Pavement Markings

HARRY B. SKINNER
Executive Director
New Haven Parking Authority
City of New Haven, Conn.

The practice of using markings on the road surface has, rather recently, come into general acceptance throughout the country. This procedure is used for the following purposes:

1. To delineate the so-called pavement centerline, i.e., the longitudinal division of the road which separates the opposite directions of travel;
2. To delineate the intended lane divisions of the road;
3. To delineate the separation of that section of the road intended for normal operating use from the shoulder section—that section of the road for use by vehicles required, for one reason or another, to slow significantly or stop;
4. To delineate the edge of the road—that point beyond which it would not be safe for a vehicle to operate;
5. To define transverse pedestrian crossings of the road;
6. To designate the point at which a vehicle is intended to stop on the approach of an intersection controlled by a stop sign or traffic signal;
7. To mark the approach to a railroad grade crossing;
8. To define the presence of a dangerous obstruction to traffic;
9. To channelize traffic through large, difficult or odd-shaped intersections where the normal operating pattern is not evident to a motorist; and
10. To convey a message to the motorist or pedestrian (normally this practice is used to supplement standard signing for regulatory controls, not to replace signing).

To be effective, pavement markings have to be seen and understood during periods of daylight as well as at night. Most pavement markings are intended to control traffic at night as well as during the daylight hours, therefore, their placement with a nighttime reflective material becomes vital. Even in areas with a relatively high level of nighttime artificial illumination the general practice is to place pavement markings with a reflective material.

While operating a vehicle, a motorist's eyes scan the road ahead for a greater percentage of the total time than they scan the roadsides. Therefore, the placement of messages and driving controls for the motorist on the surface of the road is a more logical location than signs along the edge of the pavement. This type of placement has two distinct, and severe, disadvantages: climatic conditions and traffic volumes. In the northern part of the country, where ice and snow cover the pavement surface during part of the year, pavement markings become completely ineffectual during this period. This problem can also become quite severe during a rainstorm in any part of the country, particularly at night. A similar problem exists when handling traffic at such high volumes that it is on a virtual bumper-to-bumper basis. Obviously, if no gaps exist in the traffic stream there is no opportunity to see a pavement marking. Because of these limitations, regulatory traffic controls are practically always displayed on a sign and supplemented through the use of pavement markings. The one major exception is the use of lane directional controls, such as left-hand lane arrow markings. Here it may become too expensive or aesthetically objectionable to specify individual lane operations on overhead signs.

The professional traffic engineers' guide toward uniformity of all traffic control devices, the "Manual on Uniform Traffic Control Devices," recognizes the advantages of pavement markings by outlining, in great detail, the design of railroad grade-crossing markings. This manual also provides for the use of pavement markings for those other purposes previously outlined. At this time, there is a recognized need to survey the pavement marking practices presently employed throughout the country and to establish a uniform practice in the use of pavement markings similar to that which has, to a large extent, been achieved in signing. Several committees of the Institute of Traffic Engineers and the National Joint Committee on Uniform Traffic Control Devices are presently working toward this end.

During the early stages of the development of the nation's highway system the use of portland cement concrete as the construction material created a natural centerline delineation through the use of a longitudinal contraction joint. This joint was normally sealed with a petroleum base mastic compound that created a black centerline marking against the concrete pavement surface. Black impregnants were subsequently added to the cement topping to form a black centerline. With the advent of the extensive use of asphalt as a surfacing material the use of the painted line was developed to define the centerline. The use of this centerlining material substantially reduced the number of head-on accidents, particularly those that occurred at night.

Following the general acceptance of the centerline delineations, lane lines were employed to cut down the number of side-swipe accidents as well as to increase the capacity of multi-lane facilities by keeping traffic contained in well-defined lanes.

In a further effort to reduce accidents, longitudinal demarcations to separate the normal operating lane from the shoulder or pavement edge were developed.

After extensive investigation in Louisiana, it was found that edge lines so significantly moved traffic away from the edge of the pavement that no edge line would be used on two-lane roads less than 24 ft wide (1). On one test section which consisted of a 20-ft wide pavement on a 4-deg curve with a yellow double "no passing" stripe on the centerline, the use of edge lines caused an average encroachment of 0.6 ft over the centerline during daylight hours of operation on the outside of the curve and 0.2-ft encroachment on the inside of the curve.

Investigations also proved that the use of edge markings on a multi-lane divided facility definitely moved traffic in the inside and outside lane to the left. Traffic in the outside lane moved away from the right pavement edge and traffic in the inside lane moved toward the left pavement edge.

A study involving vehicles leaving the roadway on the right along the Merritt Parkway in Connecticut (2) shows that accidents attributable to driver inattentiveness were reduced from 50 during the last year of operation prior to the placement of edge line markings to 29 the first full year of operation after the placement of the markings, and to 26 during the third full year of operation.

