REPORT OF COMMITTEE ON HIGHWAY TRAFFIC ANALYSIS

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PRINCIPAL CONCLUSIONS OF THE COMMITTEE SINCE ITS INCEPTION

The Committee on Highway Traffic Analysis was formed in 1922, and submitted a preliminary report at the meeting of the Highway Research Board that year. The committee has continued its work on the principle that highway improvement should be based upon present and future traffic demands to obtain the maximum result with available funds

The following is a brief summary of the principal conclusions of the committee during the past five years

1. Distinction between a traffic census and a highway transport survey, description of the purpose, organization, methods and costs of conducting such surveys, the use of a highway transport survey in the classification and design of highways. (Committee reports for 1922, 1923, 1924 and 1925)
2. It is useless to consider forecasting the saturation point in the utilization of motor vehicles except in congested urban districts (Committee report for 1924)
3. The acquiring of adequate rights of way for future highway development, and simplification of the method of acquisition to permit immediate occupancy is essential (Committee reports for 1924 and 1926)
4. The study of each road and the elimination of points of congestion may economically defer the need of reconstruction or widening. (Committee reports for 1924 and 1925)
5. In the consideration of traffic needs it is more essential to provide a system of connected highways than to concentrate the expenditures for highway improvement on a limited mileage of high-type surfaces. (Committee report for 1927)
6. A four-lane roadway is recommended when a survey indicates that the traffic capacity of a two-lane two-way roadway will be exceeded (Committee report for 1925)

7. Expected future traffic based on the trend of motor-vehicle registration is reasonably accurate (Committee report for 1925.)
8 The routing of through traffic through congested areas results in an economic loss both to traffic and community, and belt lines around such areas are desirable (Committee reports for 1925 and 1926)
9. The establishment of comprehensive highway improvement programs, including the budget necessary to carry these plans into effect, is essential (Committee reports for 1925 and 1926.)
10 Measurements of the foreign use of highways should be made at some distance from state boundaries to eliminate local interstate movement (Committee report for 1926)
11. Highways should be classified in terms of weight-carrying capacities (Committee report for 1926)
12 A minimum speed law may be economical for Class " A " highways in increased traffic value (Committee report for 1926)
13. Restriction of the weight of vehicles with decreased pavement design is economically justified where heavily loaded vehicles form a negligible percentage of traffic. (Committee report for 1926)

Concerning conclusion 3, the acquiring of adequate rights of way for future highway development, the committee particularly wishes to emphasize the urgent need in congested traffic areas of establishing adequate rights of way, particularly on those sections of routes which will be included in urban areas

The committee believes that the problem of establishing adequate rights of way in suburban areas and on rural highways and the present legal methods of acquisition of rights of way should be made a subject for intensive investigation in order that the most practical and expeditious method of legal procedure necessary in the acquisition of ultimate rights of way may be determined

THE METHOD BEING USED IN THE ANALYSIS OF TIME RATE AND CAPACITY FOR TWO-LANE, THREE-LANE AND FOUR-LANE ROADWAYS

TIME RATE

The time rate of a road is affected by traffic volume and physical obstacles as well as speed limits Within the practical carrying capacity of a road and with favorable traffic conditions the time rate of a road can closely and safely correspond to maximum speed limits

THE MAXIMUM CAPACITY OF A SINGLE TRAFFIC LANE

There is attached a table (Table No 1) of computed maximum

TABLE 1

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF HIGHWAYS

THEORETICAL MAXIMUM CAPACITY OF ONE-TRAFFIC LANE IDEAL CONDITIONS

Speed miles per hour	Seconds interval	Computing factor	Space interval feet	Space interval plus 17 feet	No of vehicles in 1 mile line	Vehicles per hour passing a given point
2	0 80	1 173	*5 00	22 00	240 0	480
4	0 85	1.247	*5 00	22 00	240 0	960
6	0 90	1 320	7 92	24 92	211 9	1271
8	0 95	1 393	11 14	28 14	187 6	1501
10	1 00	1 467	14 67	31 67	166 7	1667
12	1 05	1 540	18 48	35 48	148 8	1785
14	1 10	1 613	22 58	39 58	133 4	1867
16	1 15	1 687	26 99	43 99	120 0	1920
17	1 175	1 723	29 29	46 29	114 0	1938
18	1 20	1 760	31 68	48 68	108 5	1953
19	1 225	1 797	34 14	51 14	103 2	1961
20	1 25	1 833	36 66	53 66	98 4	1968
22	1 30	1 907	41 95	58 95	89 5	1969
24	1 35	1 980	47 52	64 52	91 8	1963
26	1 40	2 053	53 38	70 38	75 0	1950
28	1 45	2 127	59 56	76 56	68 9	1929
30	1 50	2 200	66 00	83 00	63 6	1908
32	1 55	2.273	72 74	89 74	58 8	1881
34	1 60	2 347	79 80	96 80	54 5	1853
36	1 65	2 420	87 12	104 12	50 7	1825
38	1 70	2 493	94 73	111 73	47.2	1793
40	1 75	2 567	102 68	119 68	44 1	1764
42	1 80	2 640	110 88	127 88	41 3	1734
44	1 85	2 713	119 37	136 37	38 7	1703
46	1 90	2 787	128.20	145 20	36 4	1674
48	1 95	2 860	137 28	154 28	34 2	1641
50	2 00	2 933	146 65	163 65	32 3	1615

* Minimum space

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capacity of one traffic lane under ideal conditions The assumption is that the cars are following one another with an interval sufficient to allow, at ten miles an hour, one second for the driver of a following car to conform to the control of the driver ahead, one and one-half seconds at thirty miles an hour, at other speeds a time allowance from a straight line curve determined by the two points indicated. The assumption is, also, that the average length of vehicle is seventeen feet

Under ideal conditions, each driver signals for slowing down and for stopping, no account being taken of the possibility of the sudden stopping of a car ahead If the possibility of a collision is considered, greater intervals are necessary.

