MARYLAND AERIAL SURVEY OF HIGHWAY TRAFFIC BETWEEN BALTIMORE AND WASHINGTON[1]

A N JOHNSON

Dean, Engineering College, University of Maryland

On July 4, 1927, the State Roads Commission of Maryland had an aerial traffic survey made of the road between Baltimore and Washington

For this purpose there were engaged the services of the Chesapeake Aircraft Company of Baltimore, who made a series of photographs taken at an altitude of about 3,600 feet The resulting photographs were on a scale of approximately 300 feet to the inch These were subsequently enlarged to a scale of about 115 feet to the inch The distance covered by the photographs, from the Baltimore City line to the District of Columbia line, was very nearly 29 miles, 127 exposures were made, so that each photograph was overlapped by the succeeding one about 50 per cent Owing to various causes, the scale of the photographs varied somewhat, as did the amount of overlap

The actual time elapsed during which photographs were taken was 27 minutes, or slightly less than 13 seconds between each exposure The time of the flight was between 4 30 and 5 P M , this hour being selected as the one most likely to show a large amount of traffic and yet with sufficient daylight to insure good photographs

In addition to the photographic record thus secured, traffic counts were made at four points, one near the Baltimore City line, one at Laurel, about half way, one at College Park, a few miles from the District of Columbia line, and another about one-half mile from the District of Columbia line Between these last two counting stations, the Defense Highway joins the Baltimore-Washington Road, thus, on the last two miles of the road there was the additional traffic due to that from the Defense Highway

At each of the traffic stations there were two observers, one counting the north bound and one the south bound traffic during the period from 3 to 6 o'clock The observers at the traffic stations noted the traffic at 5-minute intervals, from which varying rates per hour were calculated

In addition, six cars were fitted with white tops by stretching a sheet

[1] In the Proceedings of the seventh annual meeting of the Highway Research Board page 244, there was reported by the writer a description of an aerial traffic survey of the Baltimore-Washington Road made by the State Roads Commission of Maryland on July 4, 1927 This report briefly outlined the organization, but as the studies had not then been completed, no conclusions were offered

In the present paper such studies as have been made are reported, together with a recapitulation of the description of this investigation given in the Proceedings of the seventh annual meeting

