1954 in tables 2 and 3, portrayed graphically in figures 1–3, and then for 1955 in tables 4 and 5. In the interpretation of these data it should be borne in mind that they are nationwide totals and averages derived by processing in various ways the information reported by the 48 States and the District of Columbia. Each State has its own schedule of user taxes, with the rates of payment differing widely. The vehicles of each type and size group may contribute relatively more in one State and relatively less in another. This study summarizes the situation as a whole, giving approximate values of the aggregate and average payments by each vehicle group and thereby affording comparisons of the extent to which each group shares in the total burden of State road-user taxation.

Table 3.—Estimate of average State highway-user taxes paid in 1954 per vehicle, per vehicle-mile, and per ton-mile

Vehicle type	Motor vehicles registered [1]		Vehicle-miles traveled [1]		Highway-user taxes paid		Average rate of payment		
	Number	Distribution	Amount	Distribution	Amount [2]	Distribution	Per vehicle	Per vehicle-mile	Per ton-mile [3]
	Thousands	*Percent*	*Millions*	*Percent*	*1,000 dollars*	*Percent*	*Dollars*	*Cents*	*Cents*
Passenger cars	48,324	83.50	448,913	81.03	2,343,326	65.10	48	0.52	0.26
School and miscellaneous buses	57	.10	343	.06	4,390	.12	77	1.28	.22
Commercial buses:									
Intercity	23	.04	1,206	.22	23,452	.65	1,020	1.94	.17
Transit	60	.10	1,990	.36	36,812	1.02	614	1.85	.16
All commercial buses	83	.14	3,196	.58	60,264	1.67	726	1.89	.16
All buses	140	.24	3,539	.64	64,654	1.79	462	1.83	.17
Single-unit trucks:									
2-axle, 4-tire	5,882	10.17	52,742	9.52	331,779	9.21	56	.63	.27
2-axle, 6-tire	2,824	4.88	25,998	4.69	355,946	9.89	126	1.37	.23
3-axle	188	.32	2,770	.50	63,579	1.77	338	2.30	.19
All single-unit trucks	8,894	15.37	81,510	14.71	751,304	20.87	84	.92	.24
Vehicle combinations:									
Tractor-semitrailer	471	.81	17,929	3.24	391,521	10.88	831	2.18	.12
Truck-trailer	47	.08	2,100	.38	48,857	1.36	1,040	2.33	.10
All combinations	518	.89	20,029	3.62	440,378	12.24	850	2.20	.12
All trucks and combinations	9,412	16.26	101,539	18.33	1,191,682	33.11	127	1.17	.17
All vehicles	57,876	100.00	553,991	100.00	3,599,662	100.00	62	.65	.22
Regrouping of vehicle types:									
Passenger cars and light trucks [4]	54,206	93.67	501,655	90.55	2,675,105	74.32	49	.53	.26
Medium and heavy trucks and combinations	3,530	6.09	48,797	8.81	859,903	23.89	244	1.76	.15

[1] Private and commercial motor vehicles only. Publicly owned vehicles, motorcycles, and light trailers are omitted, except for publicly owned transit buses.

[2] Public Roads table DF, 1954, gives $3,639,899,000 as the amount of State imposts on highway users collected in 1954. Omitted from the amounts given in this column are fines and penalties amounting to $17,089,000, tax payments of $15,633,000 assigned to light trailers, and $7,515,000 assigned to motorcycles.

[3] Per ton-mile of average operating gross weight (for average operating gross weights, see table 9, p. 287).

[4] Two-axle, 4-tire trucks are grouped with passenger cars.

1954 State User-Tax Payments

Distribution by type of tax

Estimates of the portions of the major types of user taxes contributed by vehicles of various types and sizes in 1954 are presented in table 2. Of the $3,623 million total, passenger cars are estimated to have provided $2,343 million or 64.7 percent, but their contribution varied somewhat from one type of tax to another. They accounted for 56.7 percent of the registration fees, 69.5 percent of the motor-fuel taxes, and 80.8 percent of all other State highway-user taxes except motor-carrier taxes.

Trucks and truck combinations provided an estimated $1,192 million or 32.9 percent of all user taxes. They accounted for 40.5 percent of the registration fees and 28.5 percent of the motor-fuel taxes. By the very nature of the motor-carrier tax, the portion assigned to trucks and truck combinations would be the greatest part of the total, an estimated 88.7 percent in 1954, although the actual amount is not large when compared with the truck contribution to the other major types of user taxes.

Buses, being relatively few, made a comparatively small contribution to total highway-user taxes, $65 million or 1.8 percent in 1954. They accounted for 1.8 percent of the motor-fuel taxes, a somewhat smaller portion of registration fees, and a negligible portion of miscellaneous user taxes. The fact that buses accounted for as much as 11.3 percent of the motor-carrier taxes is the result of the more restricted tax base of that particular form of taxation.

The remaining State highway-user taxes were contributed by motorcycles and light trailers—$7.5 million and $15.6 million, respectively. These amounts together comprise less than 1 percent of all State highway-user taxes.

Registrations, travel, and taxes paid

Table 3 and figures 1–3 show the highway-user taxes paid on vehicles of various types and sizes in relation to the numbers of these vehicles registered and the distances they traveled. The total tax figure used here is that given in table 2 less the $23 million assigned to motorcycles and light trailers.

Passenger cars accounted for 83.5 percent of all vehicles registered in 1954, 81.0 percent

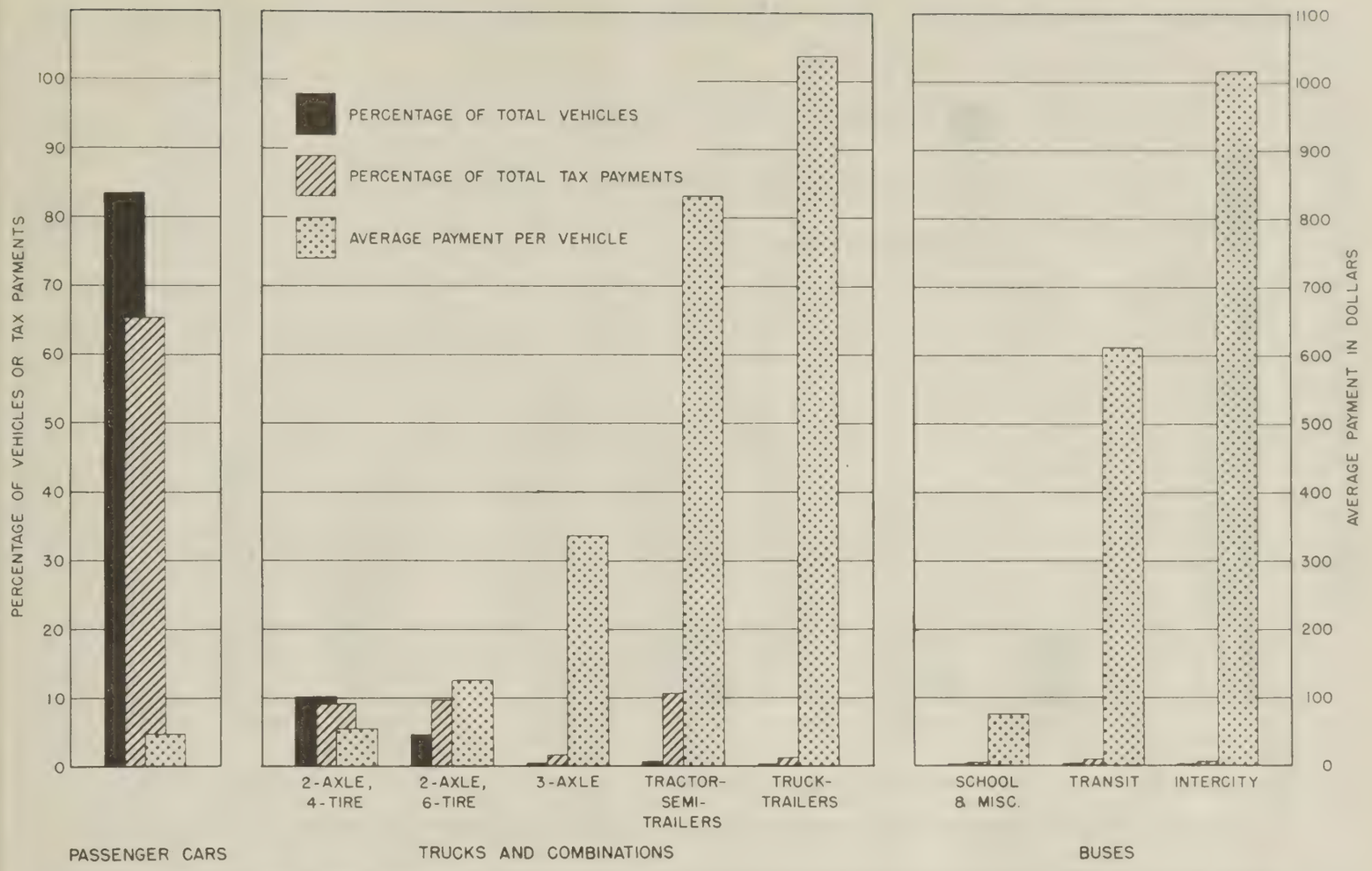

Figure 1.—Comparison of estimated registrations, tax payments, and payments per vehicle in 1954, by vehicle types.

of the mileage traveled, and 65.1 percent of the highway-user taxes. Trucks and truck combinations represented 16.3 percent of the vehicles registered, 18.3 percent of the travel, and 33.1 percent of the user taxes. Buses, which are negligible in the gross totals both as to the number of vehicles and the extent of travel, provided 1.8 percent of the user taxes, though their tax payments per vehicle were relatively high.

