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TRUCK EQUIVALENCY

BY

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TABLE OF CONTENTS

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ABSTRACT

The passenger car equivalent of trucks is developed for an entrance ramp location. The truck equivalent has been found to vary with the lane (left or right), volume, and percent trucks in the stream. Another variable -- speed -- may further affect the factor, and this will be included in further studies.

The range in the truck equivalent was generally found to be from 0.9 to 1.3.

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TRUCK EQUIVALENCY

Various techniques have been used to determine the passenger car equivalent of a truck in a traffic stream. All methods tend to show a minimum passenger car equivalent of two (2). This factor has been shown to increase with both the grade and length of grade of the roadway.

A recent study has found the passenger car equivalent to be 1.3 at points downstream from a traffic signal.

Using headway measurements, a technique similar to the latter study, the New Jersey Department of Transportation in cooperation with the BPR has conducted the present study.

The truck equivalent (E_t) is determined for various ranges in volume and percent trucks in the stream.

SITE

An entrance ramp merge with a main road is often the site of speed and density variations in the flow of traffic. The prime reason for this is the ingress of traffic and increase in volume. It is important to quantify the effect of truck traffic at these points.

The site studied is one where the sight distance, for both main road and ramp traffic, is excellent for several hundred feet upstream from the merging point. (Figure 1). The main road is level, four lanes wide -- in one direction -- dualized, and located 2000 feet downstream from a traffic signal.

The two express lanes have all passenger car traffic, while the two local lanes have both passenger car and truck traffic.

METHODOLOGY

The volume for any time period is inversely proportional to the mean headway between all successive vehicles in that time period. Sampling headways over increasingly larger intervals yields decreasingly lower volumes for the expanded period. This occurs because the maximum possible headway is the length of the time interval, and as the sampled time intervals increase, so does the maximum headway. However, the longer sampling time interval will produce a more accurate estimate of the actual expanded period volume.

As the volume on a road approaches capacity, the kinematic waves in the stream affects a greater number of vehicles. Almost all of the traffic may be forced to stop at one time or another. The influence of a truck in the traffic stream is experienced over some finite time or distance. As the vehicles accelerate from the stop, the trucks in the stream will take a little longer to attain the speed of the passenger cars; hence, a larger gap will appear in the traffic between the truck and the

