Reversible Center-Lane Traffic System—Directional and Left-Turn Usage

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For some time, traffic operations on Michigan Ave., US 12, in the city of Dearborn, had been of serious concern to the traffic engineers of the Michigan Department of State Highways and the Dearborn Public Safety officials.

This street carries approximately 46,000 vehicles per day in both directions—primarily through traffic with heavy directional movements during the morning and afternoon peak periods. It is a divided arterial with the exception of a 1.2-mi section in the western portion of the city.

The accident rate of 1920 accidents per hundred million vehicle-miles was considerably higher than the average for the area. This factor, coupled with the daily congestion, justified the interest and concern for this problem.

In a cooperative effort, the State Highway traffic engineers and the Dearborn Public Safety officials reviewed the possible methods for improving the traffic operations on Michigan Ave. The operational system selected for application was a center reversible lane system.

This report describes the system and the development of a new combination electrical sign and signal for lane-usage control, and presents an evaluation of the system operation.

•THE reversible center lane traffic system was developed for use within the city limits of Dearborn, Mich., where US 12 (a divided trunkline) becomes an undivided street through the business area. This trunkline operated with six 10-ft lanes, with parking prohibited during the peak hours in the direction of the heavy flow. Left turns were prohibited only at signalized intersections.

Traffic using this route is primarily through traffic, characterized by heavy directional movements. Accident rates have been high in this area.

After consideration of the total situation, it was decided to establish a reversible lane operation on this section of trunkline. The following conditions were requisite for effective operation:

1. Parking was prohibited at all hours.
2. The street was marked to provide five 12-ft lanes.
3. The center lane was designated as a reversible lane for the heavy directional flow: eastbound, 6:00 to 9:00 a.m. and westbound, 3:00 to 6:00 p.m. and nighttime. The center lane throughout the area was reserved for left turns.
4. During off-peak hours—9:00 a.m. to 3:00 p.m. and nighttime—the center lane throughout the area was reserved for left turns.
5. A single, overhead signal to inform motorists of the changes in traffic operation was to be developed.

DEVELOPMENT OF REVERSIBLE LANE SIGNAL

The utilization of the center lane required a single signal to inform the motorist, simply and positively, of center-lane usage as follows:

Paper sponsored by Committee on Traffic Control Devices and presented at the 45th Annual Meeting.

1. To permit three lanes of traffic, including center lane, for the peak direction while prohibiting all left turns during peak hours.
2. To permit the center lane to be used and reserved for left turns during off-peak hours.

The standard reflective signs lack sufficient flexibility and attention-attracting a ability; therefore, a new electrical signal was developed to accomplish these objectives.

In this development, Department engineers utilized the successful experience gained from development and operation of changeable message signs on the Mackinac Bridge and the TV Surveillance Project in Detroit. These lane control signals, composed of the red X and green arrow, with their implied messages, had proven excellent for obtaining the desired motorist reaction as follows:

1. Red X indicating "Lane Closed." The motorist understood immediately that he was not to use this lane, and moved out of it as soon as it was safe to do so.
2. Green arrow indicating "Lane Open." It was clear to the motorist that this lane was open for use by traffic.

The multi-lamp lane control signal developed for the TV Surveillance Project became the basic pattern for the complex reversible lane signal. The multi-lamp design permits more than one message. These messages are mounted on a quick-change panel with a louvered screen providing the disappearing legend or blankout effect. The signal case is of extruded aluminum with welded construction.

Two messages were combined in a single, compact unit as follows:

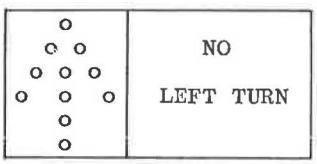
1. Eleven R-20 50-watt reflector lamps, coated with a weatherproof green coloring, provided the arrow message.
2. Thirteen R-20 50-watt reflector lamps, coated with a weatherproof red coloring, provided the "X" message (1).

The reversible lane signal is a combination of the multi-lamp lane control signal (red X and green arrow) and an internally illuminated sign presenting the messages "No Left Turn" or "Only Left Turn," as needed, and were fabricated as one device.

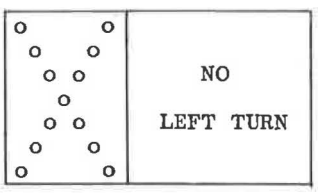
The "Left Turn" message on the signal is illuminated by 800 ma fluorescent lamps. The message is cut out of black lettering film and overlaid on yellow plexiglas. The changeable "No—Only" message was designed larger and used 27-watt incandescent yellow lamps. The larger size and yellow color is used to attract the driver's attention to the change in the message. The messages presented by the signal are as follows:

1. Morning peak hour traffic in eastbound direction. Reversible lane control sign in operation from 6:00 a.m. to 9:00 a.m. as follows:

(a) 3 lanes in eastbound direction. Use center lane for thru traffic.

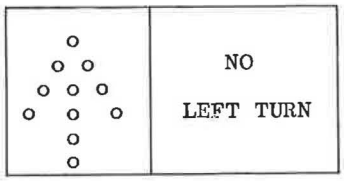


(b) 2 lanes in westbound direction. Do not use center lane.

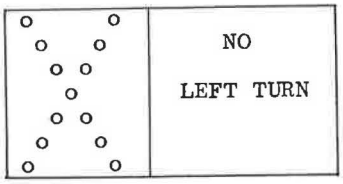


2. Afternoon peak hour traffic in westbound direction. Reversible lane control sign in operation from 3:00 p.m. to 6:00 p.m. as follows:

(a) 3 lanes in westbound direction. Use center lane for thru traffic.

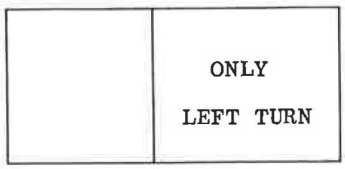


(b) 2 lanes in eastbound direction. Do not use center lane.