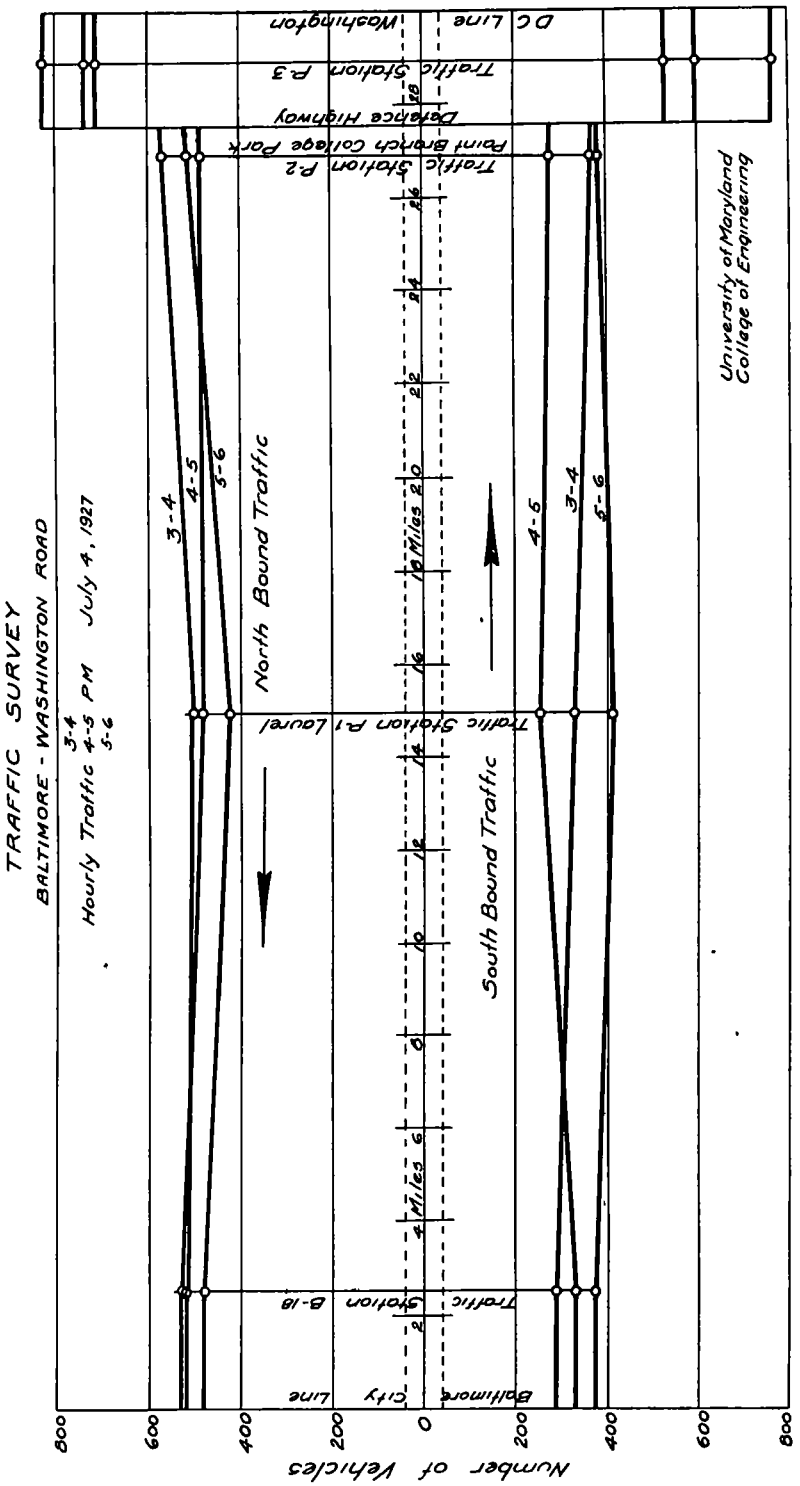
TRAFFIC SURVEY
BALTIMORE - WASHINGTON ROAD
Hourly Traffic 4-5 PM July 4, 1927
3-4
5-6
North Bound Traffic
South Bound Traffic
3-4
4-5
5-6
4-6
3-4
5-6
Traffic Station B-18
Traffic Station P.1 Laurel
Traffic Station P.2 Point Branch College Park
Baltimore Highway
Traffic Station P.3
D C Line
Washington
City Line
Baltimore
University of Maryland College of Engineering
Miles 6 4 2 0 2 4 6
Miles 2 0 2 4 6 8 10 12 14 16 18 20 22 24 26
Number of Vehicles
800 600 400 200 0 200 400 600 800

Figure 1

over them, and a driver and observer in each These spot cars, as they were called, were timed to enter the traffic on the road so as to be photographed at various points For example, in photograph 122

TABLE I

UNIVERSITY OF MARYLAND COLLEGE OF ENGINEERING—TRAFFIC COUNTS, BALTIMORE-WASHINGTON ROAD, JULY 4, 1927

Station	Actual number of vehicles			Average number vehicles per hour	Maximum and minimum rate per hour based on traffic for 5-mi intervals	
	3-4 P M	4-5	5-6			
B-18 near City Line—						
Baltimore	809	860	857	842	1,284	522
P-1 Laurel	835	739	826	800	1,236	504
P-2 College Park	940	769	881	863	1,188	600
P-3 near D C Line	1,357	1,312	1,502	1,390	1,968	912
Muirkirk		736				