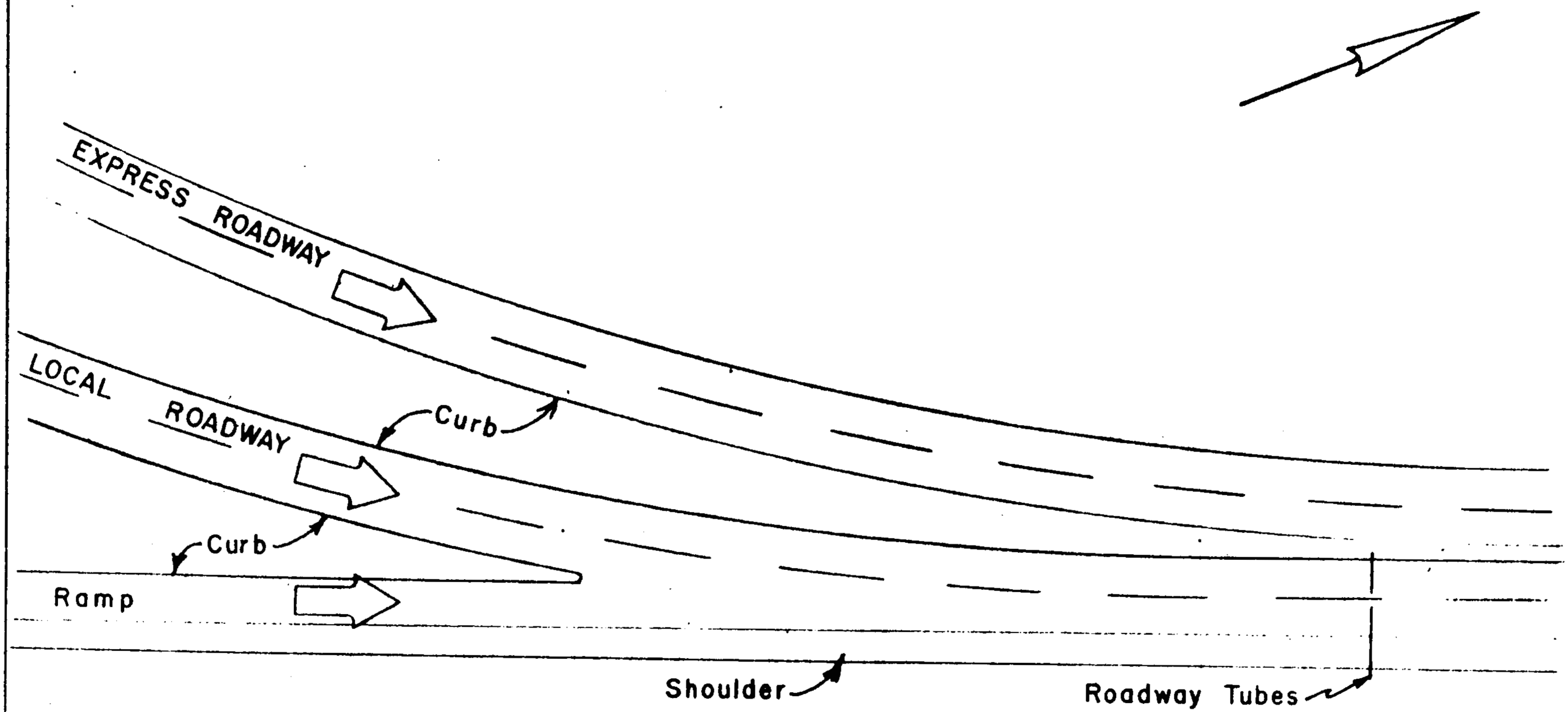

FIG. 1
PLAN
TRUCK EQUIVALENT
ROUTE 1-9
ELIZABETH, NEW JERSEY
SCALE: 1" = 50'

preceding passenger car. As the truck continues downstream, the larger gap will permit the truck to increase its speed above that of the preceding passenger car and it will eventually "close" to a normal following distance. This process can continue at the near capacity level for several miles, but in many cases, other vehicles will enter the larger gap. If other vehicles did not enter the larger gaps, it can be argued that the gap created in this case may serve to stop the wave in the stream, thereby reducing the density and increasing the total volume of the lane. Experiments at the Holland Tunnel in New York verify an increase in volume by controlling the vehicle input to the tunnel per minute.

A methodology and analysis of study, which considers the aforementioned principles, is used in this report. Traffic is sampled on a time interval basis. The method utilizes the headways of vehicles and is explained as follows:

Time interval - mean headways are determined for each of four time intervals (15, 30, 45 and 60 seconds) and are classified by the number of vehicles and the percent trucks in the stream during each interval.

A plot of mean headway versus the number of vehicles per time interval yields a straight line on log-log paper. It is to be expected that the least squares line for 0% trucks will fall below any other line. Then for a specific number of vehicles, the mean headway would be expected to increase for an increase in the number of trucks.

From the basic equation:

$$Q = Cn + E_T nT,$$

$$E_T = (Q - Cn)/Tn,$$

Where:

Q = equivalent cars (time/hc),

n = number of vehicles in a sample (time/hx),

E_T = p.c. equivalent of a truck (truck equivalent),

hc = mean headway for a sample of all p.c.,

hx = mean headway for a sample with "x" percent trucks,

C = proportion of p.c., and

T = proportion of trucks

Cn = number of cars

Tn = number of trucks.

Substituting:

$$E_T = [(time/hc) - C\ (time/hx)]/T(time/hx)$$

$$E_T = (hx/hc - C)/T. \qquad (1)$$

The mean headway for any specific number of vehicles for each percent of trucks can be substituted in equation (1). The resulting plot is E_T versus volume for all ranges in truck percentage for which data is available. The volume is determined from 3600n/time-interval.

ANALYSIS

Tables 1 and 2 give an indication of the relative slopes (B) of each regression line. The flatter slopes yield an increasing value of the truck equivalent with an increase in the number of vehicles per time interval (volume). The resulting truck equivalent for each of the time intervals is plotted against volume in Figures 2 thru 5.

Speed data was not determined for the time intervals and it is the lack of this variable which may account for the crossing of the regression lines. Headways decrease to a minimum value as speed increases and then increase for speeds in excess of approximately 40 m.p.h., in conformance with the volume-speed curve. Speed data was grouped in the present study and mean headways for all ranges of speed were plotted for a specific number of vehicles per time interval and percent trucks. A slight variation in the speed of vehicles in separate observations could cause enough variation in the resulting mean headway to affect the regression line. To reduce this possible effect of varying speeds on the resulting headways those conditions, which had a ratio of mean headway to standard deviation of less than 2.0, were rejected. Figures 6 and 7 are a plot of the mean headways and standard deviations for the four time intervals for left and right lanes. The rejected data varies both with the sampled time interval and lane, and is generally in the low volume range.

