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This is to certify that the
thesis entitled
"A Study of Driver Behavior in Highway
To -Passing Zones"
presented by

James iv. Burge
has been accepted towards fulfillment of the requirements for
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# A STUDY OF DRIVER BEEAVIOR <br> IN HIGMUY MO-PASSINE ZONES 

## By <br> JAMES WILLIAY: BURGE

## AiN ABSTRACT

Submitted to the College of Engineering of Michiçan State University of Agriculture and Applied Science in partial fulfillment of the requirements for the degree of

FASTER OF SCIENCE

Department of Civil Engineering

1956

AFPROVED


It is the policy of the Kichigan State Hichway Department to install a reflectorized sign stating "do not pass", on the right shoulder of the roadway at all no-passing zones. This is used in conjunction with pavement markings.

The Michigan State Highway Department reccived several letters from motorists suggesting that a similar sign be placed on the left shoulder of the roadway.

It was decided that a study should be conducted to determine if the additional sign would be of value.

Test areas with one and t:wo signs were studied and the per cent of drivers violating the no-passing zones in each area determined. It was found that the signs had a definite effect on motorist behavior. The additional signs reduced violations of no-passing zones on three-lane highways an average of forty per cent.

In two-lane highway areas the per cent of zone violations was so small that it was decided that the additional sign could be elininated from consideration for two-lane highways.

A study of accidents occurring on three-lane highways ras conducted to supplement the field study. The results of the accident study indicated that almost one third
of all accidents on three-lane highways in rural areas involve passing maneuvers. In 1955, over one passine accident per mile of three-lane pavement occurred.

It was decided on the basis of the total number of passing accidents that the additional sign should be recormended for installation on three-lane highways.

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I would like to extend srecial thanks to Walker Wright of the Michigan State Highway Department and Orin Lucas of the Michigan State Police who aided me in the preparation of the section dealing with passing accidents.

Joseph Marlowe and Robert Rigotti who initiated the study and Harold Sundstrom who assisted me in the collection of field data also provided invaluable assistance.

And to all the members of the Planning and Traffic Division of the Michigan State Highway Department who were always willing to help a green engineer, I can only say it was a pleasure to be associated with you.

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## INTRODUCTION

Each year the Michican State Highway Department receives numerous letters from motorists suggesting steps they feel should be taken to improve our highways. Many of these letters are valueless, but occasionally some of them offer suggestions which later are adopted and become standard practice.

In this respect the profession of Traffic Engineering differs from that of the structural engineer or the electrical engineer. People are inclined to gaze on such professions with feelings of awe and deep respect. Not so with respect to the traffic engineer. Citizens have the right to drive and own automobiles and so they also feel they have the right to make suggestions as regards traffic improvements. This often proves to be a deep headache to the traffic engineer but occasionally it proves to be of great benefit to him.

This thesis was originated due to such suggestions by Michigan motorists.

It has been the practice of the Kichigan State Highway Department when installing highway no-passing zones on two and three lane hichways in areas of limited sight distance to install the standard yellow line to indicate the
location of a no-passing zone. In addition they also place on the right hand side of the roadway a sign stating "do not pass" at the beginning of the zone; and a sign stating "pass with care" at the end of the zone. ${ }^{1}$

The "do not pass" sign will hereafter be referred to as an R-4 sign, its Michigan State Fighway Department nomenclature.

Many motorists have felt that the $R-4$ sign was not in the proper location to be effective. They felt that when a motorist in a string of traffic or behind a large truck was attempting to make a passing maneuver he was looking to the left in order to see any opposing traffic, and for this reason the signs on the right were slipping by unobserved. They felt that the addition of another R-4 sign on the left side of the roadway would reduce the number of violations of no-passing zones.

If a driver whose vision was blocked by a truck would swing out to pass he would be met by an $\mathrm{R}-4$ sign.

The value of the additional sign was debatable. Many engineers felt that Michigan, by providing signs as well as pavement markings, had more than adequately provided for nopassing zones. Others felt that the value of the additional sign would prove to be negligible. It has been felt by many

[^0]traffic experts that there is such a thing as over-signing an area and that an increase in the number of necessary signs would only serve to reduce their over-all effectiveness. Some engineers have stated that signs have no appreciable effect on traffic.

