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HSRI Report No. TrS-8

AN INNOVATIVE PEDESTRIAN CROSSWALK SAFETY DEVICE DEMONSTRATION

By
Alger F. Malo
Anthony Freed
Donald E. Cleveland
Joseph V. Arthungal
Craig Jorgeson

1971

A Joint Report By

THE CITY OF DETROIT
DEPARTMENT OF STREETS AND TRAFFIC

And

THE UNIVERSITY OF MICHIGAN
HIGHWAY SAFETY RESEARCH INSTITUTE

In Cooperation With

MICHIGAN OFFICE OF HIGHWAY SAFETY PLANNING
STATE OF MICHIGAN

And

NATIONAL HIGHWAY TRAFFIC SAFETY ADMINISTRATION
U. S. DEPARTMENT OF TRANSPORTATION

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ACKNOWLEDGEMENTS

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The public information campaign for the new information systems was greatly facilitated by the experienced help of the Traffic Safety Association of Detroit.

Special appreciation is extended to the following gentlemen who participated in the expert panel evaluation studies: Lieutenant John Logan, Detroit Police Department; Mr. Donald E. Orne, Michigan Department of State Highways; Mr. Gene Clinton, Wayne County Road Commission; Mr. Bruce Grubb, Traffic Safety Association of Detroit; Mr. H.D. Harter, Detroit Public Schools; and Dr. Herbert Bauer, General Motors Research Laboratories.

Members of the project staff deserving special recognition are: Mr. Yoshinobu Mitsuhashi, Mr. John Balog, Mr. C.L. Saraf, Mr. Naaman Peleg, Mrs. Susan Gistinger and Mrs. Cheryl Sills.

Finally, the Highway Safety Research Institute, Dr. Robert L. Hess, Director, merits special thanks for the financial and administrative support it provided.

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SUMMARY OF FINDINGS

The purpose of this pedestrian safety demonstration program was to demonstrate and evaluate innovative applications of various crosswalk information systems. Evaluations were made by traffic experts, paid driver and pedestrian subjects, and drivers and pedestrians in the general traffic stream.

At thirteen pedestrian crosswalk locations in the City of Detroit, where the levels of hazard to safe crosswalk usage were recognized to be high on the basis of accident history and expert judgment, attempts were made to improve the situation by developing dynamic displays providing assistance to pedestrians and drivers in their evaluation of and response to the traffic environment. The essential feature of this effort was the timely transmission of current information on the other group to both approaching drivers and waiting pedestrians. Using this information, the recipient of information was expected to decide by himself the most appropriate behavior on his part from the standpoints of safety and delay. It was hoped that this would lead to safer and more rational behavior by both drivers and pedestrians.

The process of information transmission, in effect, established an improved channel of communication between these conflicting users of the highway facility at the crosswalks. Specially designed information devices as well as innovative applications of conventional information devices were employed to accomplish this purpose. The informational messages were transmitted through the media of lighted signs, lighted legends, better illumination and buzzing sounds. Some displays were dynamic in character, meaning that the lighted displays came on only following an actuation by pedestrian or vehicle and were turned off after a predetermined time period; others were static, meaning that the displays stayed on all the time. Three types of information systems were evaluated: those consisting of dynamic devices only, those consisting of static devices only, and, finally, those consisting of both dynamic and static devices.

Both unsignalized and signalized crosswalks were selected for study. At unsignalized sites the driver was advised of the presence of a pedestrian at the crosswalk intending to cross the road and the pedestrian was generally advised to evaluate the traffic situation before commencing the crossing maneuver. The objective of this approach was to minimize interruption of the flow of vehicles consistent with pedestrian safety and a reasonable level of delay for drivers. At signalized intersections with pedestrian-actuated traffic signals, messages indicating the presence of a pedestrian were also displayed to drivers. The design of the configuration of the information system was innovative in character, although the devices themselves were conventional.

The evaluation of these information systems was preceded by considerable educational and publicity efforts by the Traffic Safety Association of Detroit. Two information leaflets were designed, printed and distributed through schools, universities, the police, high school driver education classes and at the sites of the demonstration installations. A press release was given to 35 community papers and all major radio and television stations. Other public information efforts were also made.

The evaluation of the information systems was carried out in three phases:

1. Traffic engineering studies related to pedestrian and vehicular traffic characteristics.
2. A survey of opinions of unfamiliar subjects paid to use the system as both pedestrians and drivers.
3. Inspection and evaluation by experts.

Evaluation based on traffic engineering studies led to the following findings.

1. There was significantly greater relative use of the crosswalk following installation of devices. This improved response took place more during daylight hours than during darkness.
2. The speed distribution of free-moving vehicles in the vicinity of the crosswalk did not respond substantially to the installations. The response of some motorists increased the dispersion of speeds at many locations but there was little detectable effect on the average speed.
3. There was a significant change in the braking response of motorists to a pedestrian waiting to cross the street after the information systems were installed. Many more slowed down and braked after the crosswalk system was implemented than did so before.
4. Increased pedestrian usage of push buttons was detected at signalized intersections. Pedestrian response to the push button at unsignalized intersections was not as great as expected.

Pedestrian and driver subjects studies yielded the following results. Drivers were usually satisfied with the crosswalk devices, and pedestrians were usually not satisfied with driver responses. Detroit drivers did not expect to have to stop or slow down significantly unless there was a traffic signal or stop sign. Pedestrians, on the other hand, expected traffic to slow down if pushing the button activated driver warning devices. It was concluded that these joint expectations created a clear danger for pedestrians at unsignalized crosswalks. Better informed drivers and pedestrians and perhaps changes in the laws regarding pedestrian crosswalks are needed if pedestrians are going to use aids such as these to cross the streets more safely.

The panel evaluation study findings are:

1. The dynamic nature of the displays was considered effective in catching the attention of the drivers and pedestrians.

2. The additional illumination would help drivers see pedestrians better and cause pedestrians to believe it was so with the result that pedestrians in some cases would use less caution while crossing.

3. The most significant adverse effect pointed out by the experts was that the pedestrian information and warning signs seemed incapable of eliminating the chance of the pedestrian believing that cars would stop for him. Another major drawback was that if the approaching driver saw the information system going off, he would either have more difficulty in seeing the pedestrians and/or believe that he is no longer required to be particularly concerned with pedestrians at the crosswalk. In spite of these, the modes of operation of the information system which were dynamic in nature and illuminated the crosswalk were believed to be capable of contributing to pedestrian safety and gaining the confidence of drivers and pedestrians in the long run.

In summary, it is believed that devices such as those demonstrated in this project have only limited value for Detroit pedestrians and traffic except in special situations.

CHAPTER 1

THE CURRENT STATUS OF PEDESTRIAN SAFETY AND THE DEMONSTRATION PROGRAM

THE PROBLEM

Pedestrian safety in urban highway traffic has been and continues to be a central concern. Accident statistics indicate that almost 56 percent of all urban traffic fatalities since 1937 involved pedestrians (1).* In 1967, slightly more than 86 percent of all pedestrian casualties occurred in urban areas (2). Data for previous years show a similar disproportionate distribution of pedestrian casualties between urban and rural areas. Currently, pedestrian deaths account for approximately 20 percent of the total fatalities resulting from motor vehicle accidents. Approximately two-thirds of all pedestrian casualties occur while crossing or entering streets (3).

There are two general areas where the majority of pedestrian problems occur (4):

1. Public gathering places such as shopping centers, entertainment centers, and transportation terminals: In these areas, pedestrian capacity problems tend to take precedence over pedestrian safety problems.
2. The typical urban intersection: In this area, pedestrian-vehicle conflicts are often more critical than pedestrian capacity problems. The present demonstration program deals with this case.

The Traditional Approach to the Problem

The traditional approach to resolving pedestrian-vehicle intersection conflict problems has been to separate pedestrians and vehicles in space by tunnels, bridges or network design or in time by allocating the right-of-way to one of the groups exclusively or to both of them alternately. In the time separation, traffic signals control both vehicular and pedestrian flows and eliminate pedestrian-vehicular conflicts as well as intra-vehicular conflicts. Often a separate signal phase is used for pedestrians alone, and sometimes additional pedestrian "WALK, DON'T WALK" signals are installed to assist the pedestrian, and to provide effective clearance intervals. Pavement markings, pedestrian refuge islands, signing, curbs, roadside barrier structures, school safety patrol groups, adult and police school crossing guards are other aids used for reducing intersectional pedestrian-vehicle conflicts.

The pedestrian safety programs devised by municipalities also include the adoption of pedestrian protection ordinances and an attempt to increase obedience to these laws by educational and enforcement activities (3). Usually, the law assigns greater responsibility for intersectional safety to drivers than to pedestrians. The model traffic ordinance for municipalities suggested by the National Committee on Uniform Traffic Laws and Ordinance, Section 11-10, states:

---

*Numbers in parentheses refer to references listed at the end of this report.

"...every driver of a vehicle shall exercise due care to avoid colliding with any pedestrian upon any roadway and shall give warning by sounding the horn when necessary and shall exercise proper precaution upon observing any child or any confused or incapacitated person upon a roadway." (5)

Chapter XI, Article V, of the "Uniform Vehicle Code" provides for model legislation for pedestrians' rights and duties. Basically, the recommendations of the "Uniform Vehicle Code" are an attempt to achieve the following objectives:

1. Pedestrians must obey traffic control signals.
2. Drivers must yield the right-of-way to pedestrians crossing in a crosswalk when the pedestrian is upon the half of the roadway upon which the vehicle is traveling, or when the pedestrian is approaching so closely from the opposite half of the roadway as to be in danger.
3. Pedestrians must yield the right-of-way to drivers when crossing a street at locations other than a crosswalk.