TABLE 1

Regression Equation Terms of $Y = AX^B$
for Headway (Y) vs. Number of Vehicles (X)

LEFT LANE

Time Interval	% Trucks	Observations*	Range of X	A	B	r
15"	0	896	3-10	8.30	- 0.77	- 0.963
	30	514	3- 8	8.67	- 0.74	- 0.984
	100	60	3- 6	6.69	- 0.62	- 0.911
30"	0	493	4-15	16.71	- 0.81	- 0.944
	30	338	4-15	18.72	- 0.85	- 0.937
	50	121	4-11	12.09	- 0.62	- 0.950
	80	73	4-12	13.34	- 0.70	- 0.987
45"	0	420	4-15	27.26	- 0.87	- 0.936
	30	301	4-19	23.65	- 0.81	- 0.920
	50	128	4-17	21.76	- 0.75	- 0.932
	70	38	6-15	38.21	- 1.00	- 0.965
60"	0	240	5-16	30.36	- 0.80	- 0.884
	30	303	4-20	40.61	- 0.92	- 0.879
	50	125	4-15	33.72	- 0.85	- 0.907
	70	27	6-12	57.81	- 1.17	- 0.960

*Refers to the number of time observations, not vehicles.

TABLE 2

Regression Equation Terms of $Y = AX^B$
For Headway (Y) vs. Number of Vehicles (X)

RIGHT LANE

Time Interval	% Trucks	Observations*	Range of X	A	B	r
15"	0	433	3- 8	8.54	- 0.73	- 0.959
	30	616	3- 8	10.34	- 0.83	- 0.975
	100	504	3- 6	11.68	- 0.90	- 0.987
30"	0	262	3-12	18.73	- 0.84	- 0.944
	30	438	3-15	21.42	- 0.89	- 0.905
	50	312	4-13	21.96	- 0.90	- 0.961
	70	355	3-12	21.61	- 0.89	- 0.930
	80	405	4-13	20.55	- 0.85	- 0.973
	100	292	3- 9	22.56	- 0.90	- 0.956
45"	0	106	3-12	36.38	- 0.95	- 0.905
	30	290	3-15	29.82	- 0.86	- 0.926
	50	287	4-16	29.96	- 0.87	- 0.930
	70	282	3-15	34.34	- 0.92	- 0.873
	100	132	3-12	30.33	- 0.85	- 0.920
60"	0	29	5-12	51.02	- 0.96	- 0.919
	30	195	3-18	43.95	- 0.91	- 0.901
	50	244	4-19	49.71	- 0.95	- 0.890
	70	203	3-21	51.49	- 0.97	- 0.805
	100	58	3-11	38.81	- 0.85	- 0.934

*Refers to the number of time observations, not vehicles.