The somewhat different grouping of vehicles given at the bottom of table 3 brings out more clearly the relation between numbers of vehicles and tax payments. Light vehicles, comprising automobiles and 2-axle, 4-tire single-unit trucks, constituted 93.7 percent of the registered vehicles in 1954, provided 90.6 percent of the travel, and accounted for 74.3 percent of the user taxes. Medium and heavy trucks and truck combinations accounted for 6.1 percent of the vehicles, 8.8 percent of the travel, and 23.9 percent of the taxes. This grouping of light trucks with passenger cars reduces the truck contribution in absolute amount. On the other hand, the percentages of tax payments and of numbers of vehicles are in a 4 to 1 ratio compared with a 2 to 1 ratio when light trucks are included in the truck category.

Some of the values for classes of vehicles within the major types in the visual classification are significant. Two-axle, 6-tire trucks represented 4.9 percent of the total number of vehicles, but contributed 9.9 percent of the taxes. Three-axle trucks, while accounting for 0.3 percent of the vehicles, made 1.8 percent of the tax payments. Truck combinations as a group comprised only 0.9 percent of the vehicles, but accounted for 12.2 percent of the tax payments. Most of this was contributed by tractor-semitrailers, the use of truck-trailers being restricted through the application of State size and weight laws.

Average rates of payment

Table 3 also compares average rates of payment of highway-user taxes per vehicle, per vehicle-mile, and per ton-mile. These averages are represented by the dot-stippled bars in figures 1, 2, and 3, respectively.

Taxes on passenger cars averaged $48 per vehicle, compared with $127 for trucks and truck combinations and $462 for buses. Within the class comprising trucks and truck combinations are found values of $56 per vehicle for 2-axle, 4-tire trucks; $126 for 2-axle, 6-tire trucks; and about $338 for 3-axle trucks. The average payment for truck combinations as a group was $850, that for tractor-semitrailers alone being $831 and for truck-trailers, $1,040. The high value for truck-trailers arises from the fact that combinations involving full trailers are generally larger and heavier than tractor-semitrailer combinations. Also, the area in which truck-trailers are permitted to operate is limited, and their use tends to be concentrated in States where the tax rates are comparatively high.

When the averages are expressed in terms of payments per vehicle-mile, passenger cars show a value of 0.5 cent; trucks and truck combinations as a group, 1.17 cents; and buses, 1.83 cents. For passenger cars and light trucks combined, the average payment was 0.5 cent per vehicle-mile, while for medium and heavy trucks and truck combinations it was 1.76 cents.

The average payment per vehicle-mile for 2-axle, 4-tire trucks was 0.63 cent, a little more than that for passenger cars. Payments for 2-axle, 6-tire trucks were 1.37 cents and 3-axle trucks, 2.30 cents. The average payment for all single-unit trucks was 0.92 cent. The rate of 2.20 cents per vehicle-mile for combinations as a group was close to the averages for each of the component groups, 2.18 cents for tractor-semitrailers and 2.33 cents for truck-trailer combinations.

Average rates of payment per gross ton-mile, based on average operating gross weight, are also given in table 3. On this basis passenger-car payments averaged 0.26 cent, compared with 0.17 cent for buses and the same amount for trucks and truck combinations. Payments for passenger cars and light trucks together were the same per ton-mile as passenger cars alone, and payments for medium and heavy trucks as a group were 0.15 cent, which is less than the average for all trucks and combinations.

As the average of the two groups indicates, payments for 2-axle, 4-tire trucks were about

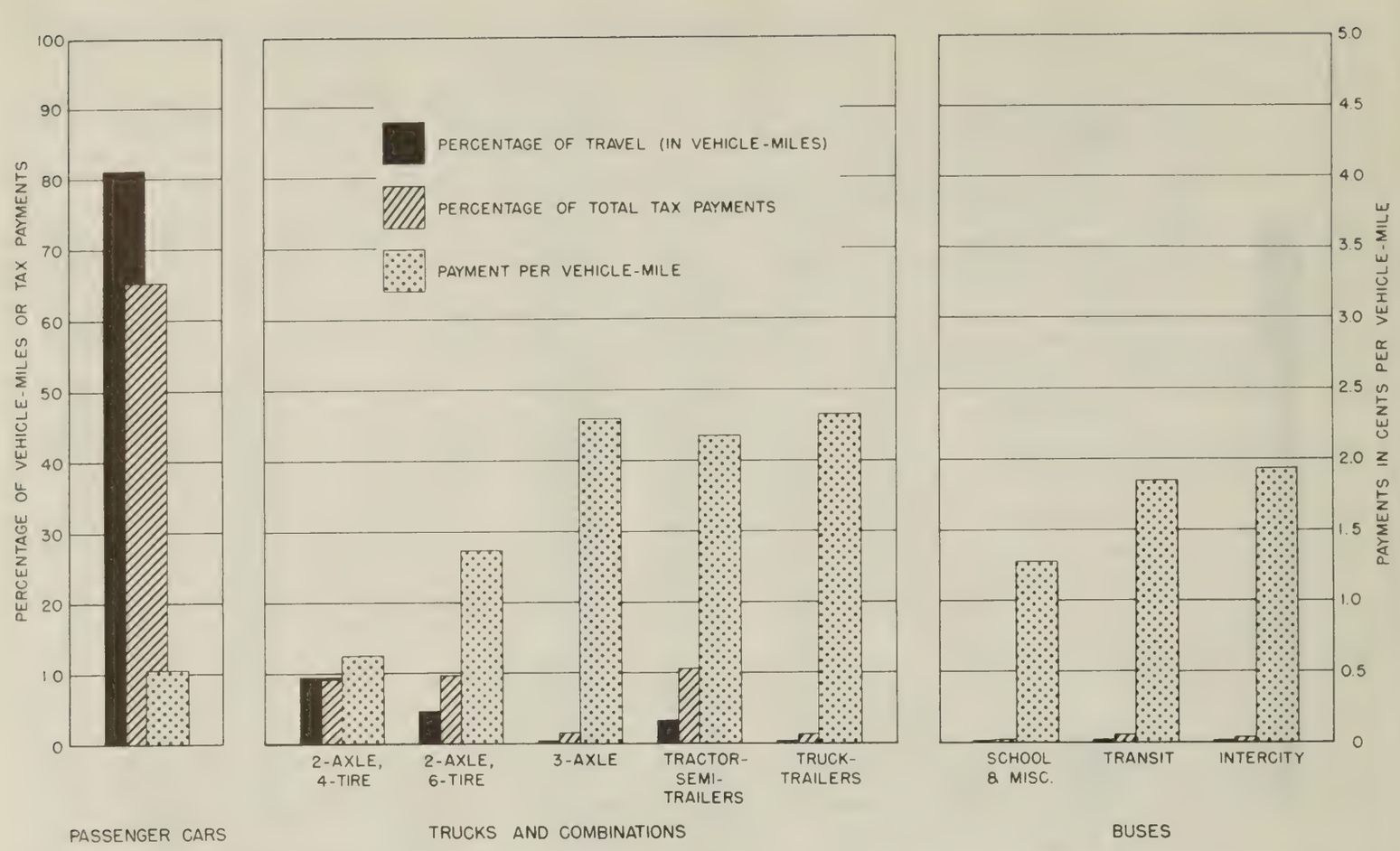

Figure 2.—Comparison of estimated travel, tax payments, and payments per vehicle-mile in 1954, by vehicle types.