Assuming that the car ahead gives the following driver sufficient warning so that the following car's brakes are applied at the instant the car ahead makes its dead stop, the interval is braking distance plus car length

In Table 2 the braking distances for zero per cent grade are approximate averages from three tables compiled, respectively, by the American Gas Accumulator Company, the Pennsylvania Department of Highways, and the Keystone Automobile Club Factors for 2, 4, 6 and 8 per cent grades were determined by the Pennsylvania Department of Highways' road tests, and will be discussed in connection with hills

Considering the factors of the first table, under ideal operating conditions, where it is assumed that a following car will safely brake to reduced speed or stop in response to signals from and in the same distance as the car ahead, it appears that maximum capacity of a traffic lane with no limitation, no physical interference with traffic ranges through 1667 vehicles at 10 M P H and 1968 vehicles at 20 M P H to the maximum of 1969 at 22 M P H, and declines through 1908 at 30 M P H and 1764 at 40 M P H to 1615 at 50 M P H

THE MAXIMUM CARRYING CAPACITY OF A TWO-LANE ROAD

The capacity of a two-lane surface will vary according to the nature of the traffic If there is very little slow traffic, both lanes may run near maximum capacity, but with 10 per cent or more motor-truck traffic on the road, the maximum capacity of a two-lane road may be stated as approximately the capacity of a single lane running full

It is assumed:

First, that with very light traffic in one lane, this lane may be freely used by rapidly moving vehicles of the other lane overtaking

TABLE 2

COMMONWEALTH OF PENNSYLVANIA—DEPARTMENT OF HIGHWAYS

Theoretical Maximum Capacity of One-Traffic Lane Emergency-Stop Condition

1/10 of square of speed braking distance at 0 per cent grade

M. P. H. speed	Minus per cent grade	Two wheel brakes: Braking distance	Two wheel brakes: Braking distance plus 17 ft	Two wheel brakes: Number cars per 1 mile line	Two wheel brakes: Capacity per hour	Four wheel brakes: Braking distance	Four wheel brakes: Braking distance plus 17 ft	Four wheel brakes: Number cars per 1 mile line	Four wheel brakes: Capacity per hour	Fifty per cent two wheel brakes and fifty per cent four wheel brake: Average braking distance plus 17 ft	Fifty per cent two wheel brakes and fifty per cent four wheel brake: Number cars per 1 mile line	Fifty per cent two wheel brakes and fifty per cent four wheel brake: Capacity per hour
10	0	10.0	27.0	195.6	1956	6.0	23.0	229.6	2296	25.0	211.2	2112
	2	12.5	29.5	179.0	1790	7.5	24.5	215.5	2155	27.0	195.6	1956
	4	15.0	32.0	165.0	1650	9.0	26.0	203.1	2031	29.0	182.1	1821
	6	17.5	34.5	153.0	1530	10.5	27.5	192.0	1920	31.0	170.3	1703
	8	20.0	37.0	142.7	1427	12.0	29.0	182.1	1821	33.0	160.0	1600
15	0	22.50	39.50	133.7	2006	13.5	30.5	173.1	2597	35.0	150.9	2264
	2	28.12	45.12	117.0	1755	16.9	33.9	155.7	2336	39.5	133.7	2006
	4	33.75	50.75	104.0	1560	20.3	37.3	141.6	2124	44.0	120.0	1800
	6	39.37	56.35	93.7	1406	23.6	40.6	130.0	1950	48.5	108.9	1634
	8	45.00	62.00	85.2	1278	27.0	44.0	120.0	1800	53.0	99.6	1494
20	0	40.0	57.0	92.6	1852	24.0	41.0	128.8	2576	49.0	107.8	2156
	2	50.0	67.0	78.8	1576	30.0	47.0	112.3	2246	57.0	92.6	1852
	1	60.0	77.0	68.6	1372	36.0	53.0	99.6	1992	65.0	81.2	1624
	6	70.0	87.0	60.7	1214	42.0	59.0	89.5	1790	73.0	72.3	1446
	8	80.0	97.0	54.4	1088	48.0	65.0	81.2	1624	81.0	65.2	1304
25	0	62.5	79.5	66.4	1660	37.5	54.5	96.9	2423	67.0	78.8	1970
	2	78.0	95.0	55.6	1390	46.8	63.8	82.8	2070	79.4	66.5	1663
	4	93.6	110.6	47.7	1193	56.2	73.2	72.1	1803	91.9	57.5	1438
	6	109.2	126.2	41.8	1045	65.5	82.5	64.0	1600	104.4	50.6	1265
	8	124.8	141.8	37.2	930	74.9	91.9	57.5	1438	116.9	45.2	1130
35	0	122.5	139.5	37.8	1323	73.5	90.5	58.3	2041	115.0	45.9	1607
	2	153.0	170.0	31.1	1089	91.8	108.8	48.5	1698	139.4	37.9	1327
	4	183.6	200.6	26.3	921	110.2	127.2	41.5	1453	163.9	32.2	1127
	6	214.2	231.2	22.8	798	128.5	145.5	36.3	1271	188.4	28.0	980
	8	244.8	261.8	20.2	707	146.9	163.9	32.2	1127	212.9	24.8	868
40	0	160.0	177.0	29.8	1192	96.0	113.0	46.7	1868	145.0	36.4	1456
	2	200.0	217.0	24.3	972	120.0	137.0	38.5	1540	177.0	29.8	1192
	4	240.0	257.0	20.5	820	144.0	161.0	32.8	1312	209.0	25.3	1012
	6	280.0	297.0	17.8	712	168.0	185.0	28.5	1140	241.0	21.9	876
	8	320.0	337.0	15.7	628	192.0	209.0	25.3	1012	273.0	19.3	772