It.was decided that a detailed study should be conducted in the field of driver behavior in no-passing zones to determine if the extra sign was desirable and to estimate what effect it might have in reducing accidents which is the primary purpose of such devices.

## REVIEW OF IITERATURE

Publications of the Highway Research Board and the Institute of Traffic Engineers were checked to see if any previous studies of this nature had been conducted. The Highway Research Board furnished a list of publications which would be of value.

The Missouri State Hiǧhray Department had conducted a study ${ }^{2}$ to compare the effectiveness of their method of pavement markings used to desicnate no-passing zones with the national standard pavement markings as used in Michigan. In Missouri, the pavement markings indicating a nopassing zone are placed in the center of the driving lane rather than adjacent to the centerline.

A comparison was obtained by observing test sections on similar sections of trunkline and tabulating the number of violations of each type of section. They found no appreciable difference between the two systems of pavement markings.

Detailed tests have been conducted to determine the characteristics of passenger vehicles. One of the most interesting tests utilized a multiple pen recorder with

[^1]detector tubes to determine the relative position of vehicles as they passed through a test section. ${ }^{3}$

In this manner the time and distance required to complete the average passing maneuver was determined.

Separate investigations had been made to determine the characteristics of vehicle operation on horizontal 4 and vertical ${ }^{5}$ curves. In both tests multiple pen recorders in conjunction with tube detectors spaced alone the highway were used to determine vehicle speeds.

The tests were primarily concerned in determining what changes in velocity take place as a vehicle traverses a horizontal or vertical curve.

No studies to determine the effect of signs in nopassing zones could be located. The number of accidents occurring yearly in no-passing zones also could not be determined from available literature. It was felt that this research would have to be undertaken in order to arrive at any conclusions as to the value of the additional signs.

[^2]
## IEFHCD OF STUDY

It was decided to conduct research in two separate sections; a field study of motorist reaction to $\mathrm{R}-4$ signs, and a check of accident records to determine what types of passing accidents were most prevalent and what steps could be taken to reduce them.

It was decided to conduct the field study by observing ve'i.cles movine through no-passing zones and tabulating the number of violations. Venicles were observed on both two and three lane hichways.

The following definitions will prove helpful in analyzing the field study.
(a) Definitions:

1. Partial Violation: Vehicle clips the ends of the yellow line; vehicle swings out over yellow line but fails to make complete crossover.
2. Full Violation: Vehicle completely passes over the yellow line while passing another vehicle; vehicle crosses over the yellow line then returns to leçal lane.
3. Single Study: A section of trunkline where a study was conducted with a single standard
sign in place; then following the addition of a supplemental sign on the left side of the roadway a follow-up study was conducted. (See Figure 1)
4. Double Study: A section of trunkline where a comparison was obtained by observation of motorists passing through a standard no-passing zone, then passing through an experinental zone. (See Figure 2)
(b) Conduct of Samples:

Two observers conducted the field operational phase of this study. Both observers were well hidden from traffic and their departmental car was out of sight. Vehicles were checked by volume, or on an hourly basis, or both for three classifications:
(I) Non-Violations
(2) Partial Violations
(3) Full Violations

Vehicles were classified as to passenger cars or trucks. The sample taken was directional in all instances; for example, in the case of the single study samples, one observer counted eastward moving vehicles passing through the standard $R-4$ test zone and the supplemental $R-4$ test zone while the other observer did likewise for westward moving vehicles. For double study samples, both observers checked vehicles moving in one direction, one observer
stationed near a standard R-4 zone and the other observer located adjacent to an experimental R-4 zone. This method was followed for both directions of traffic.

Coordination between observers was obtained through the use of field radios supplied by the Michigan State Police.

Traffic flows were observed at various hours to include both peak volume and nornal day and night volume. A study at dusk was also counted.

Two and three lane pavements were selected for the study since they afforded an opportunity to examine motorist reaction under varying trunkline conditions.

In the selection of test sites, consideration was given to problem areas, such as the US-16 and Meridian Road junction, and the US-16 and M-47 junction.