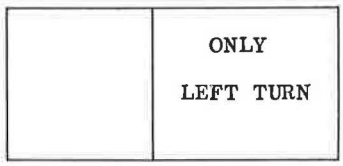


3. Off-peak hour traffic. Reversible lane control sign in operation as follows:

(a) 2 lanes in eastbound direction.



(b) 2 lanes in westbound direction.



The dimensions of the casing for the X and arrow are $31\frac{1}{2}$ by 36 in. The dimensions of the casing for the illuminated "Left Turn" sign are $61\frac{3}{8}$ by 36 in. The overall dimensions of the sign are approximately 92 by 36 in. Eight-in. letters are used for "Left Turn" and 13-in. letters for "No—Only."

Figure 1 shows the physical and electrical characteristics of this reversible center-lane signal.

Figure 2 shows the reversible center-lane signal with a view in the direction of peak eastbound traffic and displays a green arrow for center-lane usage.

Figure 3 shows the reversible center-lane signal with a view of peak eastbound traffic as seen by westbound traffic. The red "X" is displayed for westbound traffic indicating the center lane is not open for their use.

Figure 4 shows off-peak traffic in which the center lane is reserved for left turns only.

EVALUATION OF OPERATION

The reversible center-lane signals were placed over the center lane at strategic points throughout the 1.2-mi section of trunkline. They were placed at mid-block locations to present a left-turn or no-left-turn area control rather than an intersection or point control.

Figure 5 is a strip map of the reversible center-lane study area presenting the location of the signals.

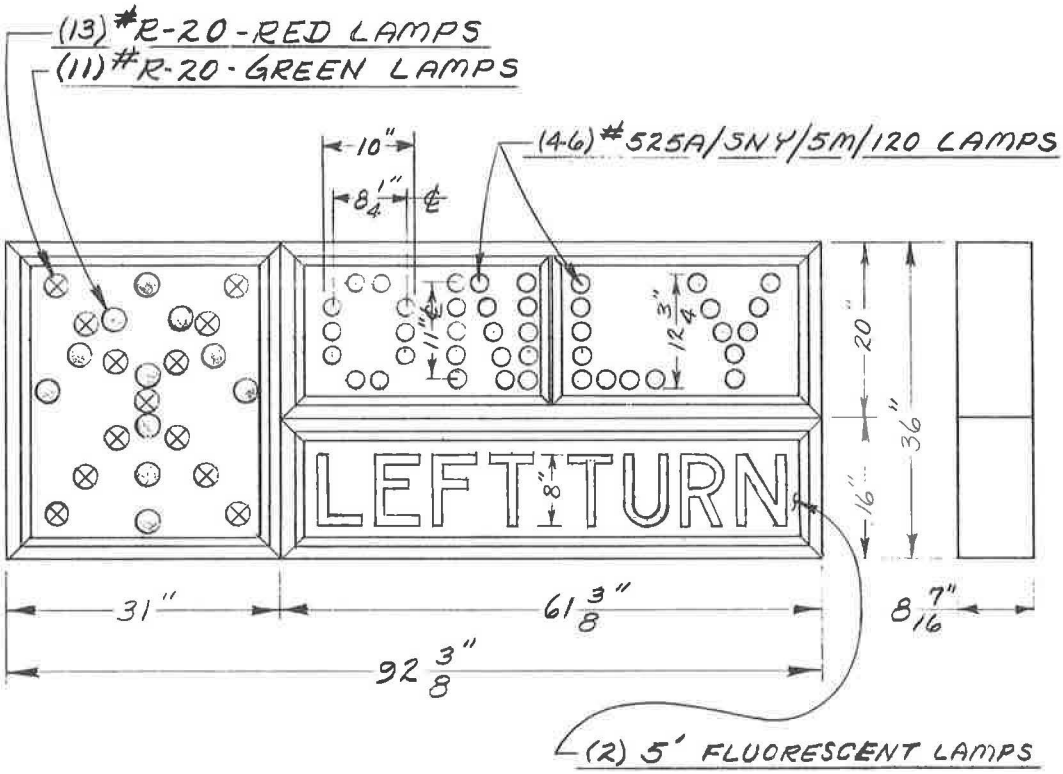


Figure 1. Physical and electrical characteristics of reversible center-lane signal.

Figure 2. Reversible center-lane signal; green arrow for center-lane usage.

Figure 3. Reversible center-lane signal, peak eastbound traffic as seen by westbound traffic, with red "X" indicating center lane not open for westbound use.

Figure 4. Off-peak traffic, with center lane reserved for left turns only.