This study also showed a tendency for cars to shift to the right, away from the centerline, after the edge line had been placed. This shift averaged 0.12 ft during hours of daylight operation and 0.41 ft during nighttime operation. The accident data available in connection with this study were not sufficiently reliable to prove a substantial reduction. However, the vehicle placement would certainly indicate a safer operation. Placement of the edge line also offered an additional element of security to pedestrians walking along the edge of the pavement. The study also indicated a more uniform speed of operation along the pavement having an edge line, particularly through a horizontal curve section.

An interesting innovation in the use of lane markings has been used in the City of Memphis, Tenn., at the intersection of East Parkway and Poplar. The Parkway north of Poplar, before its recent reconstruction, was a six-lane undivided section (Fig. 1). The Parkway, south of Poplar, was a six-lane divided roadway with a median of approximately a 40-foot width. The result was an approximately 25-ft offset to the left facing northbound traffic. This intersection configuration resulted in an accident frequency averaging 15 "sideswipe" and "fixed object" accidents each year before treatment. After the treatment, the average fell to 9 similar accidents for each year until the intersection was reconstructed, approximately four years ago. The treatment consisted of the placement of 4 by 6-in. plastic strips on 5-ft centers along the projection of the companion lane lines. These projected lane lines were placed along a gentle reverse curve through the intersection. The 4-in. dimension was placed longitudinally to the direction of movement. To overcome the possibility of any misunderstanding by

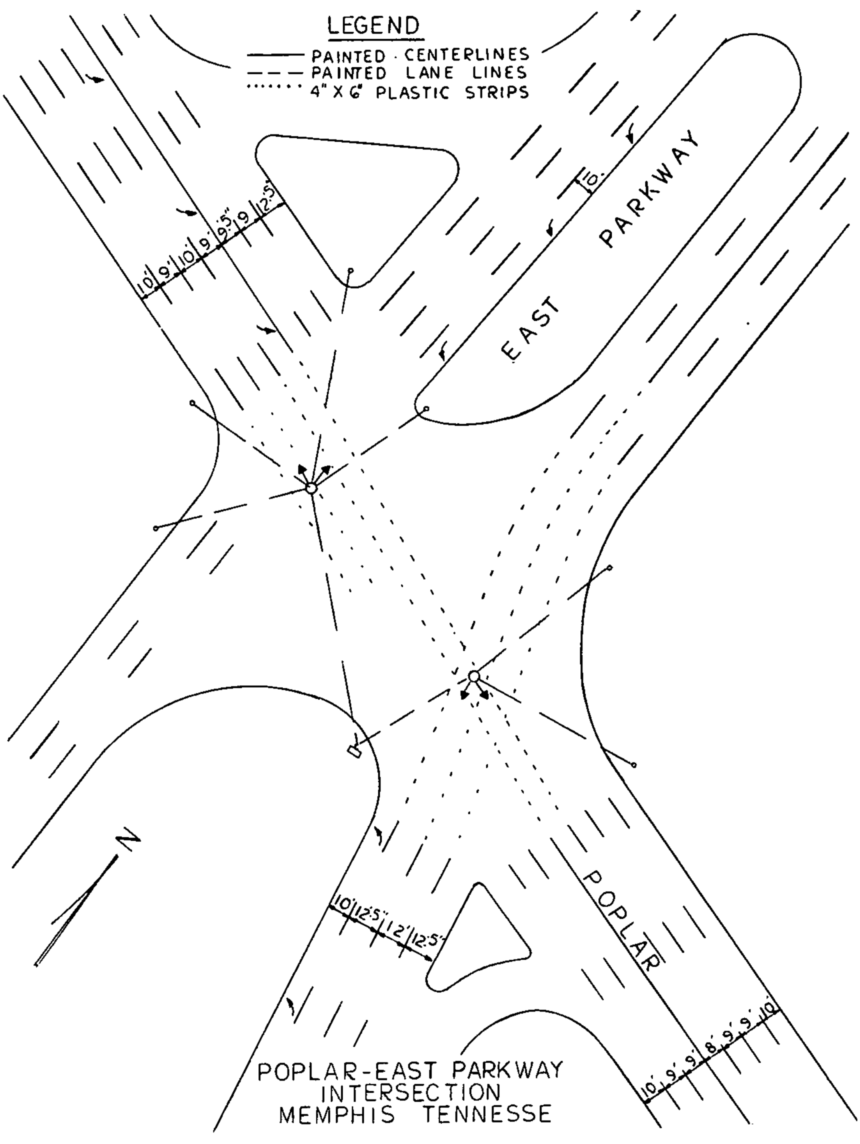
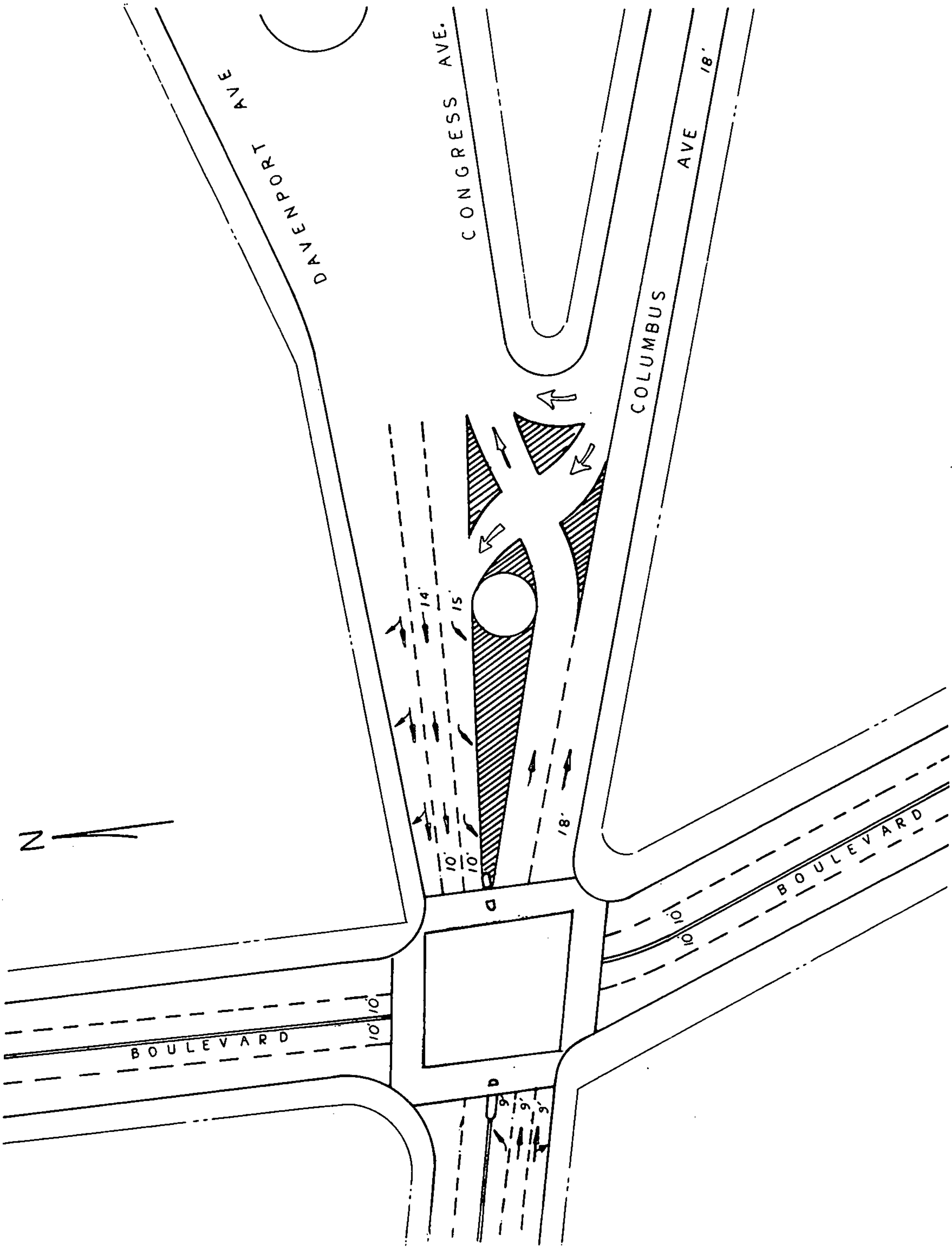