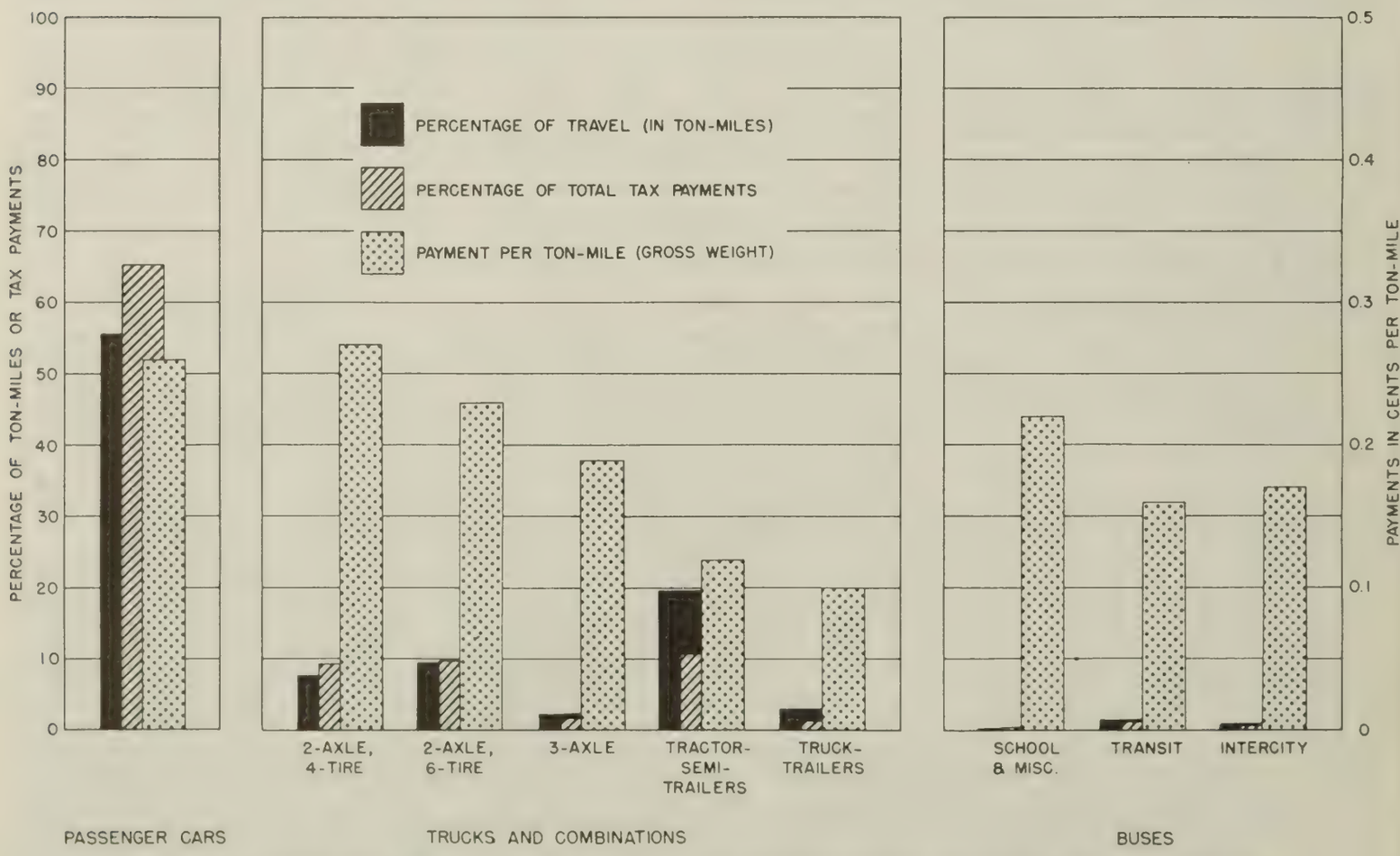

Figure 3.—Comparison of estimated travel, tax payments, and payments per ton-mile in 1954, by vehicle types.

Table 4.—Estimate of State highway-user taxes paid in 1955, by major types of vehicles

Vehicle type	Registration fees	Motor-carrier taxes	Operator's and chauffeur's license fees	Miscellaneous fees	Motor-fuel taxes	Total	
						Amount	Distribution
	1,000 dollars	*1,000 dollars*	*1,000 dollars*	*1,000 dollars*	*1,000 dollars*	*1,000 dollars*	*Percent*
Passenger cars	665,844	------	72,296	98,590	1,784,938	2,621,668	65.4
Motorcycles	1,949	------	175	620	5,264	8,008	.2
Camp and other light trailers	16,897	------	------	-------	---------	16,897	.4
Buses	11,725	10,288	787	372	43,537	66,709	1.7
Single-unit trucks	337,750	4,097	12,588	18,974	441,676	815,085	20.3
Combinations	128,112	76,659	1,573	5,456	267,630	479,430	12.0
All trucks and combinations	465,862	80,756	14,161	24,430	709,306	1,294,515	32.3
All vehicles	1,162,277	91,044	87,419	124,012	2,543,045	4,007,797	100.0

the same per ton-mile as passenger cars. For 2-axle, 6-tire trucks the average payment was 0.23 cent per ton-mile, and for 3-axle trucks it was 0.19 cent. The difference was slight between the two types of truck combinations, 0.12 cent per ton-mile for tractor-semitrailers and 0.10 cent for truck-trailer combinations.

Comparison between 1952 and 1954]

Although increased State revenue from highway-user taxes between 1952 and 1954 reflected increases in the number of vehicles registered and in the extent of their travel, rising tax rates also had a significant effect. User-tax payments on passenger cars rose from an average of $46 per vehicle in 1952 to $48 in 1954, and from 0.49 to 0.52 cent per vehicle-mile. Buses, which showed little change in numbers or in travel during the period, accounted for tax payments of $404 per vehicle in 1952 compared with $462 in 1954, and payments per vehicle-mile rose from 1.64 to 1.83 cents. For trucks and truck combinations, the increase was from $116 to $127 per vehicle and from 1.10 to 1.17 cents per vehicle-mile.

New data available since 1952 were not sufficient to justify redistributing the numbers of trucks and combinations by visual class. Consequently, the percentages developed in the 1952 analysis were applied to the 1954 registration totals to obtain the distribution for the later year. In the case of buses, new information on vehicle distribution and operating characteristics obtained from industry sources made it possible to subclassify the 1954 data.

Like the bus data, the estimates of travel developed for this analysis are believed to represent considerable improvement over those reported in the earlier study. The article "Traffic and Travel Trends, 1954,"[3] provided an estimate of total motor-vehicle travel in the United States during 1954 and a further breakdown, by visual classes, of the travel of trucks and truck combinations on main rural roads only. In order to obtain a similar classification of travel by trucks and truck combinations on secondary and local rural roads and city streets, percentages developed from the findings of motor-vehicle-use studies recently made in nine States were applied to the total travel by all types of vehicles.

[3] *Traffic and travel trends, 1954*, by Thomas B. Dimmick, PUBLIC ROADS, vol. 28, No. 11, December 1955.

Except for commercial buses, the rates of fuel consumption applied in this study were determined in the same manner as those used in the 1952 analysis. However, more recent information available from State weighing operations warranted minor modifications in the operating weights used for trucks and combinations as described subsequently. Data on average operating weights and fuel consumption supplied by the bus industry were used in the analyses made for commercial buses.

Preliminary Estimates for 1955

Insufficient information is available to allocate 1955 user taxes among classes of vehicles in the complete range used for 1954, but preliminary estimates made for the major types of vehicles—passenger cars, trucks, and buses—are indicative of the 1955 pattern. The available evidence points to the fact that although the level of tax revenues was higher in 1955 than in 1954, the percentage relations have changed little, whether these revenues are distributed by type of tax or by class of vehicle on which the tax payments are made. Table 4, which corresponds to table 2, shows the portions of the principal types of user taxes that are estimated to have been contributed in 1955 by the major classes of vehicles.

Registration fees

Registration fees are reported by all States by major type of vehicle. The only estimates in this instance are the fees attributable to camp and other light trailers and the distribution of truck fees between single-unit trucks and truck combinations.

Registration fees paid on passenger cars rose to $666 million in 1955, $62 million or 10 percent above the 1954 figure. An increase of $35 million or 8 percent brought the registration fees paid on trucks and truck combinations to $466 million. Although the contribution of passenger cars to the increase in total registration fees was greater than that of trucks and combinations, the effect on the percentage of total fees represented by each of the two classes of vehicles was negligible.

Registration fees paid on buses dropped about $1 million to a total of $11.7 million, a 7-percent decrease. This was the only reversal of the generally upward trend, but its effect on total fees is comparatively small since buses constitute only a 1-percent share. In the continued decline in the registration fees paid on this type of vehicle, the effect of a recent trend toward the granting of tax relief to buses operated for hire can be observed. Three States—Kentucky, North Carolina, and Wisconsin—were the chief contributors to the decrease.

Kentucky's bus seat fees of $8, $15, and $25, the maximum applying to all seats over 24, were reduced by a 1954 law to new rates of $5 per seat for the first 31 and $8 for each seat over that number. Consequently, bus registration fees paid to the State in 1955 decreased by two-thirds. Also largely because of rate reductions, bus registration fees paid to the States of North Carolina and Wisconsin fell off about one-third in 1955. A reduction from 6 to 3 percent in the rate of North Carolina's gross receipts tax on for-hire carriers, which is collected as part of the registration fee, took effect July 1, 1955. In Wisconsin a nominal fee of $1.00 per vehicle on certain city buses replaced a graduated weight tax having rates ranging from $20 for less than 3 tons to $60 for 5 tons plus $25 per ton over 5.

The effect of the reduced bus fees becomes more apparent when they are expressed in terms of averages per vehicle. The number of buses registered went up slightly in 1955, but the fees were $7 less per vehicle than they had been in 1954, falling from $90 to $83. The percentage decrease was about the same per vehicle as in total amount.

Registration fees on passenger cars and on trucks and truck combinations were affected by some upward revision of fee schedules and by a significant growth in the number of vehicles registered. The increase of 10 and 8 percent, respectively, in total fees attributable to these vehicle types represented a 3-percent average increase per vehicle in each case. Passenger-car fees averaged $13 per vehicle, almost the same as in 1954, and fees on trucks and truck combinations averaged $47. $1 more than the year before.

Miscellaneous taxes and fees

The other classes of highway-user taxes shown in table 4 also produced substantially higher returns in 1955 than in 1954. In 1955 motor-carrier taxes amounted to $91 million, 10 percent above the 1954 figure. There was a 30-percent increase in operator's and chauffeur's license fees, which reached $87 million in 1955, but the additional revenue from this source did not altogether represent a genuine increase. Much of it was the result of fluctuation produced by State requirements for periodic renewal. Miscellaneous fees rose 21 percent to $124 million. The $70 million of this amount which came from certificate-of-title fees and special titling taxes reflected the record volume of new car sales in 1955.