The double study zones were located in areas in which the succeeding no-passing zones had similar characteristics. Two were located on three-lane sections of US-16, and two were located on two-lane sections of US-27. (See Figure 3 for location of test areas.)

The entire period of field observations was conducted under excellent weather conditions.


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## TEST AREA LOCATIONS



Test Area A-l: Single Study Problem Area three-lane highway.
Test Area A-2: Single Study Problem Area three-lane highway.
Test Area A-3: Double Study Test Section three-lane highway.
Test Area A-4: Double Study Test Section three-lane highway.
Test Area B-l: Double Study Test Section two-lane highway.
Test Area B-2: Double Study Test Section two-lane highway.



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## TEST AREA LOCATIONS



Test Area A-1: Single Study Problem Area three-lane highway. Test Area A-2: Single Study Problem Area three-lane highway. Test Area A-3: Double Study Test Section three-lane highway. Test Area A-4: Double Study Test Section three-lane highway. Test Area B-l: Double Study Test Section two-lane highway. Test Area B-2: Double Study Test Section two-lane highway.

## TEST AREA A-1

This area was located approximately 19 miles east of Lansing, Michigan at the intersection of US-16 and M-47. This was a three leg intersection with a heavy left turning movement from US-16 to $M-47$. Approaching this intersection from the west the yellow line marking the no-passing zone was nearly obliterated and the no-passing zone sign had been removed.

Traffic approaching from the east on US-16 traversed a $2^{0}$ horizontal curve. A 400' transition distance was provided to allow right turns from US-16 to M-47. Throughout the immediate area the general road surface was level. The enclosed photographs of the area will give an idea of the existing situation.

Traffic at this intersection was studied prior to the installation of additional signs; then an after study was conducted. The study was conducted during early morning hours.

The primary problem for drivers at this intersection were vehicles stopped in the center lane waiting to make a left turn. This made a passing maneuver hazardous.

No speed limit existed at this location and the average speed of vehicles in this area as determined from

Michigan State Police reports was 50.1 mph .

The following data was obtained:

Single Sign Study conducted 23 June 1955 fron 0700 to 0830 hrs.

Double Sign Study conducted 24 June 1955 from 0700 to 0830 hrs .

| STUDY | DIRECTION | NV | F | FV | PV | 万VIOL |
| :--- | :---: | ---: | ---: | :---: | :---: | :---: |
| Before | Eastbound | 228 | 5 | 3 | 3.1 | 34 |
| After | " | 213 | 5 | 2 | 3.2 | 27 |
| Before | Westbound | 317 | 17 | 7 | 7.0 | 19 |
| After | " | 285 | 2 | 7 | 3.0 | 21 |

The eastbound traffic had only a slight reduction in total violations while in the case of the westbound traffic it was much more pronounced. The area as a whole had a reduction in violations of 50 per cent.

The over-all per cent of violations for double signed areas on three lane highvays throughout the tests averaged approximately three per cent.

One possible explanation for the low per cent of violations in the eastbound direction is that drivers realize that the center lane may be occupied by a left turning vehicle and for this reason they are reluctant to make a passing maneuver.

* See Page 7 for explanation of tables.




## TEST AREA A-2

This area is located on US-16 at the junction of Meridian Road, approximately five miles east of Lansing, Michigan.

A number of factors combined to make this a problem location. Meridian Road did not cross at one definite location, rather what existed was a pair of three leg intersections. The area was further complicated by traffic interferences from the Red Cedar Tourist Park, and the Cedar Bend grocery store and gas station.

Vehicles approaching from the east are confronted with approximately 16 signs in a short distance. The entrance to North Meridian Road is partly obscured by trees.

Vehicles approaching from the west approach from a downgrade followed by a slight curve. In the center of the area is a slight dip of about three feet plus a bridge, three lanes in width, crossing the Red Cedar River.

Four studies were made in this area. The first was conducted to determine the percentage of violations occurring with the present single signs in position. The second study was made to determine what effect an additional sign would have on drivers. The third study was made approximately two months after the previous study to try and
ascertain whether the additional sign would tend to lose its value after a certain period of time.

The fourth study was made at dusk to determine what per cent of passing violations occurred at this time.