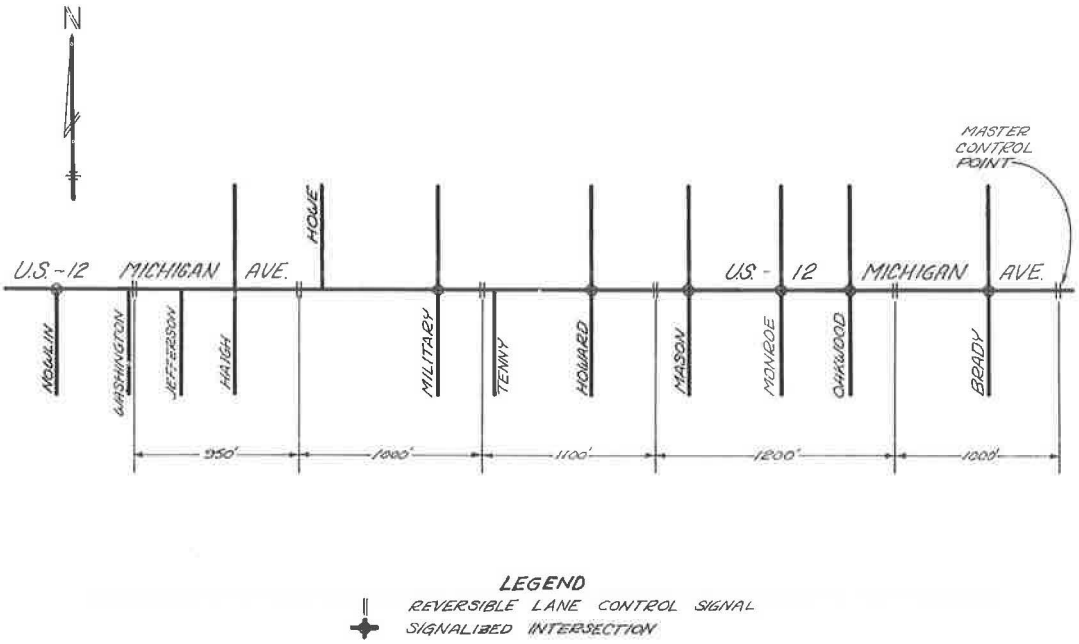


Figure 5. Reversible center-lane traffic system, showing location of signals.

TABLE 1

TRAFFIC VOLUME COMPARISONS
(Peak Period—Peak Direction, Eastbound, 6-9 a.m.)

STATION	1			3			5		
	BEFORE	AFTER #1	AFTER #2	BEFORE	AFTER #1	AFTER #2	BEFORE	AFTER #1	AFTER #2
DATE	AUG. '63	OCT. '63	JAN. '65	AUG. '63	OCT. '63	JAN. '65	AUG. '63	OCT. '63	JAN. '65
PEAK PERIOD TOTALS	4805	5190	5028	4046	4427	4855	4074	4406	4593
% INCREASE		8.0	4.6		9.4	20.0		8.1	12.7
HIGH 2 HR.	3607	4220	3953	3276	3567	3826	3122	3504	3584
% INCREASE		17.0	8.8		8.9	16.8		12.2	14.8
HIGH HOUR	2134	2605	2466	1932	2069	2302	1777	2041	2130
% INCREASE		22.0	15.6		7.0	19.1		14.9	19.9
HIGH 15 MINUTE	589	871	676	552	572	645	498	543	581
% INCREASE		47.9	14.8		3.6	16.8		9.0	15.7

The evaluation of the reversible center-lane system was based primarily on its operation during peak traffic periods. The measurements for this evaluation are (a) traffic volume comparisons, (b) travel time comparisons, and (c) accidents.

In addition, observance of the left-turn prohibition during peak periods was studied to determine the effectiveness of the left-turn area control feature of the system. Further, an investigation of the effects of street parking removal was performed as well as an inventory of off-street parking facilities.

TABLE 2

TRAFFIC VOLUME COMPARISONS
(Peak Period—Peak Direction, Westbound, 3-6 p.m.)

STATION	1			3			5		
	BEFORE	AFTER #1	AFTER #2	BEFORE	AFTER #1	AFTER #2	BEFORE	AFTER #1	AFTER #2
DATE	AUG. '63	OCT. '63	JAN. '65	AUG. '63	OCT. '63	JAN. '65	AUG. '63	OCT. '63	JAN. '65
PEAK PERIOD TOTALS	6338	6641	6321	5500	5739	5897	4406	4567	4463
% INCREASE		4.8	-0.3		4.3	7.2		3.7	1.3
HIGH 2HR.	4619	4908	4754	4278	4218	4453	3189	3361	3339
% INCREASE		6.2	2.9		-2.2	3.3		5.4	4.7
HIGH HOUR	2514	2818	2705	2351	2467	2500	1772	1867	1879
% INCREASE		12.1	7.6		5.0	6.3		5.4	6.0
HIGH 15 MINUTE	697	764	719	678	692	737	505	509	564
		9.6	3.2		2.1	8.0		0.8	11.7

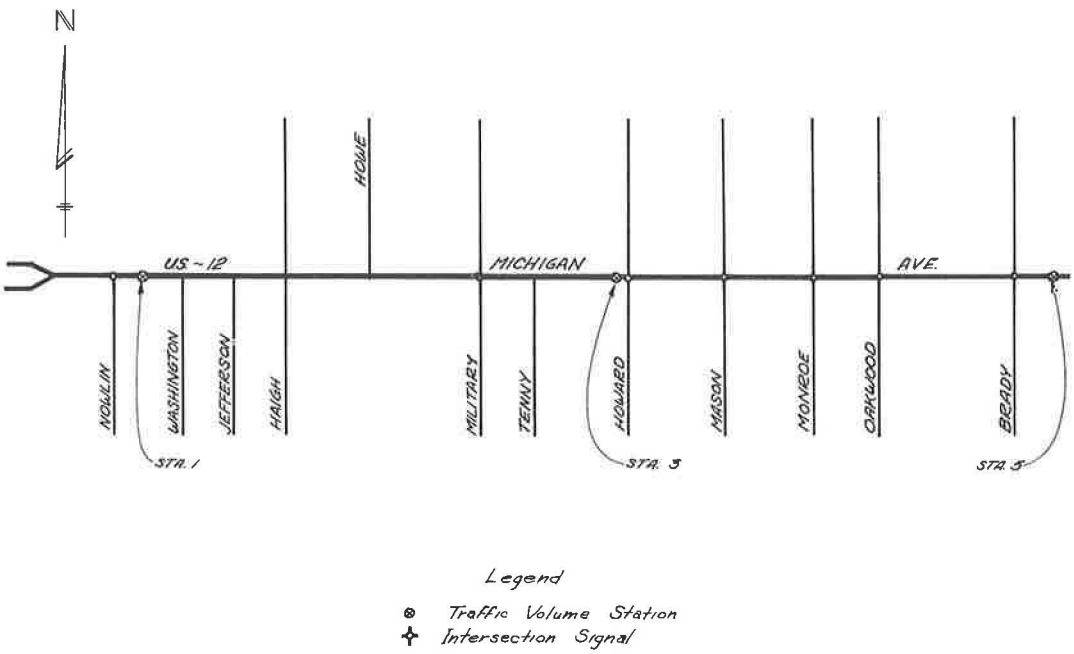


Figure 6. Reversible center-lane traffic system, showing location of traffic volume stations.