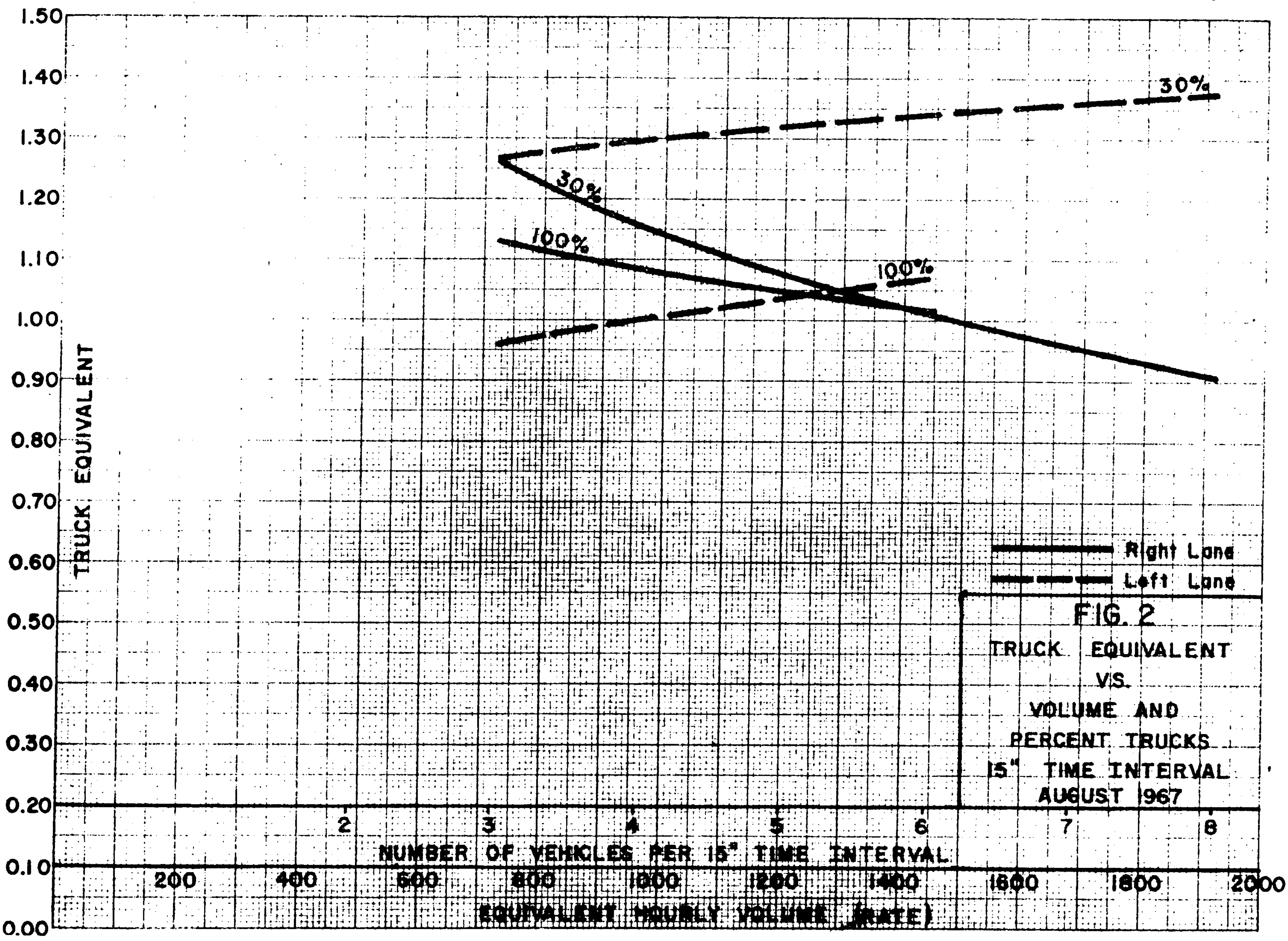

FIG. 2
TRUCK EQUIVALENT
VS.
VOLUME AND
PERCENT TRUCKS
15" TIME INTERVAL
AUGUST 1967

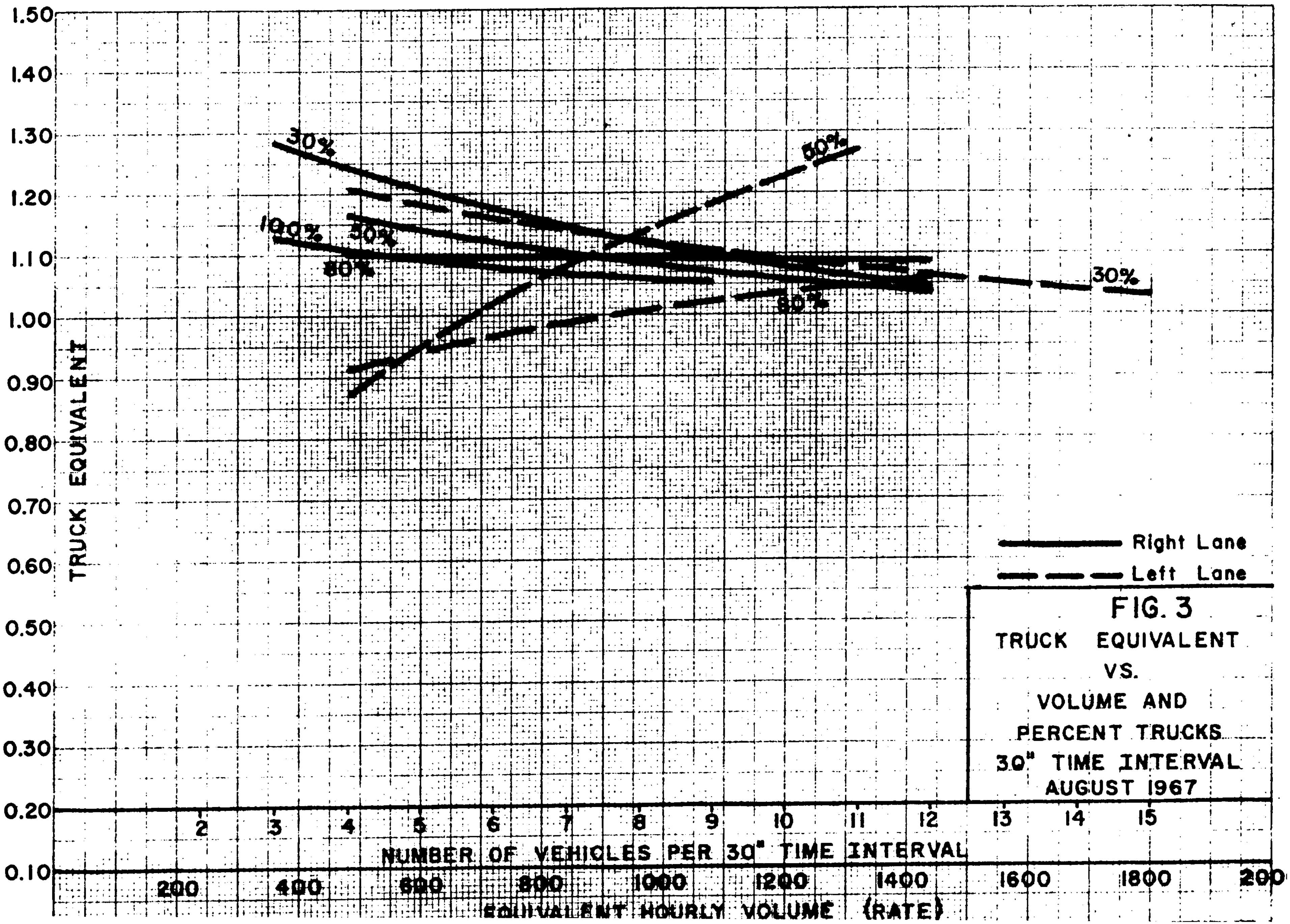

FIG. 3
TRUCK EQUIVALENT
VS.
VOLUME AND
PERCENT TRUCKS
30" TIME INTERVAL
AUGUST 1967

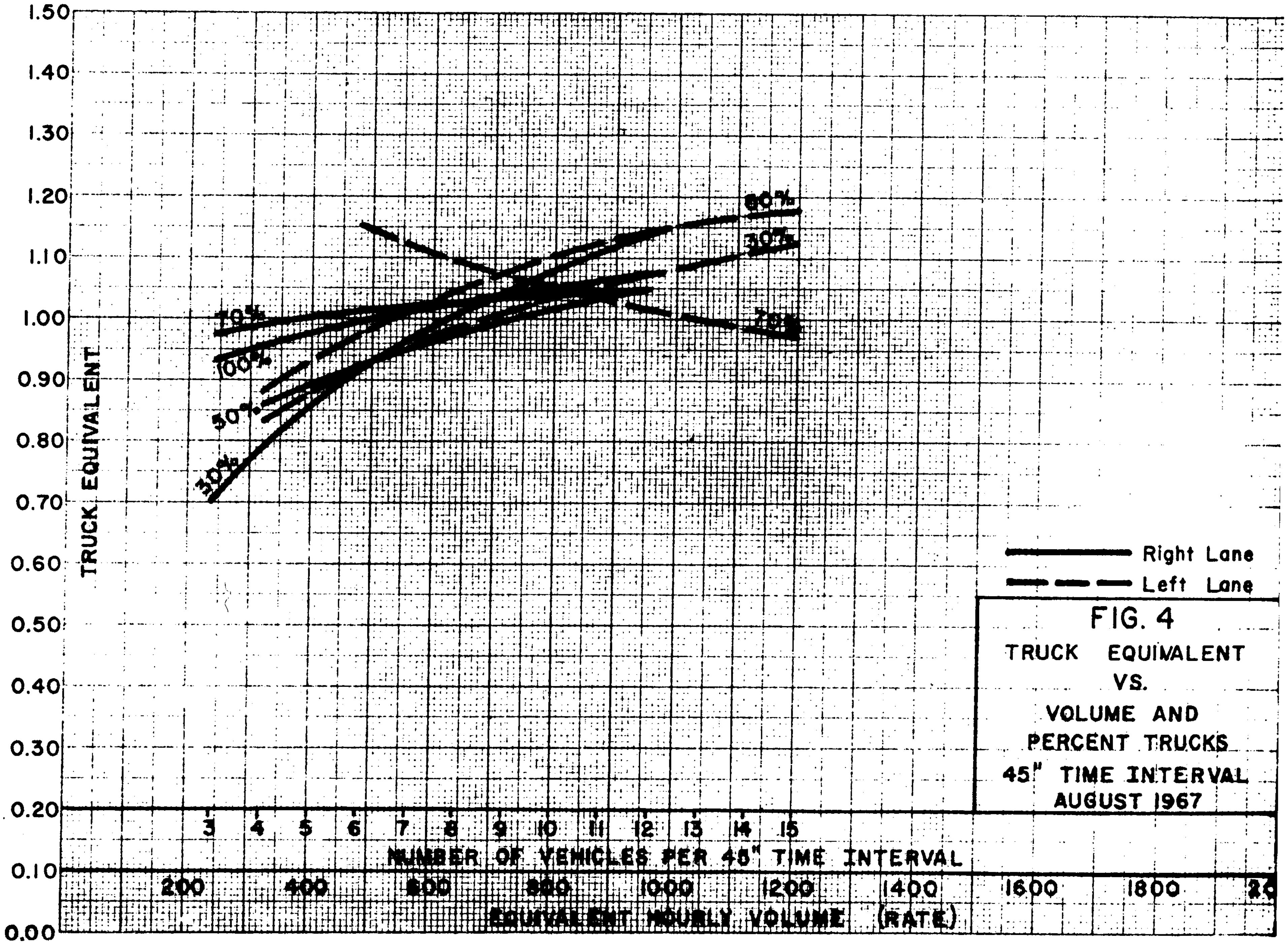

FIG. 4
TRUCK EQUIVALENT
VS.
VOLUME AND
PERCENT TRUCKS
45" TIME INTERVAL
AUGUST 1967

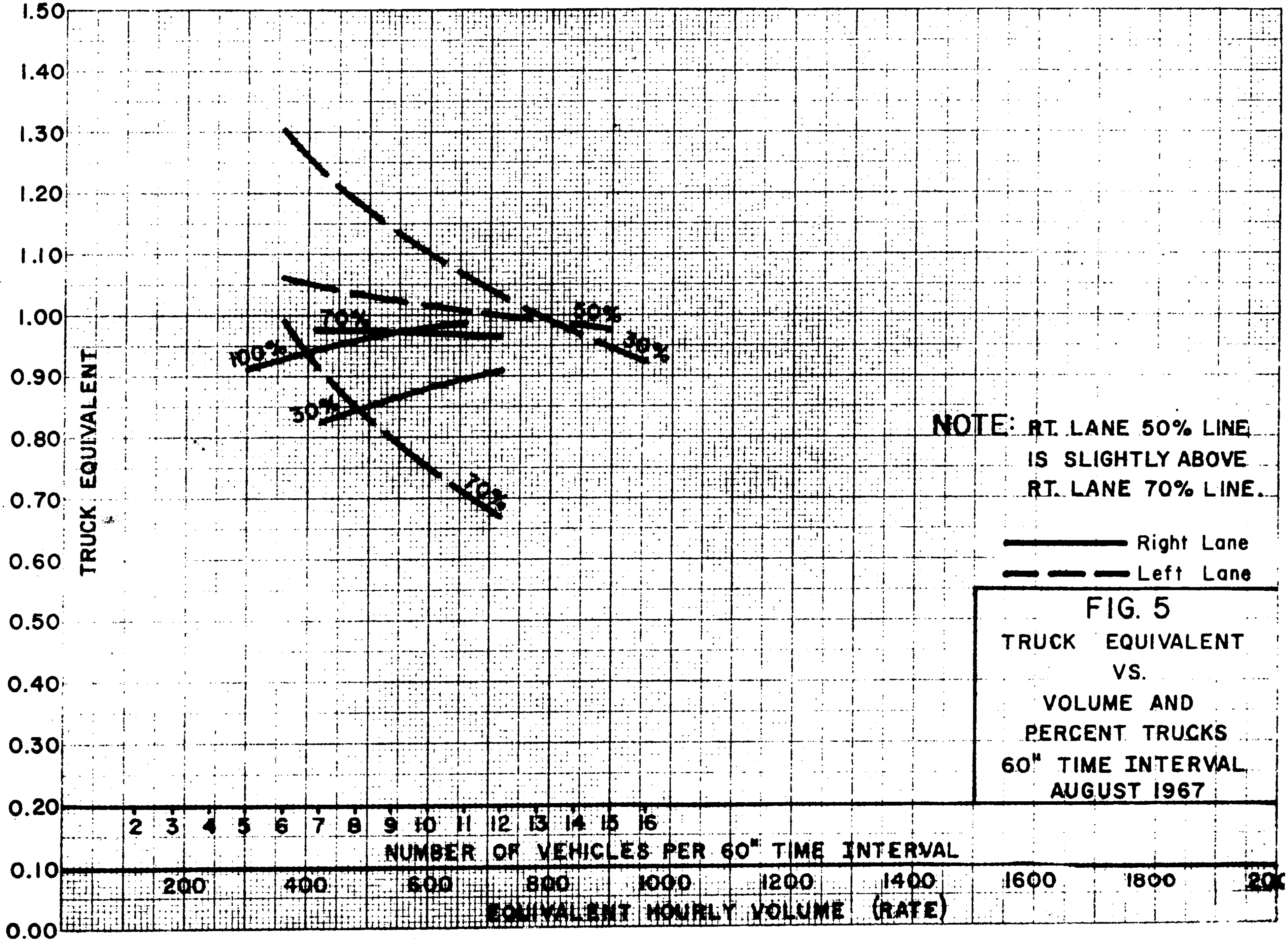

FIG. 5
TRUCK EQUIVALENT
VS.
VOLUME AND
PERCENT TRUCKS
60" TIME INTERVAL