In spite of the increase in population, motor vehicle registration and mileage driven, the statistical records of the National Safety Council indicate a decline in both the absolute numbers and mileage rates of pedestrian fatalities since the mid-nineteen thirties (3). However, this does not lead to a direct inference on the efficiency of pedestrian safety programs because of the contribution of a variety of factors such as improvements in vehicle design, highway design and traffic engineering (3).

Analysis of the Problem

At street intersections at least one of three conditions must be satisfied for a pedestrian-vehicle accident to occur; either the driver miscalculates or misjudges the situation, the pedestrian miscalculates or misjudges the situation or, through an environmental condition, the driver or pedestrian or both are prevented from reacting properly to the situation. It seems likely that the interaction of the two streams at intersections can be improved with a corresponding reduction in pedestrian accidents. A listing of the several contributing factors in the pedestrian-vehicle interaction is indicated in Figure 1-1.

A possible objective in an improved pedestrian safety program can be to give either the driver, the pedestrian, or both, sufficient information about the others' presence, with enough time allowed for proper evasive action or other positive reaction to be taken, to resolve the pedestrian-vehicle conflict. It is believed that this objective is not met by many existing systems, particularly at unsignalized intersections.

Several areas for improvement become immediately apparent. First, increase driver attention in the vicinity of street intersections. Second, improve visibility around intersections through better lighting. Third, increase the pedestrian awareness of risk at intersections. Fourth, achieve higher levels of law enforcement of vehicle speed, driver reactions and pedestrian responses at

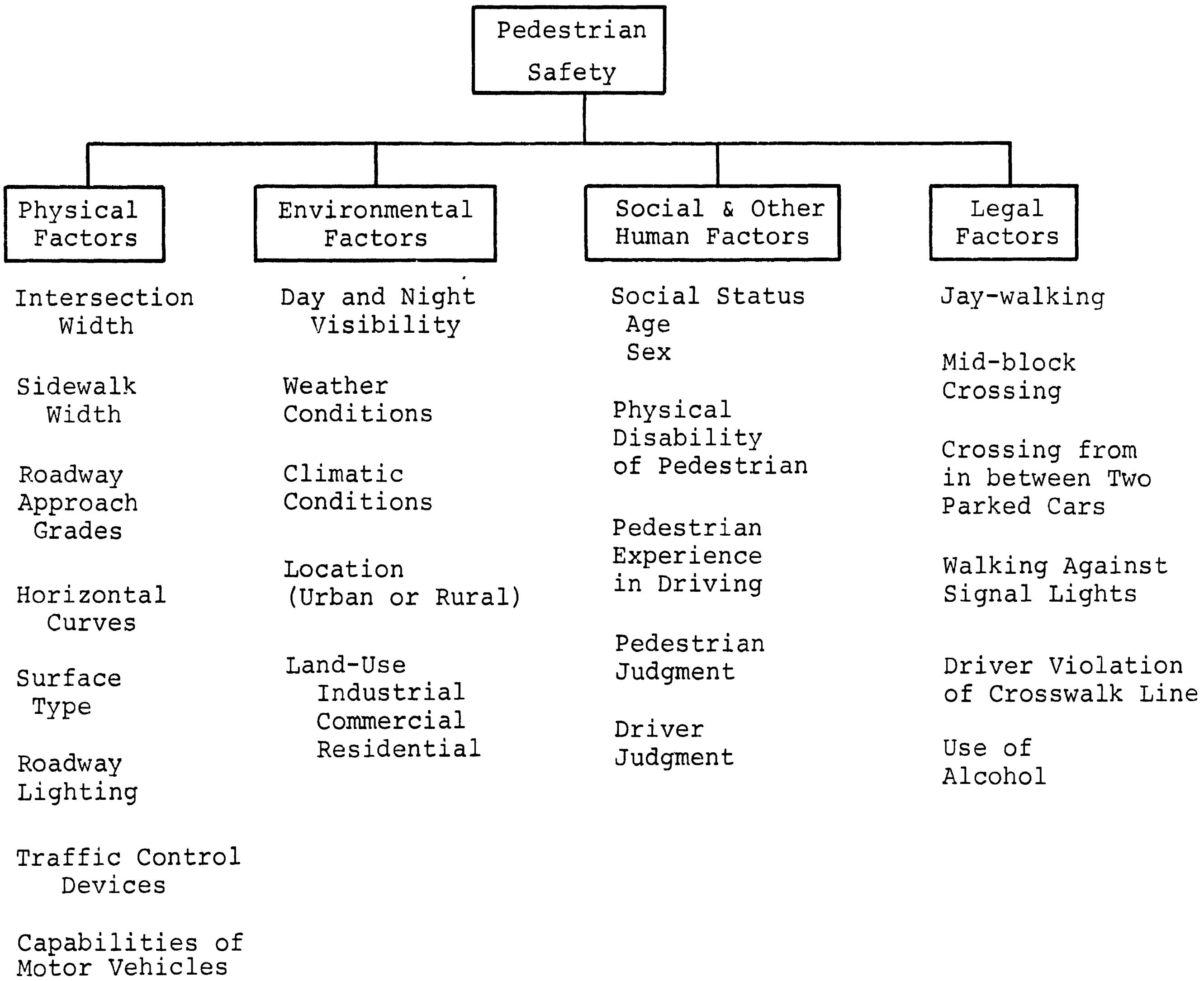


Figure 1-1

FACTORS CONTRIBUTING TO THE
PROBLEM OF PEDESTRIAN SAFETY

(VARIOUS CONTRIBUTING FACTORS)

intersections. Fifth, improve driver and pedestrian responses through education.

These five areas for improvement of pedestrian safety at intersections indicate a wide range of possible improvements and it is believed that if all were implemented, many accidents could be avoided. The present demonstration program was designed to show that innovative methods of attacking these areas can be fruitful in the State of Michigan.

APPROACH OF THE DEMONSTRATION PROGRAM

A solution which can satisfy the warning and information objectives previously described is the utilization of additional display devices at street intersections. It was decided that the demonstration program would include both signalized and unsignalized intersections. Emphasis was to be put on unsignalized intersections where traffic engineering judgment indicated signalization was not desirable and yet where pedestrian problems exist. Because of legal problems informational rather than control displays were used.

The extact nature of the displays used depended on the availability or ease of display manufacture from standard electronic components. For the driver, the device could take the form of additional lighting at the intersection or a sign message or other simple visual display as he approaches the intersection. For the pedestrian attention was given to similar types of displays. Combined devices for both pedestrian and driver were considered, but such factors as the area where each look and the required form of the message prescribed the use of a separate device for each. It was decided that the final design of the information displays should be primarily visual, all-weather, twenty-four hour, and usually dynamic devices which attempt to respond to such human factors as user willingness to follow the displayed recommendations.

It was also believed that the proposed devices should give an easily understandable signal or message to the driver and pedestrian. The driver's and the pedestrian's reactions depend not only on their ability to perceive a situation requiring caution, but also perception with enough time allowed for proper reaction.

In considering the problem systematically, it was imperative that the system be dynamic in its operation. The displays were to be activated when either a vehicle, a pedestrian, or both approached the intersection. After the resolution of the situation, the displays were to automatically shut down until the next occurrence of a pedestrian-vehicle interaction.

The activation of the display was induced by a sensing device. The sensing device was to be electronic in nature, detect the approach of either pedestrians or vehicles to the intersection, and activate the signal device to the driver approaching the intersection or the pedestrian using the crosswalk.

The display was to be effective in all weather conditions, especially under conditions of poor visiblity. It was to be readily discernable to the observer far enough from the intersection to facilitate proper implementation of its message.

The willingness on the part of the pedestrian and driver to make use of the devices was considered as an important factor. The devices were to have high reliability in their operation and any failure of either the signaling devices or sensing devices was to become readily apparent for prompt and proper maintenance. The susceptability of a device to vandalism was also to be considered.

THE DEMONSTRATION GRANT

In June 1968, the Department of Streets and Traffic of the City of Detroit received a grant from the National Highway Traffic Safety Administration through the Michigan State Office of Highway Safety Planning for the development, demonstration and evaluation of traffic information and control systems to improve pedestrian safety at crosswalks. The basic study goals were described as the desire to demonstrate the innovative use of existing equipment to improve pedestrian safety at crosswalks where present methods do not provide a satisfactory solution. To qualify for the grant, it was necessary for the Department of Streets and Traffic to show that at least an equivalent amount was to be spent by the City in continuing activities related to pedestrian safety. In 1969, an additional grant was received, making a total of $224,900 available to the City for the project.

ORGANIZATION AND MANAGEMENT

The Department of Streets and Traffic entered into a contract with The University of Michigan's Highway Safety Research Institute for assistance in all phases of the project, especially in the evaluation of the information systems used in the demonstration program.

The various agencies that participated in the study and the organization and management of the program are schematically presented in Figure 1-2.

