APPLICATIONS OF AUTOMATIC TRAFFIC RECORDER DATA IN HIGHWAY PLANNING

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SYNOPSIS

Automatic traffic recorders are being used in 46 states to obtain continuous data at more than 500 locations Data from typical stations throughout the United States have been analyzed to measure the time during which a highway section is congested and the fraction of the year's traffic which is moved under conditions of congestion, to test the results of various schedules of operation that are used in the highway planning surveys, to estimate annual traffic volume when the period of counting covers a small portion of the year, to study traffic trends and their relationship to economic factors and to probable future traffic.

It was found that there was an extremely wide variation in the ratios between maximum days or hours and the average annual daily traffic, but this variation was considerably less at locations in the southern states as compared with those in northern states The maximum day is normally 233 per cent and the maximum hour 25 4 per cent of the average annual daily traffic However, the variation in these ratios between locations is such that detailed data are necessary for a complete engineering analysis of the traffic facilities required

Tests of various schedules of operation that are used in highway planning surveys indicate that eighteen 8-hr counts properly scheduled throughout the year produce results within practical limits of accuracy, that at other locations four 8-hr counts seasonally spaced are also sufficiently accurate when used in conjunction with the former schedule, that the short count schedule is not so accurate, and its use is limited to relatively compact areas such as a city, where time loss and cost of travel may be reduced

A study of the invariance in seasonal and other types of traffic variation over a period of several years measures the limitations in the use of "factors" in the estimate of annual traffic from observations covering but a small period of time, possibly a few hours The rather remarkable uniformity in such factors provides considerable confidence in the accuracy of the estimates

As the record accumulates it will permit an analysis of the traffic trends at a large number of points widely distributed throughout the country The relatively brief record now available has already proved of value in the estimates of traffic increase upon major segments of the highways and streets of the nation

Only a few years ago complete information with regard to the volume of traffic by hours throughout the year was available only at a few bridges, where it was a by-product, and incidental to the collection of tolls. Usually these data had been summarized and were reported only as an annual total or, at best, subtotals were obtainable by months. Frequently the data could not be obtained in any form; a manifestation of business caution on the part of the owner or the operator of the facility The cost of stationing a man to secure such information during 24 hours of 365 days was greater than the cost of improvement of a mile of road with the addition of a good bituminous-treated gravel surface Today, at more than 500 points throughout the country, and in nearly every State, this information is secured by means of permanently installed counters; and at many hundreds of additional points either complete information, or a very large fraction thereof, is collected by means of portable traffic counters, and at a small fraction of the cost of manual counting.

Since the volume of detailed data is so recently available and the record correspondingly short, it is quite certain that not all of the uses of these data have been discovered. Indeed the record is in many cases so short that an adequate study of some applications of the data is not possible.

Nevertheless, it is clear that the principal uses of these data are included under the following general headings: (1) The data are of particular value in measuring the time during which a highway section is congested, and the fraction of the year's traffic which is moved under conditions of congestion, (2) Consideration of the traffic record, obtained under widely varying climatic, geographic and economic conditions, is essential in planning extensive traffic surveys such as those forming a part of the highway planning surveys, and in which some traffic information is obtained for every mile of publicly used highway; (3) Knowledge of the variations in traffic volume are required in the very frequent situation where the actual traffic count covers but a small fraction of the year and where a reasonably accurate estimate of the traffic total for the year is desired, (4) and finally, the traffic record is of vital importance in the study of traffic trends and their relationships to economic factors and to probable future traffic It is mainly with regard to the latter use that the record is inadequate; and this deficiency is being reduced with each passing month and year

The automatic traffic counters used in the state-wide highway planning surveys are of two general types; one designed to be installed permanently at key locations and referred to as a fixed-type counter; the other is portable and is used in obtaining short counts at a large number of widely separated locations and is referred to as a portable traffic counter.

AUTOMATIC RECORDERS YIELD COMPLETE TRAFFIC DATA AT LOW COST

The fixed-type machine[1], is much larger, more expensive, and more dependable than the portable traffic counter. These machines are designed to count passing vehicles without counting pedestrians. Two parallel beams of light approximately 30 in. center to center, directed across the roadway upon photoelectric cells, must be interrupted simultaneously to operate the counting mechanism. Pedestrians who interrupt only one beam at a time do not register on the machine. Every hour, on the hour, these machines stamp on the record tape the day, hour, and cumulative counter reading, thus producing an hourly record of the number of vehicles passing the location The cost of one of these machines is approximately $400 and the cost of installation for the country has averaged approximately $125 per machine. A survey of the 1938 operating costs for all States using this equipment gave an average operating cost of $43.99.

The portable-type traffic counters consist of two general types, the recording counter and the cumulative counter, commonly referred to as a nonrecording counter[2] The recording-type machine produces an hourly record by printing or photographing the cumulative counter reading on a record tape every hour on the hour. With the cumulative counter, only a record of the total traffic passing the machine is obtained from the time it was placed in operation until the machine is read by an observer In a few instances, these cumulative counters have been equipped with a clock that will start and stop the machine at a predetermined

[1] The May 1938 issue of PUBLIC ROADS carries a detailed description of these machines

[2] A simple counter of this type is described in the January 1939 issue of PUBLIC ROADS

time, thus eliminating the necessity for placing the machine and picking it up at a definite time.

The operating mechanisms of the portable counters are of two types, electrically operated and mechanically operated. The majority of the mechanically operated machines are an adaptation of a watch or clock, arranged so that the escapement is operated when the wheels of a vehicle pass over the detector. So far this type of construction has been confined to cumulative counters. However, work is in progress to make a recording counter which is entirely spring operated.

The majority of the portable machines in operation make use of a pneumatic detector which consists of a rubber tube placed across the roadway and a diaphragm of some flexible material at one end of the tube. The air impulse produced when each pair of wheels of a vehicle passes over the tube causes the diaphragm to move, which, in turn, actuates the contacting elements controlling the counting circuit, or it operates directly the escapement of the counting mechanism, depending upon the type of machine. Other detectors used with portable machines are. a photoelectric device using one light beam, and a positive-contact device consisting of two strips of spring steel enclosed in a waterproof casing, which are pressed together to make contact when the wheels of a vehicle pass over them.

The cost of portable counters ranges from $10 for the watch-type cumulative counter to $225 for the hourly-recording type machine. A number of states have constructed cumulative counters of the electrically operated type at a cost of approximately $25 per machine. All these machines have used the pneumatic detector. One state has constructed recording counters using the pneumatic detector at a cost of approximately $80 per machine. Another state has constructed a portable counter using a photoelectric detector and a photographic means of recording at a cost of approximately $125 per machine.

RECORDS AVAILABLE FROM FORTY-SIX STATES

The portable traffic recorders have not been in use long enough for the cost of their operation to have been established with any degree of accuracy. Another factor that makes it difficult to determine the cost of records obtained with these machines is that the cost depends almost entirely on the distance between stations and the schedule upon which they are operated. One state has reported a field cost of $1.62 per count for 24-hour counts obtained with the simple cumulative counter. This cost includes salary, mileage, parts, power, and incidentals. Another state reports a cost of approximately 87 cents per 24-hour count. These figures are for eastern states where stations were close together. The estimated monthly cost of operating one of the recording-type portables is $4.00. The cost of the cumulative counters is less than that, so it is very evident that the charge for salary and mileage is the major part of the cost of counting traffic with portable traffic counters

Experimental development and field tests of the automatic traffic counters were carried on throughout 1935, and during 1936 eighty-four of the fixed-type machines were placed in operation. In 1937, 115 additional counters were installed; in 1938, 120; in 1939, 168; and up to July 1940, 45 new fixed-type machines were placed in operation. A total of 532 such machines were in operation during July 1940. A complete statement of the record, by States, is given in Table 1.

Locations for the machines were chosen by the states with the assistance of the Public Roads Administration, and detailed local knowledge of economic areas within the states and of the type of traffic using individual routes were factors in the selection of locations; so that farm-to-market roads, roads used largely by tourist traffic and those upon which intercity commercial traffic is a considerable fraction of total traffic, are included among the locations.

The Public Roads Administration has issued, at monthly intervals since October 1938, a series of maps showing the location of counters in current operation and accompanied by tabulations of the average monthly traffic at each such location and the increase or decrease in such traffic as compared with the traffic volume in the preceding year. Certain of the states have issued a monthly series of maps showing similar information for the transcontinental highways which pass through the state.

TABLE 1

NUMBER OF AUTOMATIC TRAFFIC COUNTERS OPERATING IN JULY 1940 WHICH STARTED OPERATION IN

State	1936	1937	1938	1939	1940
Alabama		9		1	
Arizona	7				
Arkansas			11	5	
California		10			
Colorado	1		2	3	
Connecticut				20	
Delaware					
Florida	6		4		2
Georgia				12	
Idaho	4				
Illinois			1	5	
Indiana	4			14	
Iowa	2		10	12	
Kansas	1		3		
Kentucky		4	2	5	
Louisiana		2	2	4	
Maine			6		
Maryland		10	1	2	
Massachusetts			8		1
Michigan	1	8	1		
Minnesota	9	2		16	6
Mississippi				10	
Missouri		5	7	5	1
Montana			6	8	
Nebraska	5		2		
Nevada	1	7	2	2	1
New Hampshire		3			
New Jersey					
New Mexico	9		1		
New York			12	9	
North Carolina			4		
North Dakota	3		2	4	
Ohio	2		5		10
Oklahoma	9				11
Oregon	2	3			
Pennsylvania	1	20	1	1	7
Rhode Island		4			
South Carolina		1	6	6	
South Dakota		5			3
Tennessee		4			
Texas	4	10	2	14	1
Utah	2		4		2
Vermont		1		3	
Virginia			4		
Washington	3	7			
West Virginia	4			7	
Wisconsin	4		8		
Wyoming			3		
Subtotal	84	115	120	168	45
Cumulative total	84	199	319	487	532

AVERAGES NO INDICATION OF PEAK TRAFFIC VOLUMES

To obtain information regarding the fluctuation of traffic flow on primary highways, automatic traffic counter records for 90 stations located on the main U. S numbered highways have been analyzed. In the selection of the stations for analysis, an attempt was made to secure locations so that the figures for annual traffic volumes would cover a wide range and be geographically distributed throughout all sections of the United States. The traffic records for each of the selected stations showed the number of vehicles for practically each hour during at least one full year

Table 2 shows the location, the period

TABLE 2

LOCATION OF AUTOMATIC TRAFFIC RECORDERS USED TO OBTAIN DATA FOR STUDY OF FLUCTUATION IN TRAFFIC DENSITY

State	Location		Period used		Annual average 24-hour traffic volume
	State's recorder station No.	U S route number	From	To	
Alabama	2	72	1- 1-39	12-31-39	531
	4	78	12-25-37	12-24-38	1,073
Arizona	1	60, 70, 80	7- 7-39	7- 6-40	7,174
	4	60 & 89	1-28-39	1-27-40	1,743
Arkansas	11	63	1- 1-39	12-31-39	311
California	1	99	7-10-37	7- 9-38	5,815
	2	99	2-20-37	2-19-37	2,281
Colorado	3	85-87	2-27-37	2-26-38	4,334
	11	85	6-26-38	6-25-39	5,472
Connecticut	6 & 7	Merritt Parkway	3-31-39	3-30-40	13,624
	17	5	3-31-39	3-30-40	8,313
Florida	1	90	11-27-37	11-26-38	749
	3	41	1- 1-38	12-31-38	1,668
	4	90	5-15-37	5-14-38	3,365
Georgia	1	41 & 411	1- 1-39	12-31-39	3,238
	12	84	1- 1-39	12-31-39	632
Idaho	1	10	1- 1-38	12-31-38	2,438
	2	30	4- 3-37	4- 2-38	3,085
	3	30	1- 1-38	12-31-38	2,290
Illinois	1	45	9-27-36	9-26-37	4,057
	2	66	1-24-37	1-23-38	3,937
	7	50	12-18-37	12-17-38	3,210
Indiana	2A	20	8-28-37	8-27-38	3,490
	42A	52	7- 3-37	7- 2-38	3,071
	59A	40	1-15-38	1-14-39	3,125
	72A	31	1-15-38	1-14-39	2,293
Iowa	601	65-69	12-19-36	12-18-37	3,290
	601	65-69	1- 1-38	12-31-38	3,539
Kansas.	3	50S	2-18-39	2-17-40	2,059
	5	24 & 40	8-14-38	8-13-39	2,183
Louisiana	1	79-80	12-25-37	12-24-38	3,304
	4	90	4-24-37	4-23-38	4,226
Maine	2	1	2- 5-38	2- 4-39	1,287