Traffic Volume Comparisons

Traffic volumes were obtained within the reversible lane section for the peak directions and during the a.m. and p.m. peak periods. Volume comparisons for the peak period-peak direction are given in Tables 1 and 2.

In addition to peak period totals, the high 2-hr, high hour and high 15-min volumes are indicated. Traffic volumes were obtained on two occasions for "after" comparison.

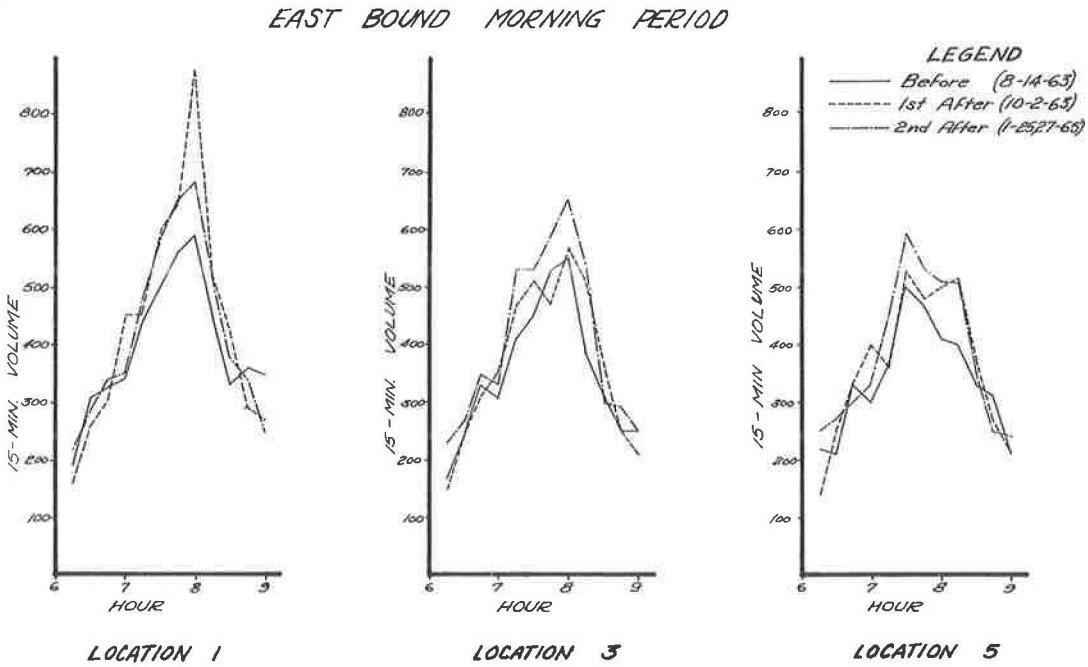


Figure 7. Reversible center-lane traffic system; peak period; peak direction; eastbound; morning.

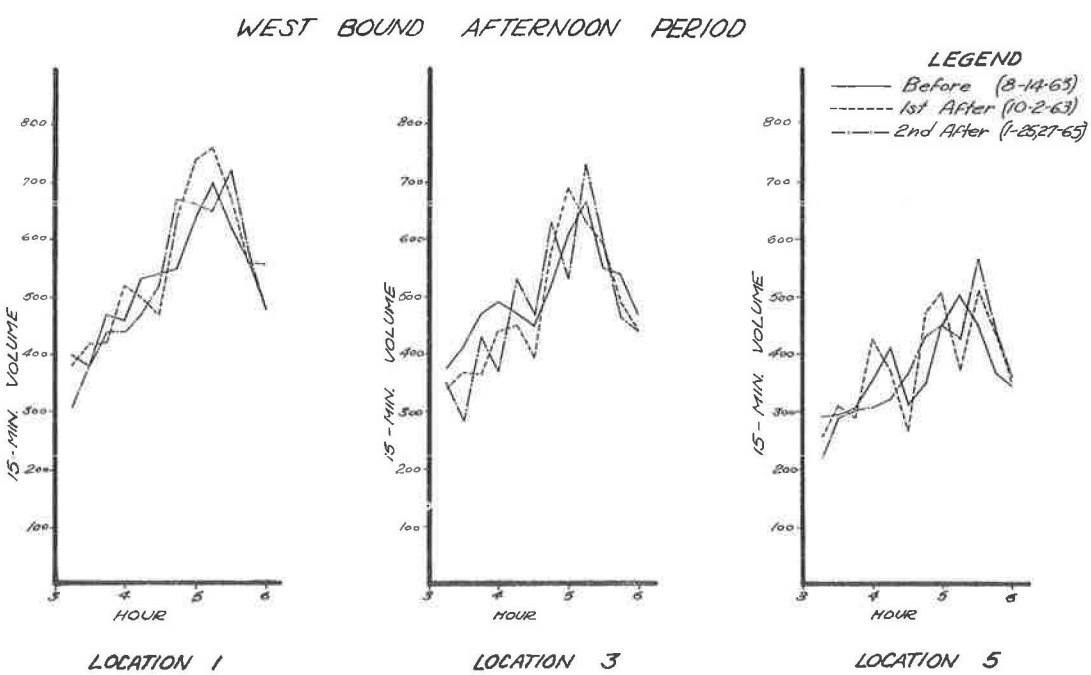


Figure 8. Reversible center-lane traffic system; peak period; peak direction; westbound; afternoon.

The first "after" was conducted in October 1963, approximately three weeks after the installation of the reversible center-lane system. The second "after" was conducted in January 1965. (During the first year of operation, adjustments and modifications were made in signalization with regard to spacing of signals and progression. Thus, the second "after" was conducted in January 1965 following these adjustments and modifications.)