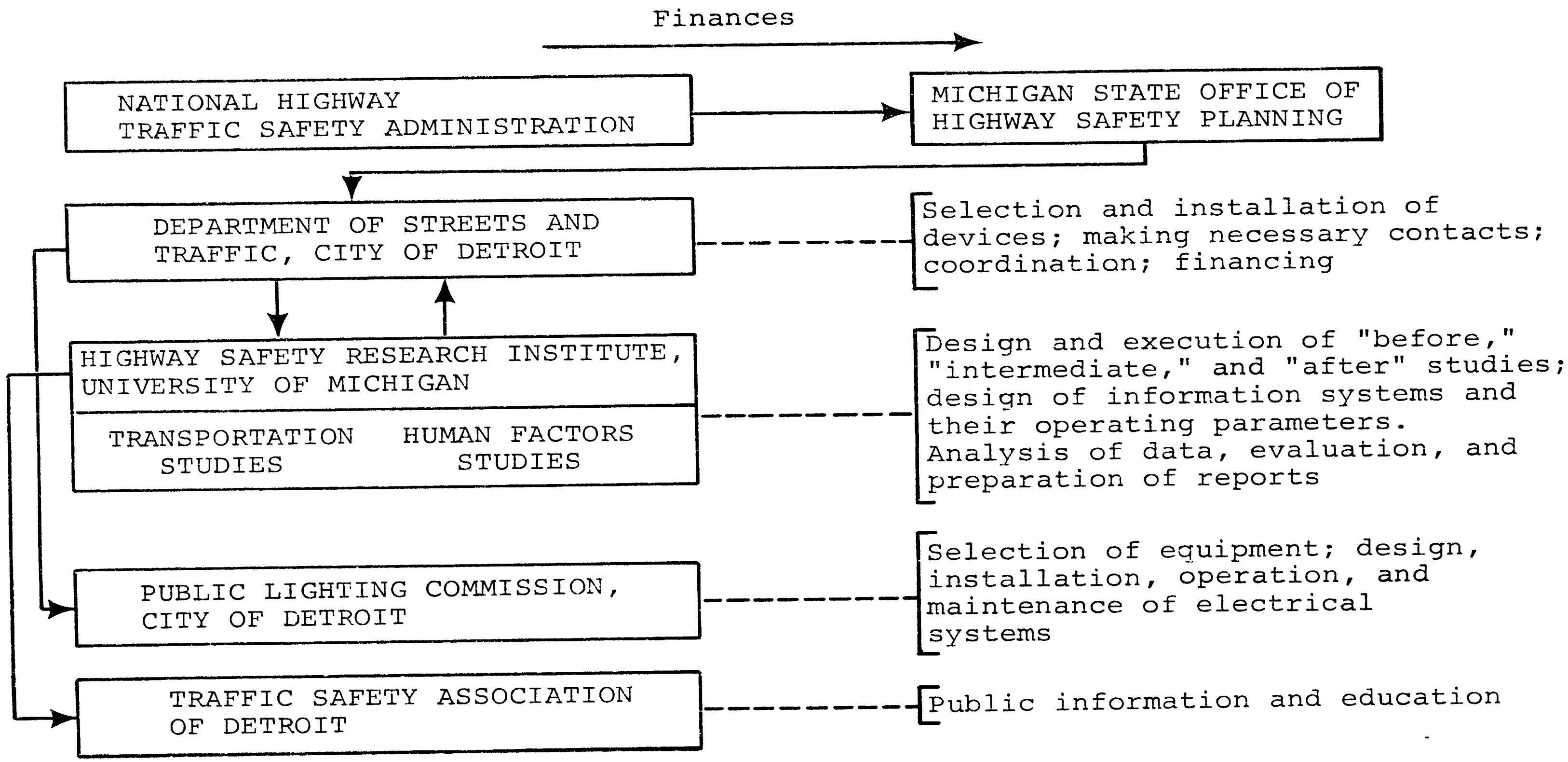


Figure 1-2

ORGANIZATION AND MANAGEMENT OF THE DEMONSTRATION PROJECT

CHAPTER 2

SYSTEM DESIGN AND INSTALLATION

LITERATURE REVIEW

As a first step toward ensuring utilization of the current engineering practice and research findings, an extensive survey of the literature was conducted. This resulted in the preparation and study of a comprehensive bibiliography relating the effects of various types of traffic engineering and control techniques to pedestrian safety. This bibliography entitled Selected Bibliography on Traffic Control for Pedestrian Safety, June 1969, has 639 entries.

DESIGN OF SURVEILLANCE AND INFORMATION SYSTEMS

Aided by the information obtained from the literature review, an extensive effort was made to ascertain the availability of innovative devices with pedestrian safety applicability and to encourage suppliers to develop such devices. In this connection, all leading United States and many foreign suppliers of traffic control equipment were contacted. However, useful information was received from only a fraction of potential suppliers. The development of the precise system used at each site was slower than expected due primarily to the innovative nature of the systems. Considerable analyses and trials were required both for equipment configurations and control and in the operation logic at each site.

The basic goals of the design of the systems were to make the driver more aware of the pedestrian and to remind the pedestrian to be careful without giving either the pedestrian or the driver the impression that he had been relieved of his basic responsibilities. To achieve these goals, six basic functional elements in various combinations were considered in the design of all systems:

1. Improvement of pedestrian detection by the use of push-button detectors which attract and respond to the pedestrian, or by automatic detection using photoelectric cells.
2. Increased illumination of the pedestrian and crosswalk by special luminaires.
3. Warning the driver of a pedestrian's presence with illuminated signs, flashing beacons, crosswalk markings, lighted plastic posts, and flashing advance warning signs.
4. Detection of vehicles approaching the crosswalk using automatic electronic detectors.
5. Informing the conflicting stream of the presence of the other stream in the approach to the crosswalk by linking information signs to the detectors.
6. Channelling the pedestrian into the designated crosswalk by the use of chain barriers, signs and improved markings.

The functional logic of the information system at unsignalized crosswalks is presented in Figure 2-1. Major efforts were made to

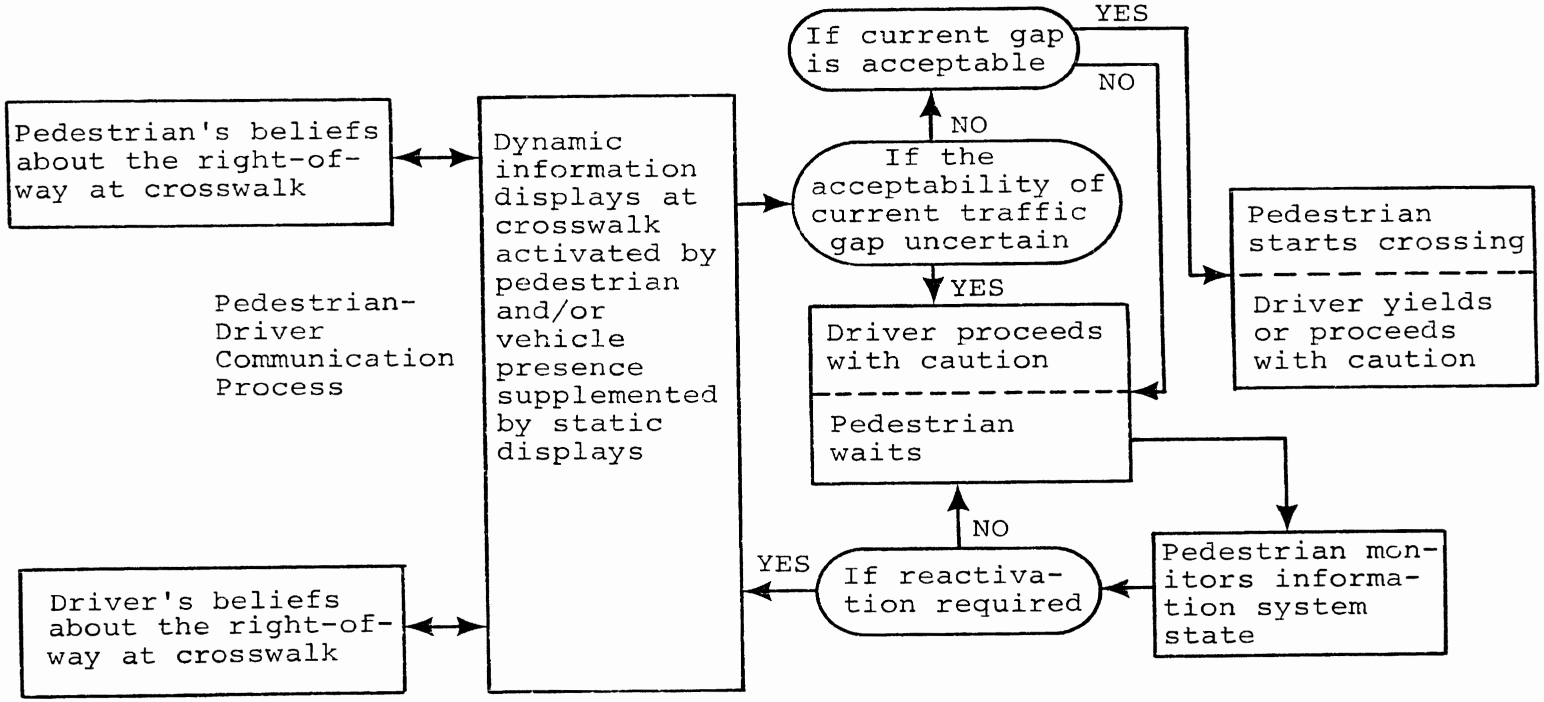


Figure 2-1

FUNCTIONAL LOGIC OF THE DYNAMIC INFORMATION SYSTEM AT AN UNSIGNALIZED CROSSWALK avoid giving the pedestrian a false sense of security. This was accomplished by avoiding resemblance to conventional pedestrian signal legends and by using displays warning the pedestrian to "Watch Out for Cars" and that "Cars Do Not Stop for Pedestrians."