TABLE 2—*Continued*

State	Location		Period used		Annual average 24-hour traffic volume
	State's recorder station No	U. S. route number	From	To	
Maryland	2	40	4- 3-37	4- 2-38	3,030
	12	40	1-22-38	1-21-39	7,250
Massachusetts	8	1	4-30-38	4-29-39	7,363
	10	6	7-21-39	7-20-40	6,476
Michigan	676	27	10- 2-37	10- 1-38	3,151
	678	23	1- 1-39	12-31-39	1,200
Minnesota	157	212-169	3-20-37	3-19-38	4,875
	159	10-52 & 169	9-11-37	9-10-38	3,730
	175	52	7- 3-37	7- 2-38	872
Missouri	5	54	7-17-37	7-16-38	1,708
	9	66	1-23-39	1-22-40	5,220
Wyoming	205	20	5-19-39	5-18-40	1,309
	204	30	1- 1-39	12-31-39	1,257
Montana	A4	10-12	10-29-38	10-28-39	982
	A7	91	6-30-39	6-29-40	495
Nebraska	2	30	1- 8-38	1- 7-39	1,619
	5	6	1- 8-38	1- 7-39	2,128
Nevada	101	40	11- 6-37	11- 5-38	1,469
	107	40	6- 5-37	6- 4-38	755
New Hampshire	1	3	9-18-37	9-17-38	1,360
New Mexico	1	85-285	6-12-37	6-11-38	1,216
	6	66	1-15-38	1-14-39	1,574
	7	70-80	8- 7-37	8- 6-38	1,461
	9	54-70	1- 8-38	1- 7-39	751
New York	5-1	(State) 5	12-31-38	12-30-39	4,458
North Carolina	3	29	1- 1-39	12-31-39	4,296
	4	19 & 23	2-25-39	2-24-40	2,540
North Dakota	102	SR 1	2- 1-39	1-31-40	356
	103	2	10-18-37	10-17-38	352
Ohio	25	42	4-12-39	4-11-40	3,645
	27	25-68	2-18-39	2-17-40	3,928
Oklahoma	1	66-69	5-15-37	5-14-38	2,111
	5	77	2-27-37	2-26-38	2,259

TABLE 2—*Concluded*

State	Location		Period used		Annual average 24-hour traffic volume
	State's recorder station No.	U. S route number	From	To	
Oregon	Rowena (3)	30	11-27-37	11-26-38	1,261
Pennsylvania	1	20	11-20-37	11-19-38	4,395
	4	6	7-24-37	7-23-38	1,231
Rhode Island	2	R I 1-A	6- 4-38	6- 3-39	1,931
South Carolina	2	15-52	12- 4-37	12- 3-38	1,583
	105	29	2-20-37	2-19-38	3,936
South Dakota	101	14-16	5-15-37	5-14-38	982
	106	18	12-31-38	12-30-39	479
Tennessee	1	31W	4-21-39	4-20-40	3,425
Texas	1	80	7- 7-39	7- 6-40	9,053
	4	77-81	1- 1-38	12-31-38	4,049
	5	80	12-19-36	12-18-37	2,427
	8	81-83	3-20-37	3-19-38	875
Utah	301	40	11-13-37	11-12-38	1,766
	302	50-91	7-10-37	7- 9-38	3,443
Vermont	A-12-2	2	11-28-36	11-27-37	1,615
Virginia	1	1	6-26-37	6-25-38	6,668
	4A	58	1-31-39	1-30-40	2,429
Washington	1	99	12-28-37	12-27-38	3,590
	3	99, 410, 101	9-11-37	9-10-38	3,385
	4	99	12-11-37	12-10-38	3,479
	10	10	4-10-37	4- 9-38	3,233
Wisconsin	2 & 3	41	1- 8-38	1- 7-39	5,614
	10	10 & 12	1- 9-37	1- 8-38	1,632

used for the analysis, and the annual average 24-hour traffic volume for each of the stations. Stations located in 43 states and having annual average 24-hour traffic volumes ranging from 311 to 13,500 vehicles were used.

Figure 1 shows the maximum 24-hour traffic volume that occurred at each location during the year, plotted against the annual average 24-hour traffic volume. For anv annual volume, there is a large variation in the peak day during the year. As an example, the roads with an annual average of about 4,000 vehicles per day have from 6,000 to 18,000 vehicles on the peak day, or a variation of 300 percent. The average relationship shown by the solid line indicates that there is a slight drop from a straight-line relationship as the volume increases, and for sections that have annual averages between 2,000 and 4,000 vehicles there is a marked sag in the curve. On an average, the maximum 24-hour traffic volume was 2.45, 2.20, and 2 34 times the annual average 24-hour volume for locations with annual averages below 2,000, between 2,000 and 4,000, and over 4,000 vehicles, respectively.

An investigation of the surface width at each location showed that all stations with annual averages below 3,400 vehicles had 2 traffic lanes. As the annual average increased above 3,400, the relative number of sections wider than 2 lanes increased until at 4,500 vehicles practically all sections were wider than 2 lanes. It, therefore, seems that the sag in the curve was due to a tendency for

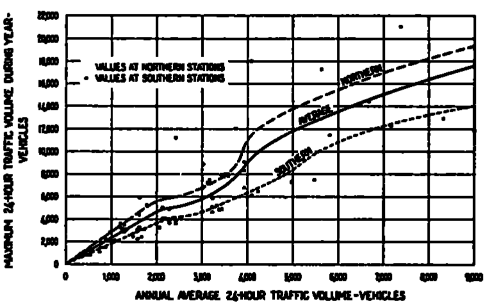

Figure 1. Maximum 24-hour traffic volume during 1 year for various annual average 24-hour traffic volumes.

some drivers to avoid heavily traveled 2-lane highways on peak days.

A further classification by geographic location showed that at stations in the north, where there usually is considerable snow and ice each winter, the number of vehicles during the maximum day averaged 2.6 times the number on the average day while in the south there were only 1.8 times as many vehicles on the maximum day as on the average day. The curves for both the northern and southern locations (Fig. 1) show the same general tendency for the slope of the curves to decrease when the annual volume reaches about 2,000 vehicles per day and then to increase and return to the normal slope at between 4,000 and 4,500 vehicles per day.

Figure 2 shows the tenth highest 24-hour traffic volume for each station plotted against the average 24-hour volume. The variation in the tenth highest values for any particular annual average 24-hour volume is considerably less than for the maximum hours. On an average, the traffic volume on the tenth highest day is 1.75 as great as the annual average 24-hour volume. Corresponding figures for the locations in the northern and southern states are 1.88 and 1.44, respectively. In other respects, the curves are very similar to those for the maximum days.

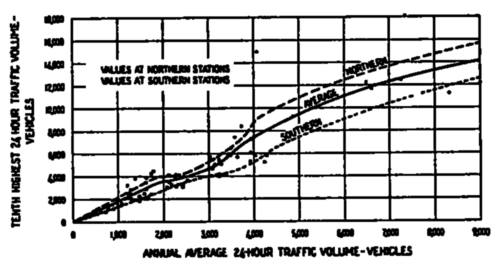

Figure 2. Tenth highest 24-hour traffic volume during 1 year for various annual average 24-hour traffic volumes.

Figure 3 shows the same average curves as presented in figures 2 and 3, together with curves for the average 24-hour volumes during the maximum week and month. The slope of all the curves decreased slightly when the annual average reached about 2,000 vehicles and then increased until at an annual average of about 4,500 the normal slope was reached. Since this was probably due to congested conditions on a number of the roads in this group, the relationships as shown by the curves on Figure 3 are preferable when considering design features to accommodate the various traffic volumes. However, Figure 4 illustrates that even these curves are of little value in determining maximums from the annual average since there is such a large variation between different stations. As an example, although the maximum day for the average locatıon is 2 32 times as hıgh as the average day, the group ranging from 1.4 to 1.8 includes a larger percentage of the locations than any other group covering a sımilar range In all cases, the maximum values for the

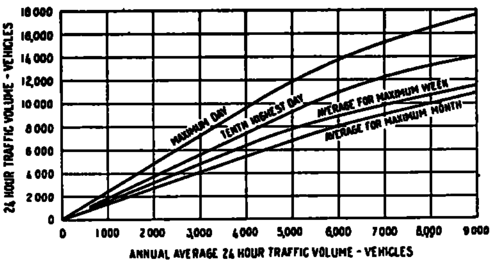

Figure 3. Relation between various 24-hour traffic volumes during year and average 24-hour traffic volume. (Determined from data for 89 highway locations).

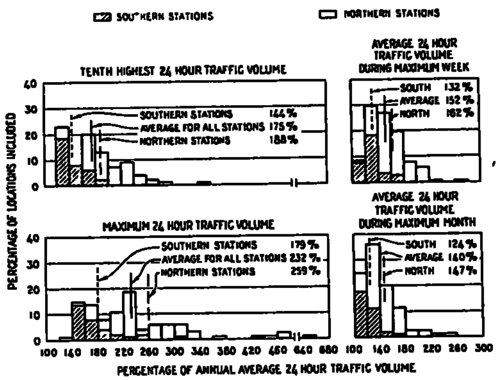

Figure 4. Variation in relation between 24-hour traffic volumes during peak traffic density periods and annual average 24-hour traffic volumes at different locations.

southern stations do not cover as great a range as the northern stations and the values for the southern stations are closer to the annual averages.

Fıgure 5 shows for different annual 24-hour traffic volumes, the average number of days during a year that the traffic volume exceeded various values. Thus, the average highway with 6,000 vehicles per day on an annual basis carried over 12,000 vehicles on 3 days, over 11,000 vehicles on 11 days, over 8,000 vehicles on 45 days, etc. The curves indicate that for the average location, the 24-hour traffic volume that is exceeded any certain number of days is nearly proportional to the annual average 24-hour traffic volume.

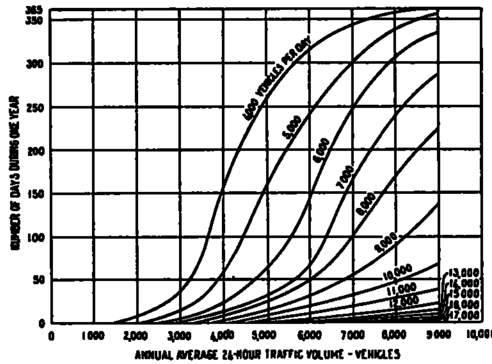

Figure 5. Number of days during a year that various 24-hour traffic volumes were exceeded. (Determined from data for 89 highway locations.)

LARGE PROPORTION OF TRAFFIC TRAVELS IN PEAK HOURS

Thus, the average highway carrying 4,000 vehıcles a day has approximately the same number of days per year with a volume ın excess of 5,000 vehicles as a highway carrying 8,000 vehicles per day has days in excess of 10,000 vehicles. The curves show 50 days ın the one case and 47 in the other.

Sınce all roads have large variation in traffic volumes for different hours of the day, and since the hourly rather than daily volume is the more practical unıt to use as a basis for measuring the capacity of a highway and for design purposes, a number of figures showing the relationships between the annual average 24-hour volumes and the individual hourly volumes are presented.

Figure 6 shows the relationship between the maximum hour during a year and the average 24-hour volume. The range in maximum hours for stations having similar yearly traffic volumes is very great. There are cases in which the maximum for one highway is nearly

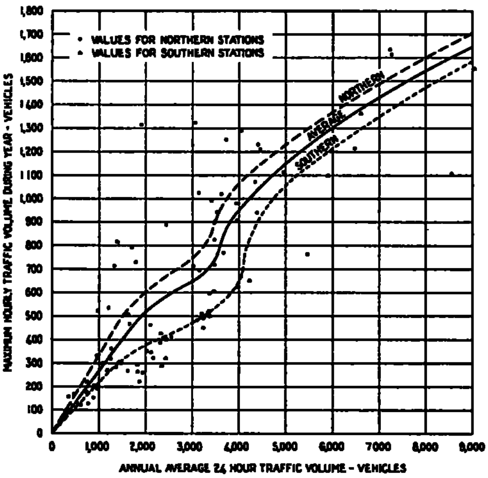

Figure 6. Relation between maximum hourly traffic volume during year and annual average 24-hour traffic volume.

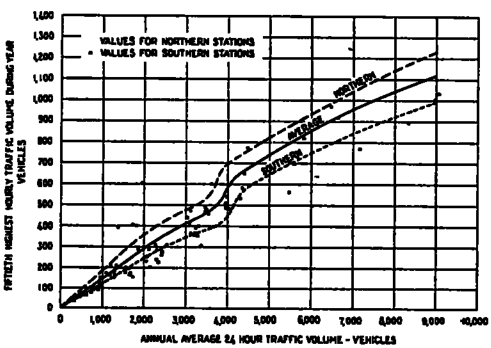

Figure 7. Relation between fiftieth highest hourly traffic volume and annual average 24-hour traffic volume.

six times as great as the maximum for another highway carrying the same total number of vehicles during a year. Even the fiftieth highest hours as shown by Figure 7 are sometimes three times as high for one station as for another with the same annual traffic.