No speed zone existed through the area and the average speed of vehicles through the area exceeded 53 mph . The following data was obtained:

Single Sign study conducted 23 June 1955 from 1600 to 1730 hrs .

Double Sign study conducted 29 June 1955 from 1600 to
1730 hrs .
Double Sign study conducted 24 August 1955 from 1600 to 1730 hrs .

| STUDY | DIRECTION | NV | FV | PV | \% VIOL | \% TRUCKS |
| :--- | :---: | ---: | :---: | :---: | :---: | :---: |
| Before | Eastbound | 841 | 16 | 13 | 3.3 | 7.7 |
| 29 June | " | 781 | 2 | 13 | 1.9 | 6.2 |
| 24 August | $"$ | 807 | 7 | 6 | 1.6 | 6.1 |
| Before | Westbound | 397 | 13 | 8 | 5.0 | 13.2 |
| 29 June | $"$ | 412 | 5 | 5 | 2.4 | 12.9 |
| 24 August | $"$ | 469 | 13 | 4 | 3.5 | 16.9 |

The dusk study was conducted October 13 th and 19th for a 55-minute period.

| DIRECTION | NV | FV | PV | $\%$ VIOL | $\%$ TRUCKS |
| :--- | :---: | :---: | :---: | :---: | :---: |
| Eastbound | 406 | 2 | 2 | 1.0 | 7.5 |
| Westbound | 227 | 5 | 2 | 3.0 | 17.6 |

The results of the tests conducted during daylight hours were very gratifying. The average per cent of violations dropped from 3.9 to 2.05. The test conducted two months later had a per cent of violations of 2.30 , indicating that the signs tended to retain their effect upon drivers.

One of the probable reasons for the effectiveness of the signs in this area was the fact that the additional signs were in a location in which they were not competing with additional signs for driver attention.

The dusk study had an average per cent of violations of 1.75 indicating that drivers are reluctant to pass under a condition of near darkness. Six of the seven full Violations in the dusk study occurred in the last fifteen minutes of the study after many opposing drivers had turned on their headlights and the visibility of the signs had been sharply reduced. For this reason it is felt that the additional signs would have little value after darkness.


## TEST ARPA A-3

This area is located on US-16 approximately two miles east of East Lansing, Michigan. It is characterized by slight dips of short duration which necessitate no-passing zones but which give to the driver the impression that he has sufficient sight distance. The grades encountered are not of a length or steepness that would cause difficulty to trucks.

The same traffic was observed through both single and double signed sections with the result that vehicle classification did not change. A total of 250 vehicles were observed passing through the test area in each direction, making a total of 500 vehicles studied. A night study was also conducted at this location in order to determine what effect the additional sign would have on night traffic.

Care was taken in the selection of the area that the succeeding no-passing zones be as similar as possible. In both directions the driver first passes through a single signed section and then through a double signed section. As the same vehicles were observed passing through both zones it was felt that a number of possible variables such as differences in driver traits were eliminated.





This area is located on US-16 approximately two miles east of Williamston, Michigan. It is definitely rolling in nature although the grades do not cause any serious problem for trucks. Little roadside interference is present.

It was selected as a standard test area and one study was conducted at this location.

The following data was obtained:

| \# SIGNS | DATE | TIME | DIRECTION | NV | FV | PV | \%VIOL |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Single | 27 Jun | 0910-1005 | Eastbound | 233 | 8 | 9 | 6.8 |
| Double | " | " " | " | 240 | 0 | 10 | 4.0 |
| Single | " | 1015-1100 | Westbound | 243 | 0 | 7 | 2.8 |
| Double | " | " 1 | " | 241 | 0 | 9 | 3.6 |

A reduction in passine violations from 4.8 to 3.4 per cent was obtained at this location. The westbound results were not consistent with the eastbound results but this could be expected to occur through normal probability of occurrence.

The combined test area results for the standard area daytime studies (Areas A-3 and A-4) indicated a reduction from 5.1 to 3.1 per cent for a total reduction of passing violations of 40 per cent. It is felt that enough observations were made that this figure can be assumed to be reasonably representative of the situation.