The displays visible to the driver were designed to inform the driver of the presence of a pedestrian in the vicinity of the crosswalk, leaving the decision relating to his action to the driver's judgment. Care was taken to avoid any resemblance to conventional controls ordering a specific action on the part of the driver.

In most cases, the displays visible to the driver were dynamic, operating only when there was a pedestrian in or about to enter the crosswalk.

Some effort was devoted to analytical and experimental research studies for evolving appropriate design criteria for the information systems. Of major importance in this phase of the project were the studies conducted to determine by laboratory tests the illumination characteristics of the Crosswalk Fixture (see next section). This information is presented in Appendix A.

The feasibility of using stroboscopic illumination for pedestrian crosswalks was also investigated. An extensive review of the literature yielded only limited pertinent information concerning the effects of stroboscopic lighting on general human perception. The results of the survey did not favor the use of intermittent visual stimulation with stroboscopic lights. As a result of this study, the selection and design of crosswalk illumination was limited to steadily lit systems. Details of this research are given in Appendix B.

DESCRIPTION OF EQUIPMENT

The devices used to develop the various combinations of information systems and their operational capabilities are briefly described below.

Lighted Push-Button Detector

The Lighted Push Button Detector is a modified design of the conventional type of push-button detector. A sketch is shown in Figure 2-2 and a photograph at an actual installation in Figure 2-7. This detector is larger than the conventional push-button detector. It has two small red lights which respond to activation by the pedestrian and a fixed message sign to indicate the desired action. The operational features of the Detector sub-system when used at an unsignalized intersection are presented in Figure 2-3. When used at an actuated signalized intersection, the pedestrian waits for the "WALK" indication after observing the flashing red lights and pushing the button.

Combination Push-Button Detector

The Combination Push-Button Detector, specially designed for this project, has innovative features as compared to the conventional type of pedestrian push-button detector. A sketch is shown in Figure 2-4 and a photograph in Figure 2-6. In addition to its large size, it is provided with a buzzer and an internally-illuminated changeable message sign. The buzzer and changeable

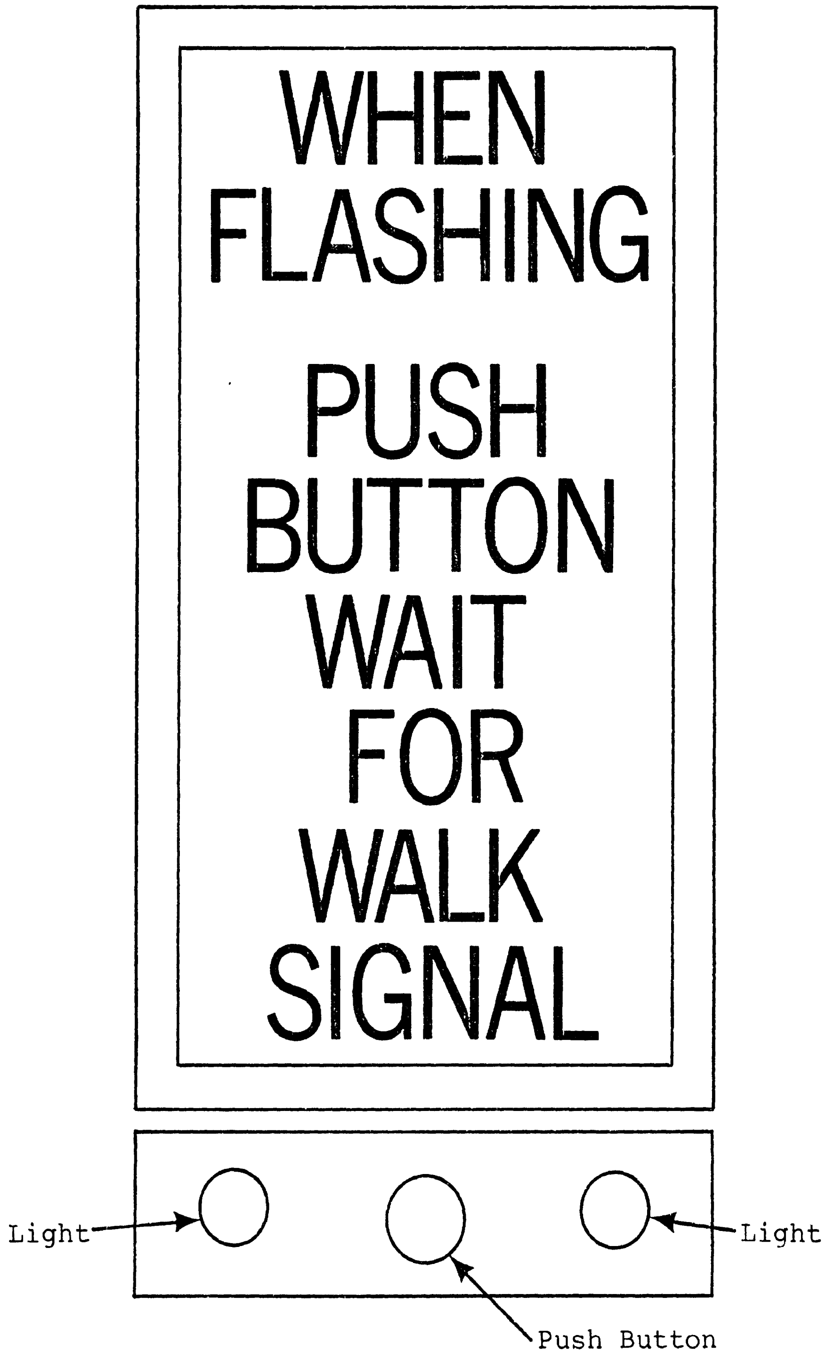
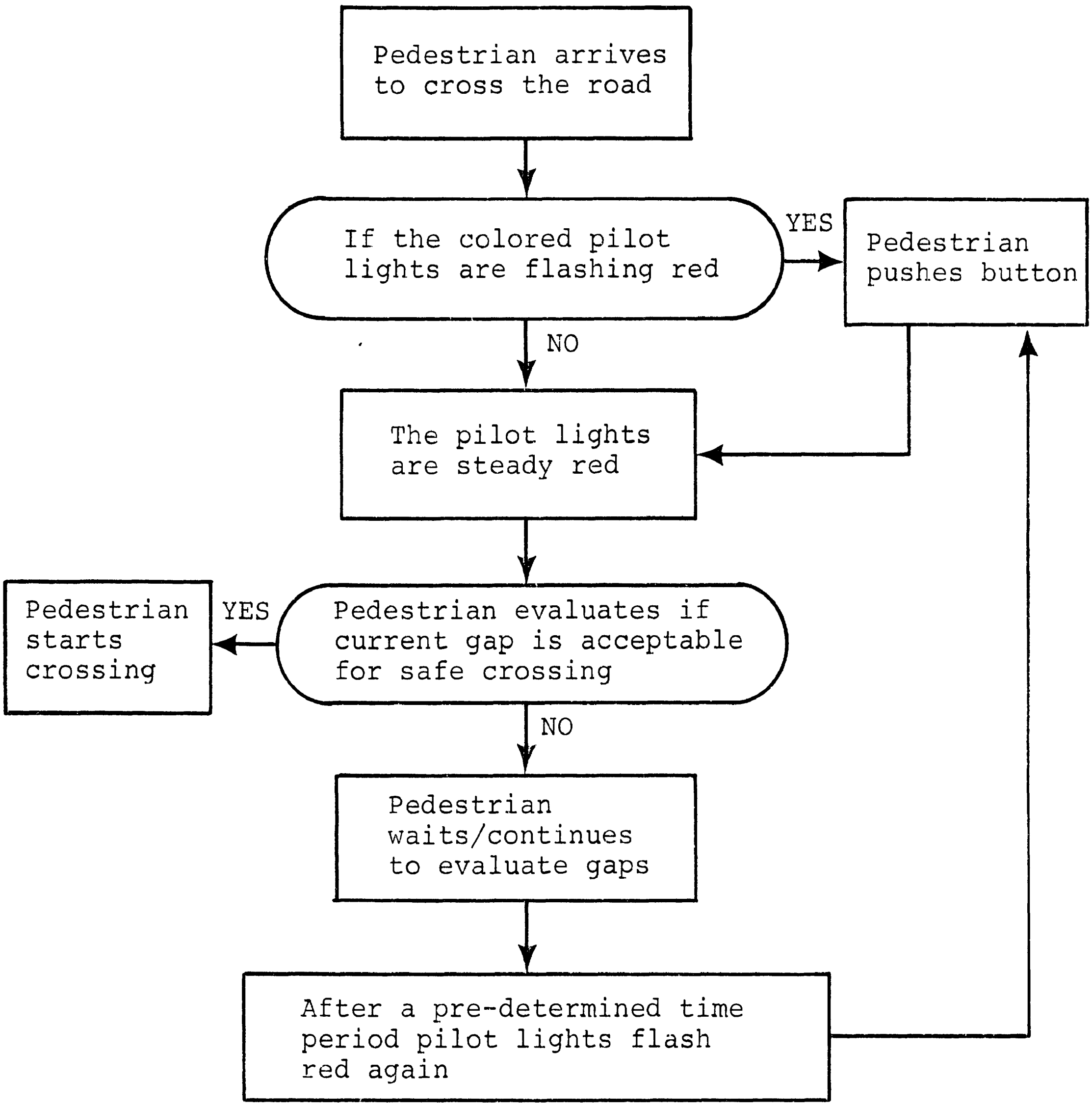