The curves for the relationship between the maximum and fiftieth highest hours and the annual 24-hour averages also have a tendency for their slopes to decrease when the annual average reaches about 2,000 vehicles and then to increase until they return to their normal slopes near 4,000 vehicles per hour. The curves for the stations located in the northern states are considerably higher than those for the stations in the southern states.

Figure 8 shows the relationship between the maximum hour, the tenth, thirtieth and fiftieth highest hours and

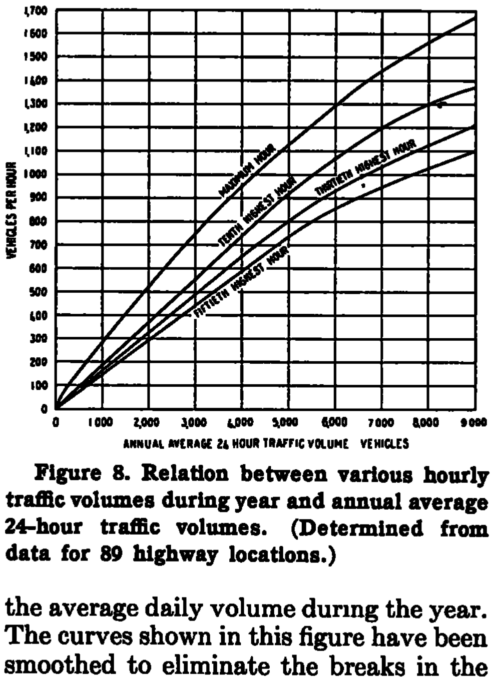

Figure 8. Relation between various hourly traffic volumes during year and annual average 24-hour traffic volumes. (Determined from data for 89 highway locations.)

the average daily volume during the year. The curves shown in this figure have been smoothed to eliminate the breaks in the curves at annual average daily volumes between 2,000 and 4,000 vehicles which were probably caused by some of the 2-lane roads in this group becoming congested during peak hours.

The variations in the percentages that the peak hourly volumes are of the annual average 24-hour volumes for different locations are shown by Figure 9. It may be seen from this figure that the variation between locations decreases as the number of peak hours that are included increases. Thus, although the maximum hours average 25 4 percent of the average daily volume, there are only 23.5 percent of the locations that the maximum is between 20 and 25 percent of the annual average, but for 69 percent of the locations the fiftieth highest hour falls within the same 5-percent range group as the average for all of the fiftieth

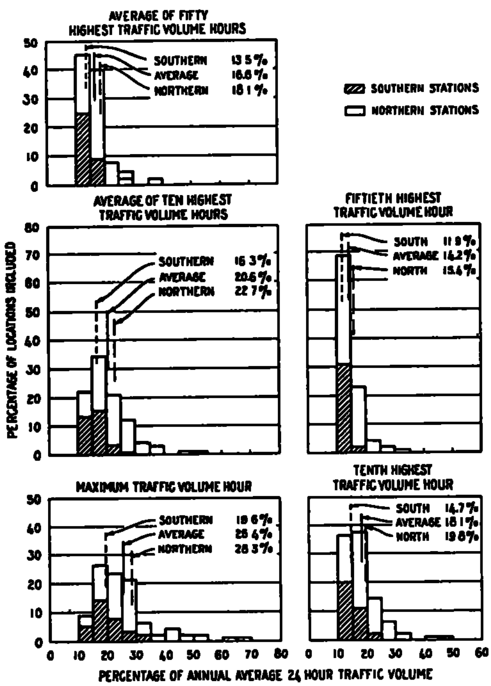

Figure 9. Variation in relation between hourly traffic volumes during peak hourly traffic density periods and annual average 24-hour traffic volumes at different locations.

highest peak hours. As with the daily volumes, the peak hourly volumes for the northern locations cover a wider range and are a larger percentage of the annual average 24-hour density than corresponding peaks for southern locations.

Data were available for the percentage of the total traffic that was out-of-state vehicles and the percentage that was commercial vehicles for 70 of the 90 locations studied. There did not seem to be any relation between the percentage of out-of-state vehicles and the the traffic volume fluctuation but, on an average, there was a slight decrease in the fluctuation with an increase in the percentage of trucks (Table 3). Since the automatic counter records do not separate trucks from passenger cars, it was not possible to determine whether this was caused by (1) the peak truck densities occurring at different times, either seasonal, daily, or hourly, than

TABLE 3

EFFECT THAT THE PERCENTAGE OF TRUCKS HAS ON THE RELATION BETWEEN THE TRAFFIC VOLUME DURING PEAK DENSITY PERIODS AND THE ANNUAL AVERAGE 24-HOUR VOLUME

Percentage of trucks included in total traffic		Number of locations	Percentage of annual average 24-hour traffic volume		
Group limits	Average		Maximum hour during year	Tenth highest hour during year	Fiftieth highest hour during year
			%	%	%
Below 15	10 9	9	27 7	21 2	15 9
15-20	17 4	19	26 2	18 4	14 6
20-25	22 6	22	26 4	18 2	14 2
Above 25	27 6	20	23 2	17 3	13 6

the peak passenger car densities, (2) the increased percentage of trucks reducing the carrying capacity of the highway so that as high hourly traffic volumes during peak hours were not possible, or (3) the drivers of passenger cars avoiding routes carrying a large percentage of trucks to a greater extent than they do other routes on peak days

Table 4 shows the relation between the number of vehicles during peak traffic density periods and the annual average 24-hour traffic volume. At the average location, there is a very rapid decrease in the average hourly volume as the number of hours included in the peak period is increased When the 50 hours of peak traffic density covering only 0.57 percent of the total time are included, the average hourly volume is only 16.6 percent of the annual 24-hour average while the one maximum hour is 25.4 percent of the annual 24-hour average. The percentage of vehicles included in the peak hours is always relatively large as compared to the percentage of time involved.

economically advisable to construct a highway to accommodate the peak traffic densities that will use the highway during the probable life of the structure, unless there is no additional construction cost involved. However, the time, percentage of time, number of vehicles, or percentage of vehicles that may be included in the peak traffic densities not cared for by the design is still an unknown quantity. Although this will depend to

TABLE 4

RELATION BETWEEN NUMBER OF VEHICLES DURING PEAK TRAFFIC DENSITY PERIODS AND THE ANNUAL AVERAGE 24-HOUR TRAFFIC VOLUME (AVERAGE FOR 60 NORTHERN AND 30 SOUTHERN STATIONS)

Time period	Percentage that average hourly traffic volume during peak density periods is of annual average 24-hour traffic volume			Percentage of total time included (annual basis)	Percentage of total annual traffic included		
	Northern stations	Southern stations	All stations		Northern stations	Southern stations	All stations
	%	%	%	%	%	%	%
Maximum month (30 days)	6 1	5 2	5 8	8 21	12 03	10 26	11 44
Maximum week	6 8	5 5	6 3	1 92	3 13	2 53	2 90
Ten highest days	8 9	6 4	8 1	2 74	5 85	4 21	5 33
Maximum day	10 8	7 4	9 7	0 27	71	49	64
Maximum hour	28 3	19 6	25 4	0 01	08	05	07
Ten highest hours	22 7	16 3	20 6	0 11	62	45	56
Twenty highest hours	20 9	15 0	19 5	0 23	1 15	82	1 07
Thirty highest hours	19 6	14 3	18 2	0 34	1 61	1 18	1 50
Forty highest hours	18 8	13 9	17 4	0 46	2 06	1 52	1 91
Fifty highest hours	18 1	13 5	16 6	0 57	2 48	1 85	2 30

PEAK TRAFFIC DATA NEEDED FOR DESIGN OF HIGHWAYS

Figure 10 shows the average number of hours each year that the traffic density exceeded various hourly traffic volumes for highways with different annual average 24-hour volumes. Thus, the average highway carrying an average of 5,000 vehicles per day had 600 hours when the traffic volume exceeded 400 vehicles per hour, 350 hours when the traffic volume exceeded 500 vehicles per hour, 275 hours when the traffic volume exceeded 600 vehicles per hour, etc.

It is generally accepted that it is not a large extent upon the funds available for construction, Figure 10 throws some light on the hourly traffic volumes for which highways with different annual traffic densities and having average traffic fluctuations should be designed. From the figure, it may be seen that for any annual average 24-hour traffic volume, there is a rapid increase in the number of hours included between each 100-vehicle change in the hourly volume when the number of hours included are greater than the 50 maximum hours, but there is only a small change in the number of hours included as the volume goes below the value shown for the thirtieth highest hour.

As an example, at the average location with an annual average 24-hour traffic volume of 4,000 vehicles, the various hourly traffic volumes are exceeded for the number of hours shown in the following tabulation.

Hourly traffic volume	Number of hours during one year
950	1
800	8
700	20
650	30
600	50
500	115
400	280

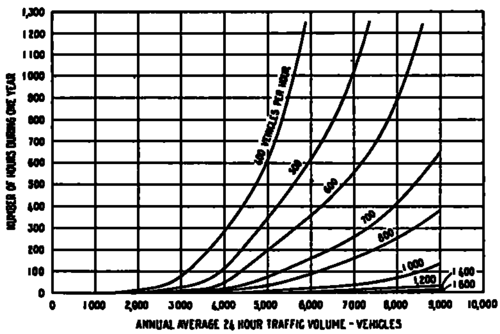

Figure 10. Number of hours that various hourly traffic volumes are exceeded on highways having different annual traffic densities. (Determined from data for 89 highway locations.)

A design based on the maximum hourly volume would be required to handle nearly 1½ times as many vehicles per hour as a design based on the 30 peak traffic volume hours, but the number of vehicles accommodated would only be increased by 1.5 percent (Table 4). For the other case, designing for a traffic volume only 30 percent less than the volume exceeded during 50 hours would result in a 560 percent increase in the number of hours of traffic not included in the design. The percentage of the total number of vehicles using the highway that would not be included in the design would be increased from 2.3 to 9.9. It, therefore, seems that for the average highway, it is uneconomical to design for a greater hourly volume than the value which will be exceeded during the 30 peak hours each year and that little will probably be gained in the construction cost and a great deal lost in expediting the movement of traffic if a design is used that will not handle the traffic volume exceeded during the 50 peak hours. The exact value to use depends upon the traffic volumes that the different designs will accommodate. Thus, if the traffic volume is such that to accommodate the hourly volume exceeded for 30 hours during a year, requires a greater number of traffic lanes than to accommodate the hourly volume exceeded for 50 hours, the lower number of lanes should probably be used.

Since this analysis has been made for highways with the average fluctuation in traffic density, the results are not applicable to all locations. For an extreme example, a comparison has been made between the station included in this analysis that had the greatest fluctuation in the hourly traffic volumes during the year and the station that was found to have the most uniform flow of traffic. The percentage of the total time during which each of these road sections carried traffic volumes in excess of different numbers of vehicles per hour and the percentage of all vehicles that passed over each road section when the hourly traffic volume was in excess of the specified traffic densities are shown by Table 5. The section with the largest variation in traffic flow had an annual average 24-hour traffic volume of 4,057 vehicles, was located in the North, and is referred to as Section A. The one with the most uniform traffic flow had an annual average 24-hour traffic volume of 4,226 vehicles, was located in the South, and is referred to as Section B.