Figure 1.

cross traffic through the intersection, the 5-ft centers were placed randomly along the Parkway. The treatment resulted in no discernible pattern to the cross street traffic on Poplar and the presence of the lane markings through the intersection had no influence on this traffic.

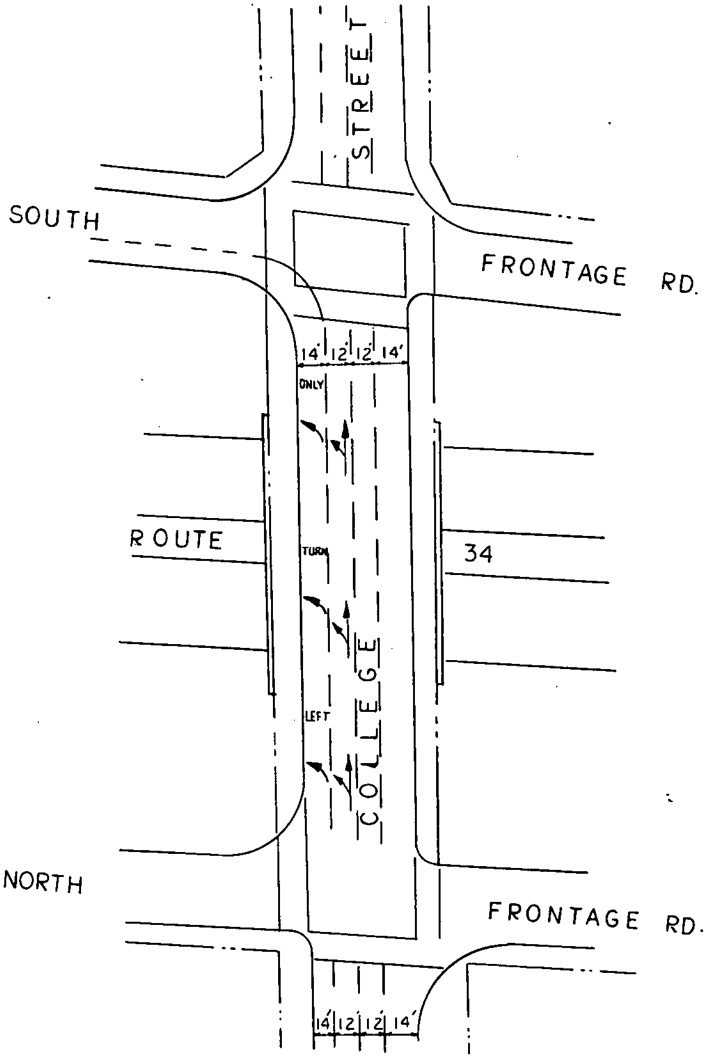
Figure 2 shows a typical program of channelization through a difficult intersection. The intersection accidents have been reduced from an average of 33 accidents per year before the treatment to 24 accidents per year after the treatment in spite of an increase in intersection volume from 30,000 to 34,000 veh/day.