Figure 2-2

LIGHTED SKETCH OF PUSH-BUTTON DETECTOR



NOTE: THE FIXED-SIGN MESSAGE READS "WHEN FLASHING PUSH BUTTON"

Figure 2-3

OPERATIONAL FEATURES OF THE LIGHTED PUSH-BUTTON DETECTOR (UNSIGNALIZED INTERSECTION)

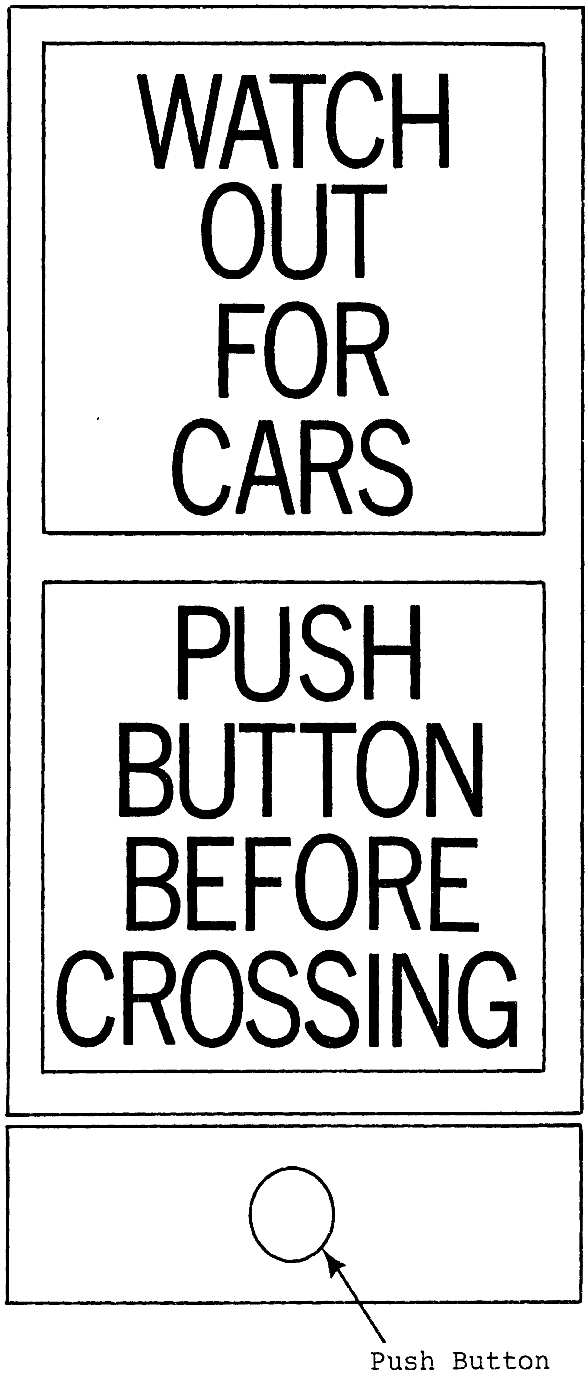


Figure 2-4

COMBINATION SKETCH OF PUSH-BUTTON DETECTOR message sign respond to pedestrian activation. The operational features of the Detector sub-system when used at both signalized and unsignalized intersections are presented in Figure 2-5.

Pedestrian Crossing Sign (see Plate 2-2)

This is an overhead sign facing the waiting and crossing pedestrians. It has an internally-illuminated 12" double-faced changeable message sign which responds to vehicle actuation. The operational features of the sign are presented in Figure 2-8.

Pedestrian Information and Warning Signs

There are three categories of these signs: (1) 18" x 24" enlargement of descriptive leaflets prepared by the Traffic Safety Association to describe the function and operation of the information systems, see Plates 2-1 and 2-2; (2) 18" x 24" sign mounted near the crosswalk and directed toward the approaching pedestrians warning them that cars do not stop because of the activated information system, see Figure 2-9; and (3) signs directing pedestrians to the crosswalk, see Figure 2-10.

Pedestrian Chains

These are chain fences on the curb to funnel the pedestrian toward the crosswalk (see Figure 2-10).

Crosswalk Markings

These are conventional and zebra-painted crosswalks intended to attract the attention of both the drivers and the pedestrians.

Crosswalk Fixture

This device is shown in Figures 2-10, 2-11, 2-12, 2-13, 2-14, 2-15, 2-16, 2-17, 2-18, 2-19, 2-20, 21-21 and Plates 2-1 and 2-2. The Crosswalk Fixture is an overhead sign designed so that an eight-foot fluorescent lamp fits compactly into the sockets provided. The one-foot width of the sign is large enough to accommodate four of the extra-high output lamps. The level of the lamps is approximately 2.5 feet from the lowest level of the signboard. The weight of the signboard is due largely to two panels of plexiglass, three feet wide and eight and one-half feet long. The panels bear the words "Cross Walk" painted in large black letters on an orange translucent background directed toward approaching drivers. The Fixture is capable of two modes of operation, namely, static and dynamic. In the static mode, it remains illuminated at all times (or during hours of darkness). In the dynamic mode, it is blanked out until an actuation occurs. A single actuation causes the dynamic display to be illuminated and stay on for a predetermined time period only; however, the illumination can be extended by successive actuations. The statically or dynamically illuminated Crosswalk Fixture floods the sidewalk and the roadway with a bright light, making pedestrians at the intersection easily visible to the driver. In addition, the very conspicuous sign catches the attention of the driver and alerts him to the pedestrian-vehicle conflict potential at the crosswalk. This is especially true in the case of the dynamic mode of operation. These functions of the Crosswalk Fixture are of particular relevance and advantage during nighttime and other low visibility conditions.