and passing slower-moving vehicles, and that there must be some extended intervals in the heavy-traveled lane to permit some overtaking and passing in the light lane Under these conditions the maximum capacity of a two-lane road, with mixed speed of traffic, is somewhat below, but very approximately equivalent to, the capacity of a single lane with traffic moving uniformly at the rate of speed of the majority of traffic units of the two-lane road being measured.

Second, that as traffic increases in the lightly traveled lane, freedom to overtake and pass is restricted, or frequent intervals between the traffic units of the heavy-traveled lane must be opened to permit units of the light lane to overtake and pass, and the sum of the part capacity of the two lanes is less than the full capacity of the one

With mixed traffic on the road, with travel speeds ranging from 15 M P H to 35 M P M, a series of determinations indicates that the average encroachment on the left-hand lane in passing is 200 feet, and freedom to pass in both lanes would fix a minimum interval of 400 feet in each lane for the rapidly moving vehicles Assuming that these average 30 M P. H and that there are an equal number of slower-moving vehicles averaging 20 M P. H, the total capacity of the two-lane road would be 5280 divided by 400, multiplied by 2 and by 30, plus 5280 divided by 400, multiplied by 2 and by 20, or 1320 per hour.

These computations, with their assumptions and approximations, take into consideration the essential fact of personal equation of driver and variety of motor vehicle Under special conditions, passing may be accomplished in considerably less than 200 feet, and can be accomplished with less than 400-foot intervals between cars in opposite lanes, but, in general, a distance of approximately 200 feet and an interval of 400 feet is advisable to reduce the risk of accident

The average capacity as determined is for the ideal condition of uniform distribution of traffic It is understood that actual carrying capacity may be greater than 1320 per hour, with attendant congestion and hazard

CAPACITY WITH ADDITIONAL LANES

The addition of third, fourth and other lanes is, in each case, a special problem involving local conditions

In order to secure the maximum increased carrying capacity by addition of third, fourth and other lanes, it is necessary to assume that, in general, all travel units use the right-hand travel lane, except for the distance of passing slower-moving vehicles proceeding in the same direction, and except that in the case of roads of four or six-lane width the travel units proceeding at maximum legal speed are assumed to travel continuously in the inside lane for their direction of travel

The three-lane width is to be considered as approaching a traffic center not connecting two traffic centers, and providing for a heavy traffic of which the direction reverses periodically, as, for instance, at a certain time large numbers of vehicles carrying people to work, at other times returning Under this condition the heavy traffic is probably to be figured as a full lane of rapidly moving vehicles, or 2000 passing 10 per cent slow vehicles, or 2200 in the direction of heavy traffic, and a comparatively small volume of traffic, probably not to exceed 500, in the direction of light travel In the direction of light travel, opportunity for rapid vehicles to pass slow vehicles will be conditioned upon frequency of similar passing in the line of heavy travel.

The four-lane width may be considered as carrying two center lanes of rapid vehicles moving in opposite directions, with 10 per cent of slow vehicles on the outer lanes, or 4400 in all

The addition of a fifth lane will probably be due to obstruction of outer lanes by parking and would furnish effectively a three-lane width A six-lane width might either provide two outer lanes for parking and an effective four-lane roadway or effective six lanes with four lanes running full and 10 per cent slow vehicles—trucks—or a total capacity of 8800.

TIME RATE ON OVERCROWDED ROADS

When a road carries traffic in excess of its practical capacity, the tendency is to reduce the speed of all the travel units to that of the slowest and approximately double the time rate

In the case of a two-lane road, overcrowding begins when the 400 feet intervals shrink so that rapidly moving vehicles of one lane cannot use the other freely for passing.

In the case of three-lane or wider roads, overcrowding results in forcing vehicles which would prefer to move rapidly into the slow outer lanes and confining them there where their time rate is approximately doubled.

TIME LOSS AT GRADE CROSSINGS AND THROUGH SMALL VILLAGES ON MAIN TRAVEL ROUTES

The extent of delay caused by a railroad grade crossing varies according to the frequency of passing trains, the time trains are permitted to stand blocking the crossing, and the density of traffic

The precautionary stop in itself creates a delay of seven or eight seconds Standing to permit an approaching or passing train to go by may consume anywhere from a few seconds to five or six minutes, according to the length and speed of the train and the time of the automobile reaching the crossing with reference to the time of the train passing

The time lost at grade crossings by trains stopped or shifting is not ordinarily a considerable cause of delay, except in towns and cities In general, control in this respect is in the hands of town and city governments Abstracts from Pennsylvania state laws and of specimen city ordinance are attached

The committee desires to stress its former recommendation against utilization of a traffic signal on a fixed base within the roadway

PENNSYLVANIA STATE LAW

P L 191-1845, No 129

Relative to the obstruction of crossings of public roads, by locomotives or cars.