Miscellaneous highway-user taxes and fees have been allocated on the assumption—borne out by the 1955 registration fees—that in spite of changes in amount, a significant shift in the proportionate contributions of the principal vehicle types has not occurred. Rate changes, which might produce such a

Table 5.—Estimate of average State highway-user taxes paid in 1955 per vehicle, per vehicle-mile, and per ton-mile

Vehicle type	Motor-vehicles registered [1]		Vehicle-miles traveled [1]		Highway-user taxes paid		Average rate of payment		
	Number	Distribution	Amount	Distribution	Amount [2]	Distribution	Per vehicle	Per vehicle-mile	Per ton-mile [3]
	Thousands	*Percent*	*Millions*	*Percent*	*1,000 dollars*	*Percent*	*Dollars*	*Cents*	*Cents*
Passenger cars	51,989	83.83	485,761	81.46	2,621,668	65.82	50	0.54	0.27
Buses	142	.22	3,598	.60	66,709	1.68	470	1.85	.20
Single-unit trucks	9,345	15.07	85,731	14.38	815,085	20.46	87	.95	.26
Combinations	544	.88	21,231	3.56	479,430	12.04	881	2.25	.12
All trucks and combinations	9,889	15.95	106,962	17.94	1,294,515	32.50	131	1.21	.18
All vehicles	62,020	100.00	596,321	100.00	3,982,892	100.00	64	.67	.23

[1] Private and commercial vehicles. Publicly owned vehicles other than transit buses are omitted.
[2] Excludes fines and penalties amounting to $17,860,000, tax payments of $16,897,000 assigned to light trailers, and $8,008,000 assigned to motorcycles.
[3] Per ton-mile of average operating gross weight.

shift, have not been an important factor in determining 1955 yields except in the case of motor-fuel taxes.

Probably the most important change in rates of user taxes other than registration fees and motor-fuel taxes was made in Colorado, where two successive revisions of the mileage-tax law had the net effect of adding a tax of 0.8 mill per ton-mile on the empty weight of the vehicle to the original 2-mill rate per ton-mile on the cargo alone. There was a considerable increase in returns from this tax, but it is not clear how much of it was brought about by the rate change. It is reported that the larger yield has been officially ascribed to improved collection procedures following the inauguration of a port-of-entry system on July 1, 1955.[4]

Motor-fuel taxes

Between March 1 and September 13, 1955, higher motor-fuel tax rates went into effect on gasoline in 14 States and on special fuels in 15, the increased rate in one State being on special fuels only. In two additional jurisdictions, 1955 was the first full year of collections at higher rates introduced in 1954, making a total of 17 jurisdictions where 1955 fuel-tax revenues were influenced by rate changes. In all but two of these States, revenues were from 11 to 35 percent higher than they were in 1954. The rise in Pennsylvania's fuel-tax revenue was 2 percent, but here the rate increase, which became effective near the end of the year, was not fully reflected in collections reported for 1955. In Kansas where the rate increase was confined to special fuels, fuel-tax revenues increased 5 percent.

Fuel taxes produced revenues from 2 to 11 percent above the 1954 levels in the 31 States which had no rate change. In only one State did they show a decrease. This was South Dakota, where deductions—chiefly refunds—rose nearly 14 percent, more than offsetting the 3-percent increase in gross collections. Although the yield of motor-fuel taxes generally rose in response to extensive rate increases as well as to an increase in the number of vehicles, the distribution of the number of gallons consumed by type of vehicle remained steady.

[4] *Automotive News*, Vol. 31, No. 3592, March 4, 1957, p. 23.

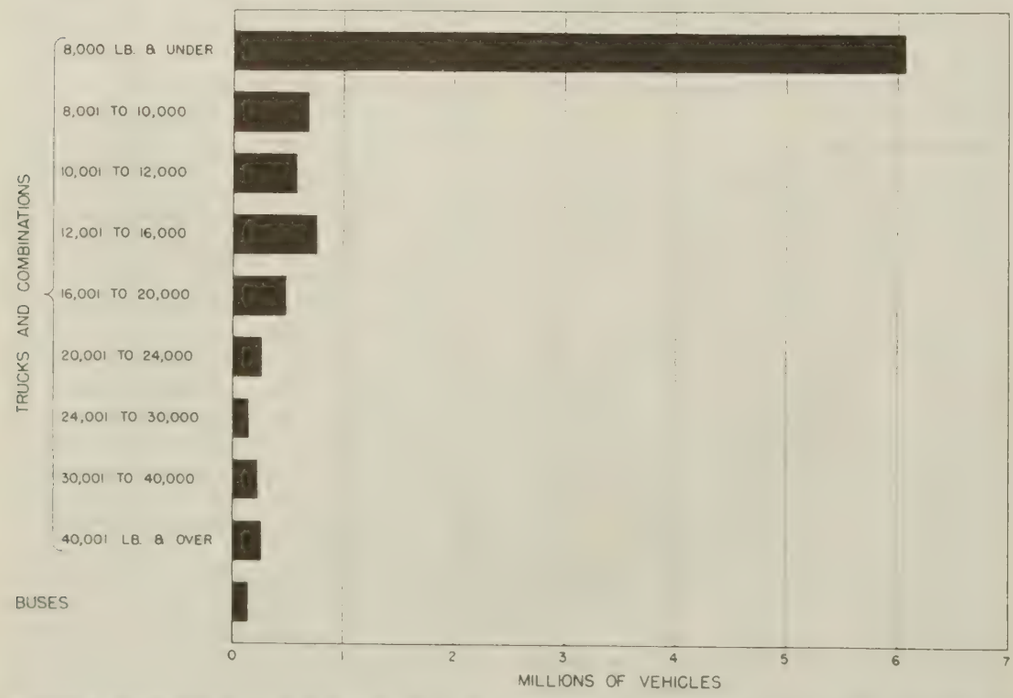

Figure 4.—Estimated distribution of commercial vehicles in 1954, by class intervals of registered gross weight or its equivalent.

Registration, travel, and taxes paid

The numbers of vehicles registered, the distances they traveled, and the highway-user taxes paid on them in 1955 are compared in table 5, which corresponds to table 3. An increase of 10.6 percent in user taxes between 1954 and 1955 was accompanied by a 7.2-percent increase in vehicle registrations and an estimated 7.6-percent increase in travel. Registrations and travel for 1955 show similar rates of increase for the principal vehicle types, passenger cars in the lead, followed by trucks and truck combinations and, finally, buses which exhibited very little change from 1954. The percentages of total registrations and total travel accounted for by passenger cars increased, though slightly, at the expense of trucks and buses. Taxes paid on the various types of vehicles showed a greater rate of increase than did numbers of vehicles or the vehicle-miles traveled. Thus, average rates of tax payments on the principal types of vehicles showed increases all along the line. Although the registration fees contributed by buses decreased, as shown in table 4, increased revenues from other user taxes, principally those on motor fuel, more than made up for the loss.

Payments on passenger cars increased from $48 to $50 per vehicle, from 0.52 to 0.54 cent per vehicle-mile, and from 0.26 to 0.27 per ton-mile. The increase in the average tax payment on single-unit trucks was from $84 to $87 per vehicle, from 0.92 to 0.95 cent per vehicle-mile, and from 0.24 to 0.26 per ton-mile. On combinations the average payment rose from $850 to $881 per vehicle, from 2.20 to 2.25 cents per vehicle-mile, but the payment per ton-mile remained 0.12 cent. Average tax payments on buses rose from $462 to $470 per vehicle, from 1.83 to 1.85 cents per vehicle-mile, and from 0.17 to 0.20 cent per ton-mile.

Vehicle Characteristics Affecting User-Tax Payments

Some discussion of the data upon which this study is based may be useful in evaluating or applying the findings. One of the first considerations was the classification of vehicles. This was also one of the principal problems encountered in making the estimates for 1952 reported in the earlier article. By the use of such information as was then available, a cross classification of trucks and truck combinations was developed in which these vehicles were classified on the basis of both simulated registered gross weight and the visual classification commonly used in traffic classification studies. Since the information needed to improve upon this analysis was not available, the percentage relations developed in 1952 were applied to the 1954 registrations to arrive at the distributions used in this article.