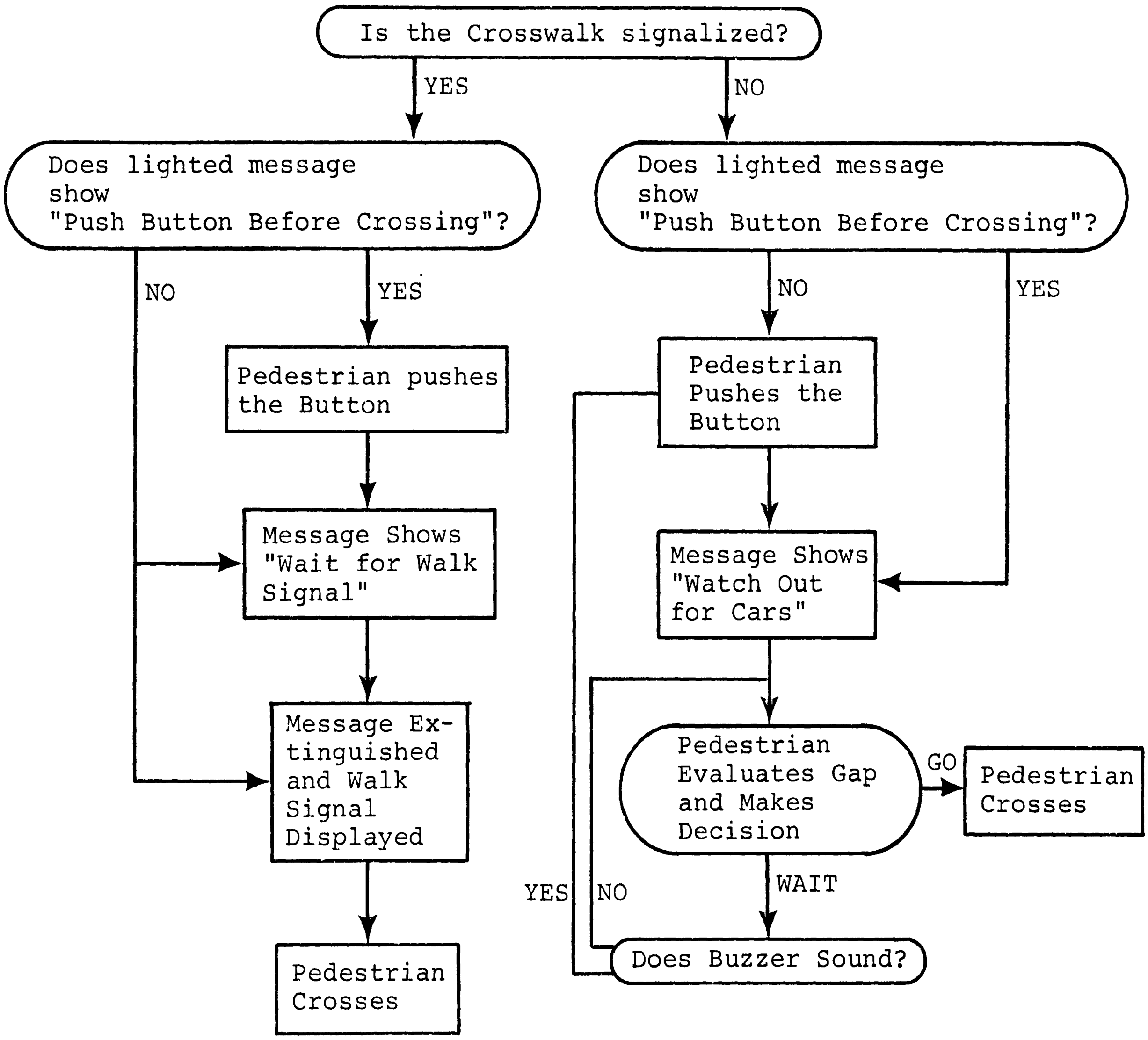


Figure 2-5

OPERATIONAL FEATURES OF THE
COMBINATION PUSH BUTTON DETECTOR

FIGURE 2-6
COMBINATION PUSHBUTTON DETECTOR

FIGURE 2-7
LIGHTED PUSHBUTTON DETECTOR

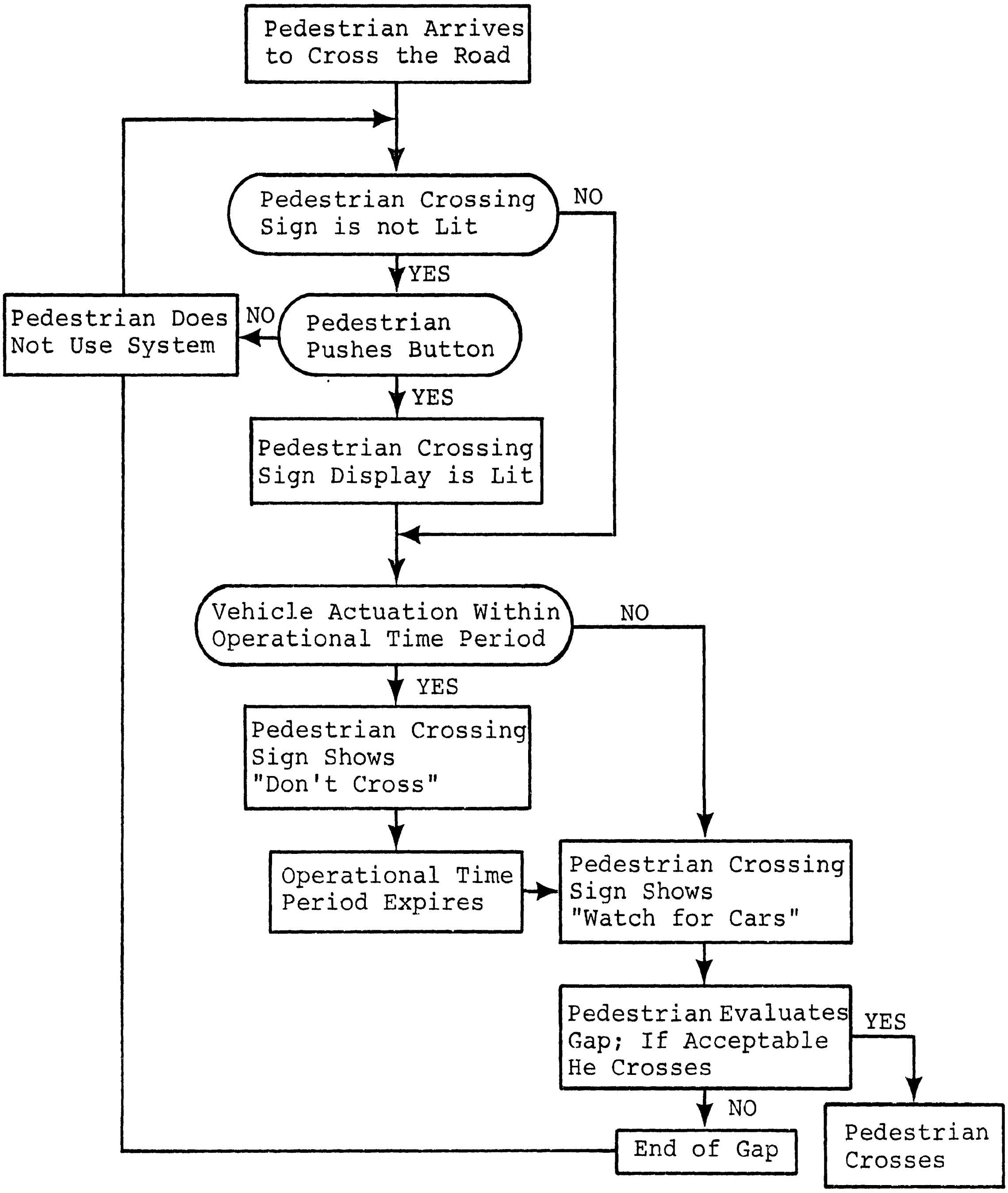
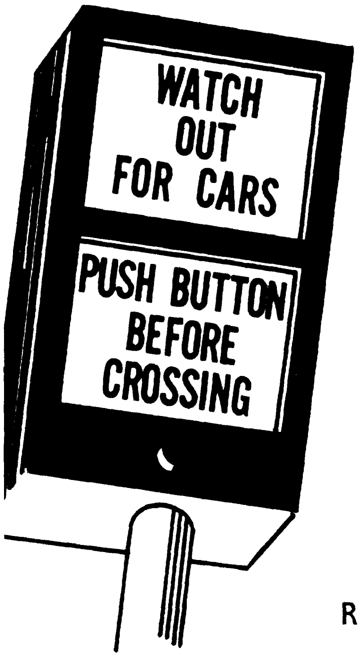


Figure 2-8

OPERATIONAL FEATURES OF THE PEDESTRIAN CROSSING SIGN

PLATE 2-1. EDUCATIONAL LEAFLET. →

So Drivers Can See You Better As You Cross



PUSH THE BUTTON –

Before Crossing, Always push the button on the pedestrian control box. This turns on the special warning signs, flashers, and lights so drivers can see you better as you cross. If the button has already been pushed, the signals are still on and you do not have to push the button again unless you hear a buzzer before you start across the street. If the buzzer sounds before you start to cross, just push the button to keep the lights and signs on.

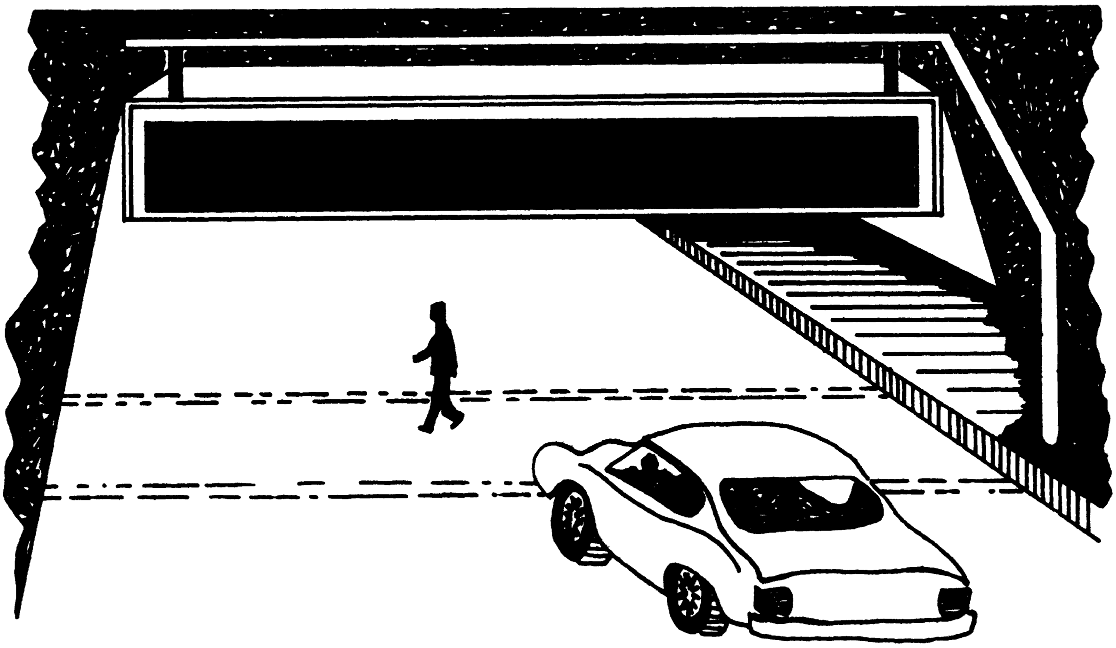
These signals are only a warning to drivers that someone is crossing or is about to cross the street. They do not make the driver stop so you must be sure before crossing that the driver sees you and can avoid hitting you.

REMEMBER, AS YOU CROSS, ALWAYS WATCH OUT FOR CARS!

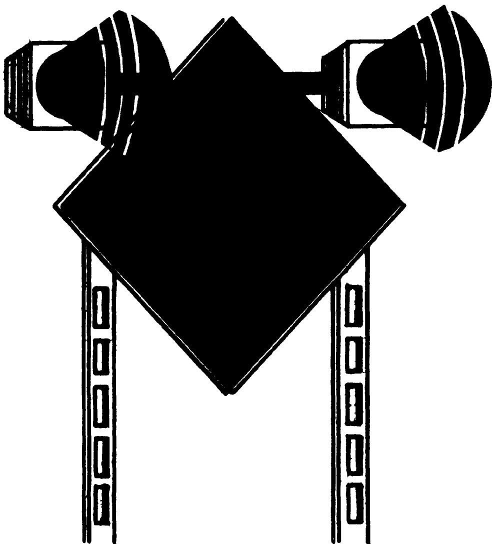
The overhead cross-'alk and advance 'arning signs aid you ı your crossing.

The lights and signs elp the driver to see ou better and warn im that you are there.

These traffic devices an help you but your afety is up to you. 'atch Out For Cars.



DON'T PLACE YOUR LIFE IN THE DRIVER'S HANDS. KEEP ALERT.