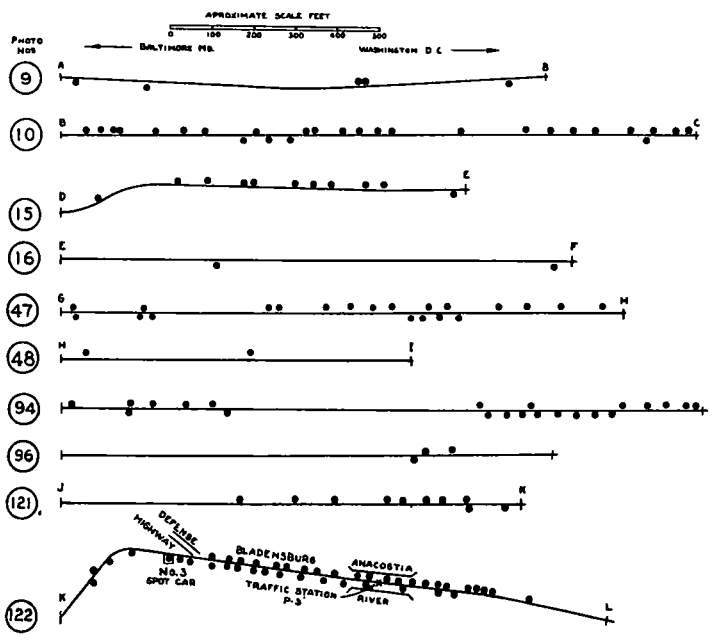

Figure 2. Distribution of Traffic Shown by Data

The numbers at left correspond to photograph numbers in Figures 3 and 4

(Figure 4) near the bend of the road where the Defense Highway branches may be seen a white dot which is car No 3 The drivers of these cars were instructed to drive with the traffic, not attempting to pass slow moving traffic, nor to hold up traffic The observers made

frequent observations as to the speed of traffic, which was from 20 to 30 miles per hour, the highest noted being 33 miles per hour.

In Figure 1, the results are shown for the traffic counts made at these stations, their relative location, and the actual number of vehicles for each hour being recorded for north and south bound traffic respectively. It will be noted that hour by hour during the three hours for which the count was made, the flow of traffic was very uniform in each direction These results are also tabulated in Table I.

While the hourly movement was nearly uniform, the variation of hourly rate for 5-minute intervals, as indicated in the last two columns of Table I, is between 500 and 1300 for that portion of the road between Baltimore and the Defense Highway The last one or two miles towards Washington which carried the additional traffic due to the Defense Highway, is seen to average nearly 1400 vehicles per hour, the variation being from a little over 900 to nearly 2000 per hour for 5-minute intervals

From the fact that the movement of vehicles for each hour is very nearly uniform, we may with sufficient accuracy for this discussion assume that during the 27 minutes the road was being photographed as many vehicles flowed on as flowed off the road, therefore, the continuous picture made up of the aerial photographs may be taken as substantially that which would be secured were it possible to take at a single instant a photograph of the traffic of the entire road Such a picture of the traffic was secured To do this, the first step was to choose the portion of each photograph which was to be used As the amount of overlap was not always uniform, it was necessary to select a longer section on some photographs than on others. This is illustrated by references to Figures 2, 3 and 4, where the numbers in the circles at the side are the same as for the corresponding photographs, which were numbered consecutively from 1 to 127 It is seen from photograph 9, Figure 3, the portion from A to B was chosen, the dots in Figure 2 indicate the location of the vehicles in that portion of the photograph On photograph 10, Figure 3, point B coincides with B in 9, and the section chosen extended to C, and so on Only a few of these photographs are shown in the figures, but they are sufficient for illustrative purposes

From the charts, thus prepared, a graphic representation of the distribution of the traffic becomes apparent To reduce this to a sketch that could be comprehended at a glance, a diagram was made that showed the number of vehicles in each quarter of a mile, as illustrated in Figure 5 But a glance at this figure is sufficient to disclose how uneven was the distribution of traffic In some quarter mile sections there is but one or even no vehicles, and nearby there may be 15 or 20 per quarter mile

From Figure 5 may be seen that the average number of vehicles per quarter mile is about 7 At a speed of 25 to 30 miles per hour, 7 vehicles,