Table 6.—Estimated distribution of trucks and combinations in 1954, by visual class and registered gross weight or equivalent

Registered gross weight	Single-unit trucks						Vehicle combinations				Total	
	2-axle, 4-tire		2-axle, 6-tire		3-axle		Tractor-semitrailer		Truck-trailer			
	Number	Distribution	Number	Distribution	Number	Distribution	Number	Distribution	Number	Distribution	Number	Distribution
Pounds	*Thousands*	*Percent*	*Thousands*	*Percent*	*Thousands*	*Percent*	*Thousands*	*Percent*	*Thousands*	*Percent*	*Thousands*	*Percent*
6,000 and under	4,970	52.800	182	1.940	-------	-------	-------	-------	-------	-------	5,152	54.740
6,001–8,000	583	6.200	326	3.460	-------	-------	-------	-------	-------	-------	909	9.660
8,001–10,000	235	2.500	452	4.800	-------	-------	-------	-------	-------	-------	687	7.300
10,001–12,000	94	1.000	471	5.000	-------	-------	-------	-------	-------	-------	565	6.000
12,001–16,000	-------	-------	700	7.440	19	0.200	31	0.330	3	0.030	753	8.000
16,001–20,000	-------	-------	411	4.360	28	.300	31	.330	1	.010	471	5.000
20,001–24,000	-------	-------	151	1.615	19	.200	78	.825	6	.060	254	2.700
24,001–30,000	-------	-------	65	.685	28	.300	39	.415	9	.100	141	1.500
30,001–40,000	-------	-------	66	.700	69	.735	87	.925	4	.040	226	2.400
Over 40,000	-------	-------	-------	-------	25	.265	205	2.175	24	.260	254	2.700
Total	5,882	62.500	2,824	30.000	188	2.000	471	5.000	47	.500	9,412	100.000

Table 7.—Estimated travel during 1954, by place of travel [1] and by type of vehicle

Vehicle type	Vehicle-miles of travel in—			Distribution of travel in—		
	Rural areas	Urban places	Total	Rural areas	Urban places	Total
	Millions	*Millions*	*Millions*	*Percent*	*Percent*	*Percent*
Passenger cars	246,300	204,305	450,605	77.64	83.85	80.34
School and miscellaneous buses	1,091	121	1,212	.34	.05	.22
Commercial buses:						
Intercity	1,190	16	1,206	.37	.01	.21
Transit	263	1,727	1,990	.09	.71	.36
All commercial buses	1,453	1,743	3,196	.46	.72	.57
All buses	2,544	1,864	4,408	.80	.77	.79
Single-unit trucks:						
2-axle, 4-tire	28,434	26,229	54,663	8.96	10.77	9.75
2-axle, 6-tire	21,477	6,032	27,509	6.77	2.48	4.90
3-axle	1,920	937	2,857	.61	.38	.51
All single-unit trucks	51,831	33,198	85,029	16.34	13.63	15.16
Vehicle combinations:						
Tractor-semitrailer	15,586	3,073	18,659	4.92	1.26	3.33
Truck-trailer	957	1,199	2,156	.30	.49	.38
All combinations	16,543	4,272	20,815	5.22	1.75	3.71
All trucks and combinations	68,374	37,470	105,844	21.56	15.38	18.87
All vehicles	317,218	243,639	560,857	100.00	100.00	100.00

[1] "Urban places" include all incorporated places and delimited urban compacts; the remainder is included in "rural areas".

Although numbers of vehicles are segregated in State registration records by major types, the further classifications required for allocating highway-user taxes in this analysis had to be estimated with the help of other sources of information. Since many States use some basis of registration other than gross vehicle weight, it was necessary to convert to gross-weight terms the data provided according to other weight or capacity groupings. This was done through the application of estimated conversion factors to the data for such States individually so as to arrive at approximate values for the registrations by gross-weight group that would have existed if all States required registration on this basis.

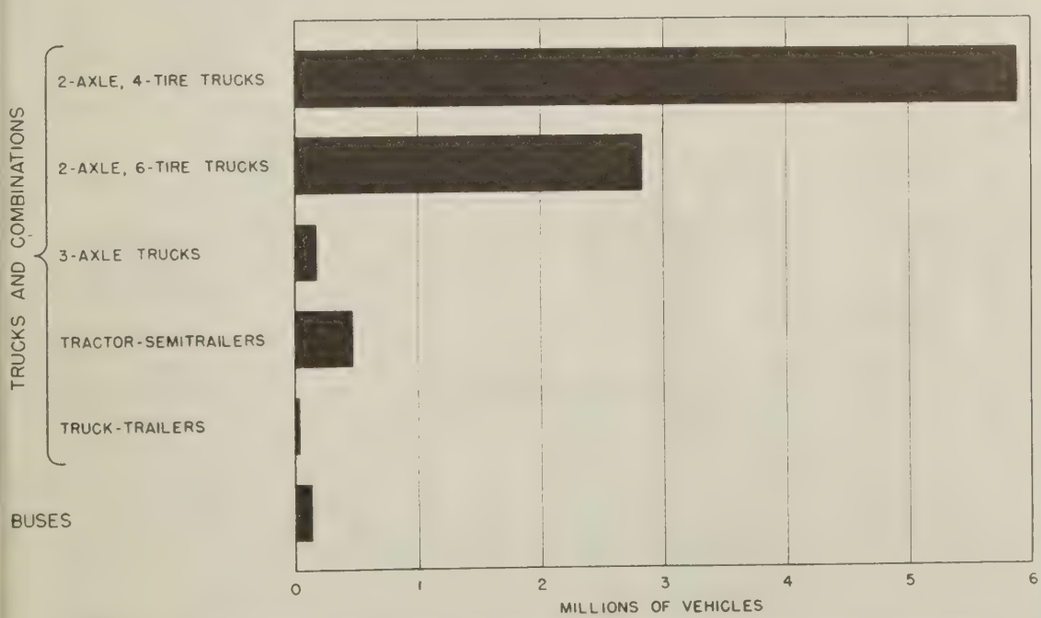

Figure 5.—Estimated distribution of commercial vehicles in 1954, by vehicle types.

The classification of the total number of trucks and truck combinations, first according to gross weight and then according to the so-called visual class is illustrated in figures 4 and 5, and the two distributions are cross-classified in table 6. The greatest proportion of all trucks and truck combinations, as would be expected, falls in the lower weight groups. Of the total, an estimated 64.4 percent or 6,061,000 vehicles fall in the group 8,000 pounds or less, and 54.7 percent are in the group 6,000 pounds or below. The groups from 8,001 to 20,000 pounds account for an additional 26.3 percent or 2,476,000 vehicles, and only 9.3 percent of all trucks are estimated to be in the groups over 20,000 pounds gross weight. Of the heaviest vehicles, a 4.2-percent segment falls in the weight class of 20,001 to 30,000 pounds.

Determination of the taxes paid by various vehicles requires considerable knowledge of the mileages they travel. While registration fees generally do not vary with the amount of travel, motor-carrier taxes do to a great extent; and fuel taxes paid vary directly with travel. Travel data are computed primarily from observation, and the visual classification of vehicles shown in table 6 (reading across) and in figure 5 is that ordinarily used in recording and publishing traffic-volume information.

Since the number of truck registrations decreases with increasing gross weight, it is to be expected that the lighter types of single-unit trucks should appear in greatest numbers on the highways. On the other hand, since heavier vehicles tend to travel greater annual mileages, their frequency of occurrence in the traffic stream is out of proportion to their numbers. For this reason the evidence of traffic counts can only be used indirectly in estimating the numbers of vehicles in each visual class. According to table 6, 94.5 percent of all freight carrying vehicles are single-unit trucks; and, of these, 62.5 percent or 5,882,000 vehicles are of the 2-axle, 4-tire class. Another 30 percent or 2,824,000 vehicles have 2 axles and 6 tires. Only 188,000 or 2 percent are 3-axle, single-unit vehicles.

Combinations number 518,000 or 5.5 percent of the total, of which one-half of 1 percent are truck-trailer combinations.

As stated at the outset, the classification of buses is by type of operation and ownership rather than by weight. This was made necessary by the wide differences in the tax liability of vehicles engaged in intercity commercial operation, in transit operation, and in nonrevenue operation.

Motor-Vehicle Travel

In order to calculate the fuel-tax payments of individual types of vehicles, the estimated travel during 1954, rural and urban, already available for major types of vehicles,[5] was further subdivided as shown in table 7. Total motor-vehicle travel on all roads and streets during 1954 was estimated to be 561 billion vehicle-miles. Passenger-car travel accounted for 80 percent of this amount or 451 billion vehicle-miles. All trucks and truck combinations contributed 19 percent of the travel or 106 billion vehicle-miles, 15 percent by single-unit trucks and the remaining 4 percent by combinations. Buses traveled only 1 percent of the total or 4 billion vehicle-miles.

Since the purposes of this analysis require that the calculation of fuel consumption and fuel-tax payments be limited to the classes of private and commercial vehicles shown in table 6 and figure 5, it was necessary to eliminate the travel of publicly owned vehicles from the estimated travel of all vehicles. Estimates for Federal civilian vehicles were determined from statistics compiled by the U. S. Bureau of the Budget, and those for vehicles of other governmental agencies were developed from reports of State highway departments.

Total travel shown in table 7 is classified by vehicle ownership in table 8, and that portion attributable to private and commercial vehicles only is displayed by visual class in figure 6. Government-owned nonmilitary vehicles

[5] See footnote 3, p. 283.