A less impressive, but equally effective, treatment is shown in Figure 3. The accidents have been reduced from an average of 12 each year before the treatment to an



PAINT TREATMENT
COLUMBUS AVE # BOULEVARD

Figure 2.

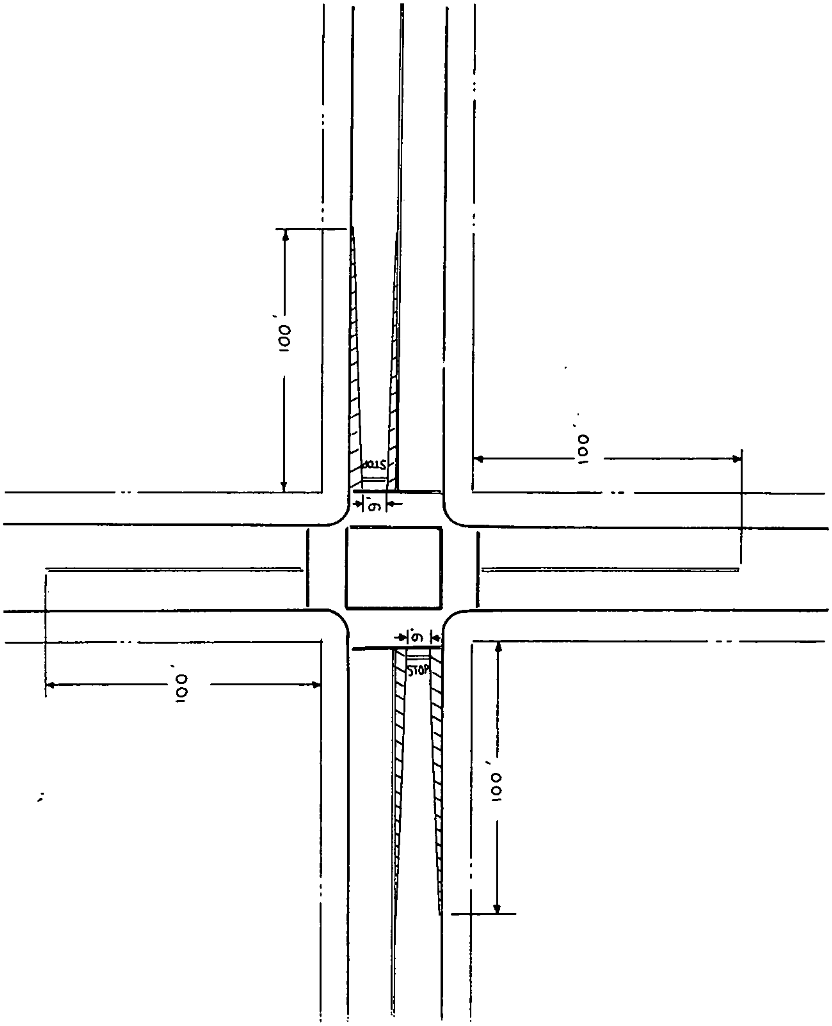


COLLEGE ST. AT FRONTAGE RD.

Figure 3.

average of 10 after the treatment with no significant change in traffic volume. In addition to the accident rate reduction, there is an apparent diminution of congestion and a subsequent increase in efficiency of the intersection.