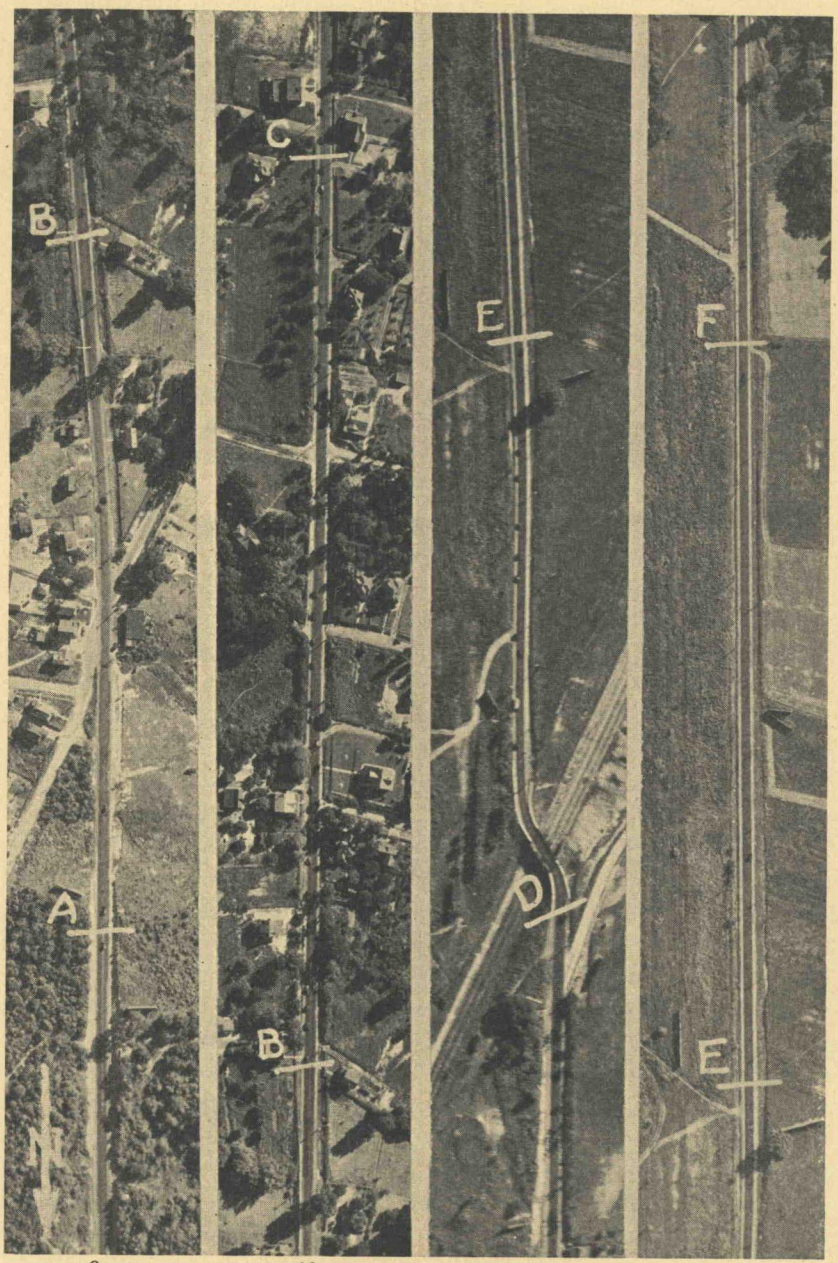

Figure 3. Aerial Views of Baltimore-Washington Road

(Courtesy of Chesapeake Aircraft Company, Inc.)