TABLE 3

REQUIRED TIME FOR EQUIVALENT TRAFFIC VOLUME
(Peak Period—Peak Direction, "Before" High 2-Hr Volume*)

	EASTBOUND		WESTBOUND	
	AFTER #1	AFTER #2	AFTER #1	AFTER #2
DATE	OCT. 1963	JAN. 1965	OCT. 1963	JAN. 1965
TIME	1 HR. 34 MIN.	1 HR. 44 MIN.	1 HR. 51 MIN.	1 HR. 56 MIN.
STATION 3				
TIME	1 HR. 48 MIN.	1 HR. 33 MIN.	2 HR. 3 MIN.	1 HR. 55 MIN
STATION 5				
TIME	1 HR. 42 MIN.	1 HR. 39 MIN.	1 HR. 54 MIN.	1 HR. 53 MIN

* THE TIME DURING WHICH THE EQUIVALANT "BEFORE HIGH 2 HR. TRAFFIC VOLUME TRAVELED THROUGH THE STUDY AREA.

Traffic volumes were obtained at five stations. Data from three stations are presented here for the traffic volume consideration. The location of the traffic volume stations is shown in Figure 6.

In general, the volume comparisons show slight but definite increases in peak direction traffic volumes.

The total traffic utilizing US 12 (Michigan Ave.) was not expected to increase a great deal, as the character of this urban traffic remains generally the same. This fact was supported by 8-hr and 24-hr traffic counts not shown here. However, the high hour and high 15-min volumes do reveal the improvement received in capacity under the reversible center lane system.

Figures 7 and 8 show the peak period traffic volumes by peak direction by 15-min intervals. These figures show the increases in volumes during the peak periods, but also show that traffic volumes over the same time intervals reached higher peaks. It appears that compared to the "before," the system permitted slightly higher volumes to pass during the same time period or passed the same volumes in a shorter time. The peak period thus seems to have begun later and ended sooner.

Table 3 indicates the time required to clear the equivalent of the "Before High 2-Hr Volume" after the system was installed.

Travel Time Comparisons

Travel times, through the reversible center-lane system, are given in Table 4. Travel time runs were conducted during the peak periods for the peak directions. For the "before" condition travel time, data were obtained in August 1963. For comparison with the system installed, travel time data were obtained in December 1963 approximately 3 months after the installation of the system and again in March 1964, approximately 6 months after its installation. Travel time comparisons were made from the number of travel time runs as follows:

TABLE 4

TRAVEL TIME AND SPEED COMPARISONS
(Peak Periods—Peak Directions)

	7 ~ 9 A.M.						4 ~ 6 P.M.					
	EASTBOUND						WESTBOUND					
	BEFORE		AFTER*			INCREASE OR DECREASE	BEFORE		AFTER*			INCREASE OR DECREASE
	MIN.	SEC.	No.	MIN.	SEC.		MIN.	SEC.	No.	MIN.	SEC.	
AVERAGE TRAVEL TIME	3	28	1	2	54	-16.0 %	4	39	1	4	09	-11.0 %
			2	2	49	-18.8 %			2	3	45	-20.0 %
	M.P.H.		M.P.H.				M.P.H.		M.P.H.			
AVERAGE SPEEDS	24.2		1	29.0		+20.0%	18.1		1	20.2		+12.0%
			2	29.8		+23.2%			2	22.4		+23.8%

* AFTER STUDY No. 1 ~ DEC. 1963, AFTER STUDY No. 2 ~ MAR. 1964

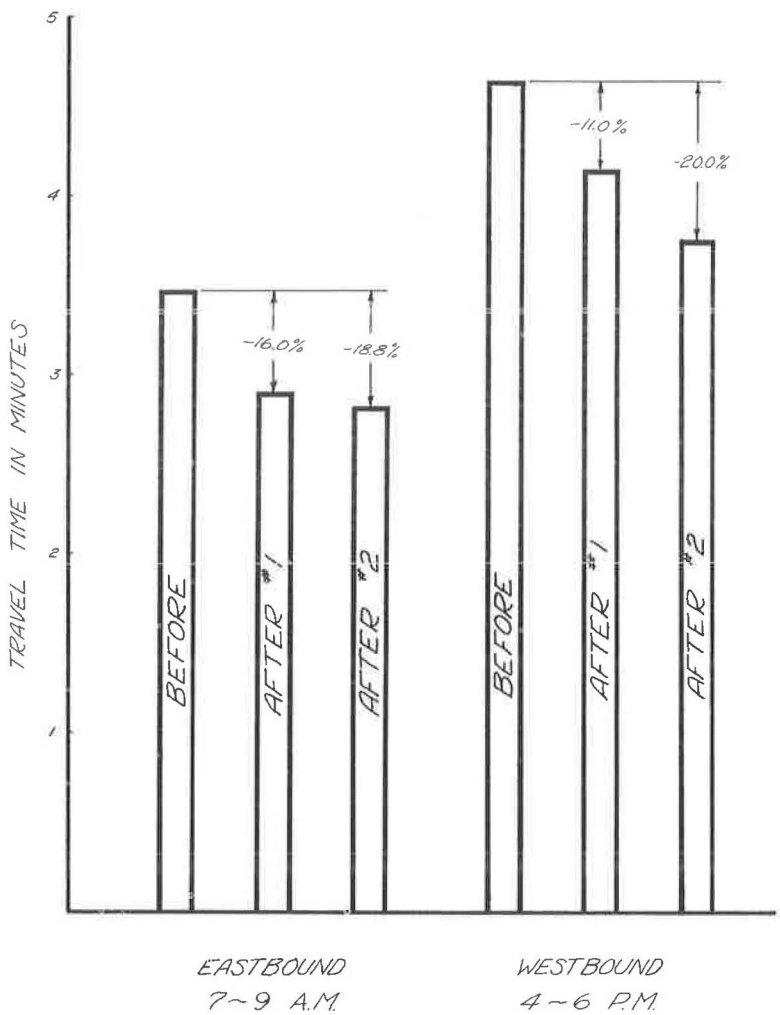


Figure 9. Travel time comparisons.