Although practically the same number

of vchicles used these two road sections in one year, the traffic on section B was rarely in excess of 500 vehicles per hour, while on section A it sometimes reached 1,200 vehicles per hour and was in excess of 500 vehicles per hour for 5 5 percent of the time. Since the percentage of the total vehicles during high density periods is greater than the percentage of time occupied by the same density periods, 25.1 percent of the vehicles traveled over section A during the 5.5 percent of

TABLE 5

Percentage of Time and Percentage of Vehicles Included during Periods that Road Sections Carried Traffic in Excess of Different Densities

Hourly volume	Cumulative percentage of total time		Cumulative percentage of total vehicles	
	Section A	Section B	Section A	Section B
Vehicles				
1,200	2		1 3	
1,100	5		3 3	
1,000	1 1		6 8	
900	1 6		9 9	
800	2 3		13 3	
700	3 0		16 4	
600	4 2		20 8	0 1
500	5 5	0 1	25 1	0 2
400	7 6	0 9	30 3	2 3
300	14 0	9 0	43 2	18 0
200	26 7	46 5	61 2	70 2
100	57 6	71 6	87 5	91 0
0	100 0	100 0	100 0	100 0

the time that the hourly density exceeded 500 vehicles. Figure 11 shows the data obtained from the automatic traffic recorders located at these two stations in a most useful form. The curve for station B shows that a highway designed to accommodate 400 vehicles per hour would be the most economical design at this location for the present traffic, since designing for a greater volume would result in a very slight increase in the number of vehicles accommodated, and designing for a traffic volume even slightly less than 400 vehicles per hour would result in a relatively large increase in the number of vehicles that would be required to use the highway during periods that the volume is in excess of the designed value

The traffic flow at station A presents a more difficult problem. Based on the annual traffic density the same design could be used at both locations but if the design at station A were based on 400 vehicles per hour, nearly half a million or ⅓ of the vehicles would use the road during periods that the traffic density exceeds the design value. A design to accommodate the same per-

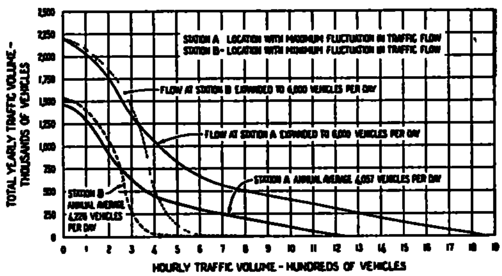

Figure 11. Cumulative frequency curves showing the number of vehicles when traffic is in excess of various hourly traffic volumes at stations having maximum and minimum fluctuation in traffic flow.

centage of vehicles as are accommodated by a design of 400 vehicles per hour at station B would have to accommodate 1,200 vehicles per hour. The actual design value for the location represented by station A would depend entirely upon the funds available and the hourly capacity of different designs. However, if the present width of surface and alinement were identical at these two locations, the highway with the traffic flow represented by station A should be given prior consideration in any construction or improvement program designed to reduce traffic congestion such as the elimination of short sight distances, increasing the surface width, increasing the number of traffic lanes, or providing grade separations

Since construction programs must be based on future as well as present traffic densities to avoid obsolescence in a relatively short time, it is essential to estimate future fluctuations in the traffic volumes as well as the future increase in the annual traffic. A study of the future variation in traffic flow can usually be based on the present fluctuation. When a cumulative frequency curve such as the one shown in Figure 11 has been determined, it will generally be safe to assume that the shape of the curve will not change materially with either an increase or decrease of average daily traffic unless it is definitely known that some local development will tend to alter the shape of the curve.

ESTIMATES OF FUTURE PEAK TRAFFIC VOLUMES

If it is assumed that an increase in the annual traffic affects all portions of present traffic volumes proportionally and that the annual daily traffic will increase to 6,000 vehicles at some future date, the cumulative frequency curves as obtained from the present records made by the automatic recorders can be expanded by increasing both values for points along the present traffic curve in the same ratio as the future annual traffic is to the present traffic. By expanding the curves for the present traffic on sections A and B in this manner to annual daily volumes of 6,000 vehicles, the expanded cumulative frequency curves as shown by the light lines on Figure 11 were obtained In a similar manner, the data for the present traffic can be expanded to any annual average daily volumes It is interesting to note that at the present time, with a volume of 4,000 vehicles per day, a larger number of vehicles travel over the highway represented by station A during periods that the traffic volume exceeds any value over 420 vehicles per hour, than will travel over the highway represented by station B when the annual daily volume reaches 6,000 vehicles.

Since the curves on Figure 11 represent locations with the maximum and minimum fluctuation in traffic flow found by analyzing 90 stations located on U. S. routes in all parts of the country, it is reasonable to expect that similar curves for practically all sections on U. S. numbered highways will fall somewhere between the curves representing these two locations for corresponding annual traffic volumes. However, the range between the two curves for identical traffic volumes is so great that they merely emphasize the importance of having at least a full year's record from an automatic traffic recorder before an intelligent analysis can be made of the traffic needs on any particular section of highway where improvements to increase the traffic capacity of the highway are contemplated

Cumulative frequency curves of the type shown in Figure 12 are useful when it is desired to compare the percentage of time that traffic on different road sections is in excess of various hourly volumes. The data obtained from the automatic traffic counters at the stations included in this analysis where the maximum and minimum fluctuation in traffic flow were recorded, have been used in plotting the curves for stations A and B, respectively. When expanding the data shown by the original curves to other traffic volumes, the values along the abscissa are increased by the same ratio as the annual traffic, while the values along the ordinate are held constant The values for stations A and B have been expanded to show the percentage of time that the traffic will be in excess of various hourly volumes when the annual average volume increases to 6,000 vehicles per day (Fig. 12). In a similar manner, the data for all 90 locations included in this study were expanded to annual 24-hour traffic volumes of 6,000 vehicles and the values averaged to obtain the average cumulative frequency curve shown in Figure 12. This curve and other curves formed by expanding the individual values to other traffic densities show the relation between time and hourly traffic density for highways with the average fluctuation in traffic flow.

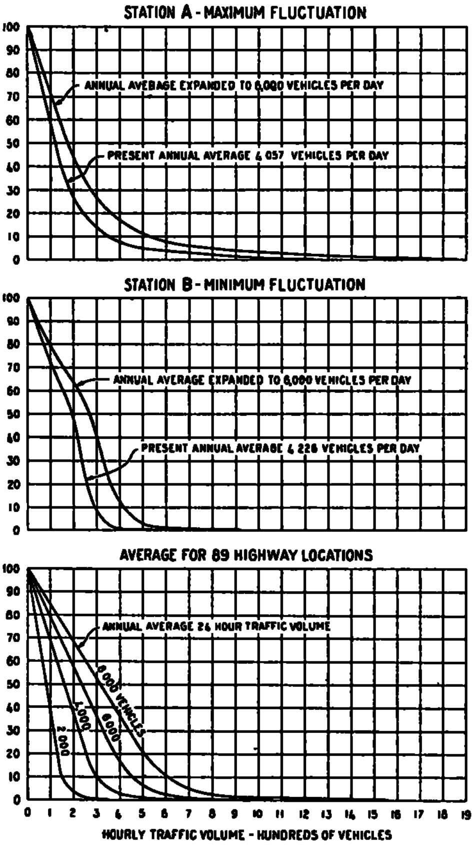

Figure 12. Cumulative frequency curves showing the percentage of time that the traffic was in excess of various hourly volumes on highways having the maximum, minimum and average fluctuation in the flow of traffic.

The method outlined for estimating the percentage of time, number of vehicles, or number of hours included in the various hourly traffic density groups when there is a change in the annual traffic, assumes that the change will affect all portions of the cumulative frequency curves proportionately. This will always be true when all portions of the traffic pattern are affected proportionately but may also be true even though there is a material change in the traffic pattern.

Since automatic hourly recording counters have only been in operation during recent years, there were only three stations where the recorders had been operated continuously for at least two years and where there had been sufficient increases in the annual traffic densities during the period of operation to check the accuracy of this assumption. At these three locations, referred to as stations C, D, and E, the total traffic volumes during the same period in successive years had increased from averages of 787, 997, and 2,794 vehicles per 24 hours to 1,357, 1,630, and 5,702 vehicles per 24 hours, respectively. The cumulative curves for the percentage of time that traffic at the three stations was in excess of various hourly volumes during each of the two different traffic density periods are shown by Figure 13. In each case, if the values shown for the lower volume curve are expanded in the same ratio as the two average 24-hour volumes are to each other, as previously outlined, the values of the curve for the higher average volume will be obtained.

While such a close agreement will probably not be found for all locations, especially where local developments tend to influence the traffic pattern and where the increase takes place over a period of 10 or 20 years, the data available now substantiate the one assumption necessary to expand the automatic recorder data to care for increased annual traffic densities.

For design and traffic control purposes it is often desirable to know the percentage of the total vehicles traveling in each direction during hours of high traffic density. This can be obtained for divided highways by using an automatic traffic recorder for each of the two directions. On undivided roadways, the automatic recorders using either light beams or the direct contact or pneumatic tube as the means of detection can be equipped with special units so that only vehicles traveling in one direction will be recorded Approximate values can also be obtained when the contact type of detector is used by placing the detector so that only vehicles traveling on one-half of the roadway will be recorded. By the proper selection of locations, the error due to vehicles traveling to the left of the center of the roadway, as when passing, can be reduced to a minimum

Cumulative frequency curves for two locations on divided highways, where automatic traffic counters obtained the number of vehicles in each direction for each hour during periods exceeding one year, are shown by Figures 14 and 15.

The percentage of time that the traffic at automatic recorder stations 2 and 3 on U. S. Route 41, 18 miles south of Milwaukee, Wisconsin, was in excess of various hourly volumes is shown by Figure 14 Station 2 recorded the south-bound traffic, while station 3 recorded north-bound traffic By adding the number of vehicles in the two directions for corresponding hours, it was also possible to obtain the total traffic on the route during each hour of the year. Although the number of vehicles traveling in each of the two directions was rarely the same for any particular hour, each direction carried the various traffic volumes below 300 vehicles per hour for approximately the same number of hours during a year as the total traffic volume in both directions was equal to twice the corresponding densities. Both directions carried traffic volumes in excess of 300 vehicles per hour for 4 percent of the time, and the total volume was in excess of 600 vehicles per hour for 4 percent of the time. The maximum volume south-bound was 632 vehicles per hour and the maximum north-bound volume was 1,232 vehicles per hour, but the total volume did not exceed 1,649 vehicles per hour. During the one hour that the total volume reached 1,649 vehicles, 74.7 percent of the traffic was in one direction. During the ten peak hours of total traffic volume, the traffic in one direction averaged 70 percent of the total traffic.

On the Merritt Parkway, at traffic recorder stations 6 and 7 near Greenwich, Connecticut, the traffic in one direction exceeded all traffic volumes below 1,100 vehicles per hour for the same number of

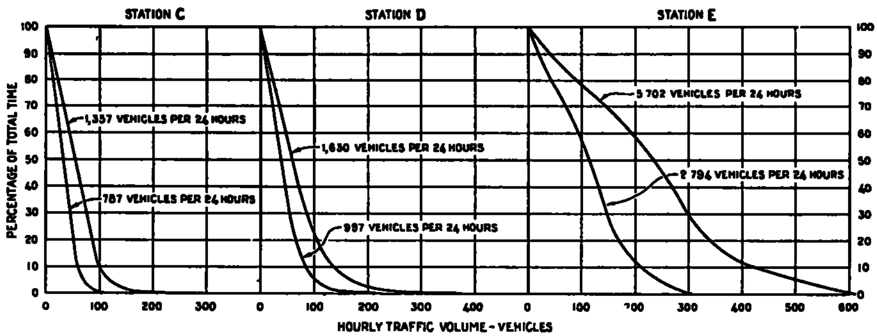

Figure 13. Percentage of time that traffic was in excess of various hourly densities at stations where there was an appreciable difference in the average 24-hour volumes for the same period in successive years.

hours as the total volume exceeded twice the corresponding densities (Fig. 15). East-bound, west-bound, and the total traffic never exceeded 1,632, 2,025, and 3,501 vehicles per hour, respectively. During the 10 peak hours, the traffic in the heaviest direction averaged 57 percent of the total traffic.

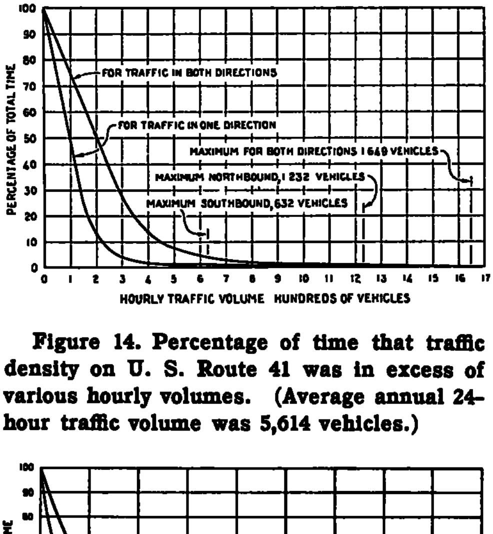

Figure 14. Percentage of time that traffic density on U. S. Route 41 was in excess of various hourly volumes. (Average annual 24-hour traffic volume was 5,614 vehicles.)

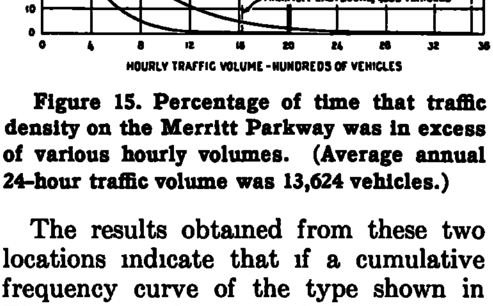

Figure 15. Percentage of time that traffic density on the Merritt Parkway was in excess of various hourly volumes. (Average annual 24-hour traffic volume was 13,624 vehicles.)

The results obtained from these two locations indicate that if a cumulative frequency curve of the type shown in Figures 14 and 15 is available for either the traffic in one direction or for the total traffic, the curves for both the traffic in one direction and the total traffic can be obtained, except for a very small portion of the total time when the peak volumes occur. It is also evident that unless practically all the vehicles are to be accommodated, designs for each direction of traffic based on half of the total volume are sufficient, but if all vehicles are to be accommodated, the design for each direction must in some cases be based on volumes as high as 70 percent of the peak total volumes.