Table 8.—Estimated travel during 1954, by type and ownership of vehicle

Vehicle type	Vehicle-miles of travel by—			Distribution of travel by—		
	Government-owned vehicles	Private and commercial vehicles	Total	Government-owned vehicles	Private and commercial vehicles	Total
	Millions	*Millions*	*Millions*	*Percent*	*Percent*	*Percent*
Passenger cars	1,692	448,913	450,605	24.64	81.03	80.34
School and miscellaneous buses	869	343	1,212	12.66	.06	.22
Commercial buses:						
Intercity	---	1,206	1,206	---	.22	.21
Transit	---	1,990	1,990	---	.36	.36
All commercial buses	---	3,196	3,196	---	.58	.57
All buses	869	3,539	4,408	12.66	.64	.79
Single-unit trucks:						
2-axle, 4 tire	1,921	52,742	54,663	27.98	9.52	9.75
2-axle, 6-tire	1,511	25,998	27,509	22.00	4.69	4.90
3-axle	87	2,770	2,857	1.27	.50	.51
All single-unit trucks	3,519	81,510	85,029	51.25	14.71	15.16
Vehicle combinations:						
Tractor-semitrailer	730	17,929	18,659	10.63	3.24	3.33
Truck-trailer	56	2,100	2,156	.82	.38	.38
All combinations	786	20,029	20,815	11.45	3.62	3.71
All trucks and combinations	4,305	101,539	105,844	62.70	18.33	18.87
All vehicles	6,866	553,991	560,857	100.00	100.00	100.00

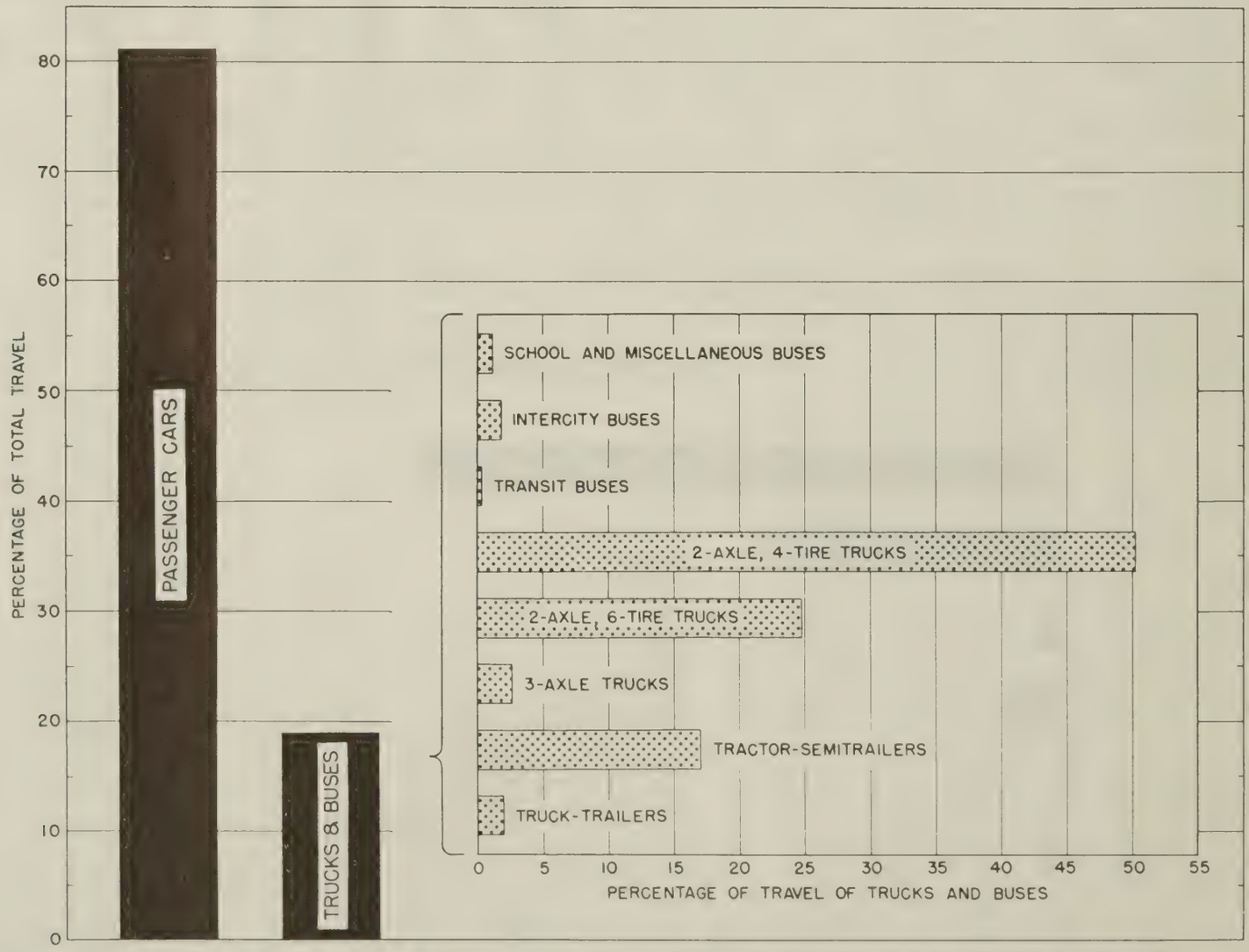

Figure 6.—Percentage distribution of travel during 1954 by passenger cars and commercial vehicles.

Table 9.—Estimated operating characteristics of various types of motor vehicles

Vehicle type	Average operating gross weight		Distribution of travel by type of fuel used			Rate of fuel consumption, by type of fuel used						
						Per mile			Per ton-mile			
									Gasoline		Diesel	
	Amount	Index	Gasoline	Diesel	Other	Gasoline	Diesel	Other	Amount	Index	Amount	Index
	Pounds		*Percent*	*Percent*	*Percent*	*Gallons*	*Gallons*	*Gallons*	*Gallons*		*Gallons*	
Passenger cars	4,025	1.00	100.0	(1)	(1)	0.067	-------	-------	0.034	1.000	------	------
School and miscellaneous buses	11,600	2.88	100.0	(1)	(1)	.125	-------	-------	.022	.647	------	------
Commercial buses:												
Intercity	23,000	5.71	38.9	61.1	(1)	.185	0.135	-------	.016	.471	0.012	0.353
Transit	23,000	5.71	60.2	35.4	4.4	.307	.228	0.364	.027	.794	.020	.588
Single-unit trucks:												
2-axle, 4-tire	4,764	1.84	100.0	(1)	(1)	.074	-------	-------	.031	.912	------	------
2-axle, 6-tire	11,290	2.96	100.0	(1)	(1)	.127	-------	-------	.021	.618	------	------
3-axle	24,102	5.99	100.0	(1)	(1)	.192	-------	-------	.016	.471	------	------
Vehicle combinations:												
Tractor-semitrailer	35,690	8.87	79.9	17.9	2.2	.241	.168	.268	.013	.382	.009	.265
Truck-trailer	46,799	11.63	79.9	17.9	2.2	.282	.197	.313	.012	.353	.008	.235

[1] Percentage negligible.

other than publicly owned transit vehicles were estimated to have traveled 7 billion vehicle-miles in 1954, leaving 554 billion vehicle-miles of travel as the contribution of private and commercial vehicles. Of this amount passenger cars accounted for 449 billion; trucks and truck combinations, 101.5 billion; and buses, 3.5 billion. The percentage distribution of this travel by vehicle groups is little changed by subtraction of the travel of publicly owned vehicles.

Vehicle Operating Characteristics

Estimating the fuel consumption and fuel-tax payments of the classes of vehicles used in this study made it necessary to determine certain of their operating characteristics, such as average gross weights, percentages of vehicles using fuel other than gasoline, and rates of fuel consumption. The results of these calculations are shown in table 9.

Use of fuels other than gasoline

While special fuels such as diesel and propane and other liquefied petroleum gases still constitute a relatively small part of the total fuel consumed on the highways—1 billion gallons out of 44 billion in 1954 [6]—the use of these fuels is almost entirely confined to the larger commercial vehicles and comprises a substantial portion of their fuel consumption. The estimates in table 9 show a percentage relation of 80–20 between the miles of travel accounted for by truck combinations using gasoline and those using special fuels, with diesel fuel accounting for most of the 20 percent.

On the other hand, information reported by the commercial bus industry supports the estimate presented in table 9 that special fuels account for 61 percent of the miles traveled by intercity buses. Fuel usage reported by cities having publicly owned transit systems shows a similar relation, special fuels accounting for 58 percent of the travel of vehicles operated by these systems. The data reported by cities also show the greatest use of propane, which accounted for 13 percent of the travel of publicly owned transit buses. The use of special fuels by privately owned transit vehicles is considerably less than this, and averaging the two reduces to 39.8 percent the proportion of all intracity-bus travel accounted for by special fuels.

[6] *Highway Statistics, 1954,* published by the Bureau of Public Roads in 1955, tables G-21 and G-25.

Estimates of fuel-consumption rates

The rates of gasoline consumption for passenger cars, trucks and truck combinations, and noncommercial buses were obtained from the equation developed for the 1952 study to indicate approximate gasoline-consumption rates for gross vehicle weights up to at least 72,000 pounds under average operating conditions. This equation represents a composite of values for numerous gross weight groups obtained from each of the several previous determinations by other investigators.

All of the gasoline rates shown in table 9 were developed by applying the derived equation to the average operating gross weight shown, except in the case of commercial buses. Fuel-consumption rates for diesel and other fuels were based on information obtained from representatives of the trucking industry and the various segments of the bus industry.