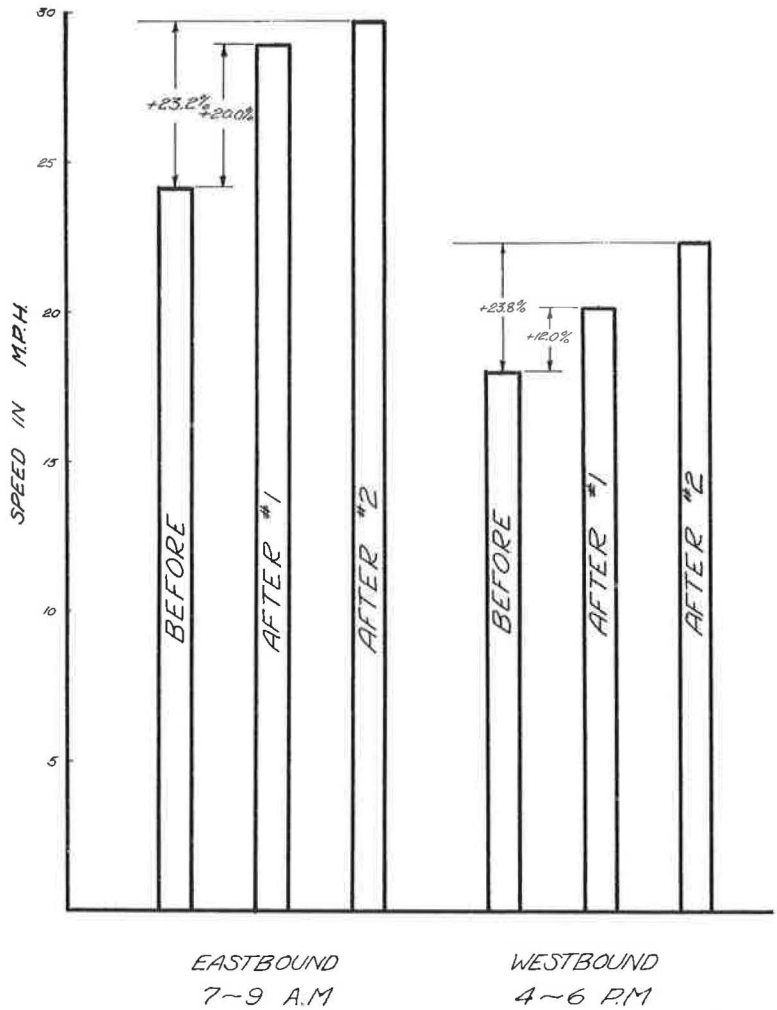


Figure 10. Speed comparison data.

	Before	After No. 1	After No. 2
AM peak	15	16	16
PM peak	12	16	16

The travel time runs were conducted in a manner to assure that speed and movement of the test vehicle were representative of the character of the traffic. In some runs the test vehicle remained in the same lane through the section, whereas in other runs lane changes were made.

Figure 9 shows the travel time comparisons.

The effect of the reversible lane system has been a reduction in travel time for peak-direction, peak-period traffic. The data obtained in the second "after" study revealed an additional reduction in travel time.

Speed comparisons are also given in Table 4. The speed comparisons reflect the decrease in travel time as a result of the increase in speed (Fig. 10). The speed comparison between the first and second "after" studies revealed an additional increase in speed after 6 months of operation.

TABLE 5

ACCIDENT STUDY
(Total Accident Summary)

TYPE OF ACCIDENT	ONE YEAR BEFORE*	1ST YEAR AFTER†	DIFF.	2ND YEAR AFTER‡	DIFF.
REAR END					
STRAIGHT	137	192	+55	147	+10
LEFT-TURN	57	32	-25	10	-47
RIGHT-TURN	18	23	+5	15	-3
TOTAL	212	247	+35	172	-40
HEAD-ON LEFT-TURN	2	0	-2	22	+20
PARKING	59	17	-42	4	-55
SIDESWIPE					
SAME DIRECTION	22	26	+4	30	+8
OPPOSING DIRECTION	3	0	-3	1	-2
TOTAL	25	26	+1	31	+6
PEDESTRIAN	9	5	-4	12	+3
FIXED OBJECT	7	4	-3	7	0
RIGHT ANGLE	31	34	+3	31	0
TOTAL	345	333	-12	279	-66

FIRST YEAR DECREASE = 12 = 3.5%
SECOND YEAR DECREASE = 66 = 19%

* SEPT. 16, 1962 TO SEPT. 15, 1963
† SEPT. 15, 1963 TO SEPT. 15, 1964
‡ NOV. 20, 1964 TO NOV. 20, 1965

Accident Study

The total accident summary by type is given in Table 5 for the time periods as follows: (a) one year before installation of system, (b) first year of operation, and (c) second year of operation.

As mentioned previously, many adjustments and modifications were made on the traffic signal system with regard to spacing and progression during the first year of the system's operation. Also, some construction work underway for most of the first year required blocking of one lane during off-peak hours. These factors rendered the first year accident record not wholly representative by the Dearborn officials. Thus it was deemed advisable to obtain the accident experience for the second year of operation which perhaps would be a more representative period.

The expected reduction in accidents related to parking. Parking was removed when the system was installed. It is also important to report that not one head-on accident occurred in the center lane when it was utilized as a reversing lane for peak traffic movements.

The first year of operation showed an increase in straight rear-end accidents. Perhaps increased volumes and speed are accountable for this increase. These rear-end accidents were associated with the signalized intersections almost entirely. The increase in head-on left-turn accidents for the second year of operation is discussed later. Table 5 indicates a decrease of 3.5 percent for the first year and 19 percent for the second year of operation.