FIELD OPERATING SCHEDULES AND THEIR SELECTION

The second of the general problems, for which automatic traffic recorder data furnish a method of attack, is that of planning the observation schedule for the traffic survey. A satisfactory schedule must require sufficient observation in the field to enable an accurate estimate of the year's total traffic, and of the various types of vehicle units into which it is divided. Results of the schedule operation should enable the analyst to make estimates of the ranges in traffic volume —in particular permit an estimate of traffic during periods of maximum volume.

The schedule should be so devised as to balance accuracy of results against cost of operation; i.e , the time for which it is necessary to pay men to count traffic should be as small as possible so that costs will be low, while the time for which traffic must be observed must be as large as is necessary to assure accuracy in the categories enumerated above

It has been recognized in earlier analyses,[3] that traffic volume is affected principally by the hour, day of the week, and the month in which the count is taken. Less predictable effects upon traffic volume result from variation in weather conditions, detoured traffic from a natural route due to construction or other reasons, holidays, foot-ball games, fairs or other social events attracting unusual traffic.

There are, of course, a very great num-

[3] Highway Traffic Analysis Methods and Results, PUBLIC ROADS, March 1929

ber of means by which allowance may be made in the schedule of operation to provide measures of the hourly, daily and seasonal fluctuations in traffic and, because of the numerous possibilities, it is feasible to test but a few of these possible schedules. Since total traffic has been measured at the automatic traffic recorders, the average daily traffic may be computed with precision, and since data are available for every hour and every day of the year at a large number of locations, any combination of hours, days and seasons may be selected and, from the selected periods, or assumed schedule, an estimated average daily traffic may be computed. Comparison of the estimated values under various assumed schedules with precise values computed from the year's complete record will establish the relative accuracy of the various schedules selected for test.

One of the schedules selected for test is the "key station schedule" first used[4] in the Western States Traffic Survey and in subsequent surveys in which the Public Roads Administration cooperated, and by the various states in the Highway Planning Surveys "Each operation covered a 10-hour period on a staggered schedule from 6 a.m to 4 p.m. and from 10 a m to 8 p.m. with splits in the count at 10 a.m. and 4 p m. This permitted a continuation series of the 10 a.m. to 4 p m. section through all operations, which were scheduled to provide two counts for each of the seven days of the week. Sufficient night counts from 8 p.m. to 6 a m. were obtained to adjust all data to a 24-hour day."[5]

When the eight-hour day became universal, this schedule was modified to cover the 6 a.m. to 2 p.m. and 2 p.m. to 10 p.m. periods alternately at intervals of 26 days, thus covering each day of the week at six-month intervals (Schedule I). Enough night counts, usually four in number, were seasonally spaced to cover the 10 p m. to 6 a.m. period. The effect of the schedule was to balance the seasonal variation in traffic, to cover the full 24 hours at each point of observation, to cover each of the days of the week at every point, and to set up the operation in such a manner as to keep a relatively small force of men continuously employed, with "days off" equivalent to those received by a man in any other form of employment.

The second schedule (Schedule II) to be tested is that applied at "control blanket count stations"; i.e., at the more important blanket count stations where a full "key station" schedule was not considered necessary, yet where a single day's count was insufficient. This control blanket count was considered to have been operated during three days—one weekday, one Saturday and one Sunday—in each of the four seasons of the year. Actually the control blanket count stations were operated during but 16 hours on each of the days, and in some instances during but 8 hours, usually from 8 a.m. to 4 p.m. In the analysis, the hour-period of observation was expanded to 24 hours by means of accurate factors computed from the key station observations or from the automatic traffic recorder data. In the present analysis the full 24-hour periods are selected to cut down the considerable volume of calculation necessary in arriving at these factors.

The third schedule (Schedule III) to be tested with the data available from the automatic traffic recorders, is one in which it is assumed that the periods of observation are each but one hour in duration. There are a total of 40 such observation periods at each station scattered throughout the year, as indicated in the sample schedule (Table 6).

[4] The Western States Traffic Survey, PUBLIC ROADS, March 1932

[5] Digest of Report on Arkansas Traffic Survey, PUBLIC ROADS, August 1936

It will be noted that under this schedule of operation, the period from 6 a m. to 7 a m. is covered in January and in July, at nearly six-month intervals The 7 a.m. to 8 a m hour is also covered in January and July, again approximately at six-month intervals, and so for all of the hours from 6 a.m. to 10 p.m. The night hours, those normally of much lesser traffic importance, are covered but once, at approximately six-week intervals throughout the year.

TABLE 6

SAMPLE SKELETON SCHEDULE

A M		
6- 7	Jan 1 (Sun.)	July 12
7- 8	Jan 13	July 24
8- 9	Jan 25	Aug 5 (Sat)
9-10	Feb 6	Aug 17
10-11	Feb 18 (Sat)	Aug 29
11-12	Mar 2	Sept 10 (Sun)
P.M		
12- 1	Mar 14	Sept 22
1- 2	Mar 26 (Sun)	Oct 4
2- 3	Apr 7	Oct 16
3- 4	Apr 19	Oct 28 (Sat)
4- 5	May 1	Nov 9
5- 6	May 13 (Sat.)	Nov 21
6- 7	May 25	Dec 3 (Sun)
7- 8	June 6	Dec 15
8- 9	June 18 (Sun)	Dec 27
9-10	June 30	Jan 7 (Sat.)

10-11 P M	Jan 1	2-3 A M	July 12
11-12 P M	Feb 18	3-4 A M	Aug 29
12- 1 A.M	Apr 7	4-5 A M	Oct 16
1- 2 A M	May 25	5-6 A M	Dec. 3

TESTS OF VARIOUS SCHEDULES

The estimates of average daily traffic under each assumed schedule are computed as follows At the key stations, traffic observed during the 6 a m. to 2 p.m., 2 p.m. to 10 p.m., and 10 p.m. to 6 a.m. periods is averaged and the three averages are totaled for the estimated average daily traffic. At the control blanket-count stations, the weekday observed traffic is multiplied by five, traffic for a Saturday and a Sunday are added, and the total is divided by seven for the counts taken during each season. The four seasonal averages, thus computed, are totaled and divided by four to give the estimated average daily traffic for the year. At the stations where traffic is assumed to have been observed only during hourly periods, the average of the two observations for each hour from 6 a.m. to 10 p m. is obtained. To these averages (16 in number) are added the observed traffic for each hour from 10 p.m. to 6 a m The result is the estimated average daily traffic under this schedule.

Tables 7, 8, and 9 present the average daily traffic computed from schedules I, II, and III, using the analysis methods previously outlined In Table 7 the stations were those located on state highway routes that carried a relatively large volume of traffic. In Table 8, stations were also those located on state highway routes, but with a light traffic volume, while in Table 9 all stations were on local routes and were usually those carrying a smaller traffic volume than the stations used in Table 8. Thirty-three stations were included in each of the above classes.

In addition to the computed averages, the true average daily traffic and the ratios of the various computed averages to the true averages, are tabulated. Weighted averages of these ratios are shown in the last line of each table

A comparison on the basis of these weighted averages indicates that schedule III generally produces closer results on state routes carrying heavy traffic, and that schedule II gives closer values on state routes that carry light traffic. When all stations are thrown together, the weighted average deviation of the ratios of computed traffic to true traffic is approximately equal for schedule I and II, and schedule III is generally closer than either of the others. How-

TABLE 7

AUTOMATIC TRAFFIC RECORDER AVERAGES FOR YEAR 1939

State Routes—Heavy traffic

State	Station	Average daily traffic				Ratio to actual average		
		Schedule			Actual average for year			
		I	II	III		I	II	III
Massachusetts	1	2,926	3,413	3,066	2,959	98 9	115 3	103 6
Pennsylvania	22	6,635	7,462	7,062	7,069	93 9	105 6	99 9
Connecticut	2[1]	3,811	4,127	3,755	3,915	97 3	105 4	95 9
Connecticut	17[2]	7,993	8,974	8,444	8,112	98 5	110 6	104 1
Florida	10	3,500	4,356	3,576	3,462	101 1	125 8	103 3
Florida	13	1,748	1,934	1,924	1,805	96 8	107 1	106 6
Michigan	676	3,241	3,926	3,430	3,460	93 7	113 5	99 1
Louisiana	14	2,999	2,977	2,974	3,046	98 5	97 7	97 6
Missouri	9	5,131	5,372	5,278	5,266	97 4	102 0	100 2
Texas	1	8,774	9,130	9,323	9,102	96 4	100 3	102 4
Colorado	11[3]	5,480	5,507	6,010	5,578	98 2	98 7	107 7
Washington	10	3,270	3,521	3,418	3,427	95 4	102 7	99 7
Oregon	2	1,012	990	989	985	102 7	100 5	100 4
California	1	6,091	6,185	6,452	6,316	96 4	97 9	102 2
California	10	4,105	4,464	4,383	4,159	98 7	107 3	105 4
Alabama	5	5,300	5,390	5,755	5,381	98 5	100 2	107 0
Alabama	7	1,488	1,592	1,547	1,612	92 3	98 8	96 0
Arizona	1	7,115	7,528	7,592	7,210	98 7	104 4	105 3
Arizona	3[6]	1,873	1,967	2,003	1,889	99 2	104 1	106 0
Arkansas	13[4]	2,191	2,118	2,186	2,169	101 0	97 6	100 8
Arkansas	14[4]	2,480	2,540	2,382	2,542	97 6	99 9	93 7
California	6[5]	2,892	2,652	2,442	2,637	109 7	100 6	92 6
California	2[5]	2,526	2,464	2,465	2,521	100 2	97 7	97 8
California	9[8]	4,015	4,073	3,805	4,141	97 0	98.4	91 9
Connecticut	12[6]	4,883	5,218	4,809	5,085	96 0	102 6	94 6
Connecticut	15[7]	9,015	9,363	9,696	9,367	96 2	99 9	103 5
Georgia	1	3,249	3,166	3,155	3,238	100 3	97 8	97 4
Georgia	3	4,347	4,430	4,260	4,363	99 6	101 5	97 6
Idaho	2	2,677	2,742	2,820	2,724	98 3	100 7	103 5
Idaho	3	2,436	2,438	2,430	2,468	98 7	98 8	98 5
Illinois	9	4,314	4,586	4,273	4,465	96 6	102 7	95 7
Indiana	59A	3,179	3,664	3,295	3,407	93 3	107 5	96 7
Iowa	601[9]	3,219	3,774	3,437	3,444	93 5	109 6	99 8
Weighted avg.						97 5	103 4	100 8

[1] February 18, 1939–February 17, 1940.
[2] February 25, 1939–February 24, 1940
[3] December 17, 1938–December 16, 1939.
[4] January 29, 1939–January 28, 1940
[5] 1938
[6] March 10, 1939–March 9, 1940
[7] February 18, 1939–February 17, 1940.
[8] February 5, 1937–February 4, 1938
[9] April 16, 1938–April 15, 1939

TABLE 8

AUTOMATIC TRAFFIC RECORDER AVERAGES FOR YEAR 1939

State Routes—Light traffic

State	Station	Average daily traffic				Ratio to actual average		
		Schedule			Actual average for year			
		I	II	III		I	II	III
Arizona	5	201	206	193	206	97 6	100 0	93 7
Arkansas	7	194	209	207	198	98 0	105 6	104 5
Georgia	11	280	295	299	292	95 9	101 0	102 4
Iowa	607	435	455	448	434	100 2	104 8	103 2
Louisiana	13[1]	151	149	153	150	100 7	99 3	102 0
Minnesota	171[2]	263	268	271	275	95 6	97 5	98 5
Minnesota	174[3]	283	293	332	298	95 0	98 3	111 4
Missouri	7	595	652	611	608	97 9	107 2	100 5
Montana	A-7	462	474	421	474	97 5	100 0	88 8
Nebraska	A-3	208	207	220	213	97 7	97 2	103 3
Nevada	114	263	226	224	228	115 4	99 1	98 2
New Hampshire	3	538	565	437	513	104 9	110 1	85 2
Oklahoma	8	1,091	1,087	1,110	1,111	98 2	97 8	99 9
Pennsylvania	7[4]	302	364	344	358	84 4	101 7	96 1
Rhode Island	3	325	337	307	326	99 7	103 4	94 2
South Carolina	104	676	687	694	665	101 7	103 3	104 4
Texas	8	863	821	877	848	101 8	96 8	103 4
Texas	9	538	532	504	526	102 3	101 1	95 8
Utah	305	724	783	765	766	94 5	102 2	99 9
Washington	9	230	226	241	222	103 6	101 8	108 6
West Virginia	8[5]	540	556	502	551	98 0	100 9	91 1
Alabama	6	614	671	701	667	92 1	100 6	105 0
California	4	772	808	736	829	93 1	97 5	88.8
Connecticut	4[6]	716	752	630	757	94 6	99 3	83 2
Florida	11	393	375	350	381	103 1	98 4	91 9
Kansas	7	898	883	952	909	98 8	97 1	104 7
Kentucky	4[7]	301	310	289	295	102 0	105 0	98 0
Maine	4	400	414	367	407	98 3	101 7	90 2
Maryland	3	386	421	401	376	102 7	112 0	106 6
Michigan	672	972	1,007	872	969	100 3	103 9	90 0
Pennsylvania	5	498	531	577	543	91 7	97 8	106 3
South Dakota	106	452	468	469	479	94 4	97 7	97 9
Wisconsin	16	892	934	993	998	89 4	93 6	99 5
Weighted avg						97 5	100 5	97 8