Unlawful for the railroad company to block crossings or streets or roads or obstruct crossings with locomotives or cars

Penalty $25 00, one-half to the commonwealth and one-half to informer.

HARRISBURG CITY ORDINANCE

Section 1 Cars not to obstruct streets, etc

18 From January 1, 1863, all railroad companies are prohibited from obstructing the streets or highways by permitting cars, trains of cars, locomotives, or other movable property to remain on said streets or highways, so as to prevent free ingress or egress to all and every person traveling on said streets or highways for a longer period than ten minutes at one time

Penalty for violation of ordinance, $5 00

December 29, 1862

Section 2 Speed of cars or trains

Not to run at a speed greater than seven miles per hour within city limits.

Penalty, $10.

COMPARISON OF TIME RATE OF BY-PASS OR BELT ROUTE THROUGH CENTER OF POPULATION

The comparison of time rate of by-pass or belt route with the time rate of a route through any center of population is necessarily a particular comparison

Under certain conditions, combining heavy local traffic with absence or failure of staggered traffic control, it may be that a round-about route through suburban or other residential streets may save time over a direct route through business streets, and, similarly, that under certain conditions a by-pass route, detouring the reduced speed zone, may effect a saving of time. It is assumed that the by-pass route is well defined with good pavement and satisfactory for the free movement of traffic

In Philadelphia the Lincoln Highway by-pass is 4 5 miles shorter than the Lincoln Highway, and there is a saving of twenty-nine minutes by using the by-pass

The north and south route by-pass is 1 1 miles longer than the main route and there is a saving of six minutes by using the by-pass

EAST AND WEST, ROUTE 1 TO ROUTE 1

	Mileage	Time	Time saved on by-pass
Direct	46 6 (round trip)	2° 38′ 30″	58′ 10″
By-pass	37 6 (round trip)	1° 40′ 20″	

NORTH AND SOUTH, ROUTE 2 TO ROUTE 12

	Mileage	Time	Time saved on by-pass
Direct	24 0 (round trip)	1° 40′ 10″	12′ 40″
By-pass	26 2 (round trip)	1° 27′ 30″	

In Pittsburgh the by-pass is 6 6 miles longer than the Lincoln Highway and four minutes was lost on the by-pass

The Lincoln Highway and Stubenville Pike, the by-pass is 2 2 miles longer than the main route and eight minutes is saved on the by-pass

	Mileage	Time	Time saved on by pass
Lincoln Highway	21 2 (one way)	59″	4′ lost
North Belt	27 8 (one way)	1′ 3″	
Lincoln Highway and Stubenville Pike	28 6	1° 18′	8′
South Belt	30 8	1° 10′	

In Harrisburg the by-pass is 0 3 mile longer than the main route and two minutes is lost on the by-pass

ROUTE 41 TO ROUTES 3 AND 4, NORTH

	Mileage	Time	Time saved on by pass
Through route via Mulberry St Bridge, Chestnut St and Front St	2 96	8″	
By-pass Cameron via Maclay St to Front St	3.24	10″	2′ lost

EFFECT OF CURVES, STEEP HILLS, NARROW BRIDGES, ROAD UNDER REPAIRS, CROSS ROADS, SCHOOL ZONES, ETC, ON CARRYING CAPACITY

The effect of curves, in addition to restricting passing, is to slow traffic to such speed that clear sight distance is equivalent to the safe