Rates of diesel-fuel consumption by truck combinations were determined on the basis of the assumption, arrived at after consultation with representatives of the trucking industry, that average fuel consumption of diesel ve-

Table 10.—Fuel consumption and tax payments in 1954, by major types of private and commercial vehicles

Vehicle type	Total miles traveled	Gasoline-powered vehicles		Diesel-powered vehicles		Vehicles powered by other fuels		Total fuel consumed		Total tax payments
		Mileage	Fuel consumed	Mileage	Fuel consumed	Mileage	Fuel consumed	Gallons	Distribution	
	Millions	*Millions*	*Million gallons*	*Millions*	*Million gallons*	*Millions*	*Million gallons*	*Millions*	*Percent*	*Million dollars*
Passenger cars	448,913	448,913	30,288	-------	-------	-------	-------	30,288	69.503	1,602.6
School and miscellaneous buses	343	343	43	-------	-------	-------	-------	43	.099	2.3
Commercial buses:										
Intercity	1,206	469	87	737	100	-------	------	187	.429	9.9
Transit	1,990	1,196	367	706	161	88	32	560	1.285	29.6
All commercial buses	3,196	1,665	454	1,443	261	88	32	747	1.714	39.5
All buses	3,539	2,008	497	1,443	261	88	32	790	1.813	41.8
Single-unit trucks:										
2-axle, 4-tire	52,742	52,742	3,913	-------	-------	-------	-------	3,913	8.979	207.0
2-axle, 6-tire	25,998	25,998	3,303	-------	-------	-------	-------	3,303	7.580	174.8
3-axle	2,770	2,770	531	-------	-------	-------	-------	531	1.218	28.1
All single-unit trucks	81,510	81,510	7,747	-------	-------	-------	-------	7,747	17.777	409.9
Vehicle combinations:										
Tractor-semitrailer	17,929	14,325	3,450	3,209	541	395	106	4,097	9.402	216.8
Truck-trailer	2,100	1,678	473	376	74	46	14	561	1.287	29.7
All combinations	20,029	16,003	3,923	3,585	615	441	120	4,658	10.689	246.5
All trucks and combinations	101,539	97,513	11,670	3,585	615	441	120	12,405	28.466	656.4
All vehicles	553,991	548,434	42,455	5,028	876	529	152	43,483	99.782	2,300.8
Fuel consumed by motorcycles, etc	-------	-------	-------	-------	-------	-------	-------	95	.218	5.0
Total fuel consumed and tax payments	-------	-------	-------	-------	-------	-------	-------	43,578	100.000	2,305.8

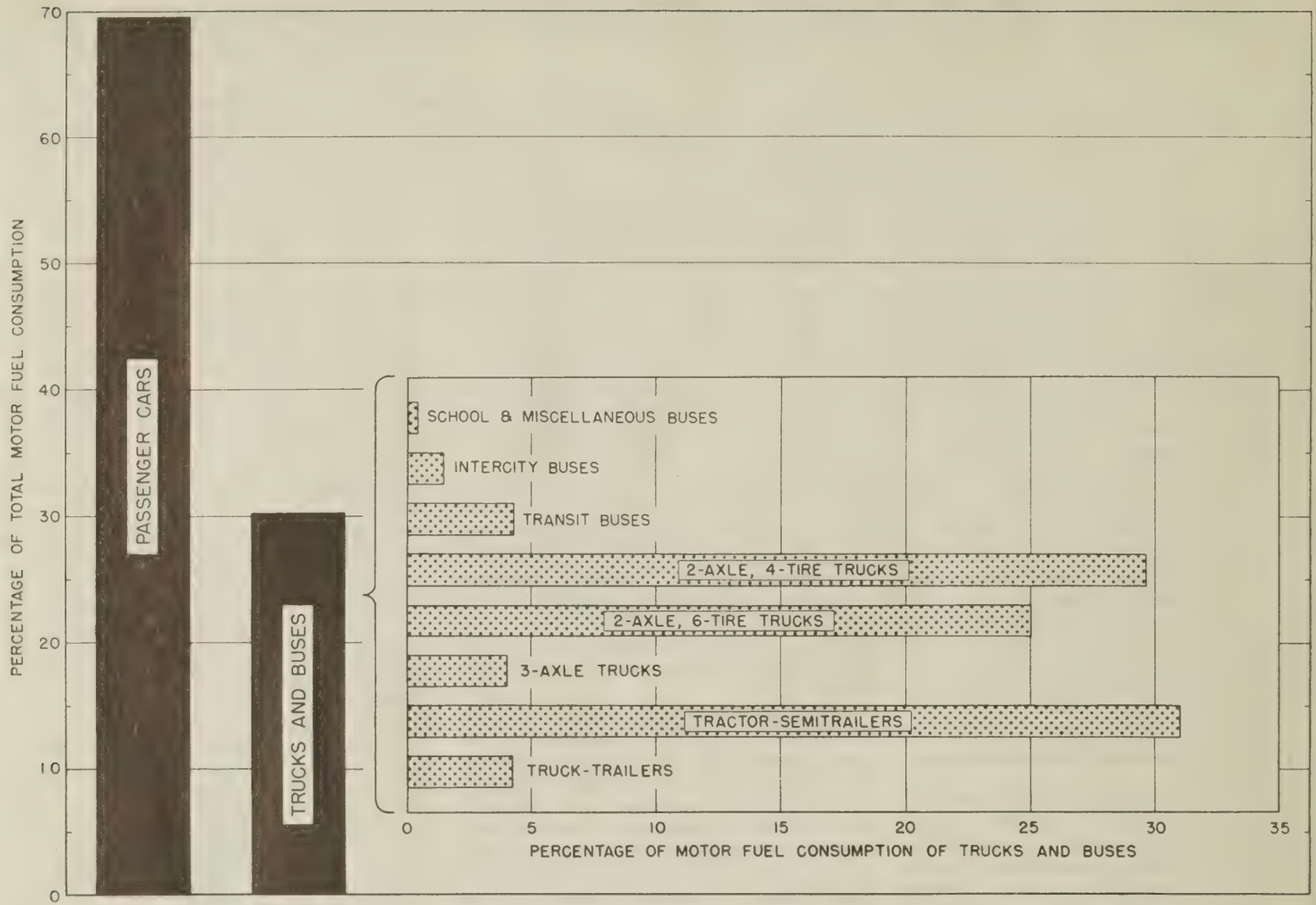

Figure 7.—Percentage distribution of motor-fuel consumption during 1954 by passenger cars and commercial vehicles.

hicles with operating gross weights above 20,000 pounds will be about 30 percent less than that of gasoline-powered vehicles of equal weight. The rate of consumption of special fuels other than diesel, when used in truck combinations, was taken as one-ninth greater than that of gasoline.

Fuel consumption and fuel-tax payments

The calculated fuel consumption for the visual classes of vehicles used in this study is shown in table 10, and the percentage distribution of the total is shown in figure 7. The fuel consumption was obtained using the total mileages shown in table 10 and the rates given in table 9.

The 43,483 million gallons of fuel of all kinds consumed in 1954 are the total reported by State agencies less 95 million gallons or 0.218 percent estimated to have been consumed by motorcycles, motor-scooters, and like vehicles.

Total fuel-tax payments in 1954 amounted to $2.31 billion. The fuel consumption represented by these tax payments is not quite the same as that reported above because the tax figure represents collections of motor-fuel taxes during the year, while the fuel-consumption figure represents fuel actually purchased during the year. In order to minimize any resulting imbalance between the two, a percentage distribution of fuel consumed was applied to the total tax payments instead of calculating the payments directly from the gallonage distribution.

Summary

Perhaps the results of this analysis are best summarized in the "Regrouping of vehicle types" found at the bottom of table 3. Here it is shown that in 1954 passenger cars and light trucks comprised about 94 percent of the registered motor vehicles and accounted for approximately 91 percent of the vehicle-miles of travel and 74 percent of the State highway-user taxes paid. In contrast, medium and heavy trucks and truck combinations as a group accounted for 6 percent of the vehicles registered, about 9 percent of the travel, and 24 percent of the user taxes.

Average tax payments per vehicle of $49 for the light vehicles and $244 for the heavier ones show the tendency of these payments to increase sharply with size and weight. Less difference is shown between the average payments of the two groups per vehicle-mile, 0.53 cent for passenger cars and light trucks and 1.76 cents for medium and heavy trucks and truck combinations, since the effect of the high annual mileages traveled by the heavy vehicles has been factored out. On a ton-mile basis the distinction is reversed, the light vehicles averaging 0.26 cent compared with 0.15 cent per ton-mile for the medium and heavy vehicles.

Because of the importance of the findings of studies of this kind, it is essential to employ analytical methods as precise as it is possible to make them. Those developed for the 1952 study, which were adopted with minor modifications for this one, are believed to be as satisfactory for a nationwide analysis as the data now available will permit. Yet, while the estimates presented here are regarded as sufficiently valid to be useful, the gaps in the basic data are still considerable.

More reliable estimates will be possible in the future as further information becomes available and as these additions to the basic data contribute to improved analytical techniques. Broadened State traffic-counting and weighing operations and additional motor-vehicle-use studies are likely sources of new information. The measurement of highway use is one of the principal requirements of the study of highway cost allocation called for by section 210 of the Federal Highway Revenue Act of 1956. It is hoped that auxiliary data produced for this study, such as estimates of vehicle registrations and traffic volumes by type and weight class of vehicle, will make possible a more accurate corresponding classification of tax payments.