Figure 11 shows the total accident summary.

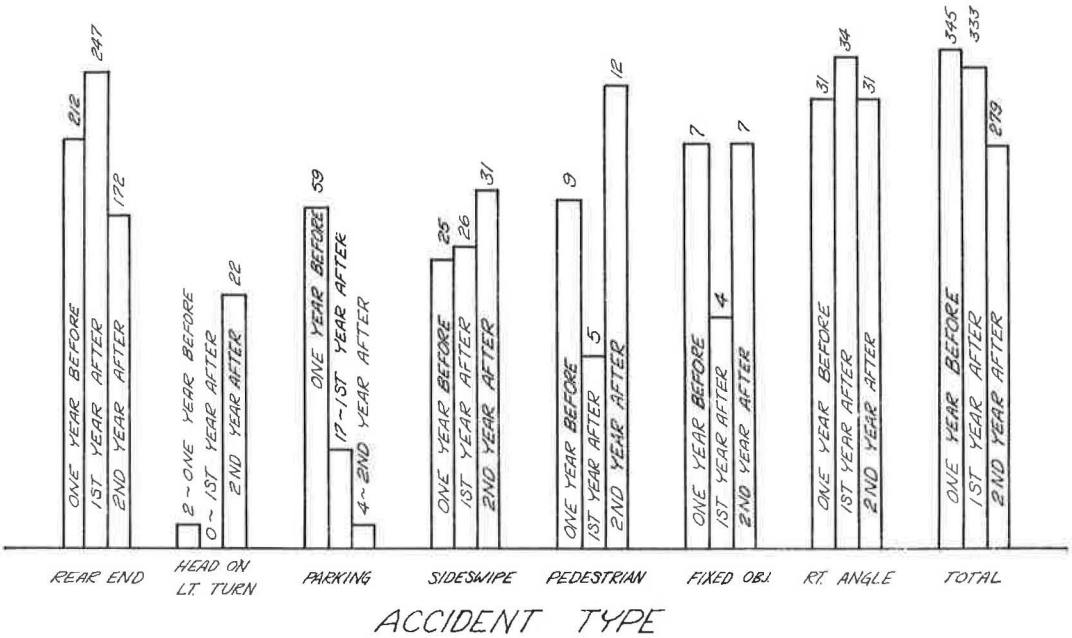


Figure 11. Total accident summary.

TABLE 6

ACCIDENT STUDY

(Total Accidents—Peak and Off-Peak Periods)

	PEAK PERIODS			OFF-PEAK
	6~9 A.M.	3~6 P.M.	TOTAL	
ONE YEAR BEFORE	31	84	115	230
1ST YEAR AFTER	34	86	120	213
2ND YEAR AFTER	30	80	110	169

Table 6 indicates the total accidents by peak and off-peak periods. The total accidents during peak periods remained essentially the same. This must be examined along with increased traffic volumes, reduced travel times, and increased speeds to obtain the true picture. Further, a decided decrease in total off-peak accidents resulted. A further examination of off-peak accidents indicated a reduction in left-turn rear end accidents as follows: before—40, first year after—20, second year after—4.

This is interesting in view of the fact that left turns are now permitted throughout the study section, whereas before left turns were prohibited at signalized intersections. It does perhaps reveal a benefit of reserving the center lane for left turns during the off-peak period.

Left-Turn Area Control Observance

Before the installation of the reversible lane system, left turns were prohibited at all signalized intersections. However, left turns were permitted mid-block.

TABLE 7

PARKING SUMMARY

(US 12, Michigan Ave., Dearborn, Mich.—Reversible Center Lane System)

NORTHSIDE : BRADY TO HAIGH

10 LOTS

750 STALLS *

41 % AVG. OCCUPANCY

SOUTHSIDE : BRADY TO NOWLIN

33 LOTS

2181 STALLS

44 % AVG OCCUPANCY

NORTHLAND SHOPPING CENTER (APRIL 1959)†

8000 STALLS

38 % OCCUPANCY

* NORTHSIDE SPECIAL ACCESSMENT DISTRICT TO PROVIDE FOR 440 STALLS BETWEEN OAKWOOD & MILITARAY A COST OF $400,000

† STUDY PERIOD WED. & THUR. AVERAGE - 9:30 AM. TO 600 P.M. FOR ½ HR. INCREMENTS

With the installation of the reversible lane system and the 5-lane operation, it was necessary to prohibit left turns during peak periods throughout the reversible lane section. During the off-peak periods, the center lane was reserved for left turns only. The left-turn message applied to the entire area or length of the section.

The reversible lane signal provides the left-turn control feature for an area basis. An attempt was made to evaluate this feature of left-turn area control vs left-turn point control. However, a left-turn control observance study was not conducted before the installation of the system. Thus a comparison was made of the left-turn area control in the reversible center lane system and the system in operation on Grand River in Detroit. The Grand River system has the center lane reversed for peak traffic flow and the center lane reserved for left turns in the off-peak period. This system, however, utilized the standard fixed message signs.

This comparison revealed no correlation between the left-turn controls on either system because of the different environmental characteristics, commercial development, and traffic characteristics as well as the important potential difference in enforcement between the two cities. The Grand River system has been in operation for several years. Therefore, a common base for comparison was not possible.

A few reports of confusion with the zone control feature of the left-turn phase of the reversible lane signal were received. It was, therefore, decided to install a reflectorized sign with the legend "Zone Control" below the electrical reversible lane signals. Observations of left-turn area control compliance were made before and after this sign

was installed. These observations covered the total area control by the reversible lane system. As mentioned before, left turns were permitted during the off-peak periods only. A comprehensive and complete collection of left-turn violations was conducted. The results of these observations revealed no significance in changes in the observance of the left-turn area control with or without the sign "Zone Control" installed. This was at the 5 percent level of probability.