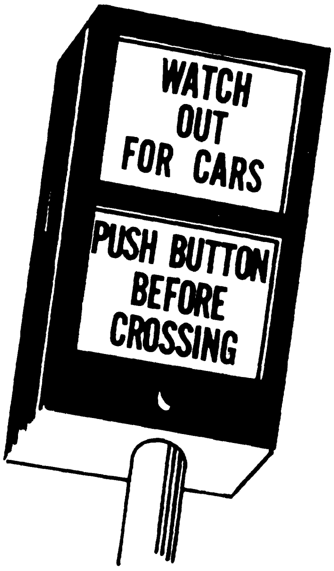
Note to drivers: These special warning signs and lights are designed to let you know that a pedestrian is crossing or is about to cross the street. You should be prepared to avoid a pedestrian in the crosswalk when any of these devices are turned on.

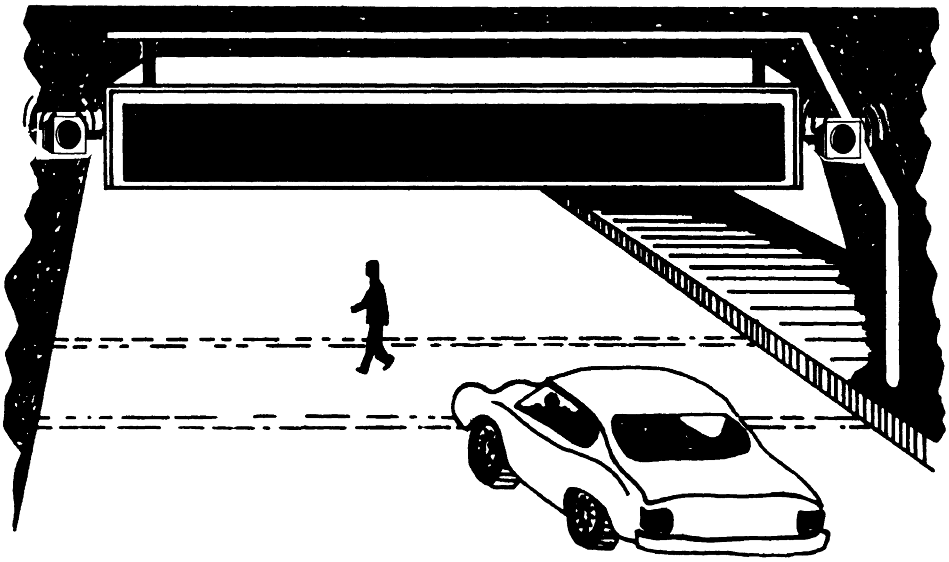
The Pedestrian Safety Project, approved by the Michigan Office of Highway Safety Planning is being conducted by the University of Michigan Highway Safety Research Institute and the Detroit Department of Streets and Traffic under a Federal Grant from the Department of Transportation.

Prepared By The Traffic Safety Association Of Detroit

PLATE 2-2. EDUCATIONAL LEAFLET.

So Drivers Can See You Better As You Cross



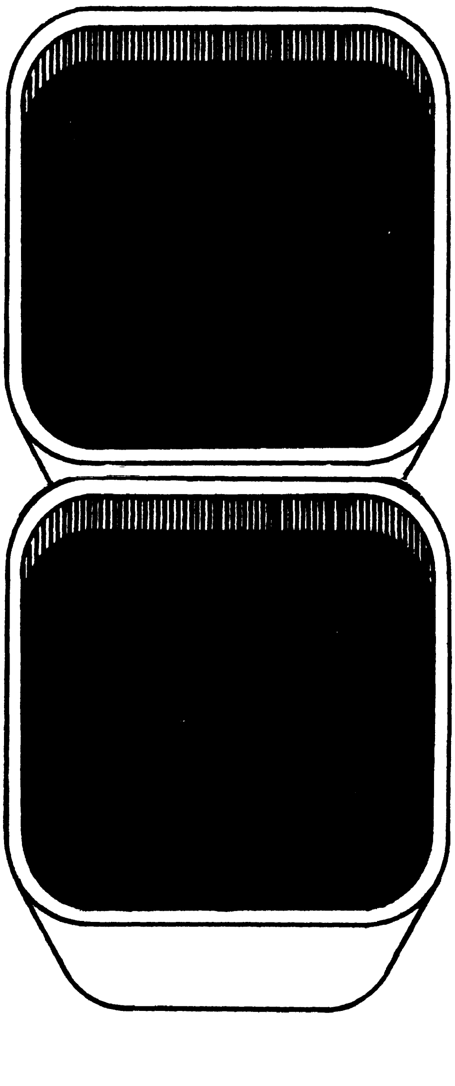


PUSH THE BUTTON –

Before Crossing, Always push the button on the pedestrian control box. This turns on the special warning signs, flashers, and lights so drivers can see you better as you cross. If a buzzer sounds before you start to cross, just push the button to keep the lights and signs on.

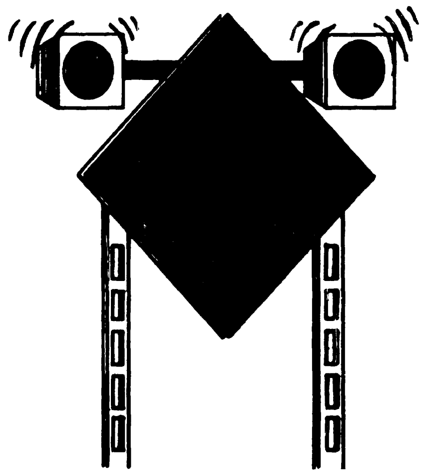
The overhead crosswalk and advance warning signs aid you in your crossing. The lights and signs help the driver to see you better and warn him that you are there.

REMEMBER, AS YOU CROSS, ALWAYS WATCH OUT FOR CARS!



When this signal is on, cars are coming. Do Not Cross. until cars have passed and then, cross with care.

Even though this signal is on, Watch For Cars as you cross because there is no signal requiring drivers to stop.



Note to drivers: You should be prepared to avoid a pedestrian in the crosswalk when Cross-Walk sign is on and yellow lights are flashing.

The Pedestrian Safety Project, approved by the Michigan Office of Highway Safety Planning is being conducted by the University of Michigan Highway Safety Research Institute and the Detroit Department of Streets and Traffic under a Federal Grant from the Department of Transportation.