U. S. GOVERNMENT PRINTING OFFICE: 1958

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State Transportation Map series (available for 39 States). Uniform sheets 26 by 36 inches, scale 1 inch equals 4 miles. Shows in colors Federal-aid and State highways with surface types, principal connecting roads, railroads, airports, waterways, National and State forests, parks, and other reservations. Prices and number of sheets for each State vary—see Superintendent of Documents price list 53.

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Single copies of the following publications are available to highway engineers and administrators for official use, and may be obtained by those so qualified upon request addressed to the Bureau of Public Roads. They are not sold by the Superintendent of Documents.

Bibliography on Automobile Parking in the United States (1946).

Bibliography on Highway Lighting (1937).

Bibliography on Highway Safety (1938).

Bibliography on Land Acquisition for Public Roads (1947).

Bibliography on Roadside Control (1949).

Express Highways in the United States: a Bibliography (1945).

Indexes to PUBLIC ROADS, volumes 17–19 and 23.

Title Sheets for PUBLIC ROADS, volumes 24–28.

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U. S. DEPARTMENT OF COMMERCE - BUREAU OF PUBLIC ROADS

STATUS OF FEDERAL-AID HIGHWAY PROGRAM

AS OF DECEMBER 31, 1957

(Thousand Dollars)

STATE	UNPROGRAMMED BALANCES	ACTIVE PROGRAM											
		PROGRAMMED ONLY			CONTRACTS ADVERTISED, CONSTRUCTION NOT STARTED			PROJECTS UNDER WAY			TOTAL		
		Total Cost	Federal Funds	Miles	Total Cost	Federal Funds	Miles	Total Cost	Federal Funds	Miles	Total Cost	Federal Funds	Miles
Alabama	$33,714	$75,766	$50,776	499.1	$20,906	$14,363	164.6	$72,633	$45,862	816.5	$169,305	$111,001	1,480.2
Arizona	15,430	30,371	26,732	168.5	9,843	8,468	64.3	28,367	24,172	184.8	68,581	59,372	417.6
Arkansas	26,326	49,111	38,480	552.7	16,231	11,181	131.1	45,067	31,986	341.4	110,409	81,647	1,025.2
California	63,338	50,724	38,046	197.5	49,003	42,438	61.4	565,349	243,384	340.9	665,076	323,868	599.8
Colorado	40,592	19,243	14,364	122.0	1,999	1,324	21.5	57,210	41,977	303.3	78,452	57,665	446.8
Connecticut	52,140	1,766	1,048	.9	5,703	3,858	1.9	40,293	27,610	36.0	47,762	32,516	38.8
Delaware	30,807	3,963	1,998	9.9	766	395	.7	14,279	8,208	73.6	19,008	10,601	84.2
Florida	11,428	75,734	58,547	376.3	15,885	11,010	60.8	58,214	39,320	265.4	149,833	108,877	702.5
Georgia	32,363	114,615	85,324	745.1	19,405	12,724	110.0	96,915	54,515	905.1	230,935	152,563	1,760.2
Idaho	41,485	15,877	12,639	94.9	2,491	1,864	38.3	18,275	12,988	135.3	36,643	27,491	268.5
Illinois	63,523	94,609	68,758	438.0	90,931	69,166	134.3	184,340	134,014	685.7	369,880	271,938	1,258.0
Indiana	133,810	35,078	20,018	217.2	15,471	8,081	217.5	55,119	34,491	275.9	105,668	62,590	710.6
Iowa	33,469	55,650	41,412	690.9	28,658	22,327	203.5	55,681	37,851	1,139.4	139,989	101,590	2,033.8
Kansas	30,194	34,144	26,474	780.1	23,764	18,221	183.8	54,096	37,816	1,097.0	112,004	82,511	2,060.9
Kentucky	55,663	38,037	26,592	122.3	6,432	4,634	24.5	64,946	45,151	232.1	109,415	76,377	378.9
Louisiana	35,683	64,705	45,709	334.2	28,063	19,267	90.6	56,650	31,513	342.1	149,418	96,489	766.9
Maine	33,645	9,984	7,374	28.0	3,983	3,090	8.0	17,172	10,335	91.5	31,139	20,799	127.5
Maryland	13,074	24,837	14,060	126.1	26,927	18,376	44.9	72,452	51,904	165.9	124,216	84,340	336.9
Massachusetts	39,791	53,259	40,353	30.3	50,135	34,004	25.8	85,356	52,944	58.5	188,750	127,301	114.6
Michigan	76,330	87,475	67,985	498.9	52,894	32,538	147.6	85,746	63,185	302.5	226,115	163,708	949.0
Minnesota	60,870	9,229	7,856	58.3	6,886	4,404	62.7	104,546	79,203	919.6	120,661	91,463	1,040.6
Mississippi	19,533	50,005	36,203	657.3	25,874	21,212	119.9	58,737	39,325	790.4	134,616	96,740	1,567.6
Missouri	36,992	61,980	43,335	1,019.9	10,231	6,885	41.8	108,434	72,762	1,055.9	180,645	122,982	2,117.6
Montana	64,756	9,717	7,204	163.3	6,319	4,381	53.4	44,739	33,320	331.0	60,775	44,905	547.7
Nebraska	61,754	10,313	6,022	202.5	7,931	4,280	104.4	58,403	39,574	1,028.6	76,647	49,876	1,335.5
Nevada	31,360	11,031	10,272	67.1	3,041	2,775	4.5	24,729	22,695	105.4	38,801	35,742	177.0
New Hampshire	18,870	8,153	5,518	26.7	2,555	2,144	2.8	22,455	15,330	54.3	33,163	22,992	83.8
New Jersey	96,271	9,168	5,087	59.4	14,985	10,729	11.2	69,558	49,875	46.1	93,711	65,691	116.7
New Mexico	17,401	13,015	10,145	61.8	5,016	3,750	51.5	44,708	36,923	303.2	62,739	50,818	416.5
New York	130,441	49,755	35,441	102.1	73,327	53,918	46.7	506,650	321,496	390.8	629,732	410,855	539.6
North Carolina	93,500	32,763	20,487	313.2	11,035	9,084	35.4	81,997	51,728	738.9	125,795	81,299	1,087.5
North Dakota	18,759	33,475	25,169	1,007.6	11,984	10,086	110.3	24,088	16,515	969.9	69,547	51,770	2,087.8
Ohio	24,611	60,423	33,171	158.4	114,658	94,854	115.3	199,574	134,395	293.1	374,655	262,420	566.8
Oklahoma	28,536	61,051	42,282	580.4	23,752	19,923	76.3	63,228	40,380	567.0	148,031	102,585	1,223.7
Oregon	35,824	11,113	8,836	46.7	8,587	6,574	34.4	37,734	29,592	183.2	57,434	45,002	264.3
Pennsylvania	149,835	81,601	50,216	170.6	31,858	22,089	60.5	253,683	167,409	377.5	367,142	239,714	608.6
Rhode Island	12,099	10,885	8,075	8.8	3,320	2,848	1.7	32,096	21,257	21.1	46,301	32,180	31.6
South Carolina	21,010	67,044	51,174	644.6	7,081	4,776	49.4	42,030	26,308	642.9	116,155	82,258	1,336.9
South Dakota	25,268	45,196	36,517	610.2	1,165	751	18.1	19,792	14,512	402.1	66,153	51,780	1,030.4
Tennessee	44,356	64,142	50,113	393.4	26,758	18,411	68.0	86,259	52,759	472.4	177,159	121,283	933.8
Texas	161,064	49,419	36,891	592.4	66,941	50,795	189.1	189,578	130,667	1,742.7	305,938	218,353	2,524.2
Utah	10,328	32,125	29,022	200.6	7,790	6,654	45.2	21,565	18,174	84.6	61,480	53,850	330.4
Vermont	16,278	11,493	9,292	33.9				19,995	15,060	33.1	31,488	24,352	67.0
Virginia	22,871	48,857	38,330	130.2	34,276	27,429	56.4	69,896	48,798	239.8	153,029	114,557	426.4
Washington	49,987	22,168	14,095	147.4	3,630	3,075	13.9	55,284	41,602	220.9	81,082	58,772	382.2
West Virginia	42,265	43,056	32,598	67.5	4,951	2,477	22.5	38,366	21,176	69.8	86,373	56,251	159.8
Wisconsin	91,455	21,467	14,061	243.7	12,072	7,787	121.2	55,036	36,696	365.1	88,575	58,544	730.0
Wyoming	5,718	24,736	20,332	170.8	1,719	1,136	18.7	45,423	38,282	260.8	71,878	59,750	450.3
Hawaii	4,688	10,600	5,254	17.0	3	1		3,532	1,723	4.4	14,135	6,978	21.4
District of Columbia	27,531	6,257	4,757	2.8	4,173	2,936	1.3	20,701	16,514	4.4	31,131	24,207	8.5
Puerto Rico	11,459	12,420	5,929	31.7	59	18		18,196	8,409	51.0	30,675	14,356	82.7
Alaska	14,236	2,930	2,930	46.3	1,410	1,410	28.2	10,680	9,173	330.8	15,020	13,513	405.3
TOTAL	2,312,731	1,920,535	1,393,303	14,069.5	1,002,877	744,921	3,299.9	4,159,852	2,680,858	20,893.7	7,083,264	4,819,082	38,263.1