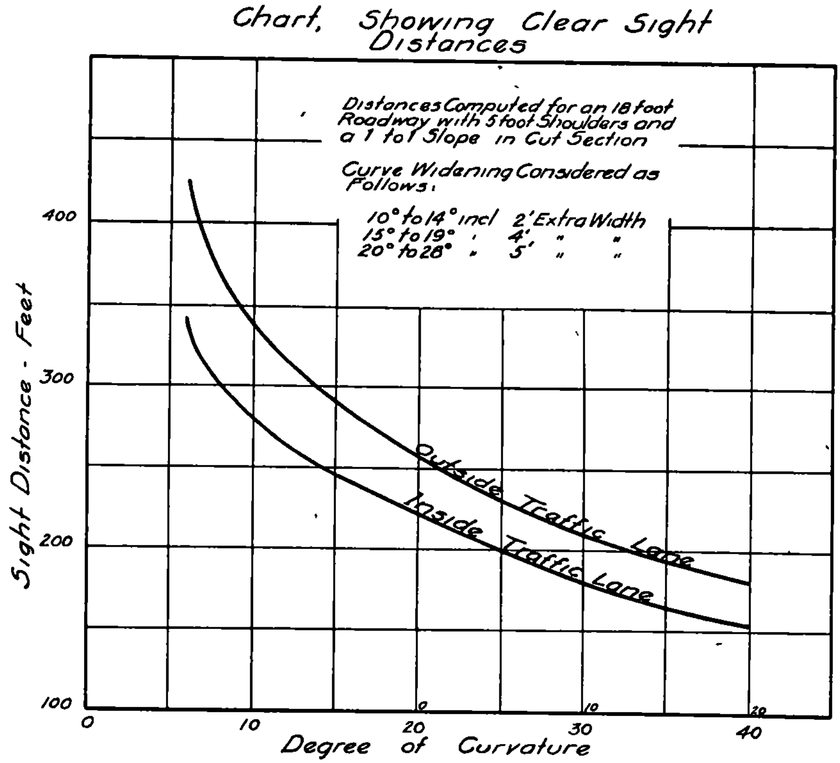

Figure 1

braking interval for the travel speed under such surface conditions as are present For instance, under average conditions, combining Table 2 and Figure 1, we see that a forty degree curve furnishes clear sight distance of 154 feet on the inner lane and 182 feet on the outer lane, and considering both lanes, the clear sight distance for the curve would be expressed as 168 feet, which is approximately safe braking interval for mixed 2- and 4-wheel brake traffic, 43 M P H on level ground, 39 M P H descending 2 per cent, 35 M P. H descending 4 per cent, 33 M P H descending 6 per cent and 31 M P H descending 8 per cent grade

Such curves as are customarily encountered on improved roads, except in combination with very steep grades or under slippery road conditions, do not materially slow down traffic although they do tend to create congestion by reducing the freedom to pass The restriction as to passing on curves is particularly significant by reason of the fact that the same physical conditions which are responsible for the curvature in the road will ordinarily make it very difficult to provide extra width for passing Fog, haze or any other conditions that reduce clear sight may be considered to reduce speed in the same way as is indicated above for curves.

The reduction, in capacity of roads, by steep hills is through the increase of distance required for braking to a standstill with increase in per cent of grades Plus grades do not have this effect, and therefore we may have the unusual condition that the capacity of a road is greater in one direction than in another.

Determinations were made, with light and with heavy model passenger cars at 10, 20 and 30 miles per hour, and the figures were amplified to cover 15, 25, 35 and 45 miles per hour, of braking distance for 0, and for minus 2, 4, 6 and 8 per cent grades (Figure 2)

The use of these figures is in connection with safety control on the assumption that there is an abrupt stoppage on the road, as for instance, caused by a collision with the necessity of the following car coming to a full stop Under this condition, it is assumed that the car ahead gives the following driver some indication of the impending accident and that the brakes of the following car are applied at the instant the road is blocked ahead The safe braking distance measures the space interval and adding the length of the car gives the figure to be divided into 5,280 and multiplied by the speed in miles per hour to indicate the capacity of road on various grades

Figure 2, drawn from Table 2 and showing curve of Table 1 for comparison, illustrates varying capacity on 2, 4, 6 and 8 per cent grades, with various speeds

In the case of long steep grades where descent is in second gear, the relation of braking distance to speed remains the same

The effect of grades, whether operated in high or in second gear, on traffic under proper control, is to reduce speed without reducing interval between cars and the result is decreased carrying capacity For any given hill, the capacity is reduced to a percentage that is expressed as the ratio of the rate of speed on grade to rate of speed on level ground with same safe braking interval Slippery road conditions can be treated in the same manner

School zones, narrow bridges, road under repairs, and other conditions that require slowing down but permit continued operation in

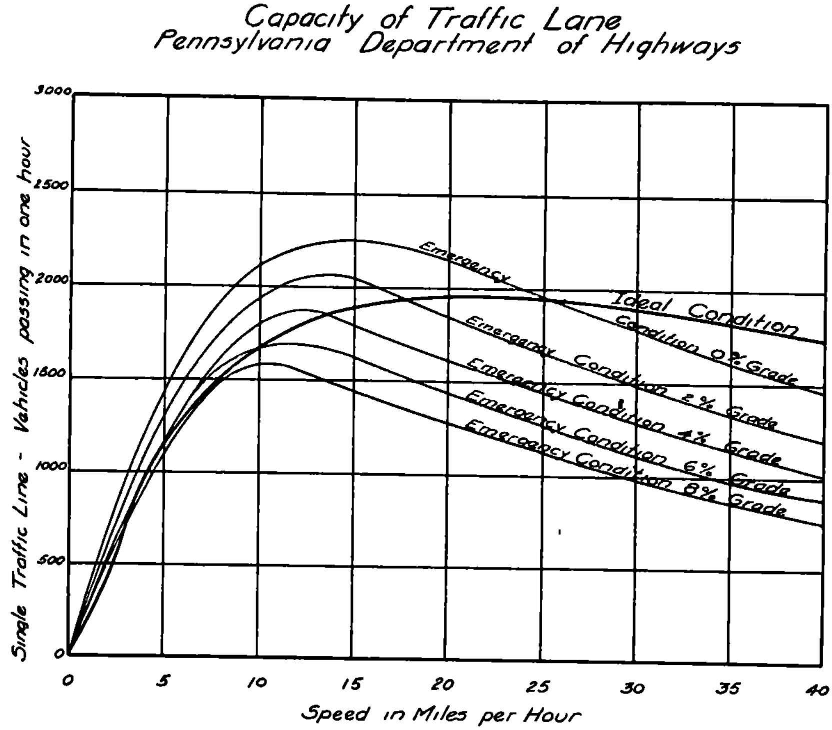

Figure 2

uninterrupted lanes at lessened interval do not reduce carrying capacity.