[1] October 29, 1938–October 28, 1939.
[2] August 6, 1938–August 5, 1939
[3] August 20, 1938–August 19, 1939.
[4] October 1, 1938–Sept 30, 1939.
[5] March 18, 1939–March 17, 1940
[6] February 18, 1939–February 17, 1940.
[7] Year 1938

TABLE 9

AUTOMATIC TRAFFIC RECORDER AVERAGES FOR YEAR 1939

Local Routes

State	Station	Average daily traffic				Ratio to actual average		
		Schedule			Actual average for year	I	II	III
		I	II	III				
Arkansas	10	250	266	268	259[5]	96 5	102 7	103 5
Georgia	2	113	131	107	113	100 0	115 9	94 7
Iowa	609	96	93	107	96	100 0	96 9	111 5
Iowa	611	58	66	78	64	90 6	103 1	121 9
Kentucky	4	308	287	289	300	102 7	95 7	96 3
Maryland	8	341	344	363	349	97 7	98 6	104 0
Minnesota	169[1]	130	134	122	136	95 6	98 5	89 7
Minnesota	178[2]	116	116	122	120	96 7	96 7	101 7
Montana	A-2	134	145	140	139	96 4	104 3	100 7
North Carolina	5[4]	141	140	149	142	99 3	98 6	104 9
Ohio	5	155	176	160	172	90 1	102 3	93 0
South Dakota	105A	242	241	250	232	104 3	103 9	107 8
Texas	22[3]	89	92	105	94	94 7	97 9	111 7
Wisconsin	19	186	185	196	195	95 4	94 9	100 5
Alabama	1[8]	374	454	402	380	98 4	119 5	105 8
Massachusetts	3[9]	209	225	175	213	98 1	105 6	82 2
Massachusetts	9	356	399	315	356	100 0	112 0	88 5
Michigan	683	335	325	311	330	101 5	98 5	94 2
Minnesota	177	547	533	526	567	97 5	94 0	92 8
Minnesota. ..	183[7]	192	188	207	184	104 4	102 1	112 5
Minnesota	184[6]	229	202	203	199	115 1	101 5	102 0
Missouri .	3	391	405	406	379	103 2	106 9	107 1
Missouri	4	440	491	431	470	93 6	104 4	91 7
North Carolina	6[11]	213	231	182	213	100 0	108 5	85 4
North Carolina	8[10]	154	164	140	165	93 3	99 4	84 8
Ohio	3[12]	241	257	242	261	92 3	98 5	92 7
Ohio .	10	468	458	452	457	102 4	100 2	98 9
Oklahoma	10	562	558	549	558	100 7	100 0	98 4
Rhode Island	1	381	398	375	389	97 9	102 3	96 4
Texas	20	356	369	380	374	95 2	98 7	101 6
Utah	304	561	591	627	593	94 6	99 7	105 7
Utah	307	1,500	1,660	1,585	1,593	94 2	104 2	99 5
Wisconsin	20	258	303	291	274	94 2	110 6	106 2
Weighted avg						97 7	102 5	98 9

[1] Aug 6, 1938–Aug. 5, 1939
[2] Aug 20, 1938–Aug 19, 1939.
[3] Nov 19, 1938–Nov 18, 1939
[4] Aug. 20, 1938–Aug 19, 1939
[5] Estimated
[6] Mar 26, 1938–May 19, 1939
[7] Jan 29, 1938–Jan 28, 1939
[8] Apr. 30, 1939–Apr 29, 1940
[9] Jan 15, 1939–Jan 14, 1940.
[10] Feb. 13, 1938–Feb. 12, 1939.
[11] Sept 11, 1938–Sept. 10, 1939.
[12] 1938.

ever, it may be remarked that the average differences are small under any of the three schedules.

A better comparison of the results may be made by arranging the number of stations under each schedule according to the percentage deviation of the computed traffic from the true traffic volumes, as indicated in Table 10.

Traffic at 73 of the 99 stations may be estimated under schedule I within 5 percent of the true values, as compared with 74 stations and 54 stations for schedules II and III, respectively. While 14 stations give results within 1 percent of true values under schedule III, as compared with 14 under schedule I, and 18 under schedule II, results at 45 stations are more than 5 percent inaccurate under schedule III as compared with but 26 such stations under schedule I, and 25 under schedule II.

TABLE 10

NUMBER OF STATIONS AT WHICH COMPUTED TRAFFIC DIFFERS FROM TRUE TRAFFIC, UNDER THREE ASSUMED SCHEDULES, DEVIATIONS BY PERCENTAGE GROUPS

Percent deviation of computed daily traffic from true daily traffic	Number of stations		
	Schedule I	Schedule II	Schedule III
0.0– 0.9	14	18	14
1.0– 4.9	59	56	40
5.0–15.0	23	22	41
Over 15.0	3	3	4
Total	99	99	99

CONSIDERATIONS IN FINAL SELECTION

From these tests, at a limited number of stations well distributed geographically and with respect to traffic volumes, it would appear that schedule III produces results with a considerably wider range of deviation from true values than schedules I or II.

Accuracy is one, and perhaps the most important, of the considerations involved in selecting a schedule of operation. Cost of operation, completeness of resulting data and practical time and distance factors involved in putting the schedule into field operation are frequently of equal importance.

In the state-wide highway planning surveys, traffic volume is but one of the many items to be investigated. At loadometer and pit-scale stations, weight of vehicle, weight of load, length, height and width of vehicle, origin and destination of vehicle trips, are a few of the many additional items with respect to which information is needed. Classification of vehicles by types is also necessary.

At loadometer and pit-scale stations, flags, flares and protection signs must be placed, since vehicles must be stopped for weighing and questioning. This preparation of a station for safe operation takes a considerable amount of time. This time requirement, together with the time needed to transport a party trained to secure this type of information from one station to another, makes practically impossible the use of a schedule based upon short periods of observation.

Use of a short period of observation reduces the amount of effective time (i.e., time that stations were actually in operation) to the total time of employment of the field parties, and greatly increases travel costs. Both these factors operate to increase very greatly the unit cost of an item of information, and thus the cost of the whole survey.

One advantage of either schedule I or II, as compared with schedule III, is that both provide much greater information with respect to normal maximum traffic volume. The maximum values recorded under either of the former schedules are during periods of from 8 to 24 hours. Maximum values are ordinarily too irregular in their occurrence to permit an accurate measure of them by means of a single hour of observation.

Still another consideration in the decision with respect to the most valuable schedule for field operation, is the probable accuracy of the estimate of the proportions of the various types of vehicles —foreign vehicles, heavy trucks, busses, etc.—in the results secured as a result of various schedules. This question is difficult to investigate, partly because of the scarcity of data. To be sure, the automatic traffic recorder has now given us a considerable sample in which we know the total number of vehicles during every hour of the year However, it is clear that the number of foreign vehicles, for example, in proportion to total vehicles changes greatly throughout the year.

In summer, foreign vehicles form 50 percent of the total traffic in some states. In the same areas the winter proportion is not over 15 percent In another state, foreign vehicles are 14 percent of the total in December and 24 percent in August The distinction between vehicle types cannot be made by the automatic traffic recorder, and the volume of data with detailed classification carried throughout every day of a full year is available for but a small number of locations.

A limited amount of investigation of this problem[6] at a few stations considered to be typical of traffic found on most rural highways is summarized in Table 11.

Other combinations, similar to those enumerated in Table 11, were examined and data for other stations were analyzed in the same manner. Tentative conclusions resulting from this analysis are stated as follows. "The standard key station schedule appears to give good results, but it is relatively a costly operation."[7]

The foregoing discussion includes an examination of the principal types of schedules that are, or have been, used in extensive traffic surveys on rural roads. Other schedules have been used in this

TABLE 11

Station No 652	Passenger cars		Trucks and combinations	Busses	Total
	Local	Foreign			
True Composition	78 2	7 1	14 5	0 2	100 0
Average of 8 runs (16-hour)[1]	69 2	12 2	18 3	0 3	100 0
Average of 8 runs (24-hour)[1]	69 2	11 9	18 7	0 2	100 0
24-hour Weekday, Saturday and Sunday[2]	69 8	12 2	17 8	0 2	100 0
24-hour Weekday, Saturday and Sunday[3]	84 6	3 2	11 9	0 3	100 0
24-hour Weekday, Saturday and Sunday[4]	76 6	8 0	15 2	0 2	100 0
16-hour Weekday, Saturday and Sunday[4]	76 2	8 4	15 2	0.2	100 0
8-hour Weekday, Saturday and Sunday[4]	73 2	9 7	16 7	0 4	100 0
Key station schedule (average of 5 runs)	78 0	6 8	15 0	0 2	100 0
Average of 2 runs[5]	77 7	8 3	13 7	0 3	100 0

[1] In months of probable maximum and probable minimum traffic.
[2] February and August
[3] May and November
[4] February, May, August and November
[5] 4-hour Weekday, Saturday and Sunday counts each season—staggered 8 a m -12 m and 4 p m.-8 p m

[6] Unpublished data from Mr H E. Cunningham, Public Roads Administration
[7] Ibid

work, but nearly all of them represent but minor modifications in the above general types.

Within cities, use has been made of a method of "extremely short counts" which was "given practical application in a survey conducted in the city of Amarillo, Texas, by members of the Engineering and Police Departments in cooperation with the Texas Highway Department."[8]

Theoretically, under proper traffic conditions, a count of one minute during each half hour or hour might be sufficient for the estimate of total traffic, but the chief obstacle to this proposal "was the loss of time involved by traveling between intersections." Finally, a five-minute observation period was selected.

The time lost between stations was overcome by placing recorders on the tops of the taller buildings in Amarillo. From certain of these buildings as many as 32 intersections could be observed without loss of time between stations. This procedure permits a recorder to observe as many as six intersections within a half-hour period, counting each intersection for a five-minute period.

Continuing a description of the method, "in estimating the hourly flow of traffic, the two five-minute counts taken within a one-hour period were added together and multiplied by six. This method of short counts in towns and cities was determined to be as accurate as making full 8-hour counts and converting them into 24-hour figures. In checking the accuracy against the full count, the error averaged approximately 3 percent.... Intersections carrying more than 4,000 vehicles in a 12-hour period were within 3 percent accuracy."

Study of reports and tests now available indicates that (1) the "key station" schedule, or a schedule of the same general type, produces a larger proportion of results within practical limits of accuracy; (2) that the 40-hour schedule previously described produces results with a considerably wider range of deviation from true values at more stations than either the "blanket count control" or the key station schedule; (3) the blanket count schedule also produces acceptable results but must be used in conjunction with other schedules or data from other sources in order to produce the "factors" necessary to bring 8-hour or 16-hour counts to a 24-hour basis; (4) collection of information such as that obtained at loadometer and pit-scale stations is a difficult matter from the standpoint of travel time and practical scheduling of field parties, and is uneconomic when based upon a "short count" schedule; (5) the short count schedule produces insufficient information with respect to maximum traffic periods; (6) the key station schedule produces accurate results in the classification of traffic by vehicle types; (7) the short count schedule by five-minute periods produces results within the limits of practical accuracy and is useful in city traffic surveys, where the time loss and cost of travel are reduced by stationing observers on tall buildings and where several stations may be observed from a single location.

[8] R O Swain, *The American City*, July 1940.

OTHER CONSIDERATIONS IN SCHEDULE SELECTION

Further analysis with respect to certain of these conclusions will be greatly facilitated by the accumulation of automatic traffic recorder data. Certain data are now available from vehicle classification counts taken throughout 1939 at 352 automatic traffic recorder stations located in 39 states. These data are of assistance in forming conclusions with respect to schedule selection.

The total traffic was separated by type of vehicle by means of classification counts taken at intervals throughout the year at the recorder sites. The number of 1939 classification counts in some states is small and, in some instances, it was necessary to supplement them by classification data secured in years other than 1939 However, the proportions of the various types of vehicles change slowly from year to year, and the inaccuracy in the number of vehicles by type is slight.

Of these stations 294 were located upon the State highway systems, and 58 were located upon local roads. Examination of the data discloses significant differences between the characteristics of traffic on these two highway systems A comparison of the results of the automatic traffic recorder operation with gasoline consumption indicates that the recorders furnish a measure of traffic representative of the country as a whole and, in states which are operating a large number of recorders, representative of traffic changes in such individual States.