AUGUST 1967

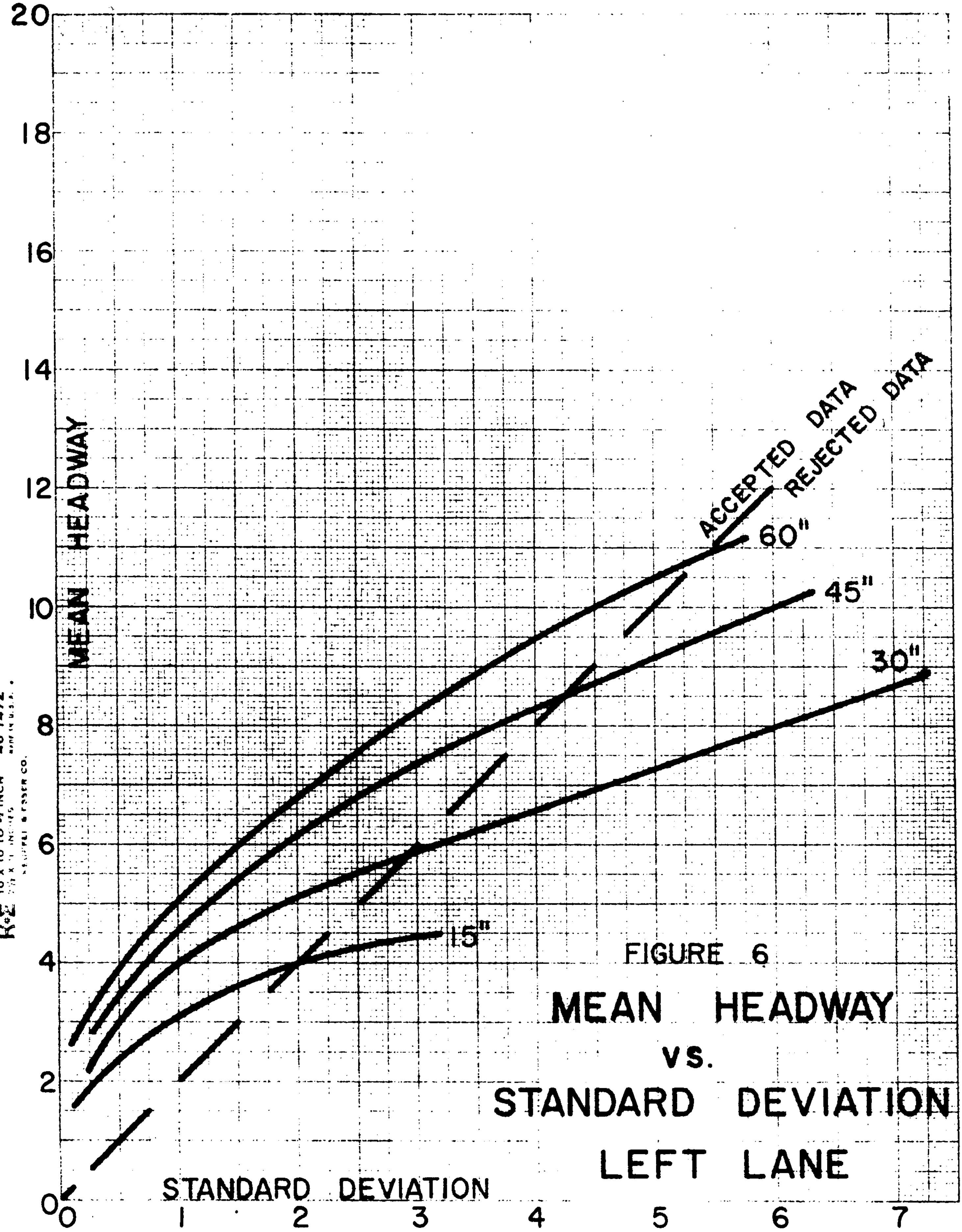

FIGURE 6

MEAN HEADWAY
VS.
STANDARD DEVIATION
LEFT LANE

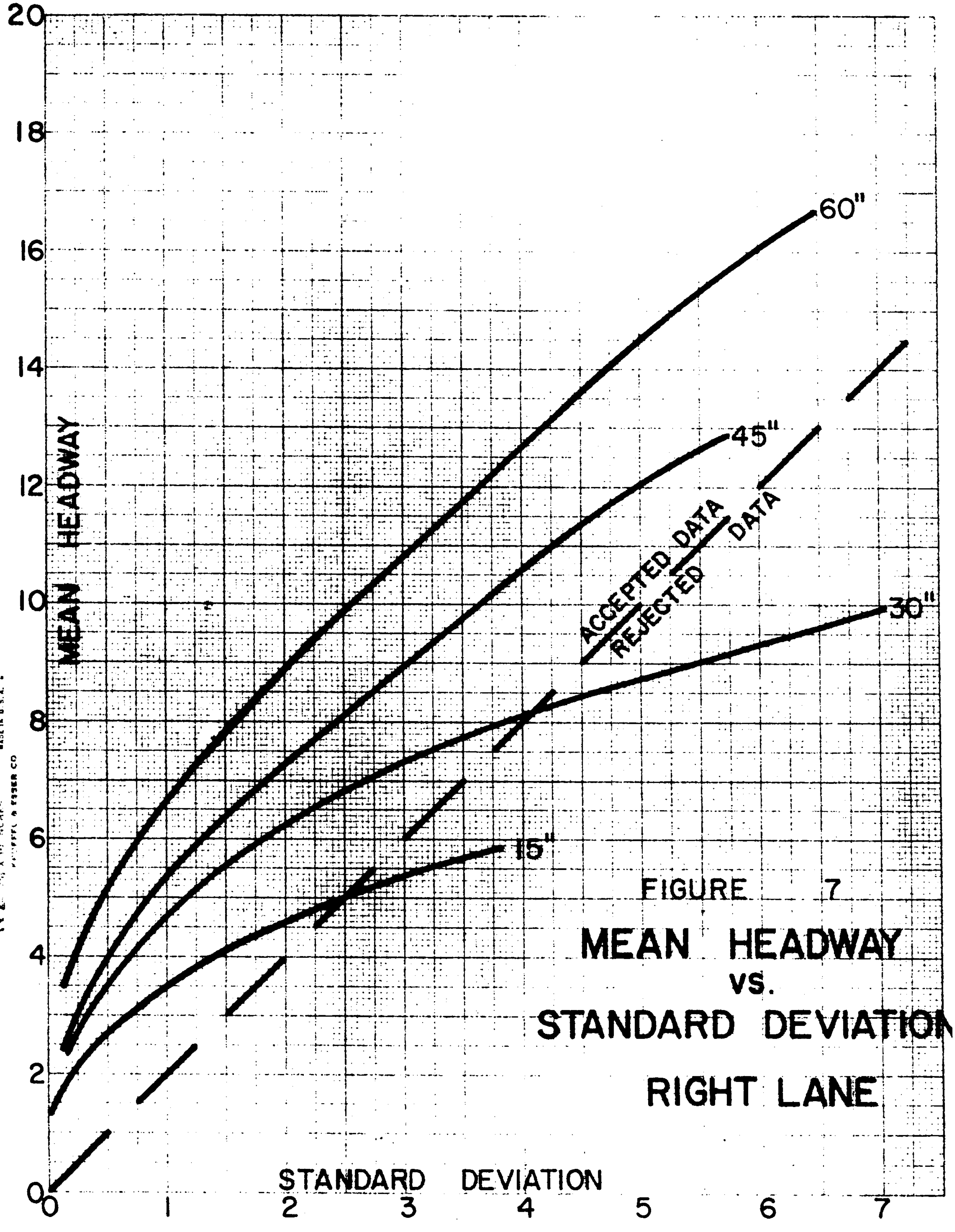

FIGURE 7

MEAN HEADWAY VS. STANDARD DEVIATION RIGHT LANE

CONCLUSIONS

Left Lane

1. The passenger car equivalent of trucks is apparently decreased by an increase in the percent of trucks in the stream.

2. Volume appears to have no effect on the equivalent factor, as the factor is approximately 1.10 throughout the range in volumes, even though there is a large variation throughout the range.