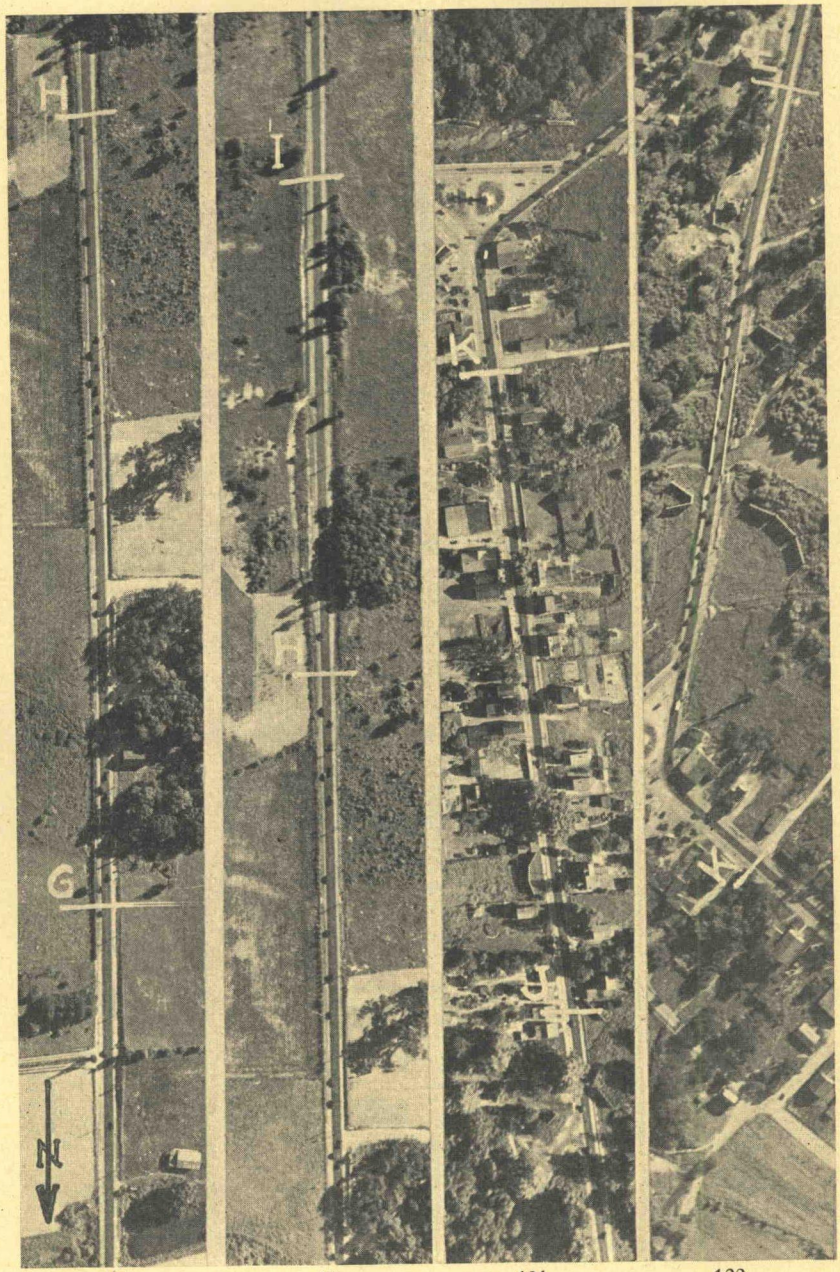

Figure 4. Aerial Views of Baltimore-Washington Road

(Courtesy of Chesapeake Aircraft Company, Inc.)

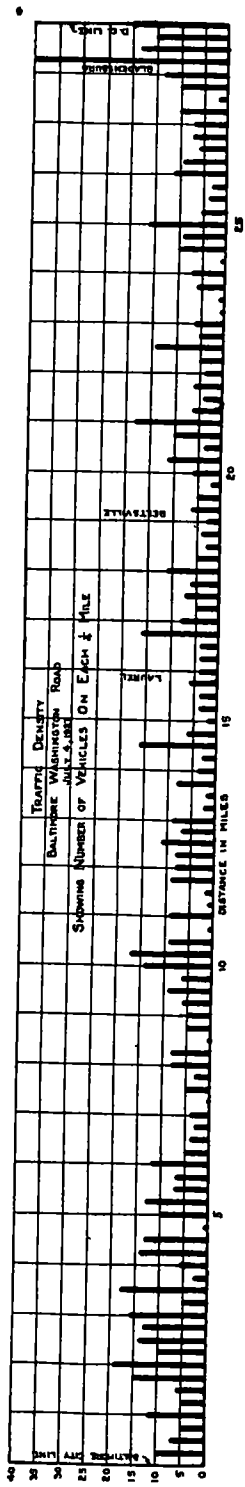
TRAFFIC DENSITY
SHOWING NUMBER OF VEHICLES ON EACH ½ MILE
BALTIMORE WASHINGTON ROAD
AUG. 5, 1937
BELTSVILLE
LAUREL
BALTIMORE CITY LINE
NO OF VEHICLES
DISTANCE IN MILES
0
5
10
15
20
25
30
35
40