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This area is located on US-27 northeast of Potterville, Kichigan. The area is definitely rural in nature and the contour of the land is sharply rolling. The pavement is two lanes in width.

It was selected as a standard test section for twolane highways. The same procedure was followed in gathering data as was used in the case of three lane highways.

US-27 is heavily traveled and during the test the average volume of truck traffic was 13.5 per cent.

The following data was obtained:

| \# SIGNS | DATE | TIME | DIRECTION | NV | FV | PV | $\%$ VIOL |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Single | 28 Jun | 1345-1458 | Eastbound | 249 | - | V | 0.4 |
| Double |  |  |  | 249 | 1 | - | 0.4 |
| Single | " | 1500-1556 | Westbound | 247 | - | 3 | 1.2 |
| Double | " | 1500-15 | Westbound | 246 | 2 | 2 | 1.6 |

As may be seen in the above data, the results were inconsistent. The per cent of passing violations was so low that no accurate trends developed. However, the small percentage of total violations in this area indicates that drivers are much less likely to violate a no-passing zone on a two-lane highway than on a three-lane highway and indicates that the additional sign may not be warranted for two-lane hichways.

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## TEST AREA B-2

This area is located on US-27 northeast of Charlotte, Michigan. The area is rural in nature and the contour of the land is sharply rolling. The area was selected as a standard two-lane highway test section.

The average percentare of the traffic volume composed of trucks during the test was 20.5 per cent.

The following data was obtained:

| \# SIGNS | DATE | TITE | DIRECTION |  |  | I | \% VIOL |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Single | 28 Jun | 0935-1045 | Eastbound | 248 |  | 2 | 0.8 |
| Double |  |  |  | 250 | - | - | - |
| Single | " | 1049-1250 | Westbound | 245 |  | 5 | 2.0 |
| Double | " |  |  | 250 | - | - | - |

The results in this area also were inconclusive. One noticeable item was the complete lack of full violations. This bears out the contention that the additional sign is not necessary for two-lane highways.

Averaging the results together of test areas B-1 and $\mathrm{B}-2$ shows a reduction in violations in the double signed areas but the number of violations observed was so slight that the probability of the statistics being in error is great.



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## ANALYSIS OF FIELD DATA

The resultsof the studies conducted on the threelane highways were very encouraging as a whole. In all cases the additional sign caused a reduction in violations of no-passing zones. Reductions ranced from eightcen to fifty per cent of the number of violations reported for the zones with only a single sign installed. (See Figures 4 and 4).

Of particular importance is the high percentage of violations in three-lane highway no-passing zones. Even with the additional sign the percentage of violations was still over three per cent. This indicates that the additional sign, although helpful, will not completely remedy the situation.

The night study, although not extensive, tends to indicate that drivers maintain this high rate of violations after dark. The value of the additional sign at night appears to be sharply reduced.

The dusk study indicated that drivers tend to reduce passing maneuvers at twilight until all drivers have turned on their headlights. After that point is reached, drivers tend to focus their attention upon the headlights of opposing drivers rather than upon traffic control devices such as reflectorized sicns and pavement markings.

Figure 6)
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The results of the tests on two-lane highways (See Figure 6) were somewhat inconclusive as the number of violations noted was so slight that no definite trends or patterns could be detected.

However, the over-all violation rate of only 1.1 per cent was so low that it is felt that any improvement of traffic conditions would probably be so slight that expenditures for additional signs are not warranted. For this reason, it is felt that the additional siçn can be eliminated from consideration for two-lane highways.

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## PASSING ACCIDENTS STUDY

It was decided that a determination of the number of passing accidents occurring on three-lane highways and their general characteristics would be of value in completing the study. Unfortunately, this information was not readily available. Not even a rough estimate of the number of accidents could be obtained.

It was decided to check the individual accident reports for three-lane highways for the first nine months of 1955. The number of accidents and their general type were tabulated as well as the date and time of their occurrence. The number of passing accidents occurring in speed control zones and no-passing zones is still in doubt because each accident of this type requires that a special entry be made on the standard accident report form. (See Traffic Control box, Figure 7.)

A total of 586 accidents were scanned and of this number 179 occurred because of an attempted passing maneuver. There were six general types of passinE accident.