Right Lane

1. There is a large variation in the factor at the lower volume ranges, but as volume increases, the factor levels off at approximately 1.05.

2. There is apparently no variation in the factor with an increase in the percent trucks in the stream.

Overall, the presence of trucks in the left lane has a decreasing effect on the service volume above that of the right lane.

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REFERENCES

Highway Capacity Manual, HRB SR87, 1965, pages 101-4.

Truck Equivalency, D. W. Gwynn, 1966, New Jersey Department of Transportation

Traffic Flow Theory, HRB SR79, 1964, page 131.

Effect of Grades on Service Volume, K. Moskowitz and L. Newman, HRR 99, pages 224-43.

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ADDENDA

1. "Ramp" refers to Humboldt Street, a one-way, one-lane road feeding into the local roadway. (There is no change in elevation, as the name ramp implies.)

2. The local roadway has an AADT of approximately 16,000.

3. Data was collected at the following times:

   Friday, May 26, 1967 from 8:30 a.m. to 7:00 p.m.

   Wednesday, May 31, 1967 from 7:15 a.m. to 7:00 p.m.

   Thursday, June 1, 1967 from 7:15 a.m. to 7:15 p.m.

4. Data for both left and right lanes was taken at the same time, using a twenty-pen recorder and roadway tubes.

   Vehicle type was indicated manually with a keyboard connected to the recorder.