Narrow bridges and repair operations that necessitate one-way travel, reducing a two-lane width to a one-lane width, decrease capacity by the loss of time in starting plus a loss in proportion to the length of the one-way section due to necessity of clearing the section before starting the opposing traffic

School zones, cross roads, railroad crossings, repair operations and other conditions that actually stop traffic reduce road capacity, according to frequency of the stops, by the percentage of loss of time to the average vehicle This loss of time may be measured by the time of standstill plus an allowance of time, (not the entire time) for resuming normal operation, as a percentage of the total (normal operating plus standstill plus intermediate) time The most usual occurrence of reduction of capacity through halting of traffic is in the case of a highway entering a city without the benefit of traffic control and under this condition the capacity of a road may be reduced fifty per cent or more

Each stop causes loss of time which may be expressed as one-half of the time of braking to stop, all of the standstill time, starting time and one-half of the time required to accelerate to traveled speed.

The braking to stop loss is ordinarily to be included as part of the standstill loss since the time lost by a line of vehicles is equivalent to the time lost by the leading car, and there is usually sufficient latitude in the enforcement of the light control so that cars passing the stop light in the instant of change continue

Stop-watch observations at Fourth and Market Streets, Harrisburg, Pennsylvania, for traffic leaving the business district under approximate open road conditions, indicate three-second yellow flash, thirty-second red flash, one-second loss in starting, seven-seconds loss in accelerating, total loss forty-four seconds

The accelerated speed on Market Street was about 18 M P. H. On actual open road, accelerating further from 18 M. P H to 30 M. P H. would occasion no additional loss of time as the interval between the cars would widen out with further acceleration of speed. With one such stop in a mile, a car traveling 30 M P H. would operate two minutes, or 120 seconds out of 164 seconds of time, and the driver's loss of time would be 27 per cent which would also represent the loss in carrying capacity of the road With two stops in a mile, the operating time is 120 seconds in 208 seconds, and the loss is 42 per cent. Similarly, with three stops per mile, the loss is 52 per cent.

The study of the reduction of carrying capacity for any road is simplified by the realization of the fact, that the limitation, so long as it does not reduce the carrying capacity below the required capacity, is not serious The traffic on the majority of roads is relatively low at a point of junction or of entry A short section adjacent to the point of junction or of entry, then, is the critical section where the carrying capacity of the road should be 100 per cent. At such points on the road as the natural variation of traffic shows a 20 per cent reduction below that of the point of entry or junction, as for instance, any physical condition of the road decreasing the capacity, providing it does not decrease the capacity more than 20 per cent, is in this respect immaterial.

FUTURE OF MOTOR TRUCK AND OMNIBUS TRAFFIC AND DEVELOPMENT OF COMMON CARRIER BUSINESS

In forecasting the future traffic on highways outside of municipalities, an important factor is the development in the utilization of the motor truck and omnibus The following predictions, based upon available data and trends in the development of commercial highway transport, are submitted for consideration when the amount and character of commercial traffic on highways are being estimated

There will be a constant diminution of the percentage of through commercial motor truck traffic on streets of intercepted municipalities as by-pass highways are made available around urban districts.

There will be a slight increase or stability in the percentage of motor trucks of pay-load capacities of five tons or over in urban areas The following annual production data as compiled by the National Automobile Chamber of Commerce indicate this trend 1922, 2 9 per cent, 1923, 2 3 per cent, 1924, 3 2 per cent, 1925, 4 1 per cent, 1926, 3.5 per cent.

There will be an increase in the haulage of heavy loads carried on three axles especially after legislation favorable to six wheel vehicles is included in state statutes

Motor buses may be expected to have the maximum over-all-width allowed by legislation. Apparently the most general legal maximum width of 96 inches will not be modified in the near future However, the California practice of allowing common carriers to have a maximum width of 102 inches when used on roadways exceeding 15 feet in width, may be an indication of the adoption of special legislation in other states

Steam railroads gradually will turn over short line passenger traffic to motor buses and the haulage of less-than-carload freight up to distances of from 30 to 50 miles, to motor trucks There will be an increase in the utilization of motor buses and trucks by railroads either owned by or under contract with the railroads, providing that safe methods of handling mail and express can be assured

Abandonment of many short line steam railways, as now operated, will be followed by replacement of rail cars by the utilization of motor bus and truck service on public or private highways

It is self evident that the development of common carrier highway transport will be affected by future national and state legislation. As there appears to be general agreement on the part of operators, users.

and the public as to the desirability of control of operation of common carrier passenger highway transport service following the obtaining of certificates of public convenience and necessity, no fundamental variation from current practice, where sound and equitable legislation has been adopted, is apparent It is not anticipated that there will be a general adoption, in the near future, of legislation governing the operation of common carrier freight highway transport service

AUTOMOBILE OWNERSHIP AND USE OF THE HIGHWAYS

From a study of the license numbers of cars passing the traffic stations in Tennessee and the registration records in the office of the Registration Bureau it was found that there was a close relation between the rural and urban ownership and rural and urban vehicles on the roads By urban is meant all vehicles in incorporated villages and cities, and by rural is meant all other vehicles

COMPARISON FOR STATE

Rural ownership	34 0	Urban ownership	66 0
Rural travel	33 0	Urban travel	67 0

COMPARISON BY DIVISIONS

Division	Rural ownership	Rural travel	Urban ownership	Urban travel
No 1	39 0	41 0	61 0	59 0
No 2	32 8	29 0	67.2	71 0
No 4	29 0	28 5	71 0	71 5

In as small a unit as the county where one or two stations are located there is enough conformity in percentages to indicate an approximate relation between the rural registration and rural travel, and urban registration and urban travel

The following conclusions appear to be warranted for areas similar to Tennessee:

1. That the travel on the roads is proportional to the location of ownership for both rural and urban travel.
2. The relation between ownership and travel is not a straight line relation though the two percentages increase or decrease together.
3. The smaller the area considered the greater is the effect of local conditions and type of road.