1. Sideswiping: Either sideswiping the vehicle passed or sideswiping a vehicle approaching from the opposite direction. Often vehicles approaching head-on would swerve and the vehicles would sideswipe.
2. Passing and being cut off: This was an all too frequent type of accident, in which a vehicle would be passing another vehicle or group of vehicles when one of them would swing out and an accident would result.
3. Passing and losing control: The driver would lose control of his vehicle when making a passing maneuver and run off the roadway.
4. Passing and hitting the rear end of a left turning vehicle: A vehicle would swing out to pass and run into the rear end of a left turning vehicle.
5. Passing and cutting in: Attempting to cut in a column of vehicles after completing a passing maneuver.
6. Passing--head-on collision: Two vehicles occupying the center lane in a passing maneuver and colliding directly.

Ionthly accidents were plotted against the average daily traffic per month on three-lane highways as determined from continuous counting stations. (Figure 9) Accidents by hour of occurrence also were plotted against hourly traffic volumes. (Figure 8)

Ficure 8 indicates that a large number of accidents occur after darkness and at a time of low traffic volumes. It is doubtful if additional signs will help drivers in this category.

Figure 9 indicates that passing accidents reach a
peak in June although the peak traffic volumes do not occur until August. Also accidents are at a minimum during winter months when pavement markings are likely to be obscured by weather conditions.

Only 8 out of a total of 179 passing accidents were listed as having occurred in a no-passing zone. The accuracy of this particular section of the accident report is debatable. Should this section be accurate, it would indicate that the small number of accidents occurring in nopassing zones would not warrant the installation of additional signs.

It is felt that little reliance can be placed upon this and that the figure of 179 total passing accidents should be used as the basis for a decision. As there are only 180 miles of three-lane pavement in the state of Michigan the passing accident rate for the year will surpass ona accident per mile of higlnay.

It is felt that the number two form of accident, passing and being cut off, could be reduced by requiring the installation of side view mirrors on all automobiles. At the present time, side view mirors are required for trucks but passenger cars are not required to be so equipped. This is a prevalent form of accident on four lane divided and undivided highways also.
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peak in June although the peak traffic volumes do not occur until August. Also accidents are at a minimum during winter months when pavement markings are likely to be obscured by weather conditions.

Only 8 out of a total of 279 passing accidents were listed as having occurred in a no-passing zone. The accuracy of this particular section of the accident report is debatable. Should this section be accurate, it would indicate that the small number of accidents occurring in nopassing zones would not warrant the installation of additional signs.

It is felt that little reliance can be placed upon this and that the figure of 179 total passing accidents should be used as the basis for a decision. As there are only 180 miles of three-lane pavement in the state of Michigan the passing accident rate for the year will surpass one accident per mile of highway.

It is felt that the number two form of accident, passing and being cut off, could be reduced by requiring the installation of side view mirrors on all automobiles. At the present time, side view mirors are required for trucks but passenger cars are not required to be so equipped. This is a prevalent form of accident on four lane divided and undivided highways also.


VIOLATIONS IMDICATED
(Cheek One or More for Esech Vehlielo)




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(Explain in Remarks)
Was road under construction or repair? $1 \square_{2} \quad \square$
Was road a detour?
REMARKS AND RECOMMENDATIONS
Should driver be reexamined to determine his competency for a license?

$\square$ Sbould acene of accident receive traffic engineering attention? Why? Did you invertigate thin aocident at the soene of ita oocurrence?
Indicate on this Diagram What Happened

1. Draw heavy lines to show streete 2. Name streets
2. Draw arrow pointing north
3. Show veh. and ped. thus. 4. Show veh. and ped. thus.
Vehicles
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4. Show angle of collision