The areas where left-turn violations existed to any consequence were at the extreme ends of the system and at Monroe (Fig. 5). This led to a review of the spacing of the reversible lane signals. Additional signals are being considered for these locations to provide as complete information as possible.

It was also felt that additional education and enforcement would readily eliminate any remaining misunderstanding over the area control for left turns.

Parking Summary

The reversible lane system required the removal of curb parking from both sides of Michigan Ave., and a total of 170 stalls were removed.

The off-street parking facilities provided by Dearborn were more than adequate to offset the loss of street parking.

The inventory of parking availability and its present occupancy is given in Table 7. A comparison of these factors to the Northland Center parking lots is presented to verify relative adequacy.

SUMMARY AND CONCLUSIONS

The reversible center lane system installed on Michigan Ave. (US 12) in Dearborn, Mich., resulted in the following improvements in operation.

Traffic Volume Comparisons

The comparisons of operation by traffic volume can best be illustrated by the increase in high hours and high 15-min volumes at 3 traffic stations. These data are shown as of January 1965, one year and four months of operation.

Morning Peak (6:00-9:00 a.m.), Eastbound Traffic, 3 Lanes

Item	Station		
	1	3	5
High hour	2,466	2,302	2,130
Increase (%)	15.6	19.1	19.9
High 15-min	676	645	581
Increase (%)	14.8	16.8	16.7

Afternoon Peak (3:00-6:00 p.m.), Westbound Traffic, 3 Lanes

Item	Station		
	1	3	5
High hour	2,705	2,500	1,879
Increase (%)	7.6	6.3	6.0
High 15-min	719	737	564
Increase (%)	3.2	8.0	11.7

Travel Time Comparisons

The average travel time decreased and average speeds increased for all travel time runs as follows:

Morning Peak (7:00-9:00 a.m.), Eastbound Traffic, 3 Lanes

Item	Period		
	Before	After No. 1	After No. 2
Avg. travel time	3 min 28 sec	2 min 54 sec	2 min 49 sec
Decrease (%)		167.	18.8
Avg. speeds	24.2 mph	29 mph	29.8 mph
Increase (%)		207.	23.2

Afternoon Peak (4:00-6:00 p.m.), Westbound Traffic, 3 Lanes

Item	Period		
	Before	After No. 1	After No. 2
Avg. travel time	4 min 39 sec	4 min 09 sec	3 min 45 sec
Decrease (%)		11.	20.0
Avg. speeds	18.1 mph	20.2 mph	22.4 mph
Increase (%)		12.	23.8

Accident Summary

The accident summary for one year before as compared to the first year and second year of operation shows a decrease in 3.5 percent and 19 percent, respectively. As expected, a reduction in accidents occurred when parking was removed. This affirms very definitely the effect of parking removal on accidents.

Some types of accidents increased during two years of operation. Certain types of accidents were not associated with the reversible center-lane system. However, all are presented for the general trend. Past experience has shown definitely that rear-end accidents will occur at signalized intersections. The increase in this type during the first year cannot completely be explained. The many adjustments to the traffic signal system and modification in spacing and progression may have some bearing on this fact. Increased speed for increased traffic volume may be a contributing factor.

Nevertheless, the general result is a reduction in total accidents with the reversible center-lane system in operation.

When the increase in traffic volumes and the decrease in travel time are taken into account, the system perhaps provides greater potential safety than before its installation.

The left-turn area control which presented a new concept for this type of prohibition has been successful with minor exceptions. These exceptions, it appears, can be rectified by additional reversible lane signals at the extremities of the study area and in the vicinity of the Monroe intersection.

The planning by Dearborn officials for the off-street parking program simplified and eased the curb parking removal. No extreme inconvenience resulted for the business area in general. Actually, the business community in this area has become more active since the program for off-street parking was initiated.

Conclusion

Finally, the general conclusion of this evaluation is that the application of the reversible lane system to a two-way street, with heavy directional movements, is a proven success in providing increased traffic volumes and reduced travel time in the peak period and still improved the accident experience, respectively.

The system on US 12 (Michigan Ave.) in Dearborn has received highly favorable public acceptance and excellent support from Dearborn officials.

ACKNOWLEDGMENTS

The success of the conduct of this project is due to a great extent to the excellent cooperation and support of personnel from many governmental agencies, the Department of State Highways, the Wayne County Road Commission and the City of Dearborn.

The cooperation of the following City of Dearborn officials is hereby gratefully acknowledged: The Honorable Orville Hubbard, Mayor; George Lewis, Director of Public Safety; Howard Lilley, Engineer; and Garrison Clayton, Police Chief.

The general assistance and cooperation of Lieutenant William Roberts contributed greatly to the successful conduct and completion of this project.

Hereby acknowledged is the extensive time and individual effort of Stanley Lingeman, then Assistant District Traffic Engineer, Department of State Highways, involved with the initial promoting and thereafter coordinating the planning, installation and operation of the reversible center-lane traffic plan herein evaluated. Mr. Lingeman was also responsible in part for the accident data used for the system evaluation.

Many persons provided technical assistance in the development, installation and evaluation of the reversible center-lane system. Their contribution is acknowledged as follows: From the Department of State Highways, Edward F. Gervais, for the basic design and development of the reversible lane signals; Robert C. Harp, Office of Maintenance, for his technical assistance in the development and design of the reversible lane signals and in the installation of the system; Joseph Hobrla and others from the Electrical Devices Unit of the Traffic Division, for assisting the coordination of the installation of the system and the coordination of the traffic signal operation; Charles L. Richard, Traffic Division, for his invaluable assistance in design, development and continued review of the system and for contributing technical information to this report; Nejad Enustun and Herbert Schoepke for assisting in the compilation and analysis of study data for this report; and Wayne County Road Commission for their cooperation and assistance in effecting the expeditious installation of the system.

REFERENCE

1. Bushnell, and Richard, Blankout Signals for Freeway Traffic Control. TV Surveillance Project Rept., MSHD, 1963.