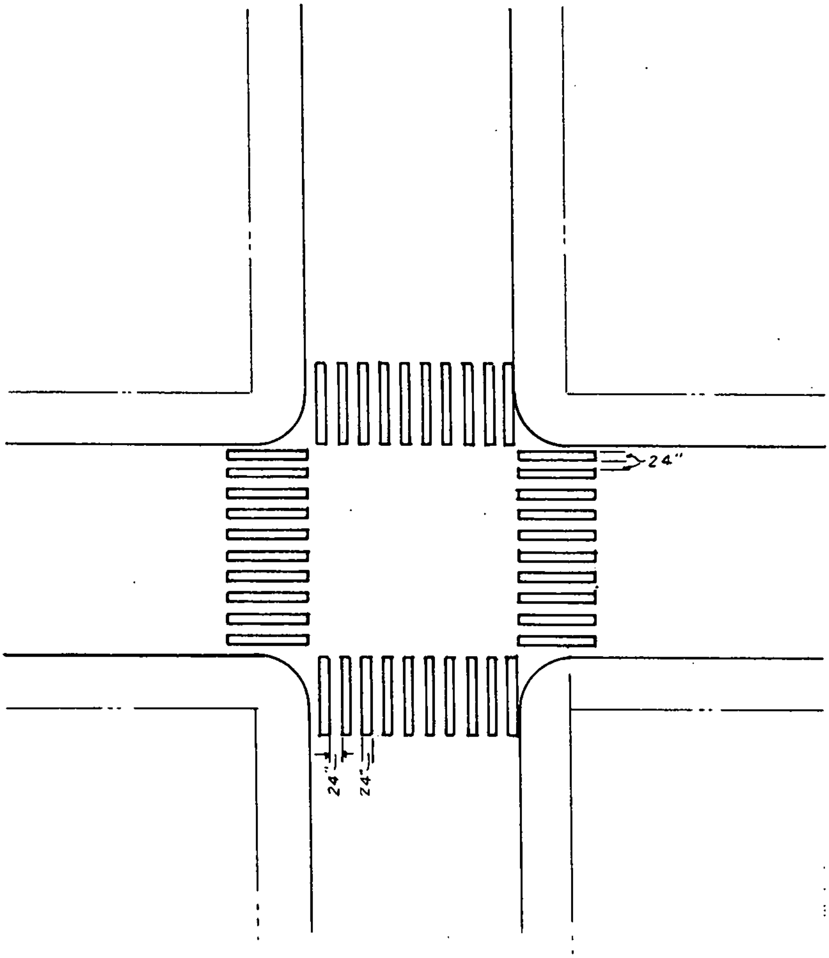
Another program aimed at reducing accidents was implemented in New Haven, Conn., by painting a special intersection treatment pattern at intersections displaying a particularly high incidence of accidents. This program is employed at the approach to a stop intersection (Fig. 4). During the two years that this program has been in effect, 7 intersections have shown an average of 32 percent reduction in accidents, whereas 2 intersections showed a 63 percent increase in accidents with no significant change in volume nor traffic pattern. The program has been sufficiently effective to warrant



PAINT TREATMENT
TYPICAL INTERSECTION
Figure 4.

repainting this special intersection program each year. Obviously, an uncontrolled use of the program would dilute the effects on the motoring public. Therefore, the city has limited the number of approaches treated in this fashion to 24 approaches out of a total of 1340 approaches to stop signs.

The use of pavement markings to delineate pedestrian crossings is generally accepted. A study of England's zebra crosswalk marking by R. L. Moore of the Road Research Laboratory showed that in the London area an increase in crossing in the prescribed manner for men from 45 to 53 percent after the markings were placed, for women from 63 before to 69 percent after the crossings, and for children from 60 to 81 percent after the placement of the crosswalks. Another Road Research Laboratory study by W. H. Glanville showed that the use of the zebra crosswalk coupled with a pedestrian education program resulted in a 7 percent decrease in pedestrian accidents,



CROSSWALK TREATMENT

Figure 5.

that accidents went down more in towns using the crosswalks than in towns not using them and that accidents fell 8 percent in towns while falling only 2 percent in the rural districts. Figure 5 shows a layout of the zebra-type markings.

Probably the most recent innovation in pavement markings is the use of markings to convey word messages and/or symbols to the motorist. This practice has resulted in a virtually inexhaustible list of messages being passed onto the motorist. Of the more generally accepted practices the word STOP is used probably as frequently as any other message. A study done in England (1) shows that the inclusion of the word "HALT" on the pavement resulted in a 6.7 percent increase in observance to the stop sign and a 1.4 percent decrease in violations of the stop sign. The study also showed a 50 percent reduction in personal injury accidents on all vehicles approaching the intersections after placing the message.

CONCLUSIONS

The use of pavement markings has been unquestionably successful in controlling traffic. This paper has briefly summarized the uses, the limitations and the success of a few of the programs related to the use of such markings. In closing, remember that we live in an urban setting which should be made as attractive and livable as possible. An unrestrained program of painting streets can be just as objectional as a streetscape hidden by an endless row of traffic control signs.

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Addendum

EXAMPLE OF PAVEMENT MARKINGS STANDARDIZATION

The Denver, Colorado, pavement markings standards are presented to illustrate techniques employed by this city.