MARYLAND AERIAL TRAFFIC DENSITY SURVEY

In cooperation with the State Roads Commission of Maryland, there was organized a plan to take aerial photographs of the traffic on the Washington-Baltimore Road on July 4, 1927 Arrangements were made accordingly with Major Tipton, of the Chesapeake Aircraft Company of Baltimore, to take the pictures, beginning at the city line of Baltimore, starting at 4 30 P. M

The time of the day was chosen which was expected would yield the largest traffic density—some time between 4 and 6 o'clock in the afternoon Therefore, the exposures were made as late in the afternoon as was deemed practicable to have remaining sufficient light for good negatives Exposures were made continuously to the District of Columbia line, a distance of about thirty miles. The actual flying time was approximately twenty-seven minutes, during which 126 exposures were made from an altitude of 3600 feet. The overlap of one picture with the following is about fifty per cent and the camera used was such that at this elevation the scale of the pictures was 1 inch = 300 feet. Enlargements to different scales were made, and it was finally decided that the photographs should be enlarged to give a scale of 100 feet to 1 inch The resulting pictures were exceptionally clear and show sufficient details to identify traffic readily.

It will be appreciated that this photographic record of the road, which includes a strip of land approximately 2000 feet on either side of the line of the Washington-Baltimore Highway will prove of value in many other ways than for the immediate purpose of studying traffic movement.

In connection with the airplane-picture survey, there were stationed two observers at each of four different points along the road. These observers counted the traffic every five-minute interval in each direction during the period from 3 o'clock until 6 There were, in addition, six motor vehicles with white sheets drawn over the tops, which started from fixed stations at certain times, so that they would be included in the pictures at different pre-determined points along the road. These spot cars, as they were called, kept a log of their speed and mingled with the traffic, trying neither to overtake nor to hold it back.

There was also a party of observers stationed at the overhead bridge at Muirkirk, who counted the traffic in each direction from 4 until 5 o'clock, and, in addition, during this time exposed ordinary camera pictures every minute.

From the total of these data it is evident there exists a very complete record of the traffic movement during the hours counted In addition, there have been taken from time to time, during hours when a large amount of traffic was expected, additional counts for purposes of comparing the density observed on July 4 with the traffic density occurring at other times

Owing to the fact that the airplane photographs were completed and received but a comparatively short time ago, there has not been opportunity to make a detailed study of them, so that at present only general deductions can be made The first thing that strikes the eye is the many open spaces, extending for a quarter of a mile or so, where there is comparatively little traffic, also, that there was no tendency for the various groups of vehicles to exceed 30 miles per hour, although the allowable speed limit as posted at intervals along the road is 40 miles per hour

The attached table shows the results of the traffic counts at the different stations, taken on July 4, also on July 17, and again on October 2 The number of vehicles in each direction on July 4 was approximately the same It is seen that the greatest number of vehicles per five-minute interval, reduced to the rate per hour, is 1968, the average at this station (P-3) near the District of Columbia line, for the actual three hours counted being 1390, and the minimum rate for a five-minute interval being 912 per hour This traffic count was taken near the District of Columbia line just before traffic divides, in going from Washington between the Baltimore Road and the Defense Highway leading to Annapolis This latter road evidently took, as an examination of the table shows, about one-third of the traffic noted at the District of Columbia line station, indicated as P-3 On the remainder of the road the actual traffic was a little over 800 per hour with a maximum for five minutes of about 1200 per hour, and a minimum rate of between 500 and 600 per hour

The condition of the road under this traffic varies from the clear spaces to two lines of vehicles moving in opposite directions, the average spacing of vehicles being, perhaps, six or more car lengths These crowded sections would extend for several hundred feet, and would be followed by a comparatively clear stretch of road. Until a more detailed study is made of the airplane photographs, only these generalizations can be made

The results of further study, it is now planned, will be submitted in a future report of the committee.