In Connecticut and Oregon, the classification of vehicles was not so detailed as that reported by all the other states, so that the discussion which follows applies only to the results of operations at 334 stations in 37 states.

The proportion of foreign traffic using state highways varies widely among the states, and is affected by two major influences: (1) The geographical position and size of the state; (2) the amount of recreational traffic as compared with the amount of local traffic. It is probable that in few states are the automatic traffic recorders sufficient in number so that, if manual operations were made at each location, good averages of the amount of foreign travel would be obtained, yet in Florida, which attracts large numbers of tourists, foreign travel, measured at 10 traffic recorders, is nearly 40 percent of the total Nevada attracts a small amount of tourist travel, but, because of its geographic location adjacent to the Pacific Coast States, foreign travel measured at 11 recorders is also nearly 40 percent of the total Near the other extreme is Texas, with foreign travel of slightly more than 10 percent, measured at 18 traffic recorders. Texas attracts a relatively small amount of tourist travel and is not much used as a "bridge" by foreign vehicles traveling to other states.

For all states, the percentage of foreign vehicles measured at automatic traffic recorders is 21.08 on state highways, and 1.72 on local routes, a ratio of more than 12 to 1. This may be compared with results of a traffic survey in Indiana, showing 17.5 percent foreign use of state highways and 3.4 percent foreign use of county roads.

Bus traffic is less than 1 percent (0.88 percent) of travel upon state highways and is negligible in amount upon local routes although, because of the low volume of travel upon local routes, it amounts to 1.72 percent of the total. Busses are predominently local vehicles, i.e., ordinarily they carry registration plates of the state in which the recorder is located. Fourteen out of 15 busses traveling state highways carry tags of the state in which the highways are located and bus travel on local routes is entirely by local vehicles.

Heavy trucks (those with rated capacities of 5 tons, or more) use the highways with but slightly greater frequency than busses They are 1.01 percent of all vehicles measured at automatic traffic recorder stations, and nearly all of these are found on State highways Eleven percent of heavy trucks are foreign vehicles as against 7 percent of the busses.

While the foregoing statement about the number of heavy trucks is true with regard to totals, an inspection of the detailed data discloses concentrations of heavy trucks much greater than those of busses. At several of the recorders located in California, Connecticut, Massachusetts, and Pennsylvania, heavy trucks averaged upwards of 100 per day during 1939 and reached 667 per day at stations 8 and 19 in Connecticut. At the single station available in Illinois, heavy trucks averaged 270 per day, while bus traffic at this station was but 13 per day. The significance of such concentrations of heavy trucks is clear to the builder of highways and bridges.

A study of individual stations indicates a slight tendency toward increase in the proportion of heavy trucks with increase in volume of total traffic; i.e., the percentage (as well as the number) of heavy trucks tends to increase with an increase in the total number of vehicles using a route In contrast, the percentage of foreign vehicles decreases generally with an increase in the total number of vehicles, although this tendency is not sharply marked.

TABLE 12

SEASONAL VARIATION IN TOTAL MOTOR VEHICLE TRAFFIC ON STATE HIGHWAYS AND LOCAL ROADS

Month	Average daily traffic		Percent of average month	
	State highways	Local routes	State highways	Local routes
January	1,608	276	75 68	80 00
February	1,607	245	75 63	71 01
March	1,838	278	86 50	80 58
April	2,018	311	94 98	90 14
May	2,165	335	101 89	97 10
June	2,306	358	108 53	103 77
July	2,594	394	122 09	114 20
August	2,633	396	123 93	114 79
September	2,384	403	112 20	116 82
October	2,233	390	105 09	113 04
November	2,104	384	99 02	111 30
December	2,007	370	94 46	107.25

During the past year monthly reports of the operation of traffic recorders have been made to the highway planning survey organizations by the Public Roads Administration. It is now possible to measure the seasonal variation in traffic volume during 1939 from state and local routes, as indicated in Table 12.

Seasonal variation is similar on the two classes of routes, although the travel peak is earlier and higher on the state routes. The seasonal peak on state highways is in August, travel in that month exceeding that of the average month by nearly 25 percent. Travel on local routes is greatest in September and is about 17 percent greater than in the average month. The point may be more inclusively stated by noting that travel during the last four months of the year is 34.2 percent of the total on State routes and 37 4 percent of the total on local routes.

THE USE OF FACTORS IN ESTIMATING ANNUAL TRAFFIC

The automatic traffic recorder data have been of invaluable assistance in the solution of another problem—that of estimating annual traffic volume when the period that traffic was observed covered but a few hours. There are hundreds of thousands of miles of public highways upon which traffic volume is below 25 vehicles per day, and only a limited expenditure for traffic information is justified upon such routes. Many intermediate points between key stations upon routes of considerable traffic importance, need be observed only during short periods of time to produce acceptable data with regard to variation of traffic between points at which more complete observations have been made At such points a "factor" derived from known traffic patterns (frequently from the continuous data collected at automatic recorders) is necessary in estimating annual traffic.

These factors must be based upon traffic patterns that are typical and reasonably invariant over a period of time That is, they must be typical, or representative, in order that they will apply to many stations. They must be reasonably invariant because, if sharp changes occur in seasonal patterns (or other patterns needed), the factors derived for use in one year do not produce close estimates of annual traffic when applied to traffic data for short periods of time in later years The term "reasonably invariant" is used because experience indicates that absolute invariance in patterns is not to be expected.

TABLE 13

SEASONAL VARIATIONS IN TRAFFIC ON VIRGINIA STATE HIGHWAYS

Monthly variation in percentage of average monthly traffic

Month	1926		1927		1928		1929		1930		1931	
	Urban	Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban	Rural
January	73	73	73	73	73	73	73	73	72	72	72	72
February	71	72	70	72	71	72	71	72	71	72	71	72
March	73	98	73	98	74	98	73	98	73	98	74	98
April	95	101	95	101	95	101	95	101	95	101	95	101
May	104	101	104	101	103	100	103	100	104	101	104	101
June	106	98	106	98	106	98	105	98	105	98	105	98
July	112	99	112	99	112	99	112	99	112	99	112	99
August	123	134	124	134	123	134	124	134	124	134	123	134
September	115	117	115	117	114	117	115	117	115	117	114	117
October	112	102	112	102	112	102	112	102	112	102	112	102
November	111	100	111	100	111	102	111	102	111	102	111	102
December	105	101	105	101	106	102	106	101	106	101	106	101

Sections of highways within a ten-mile radius of cities are designated as urban, others as rural, by Virginia Highway Commission.

One measure of the invariance in seasonal traffic variation is presented in Table 13 showing seasonal variation of urban and rural traffic for each year from 1926 to 1931, inclusive, in the State of Virginia These figures are taken from the graphs which form a part of the annual traffic flow maps prepared by the Virginia Highway Commission Traffic data are available for the whole State highway system and are shown in the maps A glance at the table indicates the remarkable lack of substantial change in the seasonal indices for both urban and rural traffic during these six years.

Other comparisons are shown in the series of charts (Figures 16, 17, 18, 19, and 20) for Arkansas, Connecticut, Florida, Ohio, and Pennsylvania. In each of these comparison has been made between the seasonal characteristics derived from former traffic surveys, and the seasonal characteristics of traffic at the automatic traffic recorder stations in each State operated during the year 1939. In each case the data are related to the average monthly traffic volume as 100 percent

Of course the number of traffic recorders operated in 1939 is much smaller than the number of stations from which the original seasonal indices were obtained. In the comparisons, data from states with the largest number of traffic recorders and an early traffic survey, were used. Connecticut and Pennsylvania, each operated 22 traffic recorders during

1939; and in no state was the number of recorders less than 10

The Arkansas comparison (Fig. 16) indicates the very slight change in seasonal variation from 1934–1935 to 1939. Again in Connecticut (Fig. 17) and over the same period of time, the changes in seasonal variation are small. In Florida, the indices are also fairly close. The sharp drop in the index from January 1933 to February 1933 in Florida undoubtedly reflects the large number of persons who left Florida just before the Nation-wide "bank panic" of February 1933. That this drop was not even greater is due to the fact that local traffic, which makes up the bulk of total traffic even in a "tourist" state such as Florida, was not so greatly affected by the unusual social conditions existing during that period of financial strain.

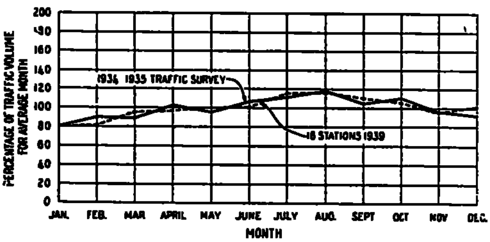

Figure 16. Changes in seasonal variation of traffic flow in Arkansas

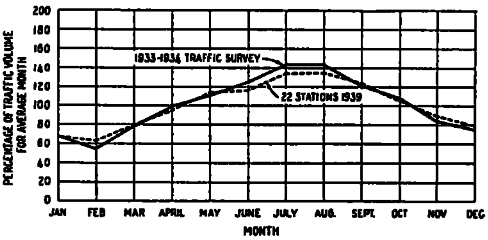

Figure 17. Changes in seasonal variation of traffic flow in Connecticut

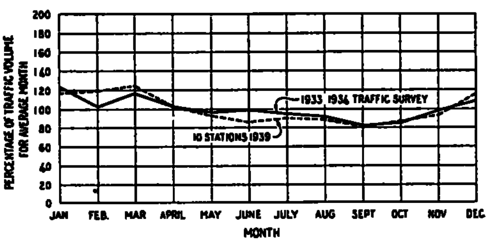

Figure 18. Changes in seasonal variation of traffic flow in Florida

In Ohio, the comparison of seasonal variation is between the years of 1925 and 1939. Here the agreement is not so close as in the other examples cited above And finally, in Pennsylvania, the comparison is for 1923–1924 with 1939 and there is still less close agreement between the indices than in Ohio. These two states indicate that traffic volume has tended to be more evenly distributed throughout the year in the latter part of the last 15 to 17 years This large decrease in the amplitude of the seasonal variation since 1923 reflects the much larger winter use of the motor vehicle in 1939. Better roads and much more complete snow removal have been two of the reasons for this greater winter use; though the great increase in the dependability of operation of the motor vehicle

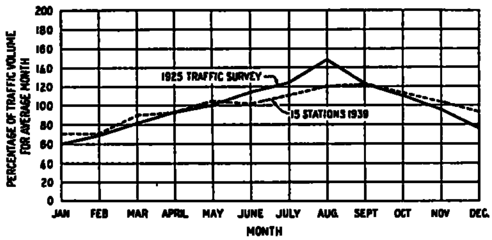

Figure 19. Changes in seasonal variation of traffic flow in Ohio

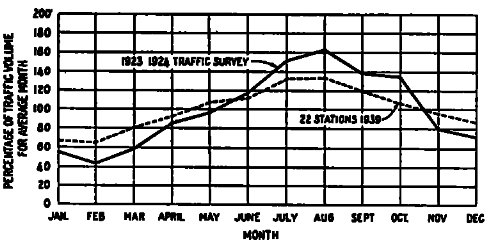

Figure 20. Changes in seasonal variation of traffic flow in Pennsylvania

should not be overlooked in this connection.

Taking the Pennsylvania graphs, we find that the change from minimum to maximum values of the seasonal index in 1923–1924 was from about 40 to 160, i.e., a range of four times. Corresponding values in 1939 are from a minimum of 65 to a maximum of 133, i e., a range of two times

Thus, while there has been considerable change in seasonal indices over the longer period, with the increased reliability of operation of motor vehicles, better roads and snow removal over the whole highway system, during the latter part of the period under discussion, the apparent change in seasonal variation has been small indeed.

It may also be noted that this relative invariance in seasonal change during the latter part of the above period is more or less independent of the particular type of seasonal variation under consideration For example, Florida's seasonal traffic indices differ widely from those of Arkansas and even more widely from those of Connecticut. The minimum traffic in Florida falls in September; whereas in Arkansas, it is in January; and in Connecticut, it is in February. Nevertheless the *change* in seasonal variation is nearly as small for all three states during the period from 1934–1935 to 1939.

There are other patterns of traffic which are "reasonably invariant" in the sense that term has previously been used Examination of Tables 14, 15, and 16 with data from automatic recorders on State routes, divided between heavy and light traffic stations, and on local routes, together with the computed ratios of several hour period totals to total daily traffic discloses interesting and significant facts. For example, the percentage of the day's traffic traveling between 7 a m. and 7 p m. is 71.9 for all routes and by classified routes is

15 state routes—heavy traffic	71 0
21 state routes—light traffic	75.8
14 local routes	78 1

Mr. R. O. Swain, in the article from *The American City* previously quoted, states, "That hourly traffic flow also cuts certain patterns is another Cherniack theory which may be applied to Texas traffic. Of value in this connection is the movement of motor-vehicle traffic between 7 a.m. and 7 p.m. Between these 'daylight' hours, Cherniack figures show that approximately 70 percent of the traffic moves in both rural and urban areas On Texas highways, according to data taken from the highway planning survey's 20 automatic traffic recorders, this 'daylight' percentage is 73.23."