TRAFFIC ENGINEERING DIVISION OF PUBLIC WORKS

POLICY AND PROCEDURE MEMORANDUM

C. TRAFFIC SIGNS, MARKINGS, AND METERS

No. 8 Pavement Marking

August 30, 1965
Rev. March 2, 1967

I. Purpose

The purpose of this memorandum is to establish the standards for pavement marking, including centerlines, lane lines, crosswalks, stop lines, and pavement messages.

2. Line Marking, Definitions

The terms used in this memorandum in reference to line marking are defined as follows and illustrated in the sketch below:

Outside Lane - a lane which is adjacent to a raised curb or, where curbs do not exist, a lane which is adjacent to the edge of the pavement.

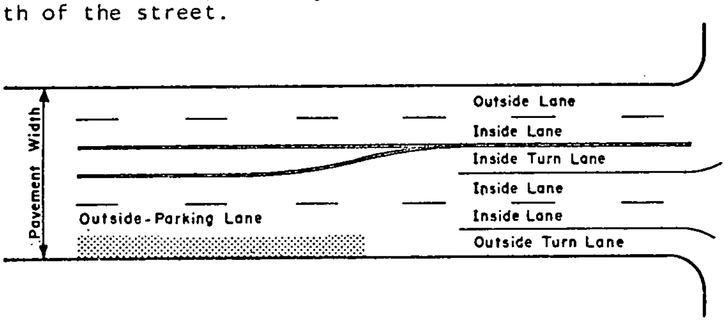
Inside Lane - a lane which is not adjacent to a raised curb, an edge of pavement, or parked vehicles.

Outside-Parking Lane - a lane which is adjacent to parked vehicles and which includes sufficient width to accommodate both a moving vehicle and a parallel parked vehicle.

Inside Turn Lane - a lane which is not adjacent to a raised curb, an edge of pavement or parked vehicles, and which is used to accommodate turning vehicles separate from lanes intended for through traffic.

Outside Turn Lane - a lane which is adjacent to a raised curb or an edge of pavement and which is used to accommodate turning vehicles separate from lanes intended for through traffic.

Pavement Width - the face-of-curb to face-of-curb or, where curbs do not exist, the edge-of-pavement to edge-of-pavement width of the street.



3. Line Marking, Dimensions

The dimensions used in the tables on the pages following the text are developed from what are called Absolute Minimum and Desirable Minimum lane widths. The Absolute Minimum dimensions are the narrowest which should be used in normal practice. If narrower lane widths are used, full usage of those lanes cannot be assumed except under low speed, congested conditions. The Desirable Minimum widths are two feet wider and should be used as the minimum for design. In addition an extra foot has been assigned to Outside Lanes wherever the pavement is wide enough to provide Desirable Minimum lane widths for the remaining lanes.

Type of Lane	Absolute Minimum Lane Widths	Desirable Minimum Lane Widths
Outside Lane	10'-0	12'-0
Inside Lane	9'-0	11'-0
Outside-Parking Lane	17'-0	19'-0
Inside Turn Lane	9'-0	10'-0
Outside Turn Lane	9'-0	11'-0

4. Line Marking, Construction and Use of Tables

The tables on the pages following the text have been created to serve as a guide for the design of lane widths for various combinations of pavement width and parking regulations. They will be useful for both geometric design and pavement marking layout in the field. Unusual conditions will arise which are not shown in these tables, but the principles under which these tables have been constructed can be used to fit those conditions.

The number of lanes in the tables refers to the total of all lanes on the street being designed, including turn lanes, and irrespective of the direction of travel on those lanes. For example, the recommended widths of four lanes on a 40 foot street is the same whether that street is operated with two lanes in each direction or with four lanes in one direction.

The reference to parking in the tables is for parallel parking only. "No Parking" refers to both sides of the street.

Inside Turn Lanes (normally left turn lanes) have been designed so that they remain at absolute minimum width unless there is sufficient pavement width to provide desirable minimum width for the through lanes. Where desirable minimum widths can be achieved or exceeded for through lanes, the Inside Turn Lane is increased to a maximum of 12'-0. In the tables, the Inside Turn Lanes have been shaded for quick identification.

Outside Turn Lanes (either left or right turn) have been designed so that they increase along with through lanes as pavement width increases, to a maximum of 12'-0. In the tables, the Outside Turn Lanes have been shaded for quick identification.

The tables use feet and inches, and the apportionment of five or seven lanes across some pavement widths results in fractions of an inch, since 12 inches is not divisible by five or seven. To avoid this in the tables, and to make the lane dimensions as error-proof as possible, rules of apportioning have been used for pavement widths which are not divisible by five or seven into whole feet and inches. Using these rules, the number of inches apportioned to the five or seven lanes is the same for each lane.