Figure 5

per quarter mile would give an average flow of about 800 per hour, which was the number as shown by the actual traffic counts

To illustrate more clearly how uneven was the distribution of the traffic, we will refer again to Figure 2 and compare the number of vehicles shown in photograph 9 with the adjacent photograph 10, photographs 15 with 16, 47 with 48, 94 with 96, and 121 with 122, where the rate for the latter was about 40 vehicles per quarter mile

From many observations of traffic on this particular road, it has been ascertained that a crowded condition occurs when the hourly rate

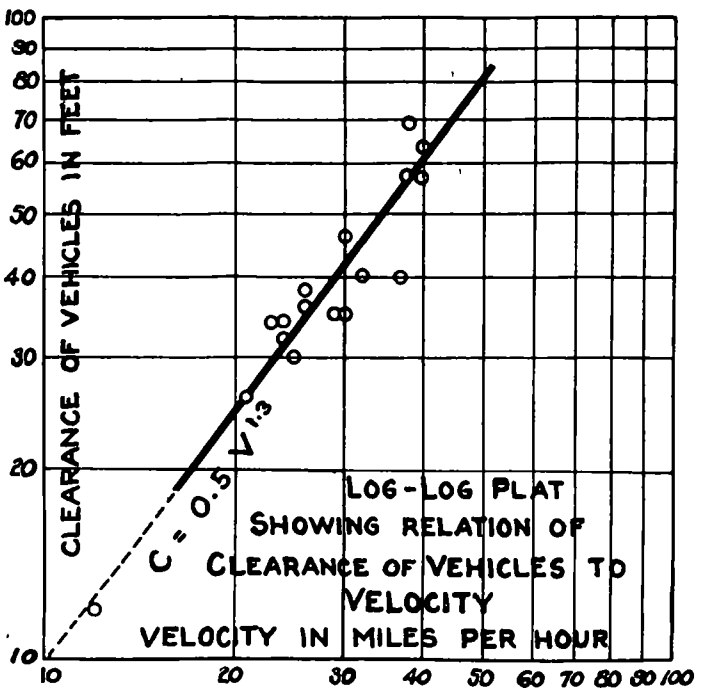

Figure 6

over a 5-minute period lies between 800 and 1000 vehicles, that is it begins to be inconvenient for the faster moving vehicles to overtake a slower

The actual discharge per hour of this traffic was about 800, yet traffic so used the road as to cause serious congestion at a great many points, as may be noted from Figure 5 which shows the frequency with which various quarter miles carried more than 7 vehicles In fact, we find that 50 per cent of the road was crowded, that is having more than 7 vehicles per quarter mile, while about 20 per cent had from 5 to 7 vehicles, and 30 per cent 0 to 4 vehicles per quarter mile, illustrating how inefficiently the traffic made use of the roadway

In addition to Figure 2, some of the corresponding photographs are reproduced in Figures 3 and 4, only that portion of the photographs being used which contained the roadway

In a paper by the writer presented to the American Society of Civil Engineers on January 22, 1925, and printed in the *Transactions*, vol 89, page 259, it was stated that from the best observations he had been able to make that the clearance of vehicles appeared to vary in the neighborhood of the square of the velocity, that is, as a line of vehicles increased their speed they increased the distance between individual cars as the square of the velocity.