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ACCIDENT TABULATIONS
(From $1 / 1 / 55$ to $10 / 15 / 55$ )

| TYPE | ACCIDENTS | INJURIES | DEATHS | SPEED <br> ZONE | NO PASSING <br> ZONE |
| :--- | :---: | :---: | :---: | :---: | :---: |
| Sideswiping | 54 | 32 | 0 | 18 | 0 |
| Cut off by <br> Passer | 34 | 3 | 0 | 11 | 1 |
| Losing Control | 33 | 39 | 0 | 8 | 2 |
| Hitting Left- <br> Turning Vehicle | 23 | 6 | 0 | 10 | 1 |
| Passing and <br> Cutting In | 23 | 6 | 3 | 2 | 4 |
| Head-on Collision | 12 | 11 | 6 | 8 | 0 |
| TOTALS | 179 | 97 | 9 | 57 | 8 |

ACCIDENTS BY HIGHHAY

| ROUTE | PASSING <br> ACCIDENTS | TOTAL <br> ACCIDETTS | PER CENT <br> WITH TRUCKS | INJURIES | DEATHS |
| :--- | :---: | :---: | :---: | :---: | :---: |
| US-12 | 36 | 103 | 47 | 22 | 1 |
| US-16 | 71 | 249 | 35 | 32 | 2 |
| US-24 | 48 | 159 | 69 | 31 | 6 |
| US-25 | 24 | 75 | 17 | 9 | 0 |

SUITIARY AND CONCLUSIONTS

It was demonstrated by the results of the field study that the additional sign did have a beneficial effect on motorist observance of no-passing zones.

In the three-lane standard test sections a reduction In violations of forty per cent was obtained. The signs appeared to have their greatest value during daylicht hours and their effect upon motorists was sharply reduced during darkness. The field study also indicated that the additional sign was not a complete solution to the problem for three-lane highways. Approximately three per cent of the drivers traversing the average no-passing zone will still violate it.

The field study in two-lane hichway areas indicated that the number of drivers that violate a no-passing zone on a two-lane highway are in such a minority that any improvement of the situation by installing additional signs would probably be slight. It is felt that the additional sign is not warranted in this case.

The results of the passing accident study' show that passing maneuvers are involved in almost one third of a.ll three-lane highway accidents in rural areas. Over one passing accident per mile of three-lane highway occurred

In 1955. Nine deaths and ninety-seven injuries resulted from these accidents alone in the first nine and one-half months of 1955.

It is felt that any measures that can be taken to reduce this total should be inaugurated. Although the accident reports listed only eight of the accidents as having occurred in no-passing zones, it is felt that this is probably highly inaccurate and does not present a true picture of the situation.

The seriousness of the situation and the denonstrated value of the additional sign will warrant its installation on three-lane highways. The cost of the additional signs would be approximately eight dollars each installed. The total cost of signing all the three-lane highways would probably be less than three thousand dollars.

The question has been raised as to whether it would be a wise decision to double sien certain areas and leave other areas equipped with only a single sign. We are presently using in some problem locations double stop signs and double indication traffic signals. The same reasoning could also be applied to this situation.

A basic problem with highway signs is the firm of dirt and grime they accumulate over a period of time that
tends to reduce their visibility. 6 The additional sign should help to reduce the loss in sign effectiveness.

Another question has been raised is the effect upon drivers of the blank back of the signs when approaching from the opposite direction. It has been previously demonstrated that roadside objects do have an effect upon motorists. 7

In this case, any effect would be so slight that it would be necligible. Possibly the back of the sign could be utilized as a mounting for the safety posters now being installed upon highways.

[^3]
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5. "Speed Characteristics on Vertical Curves", Volune 32, Highway Research Board, B.A. Lefeve. pp. 395-413.
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[^0]:    ${ }^{1}$ Michigan Manual of Uniform Traffic Control Devices

[^1]:    2"Effect of Barrier-Iine Location at No-Passing Zones", Vol. 31, Hwy Research Bd, C.E. Prisk. pp. 356-374.

[^2]:    3"Procedure Employed in Analysis of Passing Vehicles" Vol. 18, Hwy Research Bd, E.H. Holmes. pp. 368-370 4"Driver Performance on Horizontal Curves" Vol. 33, Hwy Research Bd, A. Taragin, pp. 446-466 5"Speed Characteristics on Vertical Curves" Vol. 32, Hwy Research Bd, B.A. Lefeve. pp. 395-413

[^3]:    ${ }^{6}$ "Night Visibility", Bulletin 89, Highway Research Board 1954.
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