Pavement Width Increments Not Divisible Into Whole Feet and Inches	5 Lanes (Inches Per Lane)	7 Lanes (Inches Per Lane)
1 foot	2 inches	2 inches
2 feet	5 inches	3 inches
3 feet	7 inches	5 inches
4 feet	10 inches	7 inches
5 feet		9 inches
6 feet		10 inches

This system of apportionment of inches introduces errors, but the maximum error of plus or minus two inches in five lane designs and plus or minus three inches in seven lane designs is not significant in terms of the accuracy of pavement marking procedures. The benefits in reducing errors between reading the tables and marking the pavement are expected to outweigh the minor inaccuracies.

In selecting a design where parking is presently permitted, considerable thought must be given to the permanency of that parking.

If there is contemplated the addition of Outside Turn Lanes at some future date, the Outside-Parking Lane dimension in the tables should be abandoned in favor of the combination of the widths of an Outside Turn Lane and an Inside Lane. Similarly, if parking is to be prohibited to provide an additional through lane in the future, the present Parking Lane should be the combination of the widths of an Outside Lane and an Inside Lane. Thought given to these possibilities initially may save a complete re-striping in the future.

5. Line Marking Design

Centerlines in the built-up or urban portions of the City will be either double yellow or solid white in design, according to the standards of the Manual or Uniform Traffic Control Devices. In rural areas where no-passing zones must be established on two-lane highways, the rural system of centerline marking using a dashed white centerline accompanied by solid yellow no-passing lines may be used. Double yellow and solid white centerlines shall be broken at all intersections of city streets and all traffic signal locations not at city streets. Where such centerlines curve or jog through intersections, they may be continued through such intersections in the form of short dashes. Centerlines shall not be broken for driveways unless they are controlled by traffic signals.

Lane lines will be dashed white lines with a ratio of 15 feet of paint and 25 feet of gap. Turn lane lines, or lane lines where lane changing is to be discouraged, shall be solid white, and may be marked double the usual width for added emphasis. Turn lane lines shall be continued through intersections in the form of a solid white line where multiple turns are permitted.

The width of lines used for line marking will normally be about five (5) inches. The space between double yellow lines, or between a dashed white and solid yellow lines, shall be no less than three (3) inches and no more than four (4) inches.

Included in this memorandum are drawings illustrating typical intersection designs and channelization procedures. These should be of value for both geometric design and field layout. Although these drawings show traffic buttons as an optional feature, current policy dictates that these be used at only the most critical locations.

6. Crosswalk Locations

The following types of intersections or locations shall be marked with crosswalks on all legs:

Intersections of Major Arterial Streets with other Major Arterial Streets.

Intersections of Major Arterial Streets with Collector Streets.

Intersections of Collector Streets with other Collector Streets.

Intersections or midblock locations controlled by vehicular or pedestrian traffic signals.

Intersections adjacent to school blocks, and along selected home-school routes.

The exceptions to the above locations will be as follows:

Those intersections where certain crosswalks are omitted to encourage the use of another crosswalk with pedestrian right of way assignment.

Those intersections where all crosswalks are omitted to encourage the use of crosswalks at another location with pedestrian right of way assignment.

Those intersections so rural in nature or so outlying in relation to the built-up part of the city that no pedestrians can reasonably be expected to use the intersection.

Those intersections along parkways or freeways where the inside crosswalks (between the two intersections formed by the parkway or freeway roadways) are omitted because of little pedestrian usage and the need to maintain adequate vehicular storage between these roadways. However, at such locations where pedestrians demonstrate usage of these inside crosswalks, they shall be marked.

7. Stop Line Locations

The following types of intersections or locations shall be marked with stop lines on all approach legs:

a. Intersections or midblock locations controlled by traffic signals.

b. Intersections controlled by school stop sign flashers, but stop lines shall be placed only on approach legs controlled by the flashers.

There are no exceptions to the above locations.

8. Crosswalk and Stop Line Design

Crosswalks and Stop Lines will be white in color. Crosswalks will be ten (10) feet wide as a minimum, but may be wider where wider sidewalks approach the intersection. In the downtown area, crosswalks shall be the width equal to the distance between curb and building (property) line, wherever that distance is paved in the normal manner as total sidewalk. Crosswalks connecting setback sidewalks will have one line at the back line of the sidewalks and the other ten (10) feet toward the intersection. Crosswalks connecting attached sidewalks will have one line as an extension of the curb line, and the other line ten (10) feet away from the intersection.

Stop lines will be located four (4) feet in advance of a crosswalk where both are called for, creating a two (2) foot clear distance between the stop line and crosswalk line. Stop lines will be located ten (10) feet in advance of a curb line or edge of pavement where crosswalks are not called for. Stop lines will generally be parallel to a crosswalk, but in those instances where medians are more than two (2) feet back of a crosswalk, the stop line should end at that median rather than be parallel to the crosswalk. In addition, in rare instances there will be special conditions where stop lines will be set back from an intersection because of driveway or turning radius considerations.

Crosswalk lines will be twelve (12) inches in width. Stop lines will be twenty-four (24) inches in width.

The drawings attached as a part of this memorandum illustrate typical crosswalk and stop line installations.