The aerial photographic survey of traffic affords a means of making far better observations than is possible otherwise The fact that adjacent photographs overlap, the same group of vehicles may be found in two succeeding pictures, but displaced by the distance that they traveled between the times of the successive exposures Thus, a number of observations could be made showing the speed as platted against the clearance If the time between exposures was known accurately, as well as the scale of photographs, then the elements necessary would be known accurately The facts are that the scale of the different photographs varied somewhat, as well as the interval between exposures, and it would be expected that observations made, as here outlined, would vary somewhat

In Figure 6 are the results of such plats on a double log scale, and it is seen that while there is more or less variation from one observation to another, there is a very general straight line trend From these observations it is shown that the clearance varied approximately as the 4/3 power of the velocity The general formula for the number of vehicles passing a given point at a given velocity of V miles per hour, with an average car length of 15 feet is

$$N = \frac{5{,}280\ V}{C + 15}$$

Where C is the clearance between the cars If we introduce in this formula the value for C, as here found, we have the discharge per hour of vehicles in single line as

$$N = \frac{5{,}280\ V}{0\,5\,V^{1\,3} + 15}$$

The number of vehicles that will pass at varying speeds are shown in Figure 7 by curve A, and the maximum number 12,800 is obtained at a speed of a little less than 35 miles per hour.

The curve B shows the relationship between the discharge of vehicles and velocities on the assumption that the clearance varies as the square, of the velocity From the nature of the observations made from the photographs of the traffic, the results obtained from them are probably very much closer to actuality than the assumption made that the

velocity varied as the square Where the velocity varies as the square, it is noted that maximum discharge, about 2,600 vehicles per hour, occurs at a speed of 15 miles per hour, and that for higher speeds the curve turns down rather sharply, whereas, if we assume the clearance varied as found for curve A, the maximum is about 2,800 and the curve is more nearly flat for velocities from 20 to 50 miles per hour, that is for these velocities the number discharged per hour does not vary greatly According to these figures then at 30 to 40 miles per hour, with vehicles going in each direction, on a two-lane road, there should be a total discharge of about 5,600 per hour For short intervals of time, such a rate

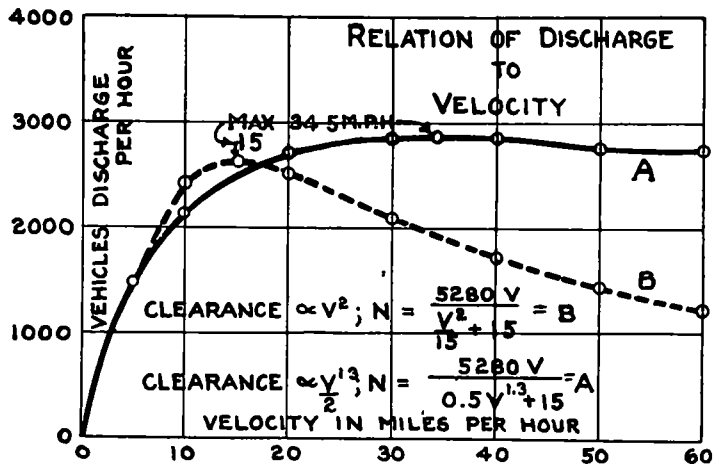

Figure 7

of discharge did actually occur But so far as the writer has been able to find, there is no record of any hourly discharge of a single line of vehicle exceeding 2,000 The maximum reported for the Holland Tunnel traffic was just under this amount, about 1,900 [2]

A conclusion to be drawn from the aerial traffic survey is the importance of any regulation which will tend to greater uniformity in the distribution of traffic and that whatever will help to do this will to that extent increase the efficient use of the road

Inasmuch as the Baltimore-Washington Road is to be widened to 40 feet, a section of this increased width from 20 feet to 40 feet having already been completed, the comparison between another aerial survey of the traffic and this one will doubtless reveal much interesting and valuable information.

[2] See Engineering News-Record for December 27, 1928, p 947