Thus the data shown in these tables are close to results obtained elsewhere. It is also significant that the proportion of traffic moving during "daylight is greater on the local routes (78.1 percent) as compared with the proportion on heavily traveled State routes (71.0 percent).

Still another way of examining this question is to compare the "night" traffic (10 p.m. to 6 a.m) on the various classes of routes The average is 12.7 percent of the full day's travel during night hours for all routes, and by classified routes is:

State routes—heavy traffic	13 5
State routes—light traffic	9 3
Local routes	7 3

Travelers on local routes are found proportionately about half as often during the night hours as upon the heavily traveled state routes.

Incidentally, the ratios of the total daily traffic shown in the above tabulations indicate that the 8 a.m. to 4 p.m. period is the best, from the standpoint of stability in results, for "blanket counts" on light traffic routes, whether these routes be on the state highway sys-

TABLE 14

TRAFFIC BY HOURLY PERIODS AT AUTOMATIC RECORDER STATIONS—STATE ROUTES, HEAVY TRAFFIC, 1939

State	Station No	Route	Total yearly volume	Volume by time of day					Ratio to total volume				
				6 a m to 2 p m	2 p m to 10 p m	10 p m to 6 a m	8 a m to 4 p m	7 a m to 7 p m.	6 a m to 2 p m	2 p m to 10 p m	10 p m to 6 a m	8 a m to 4 p m.	7 a m to 7 p m
Mass	1	Mass 8	1,045,290	357,007	558,993	129,290	438,746	720,648	34 2	53 5	12 3	42 0	68 9
Mass	8	US 1	2,110,370	801,639	1,040,069	268,662	966,815	1,490,998	38 0	49 3	12 7	45 8	70 7
Conn	2[1]	US 1	1,365,076	475,784	624,939	264,353	590,833	901,065	34 8	45 8	19 4	43 3	66 0
Conn	17[2]	US 5	2,949,154	1,014,094	1,396,555	538,505	1,194,075	1,913,666	34 4	47 3	18 3	40 5	64 9
Fla	10	US 1	1,260,823	548,867	576,310	135,646	657,113	961,999	43 5	45 7	10 8	52 1	76 3
Fla	13	US 41	658,659	274,331	316,150	68,178	313,335	493,356	41 6	48 0	10 4	47 6	74 9
Mich	676	US 27	1,265,045	490,464	623,114	151,467	596,616	912,106	38 8	49 2	12 0	47 2	72 1
La	14	US 90	1,109,565	463,276	516,364	129,925	543,593	830,583	41 8	46 5	11 7	49 0	74 9
Mo	9	US 66	1,879,116	704,713	930,552	243,851	827,618	1,305,289	37 5	49 5	13 0	44 0	69 5
Tex	10	US 80	510,302	228,814	237,471	44,017	262,527	401,863	44 9	46 5	8 6	51 4	78 7
Colo	11[3]	US 85	1,944,663	809,980	924,853	209,830	945,578	1,452,261	41 6	47 6	10 8	48 6	74 7
Wash	10	US 10	1,200,884	495,714	585,353	119,817	578,385	892,854	41 3	48 7	10 0	48 2	74 3
Oreg	2	US 99	337,721	148,001	150,424	39,296	183,120	256,884	43 8	44 6	11 6	54 2	76 1
Calif	5	US 101	289,015	119,347	142,217	27,451	153,775	225,398	41 3	49 2	9 5	53 2	78 0
Calif	10	US 60 & 99	1,399,962	538,271	619,621	242,070	657,227	960,344	38 4	44 3	17 3	46 9	68 6
Total			19,325,645	7,470,302	9,242,985	2,612,358	8,909,356	13,719,314	38 7	47 8	13 5	46 1	71 0

[1] February 18, 1938-February 17, 1939
[2] February 25, 1939-February 24, 1940
[3] December 17, 1938-December 16, 1939

TABLE 15

TRAFFIC BY HOURLY PERIODS AT AUTOMATIC RECORDER STATIONS—STATE ROUTES, LIGHT TRAFFIC, 1939

State	Station No	Route	Total yearly volume	Volume by time of day					Ratio to total volume				
				6 a m to 2 p.m	2 p m to 10 p m	10 p m to 6 a m	8 a m to 4 p m	7 a m to 7 p m	6 a m to 2 p m	2 p m to 10 p m	10 p m to 6 a m	8 a m to 4 p m	7 a m to 7 p m.
Ariz	5	Ariz 69	72,311	31,060	35,688	5,563	38,860	58,239	43 0	49 3	7 7	53 7	80 5
Ark	7	SR 50	63,629	30,821	28,739	4,069	34,725	51,509	48 4	45 2	6 4	54 6	81 0
Ga	11	Ga 93	100,559	42,729	50,124	7,706	52,483	77,861	42 5	48 9	7 7	52 2	77 4
Iowa	607	US 18	154,537	65,870	74,135	14,532	81,364	118,994	42 6	48 0	9 4	52 7	77 0
La	13[1]	SR 21	54,938	29,262	22,097	3,579	31,850	46,445	53 3	40 2	6 5	58 0	84 5
Minn	171[2]	TH 32	91,365	36,512	44,943	9,910	46,443	66,759	40 0	49 2	10 8	50 8	73 1
Minn	174[3]	TH 104	107,561	52,349	49,145	6,067	60,716	85,521	48 7	45 7	5 6	56 4	79 5
Mo	7	US 60	212,287	91,694	103,239	17,354	109,796	165,286	43 2	48 6	8 2	51 7	77 9
Mont	A-7	US 91	173,345	65,897	89,974	17,474	85,732	128,910	38 0	51 9	10 1	49 5	74 4
Nebr	A-3	US 95	77,735	32,381	38,198	7,156	39,365	59,004	41 7	49 1	9 2	50 6	75 9
Nev.	114	US 95	83,728	35,063	41,519	7,146	43,385	65,096	41 9	49 6	8 5	51 8	77 7
N H	3	N H 104	178,359	78,442	88,170	11,747	98,509	141,225	44 0	49 4	6 6	55 2	79 2
Okla	8	US 62	292,276	118,045	143,160	31,071	143,739	217,263	40 4	49 0	10 6	49 2	74 3
Pa	7[4]	Pa 252	130,672	50,721	68,134	11,817	58,975	93,890	38 8	52 1	9 1	45 1	71 9
R I	3	Foster Center	118,034	42,640	63,706	11,688	54,334	84,617	36 1	54 0	9 9	46 0	71 7
S C	104	US 178	244,745	101,309	114,861	28,575	120,267	179,797	41 4	46 9	11 7	49 1	73 5
Tex	8	US 81	287,269	113,812	140,050	33,407	136,034	206,308	39 6	48 8	11 6	47 4	71 8
Tex	9	US 285	180,932	68,411	95,733	16,788	81,180	132,950	37 8	52 9	9 3	44 9	73 5
Utah	305	US 89	258,738	111,994	122,549	24,195	133,345	199,005	43 3	47 4	9 3	51 5	76 9
Wash	9	SH 11F	71,984	30,552	35,312	6,120	38,070	56,209	42 4	49 1	8 5	52 9	78 1
W. Va	8[5]	US 219	157,409	69,344	76,527	11,538	85,479	125,615	44 1	48 6	7 3	54 3	79 8
Total			3,112,413	1,298,908	1,526,003	287,502	1,574,651	2,360,503	41 7	49 0	9 3	50 6	75 8

[1] Oct 29, 1938-Oct 28, 1939
[2] Aug 6, 1938-Aug 5, 1939
[3] Aug 20, 1938-Aug 19, 1939
[4] Oct 1, 1938-Sept 30, 1939
[5] Mar 18, 1939-Mar 17, 1940.

TABLE 16

TRAFFIC BY HOURLY PERIODS AT AUTOMATIC RECORDER STATIONS—LOCAL ROUTES, 1939

State	Station No	Route	Total yearly volume	Volume by time of day					Ratio to total volume				
				6 a m to 2 p m	2 p m to 10 p m	10 p m to 6 a m	8 a m to 4 p m	7 a m to 7 p m	6 a m to 2 p m	2 p m to 10 p m	10 p m to 6 a m	8 a m to 4 p m	7 a m to 7 p m
Ark.	10	Co Rd	74,190	36,487	33,926	3,777	40,599	60,699	49 2	45 7	5 1	54 7	81 8
Ga.	2	Co Rd	41,156	18,965	19,958	2,233	21,575	33,702	46 1	48 5	5 4	52 4	81 9
Iowa	609	Co Rd	34,114	15,051	16,377	2,686	18,039	26,314	44 1	48 0	7 9	52 9	77 1
Iowa	611	Co Rd	23,356	11,810	10,218	1,328	14,221	19,586	50 6	43 7	5 7	60 9	83 9
Ky	4	Keene Rd	105,911	48,342	49,544	8,025	52,402	82,129	45 6	46 8	7 6	49 5	77 5
Md	8	Queen Anne Rd	127,563	58,386	58,588	10,589	63,817	95,230	45 8	45 9	8 3	50 0	74 7
Minn	169[1]	SAR 15	49,477	25,646	19,960	3,871	27,970	38,409	51 8	40 4	7 8	56 5	77 6
Minn.	178[2]	SAR 10	43,396	21,171	19,910	2,315	24,388	34,898	48 8	45 9	5 3	56 2	80 4
Mont	A-2	Co Rd	49,019	19,449	25,801	3,769	24,976	37,969	39 7	52 6	7 7	51 0	77 5
N C	5[3]	Co. Rd	51,653	22,429	26,259	2,965	27,054	41,559	43 5	50 8	5 7	52 4	80 5
Ohio	5	Co Rd	47,332	22,701	22,226	2,405	27,681	38,701	48 0	47 0	5 0	58 5	81 8
S D	105A	Co Rd.	86,127	35,792	42,478	7,857	43,298	65,770	41 6	49 3	9 1	50 3	76 4
Tex	22[4]	Co Rd.	29,887	13,218	14,692	1,977	15,530	23,754	44 2	49 2	6 6	52 0	79 5
Wis	19	CTH "A"	66,841	27,836	32,600	6,405	32,843	49,750	41 6	48 8	9 6	49 1	74 4
Total			830,022	377,283	392,537	60,202	434,393	648,470	45 4	47 3	7 3	52 3	78 1
Grand total, Tables 12, 13 and 14			23,268,080	9,146,493	11,161,525	2,960,062	10,918,400	16,728,287	39 3	48 0	12 7	46 9	71 9

[1] August 6, 1938–August 5, 1939.

[2] August 20, 1938–August 19, 1939.

[3] August 20, 1938–August 19, 1939

[4] November 19, 1938–November 18, 1939

tem or are local routes. Eighty-six percent of the local routes vary less than 5 percent from the average during that 8-hour period, as compared with 81 percent of the light traffic routes and 66 percent of the heavy traffic routes on the state highway system.

These "reasonably invariant" ratios provide confidence in the estimates of total yearly traffic volume from traffic samples taken during relatively short periods of observation. The methods of deriving factors, and their application have previously been rather completely discussed in PUBLIC ROADS,[9] and it is unnecessary to repeat this discussion.

TRAFFIC TREND ANALYSIS

The results of the automatic traffic recorder operations permit an analysis of the trends of traffic and, as the record accumulates, will be of increasing value for this purpose. As indicated in Table 1, in 1937 there were 199 recorders in operation. However, not all of these were operated for the full year While the record is now rather short, it may be stated that over this period the percentage increases in traffic at all stations closely approximate the increase in gasoline consumption.

It seems likely that the traffic data might provide a rather good measure of business activity—both in general and for small areas or regions. The fact that both trucks and passenger cars are in the stream of traffic would mean that business, as well as pleasure or recreational traffic are reflected by the data. And since from 80 to 85 percent of all trips outside city limits are of less than 20 miles in length,[10] local characteristics must be well represented in the data. These characteristics are essential in an index of regional business activity and, properly weighted, should combine to provide equally good indices of national business activity.

But the chief value of the trends of traffic is their usefulness in the estimation of future traffic. When it is recalled that many of the elements of the highway have a long life and that some of them, structures such as bridges for example, frequently require large expenditures, the importance of an estimate of future traffic is apparent.

The traffic estimate also provides a basis for estimating future highway income and thus permits the setting up of a rational budget of expenditures for improvements; i.e., a plan of improvement. The more accurate and representative the traffic trend, the more dependable and useful the plan of improvement. The automatic recorders furnish a volume of data covering a wide-spread area, more accurate and more useful in trend analysis than any previously gathered.

[9] Highway Traffic Analysis Methods and Results, PUBLIC ROADS, March 1929.

[10] R H Paddock and R. P Rodgers PUBLIC ROADS, May 1939.