9. Pavement Messages

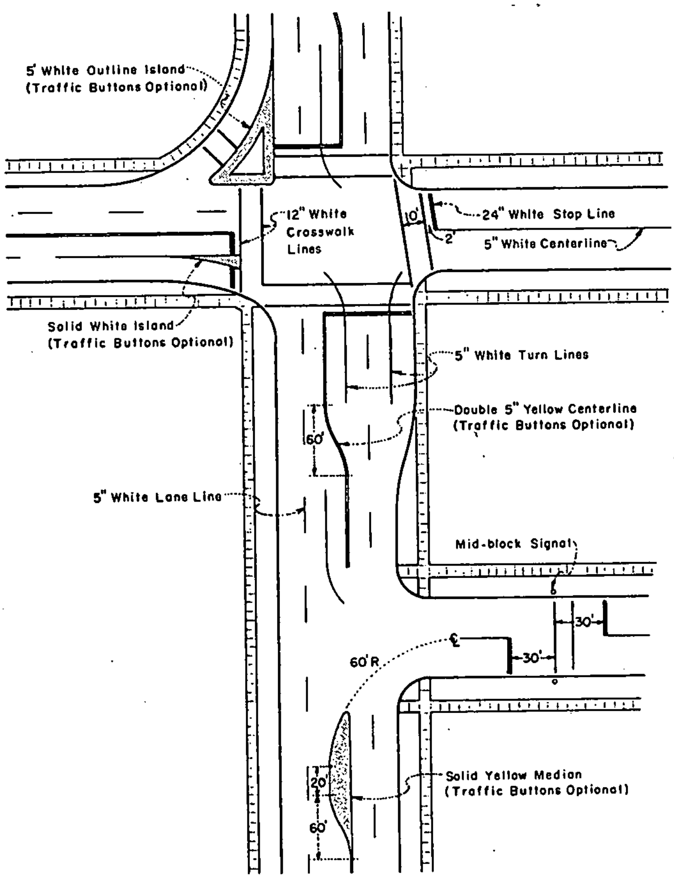
School pavement messages will be white in color. Design and locations will be as noted in the memorandum entitled "School Sign and Marking Installation."

Turning movement messages, consisting of arrows and the word "ONLY", will be white in color. They will generally be located only in lanes which have been continuous for more than a block and which end in mandatory turn lane situations. They may be used in other situations as required.

PAVEMENT MARKING

ILLUSTRATING:

1. Stop line and crosswalk line design for intersections other than downtown exclusive pedestrian phase locations.
2. Centerline and lane line design for conventional pattern and continuous left turn lane pattern.

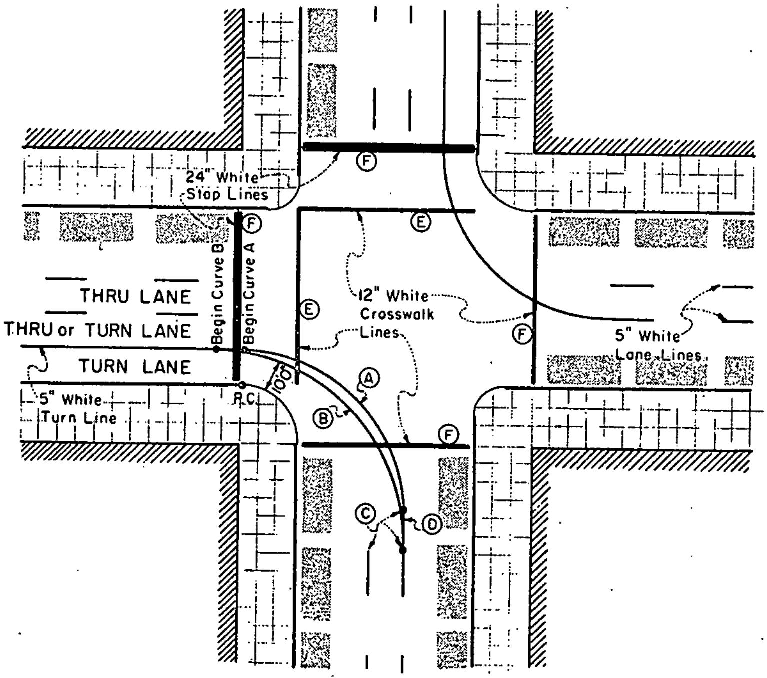


PAVEMENT MARKING

ILLUSTRATING:

1. Stop line and crosswalk line design for downtown exclusive pedestrian phase intersections only.

2. Turn line design for double turns at any location.



Ⓐ If Turn Lane width is 10'-0 or less, begin radius opposite P.C. of corner radius.

Ⓑ If Turn Lane width is more than 10'-0, begin radius back from P.C. of corner radius so that minimum width of lane is 10'-0.

Ⓒ Begin lane lines at end of radius.

Ⓓ Turn Lane line should intersect the lane line which will provide the Turn Lane with two through lanes going away from the intersection, except where only two through lanes are available.

Ⓔ Line up with curb line.

Ⓕ Line up with property line.