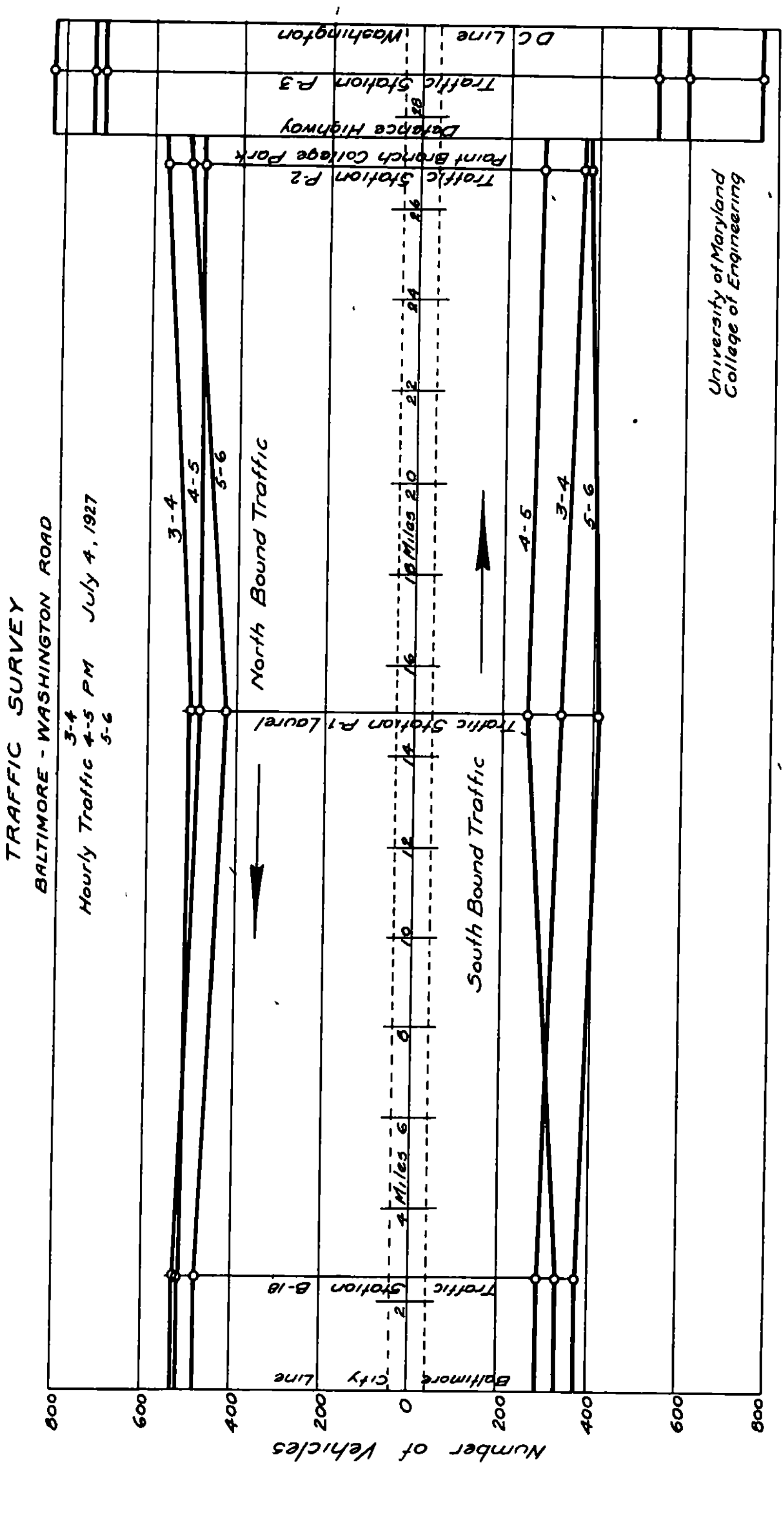
TRAFFIC SURVEY
BALTIMORE - WASHINGTON ROAD
Hourly Traffic 3-4 4-5 5-6 PM July 4, 1927
North Bound Traffic
South Bound Traffic
Baltimore City Line
Traffic Station B-18
Traffic Station P-1 Laurel
Traffic Station P-2
Point Branch College Park
Defense Highway
Traffic Station P-3
DC Line Washington
Miles
Number of Vehicles
University of Maryland
College of Engineering

Figure 3

TABLE 3

UNIVERSITY OF MARYLAND, COLLEGE OF ENGINEERING

TRAFFIC COUNTS, BALTIMORE-WASHINGTON ROAD, JULY 4, 1927

Station	Actual number of vehicles 3-4 P M	4-5	5-6	Average number vehicles per hour	Max and min rate per hour based on traffic for 5 mi intervals	
B-18 near City Line—Baltimore	809	860	857	842	1284	522
P-1 Laurel	835	739	826	800	1236	504
P-2 College Park	940	769	881	863	1188	600
P-3 near D C Line	1357	1312	1502	1390	1968	912
Muirkirk		736				

TRAFFIC COUNTS AT MUIRKIRK, BALTIMORE-WASHINGTON ROAD, JULY 17, 1927

4-5 P M	Actual number of vehicles 5-6	6-7	7-8	Average number vehicles per hour	Max and min rate per hour based on traffic for 5 mi intervals	
504	673	671	595	607	924	348

TRAFFIC COUNTS AT MUIRKIRK, BALTIMORE-WASHINGTON ROAD, OCTOBER 2, 1927

1-2 P M	Actual number of vehicles 2-3	3-4	4-5	5-6	6-7	Average number vehicles per hour	Max and min rate per hour based on traffic for 5 mi intervals	
South								
222	272	322	366	505	575			
North								
315	350	383	414	335	340			
537	622	705	780	840	915	733	1284	348

NEW TRAFFIC FLOW RECORDER IN USE ON CLEVELAND TRAFFIC SURVEY

J G McKAY

United States Bureau of Public Roads

A new device, designed to measure and record the speed of a vehicle at any instant during a run or trip and simultaneously to record the elapsed time and distance since the beginning of the run, is being used by the Bureau in connection with the highway-planning survey now in progress in cooperation with the County Commissioners of Cuyahoga County, Ohio, in the Cleveland Metropolitan Region

The device consists, essentially, of a clock, a speedometer, and an odometer, the three so mounted as to be within the field of a motion-picture camera, with which they can be photographed simultaneously