Prepared By The Traffic Safety Association Of Detroit

FIGURE 2-9
PEDESTRIAN INFORMATION AND WARNING SIGNS

FIGURE 2-10
PEDESTRIAN CHAIN AND SIGNS

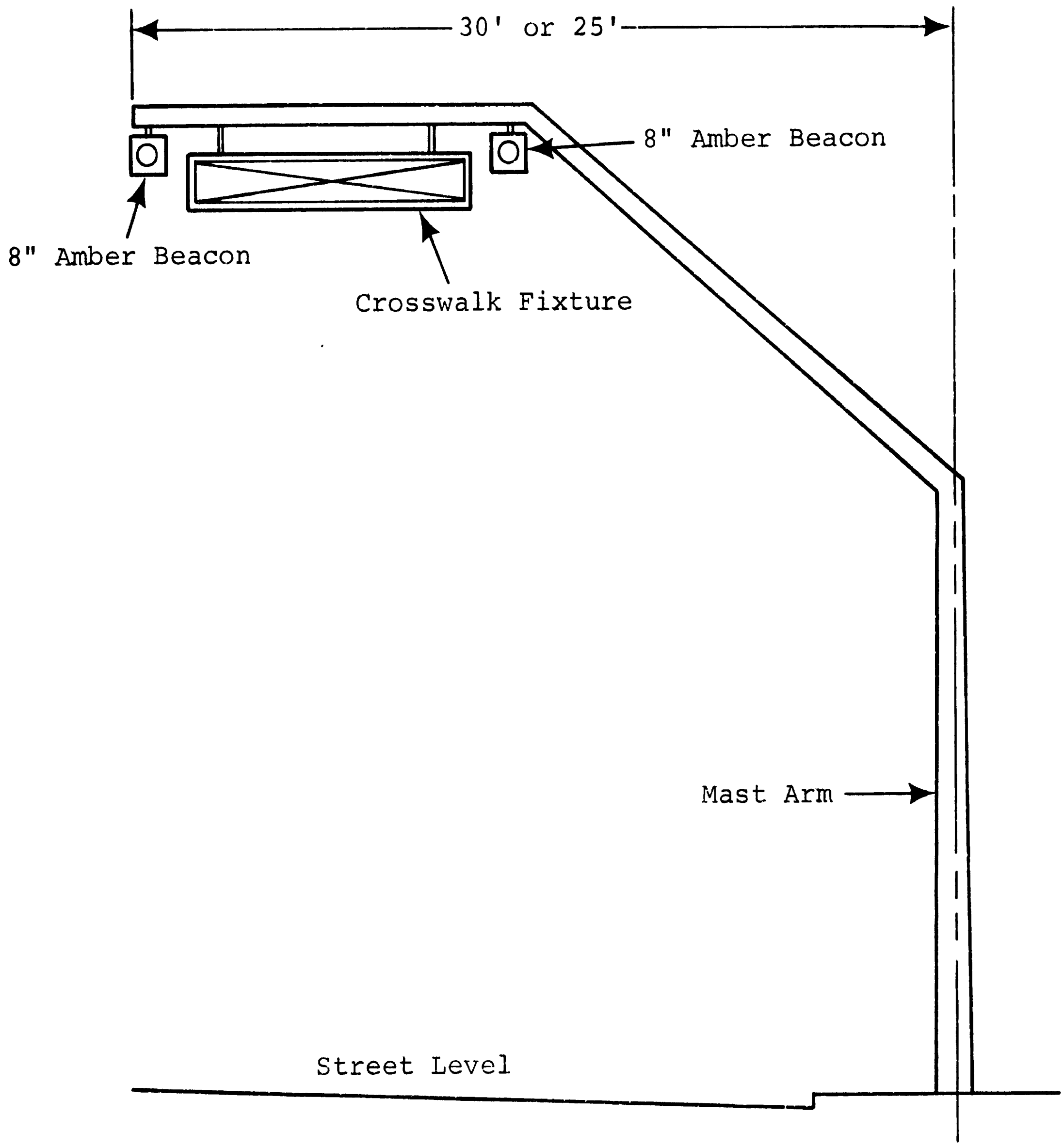
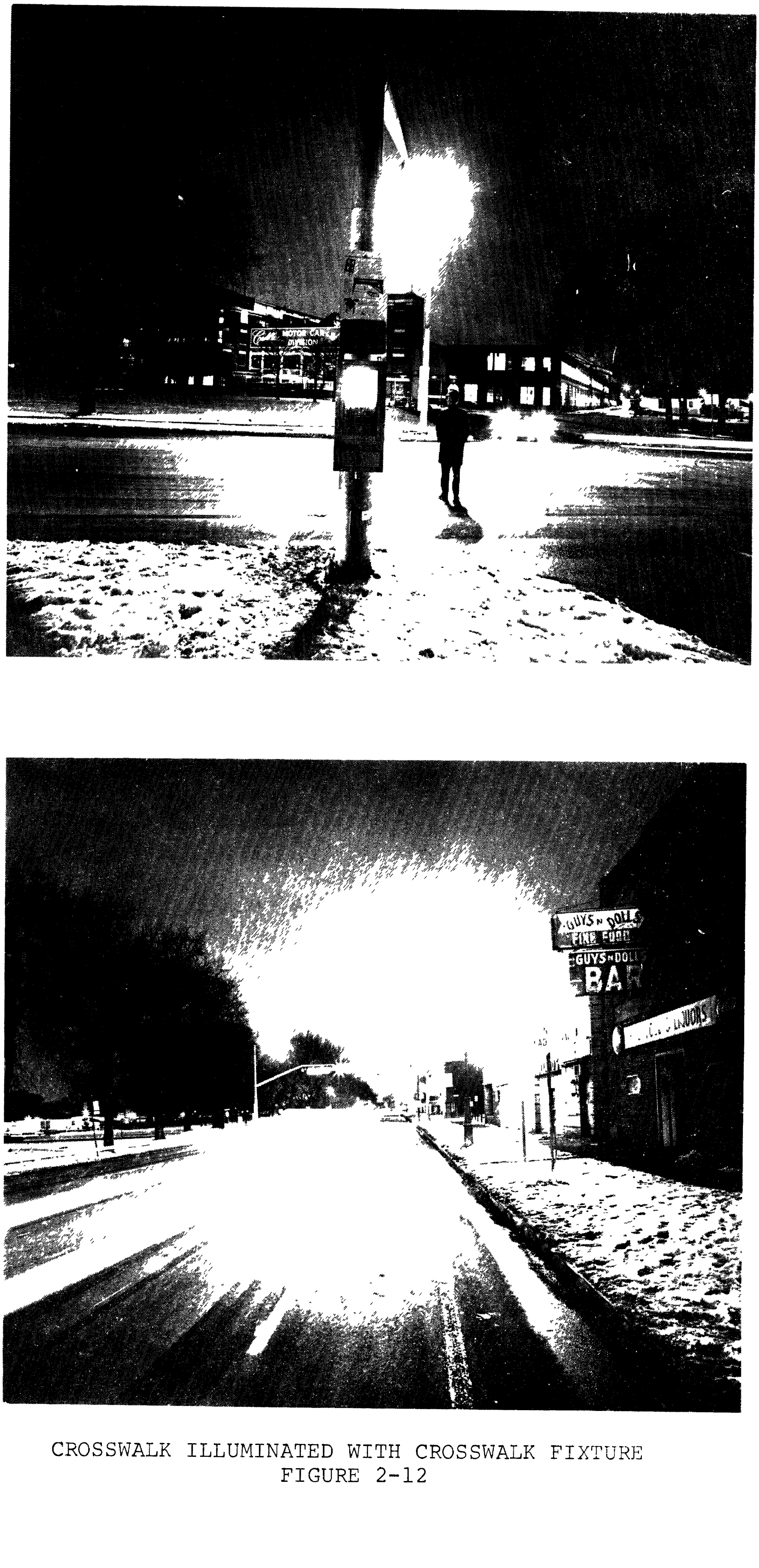


Figure 2-11

CROSSWALK FIXTURE AND AMBER BEACON



CROSSWALK ILLUMINATED WITH CROSSWALK FIXTURE
FIGURE 2-12

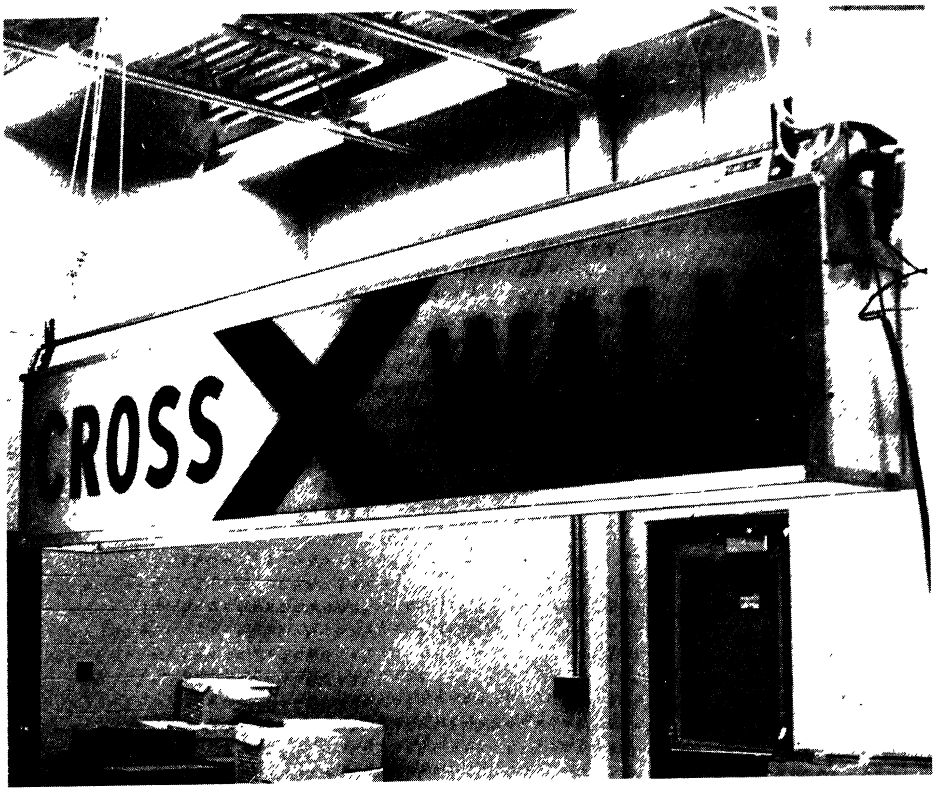


FIGURE 2-13
CROSSWALK FIXTURE

FIGURE 2-14
ADVANCE WARNING SIGN

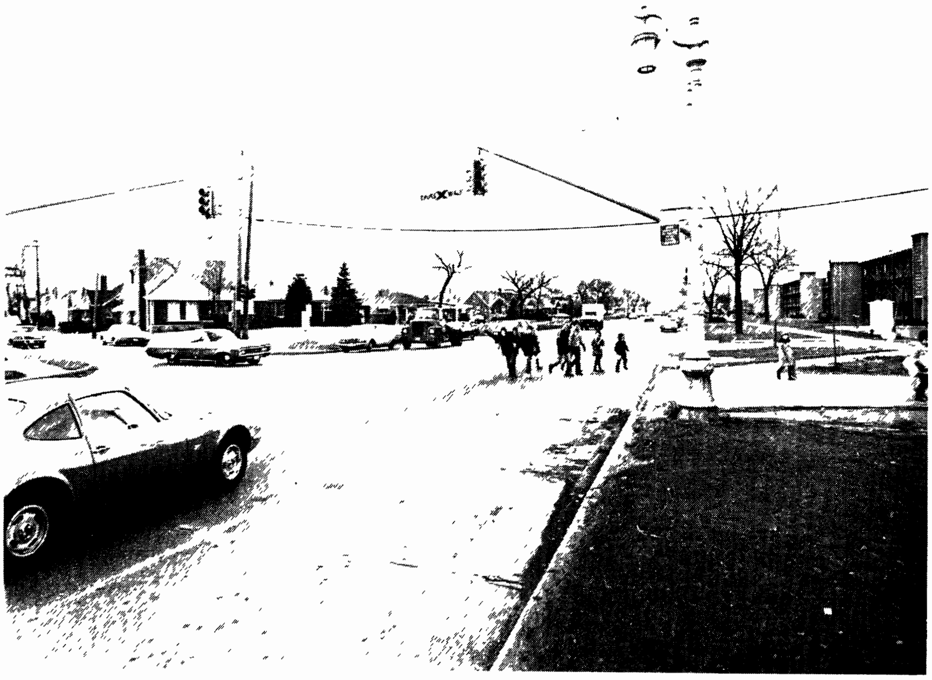


FIGURE 2-15
TYPICAL INSTALLATION WITH SIGNALS AND SPAN WIRE

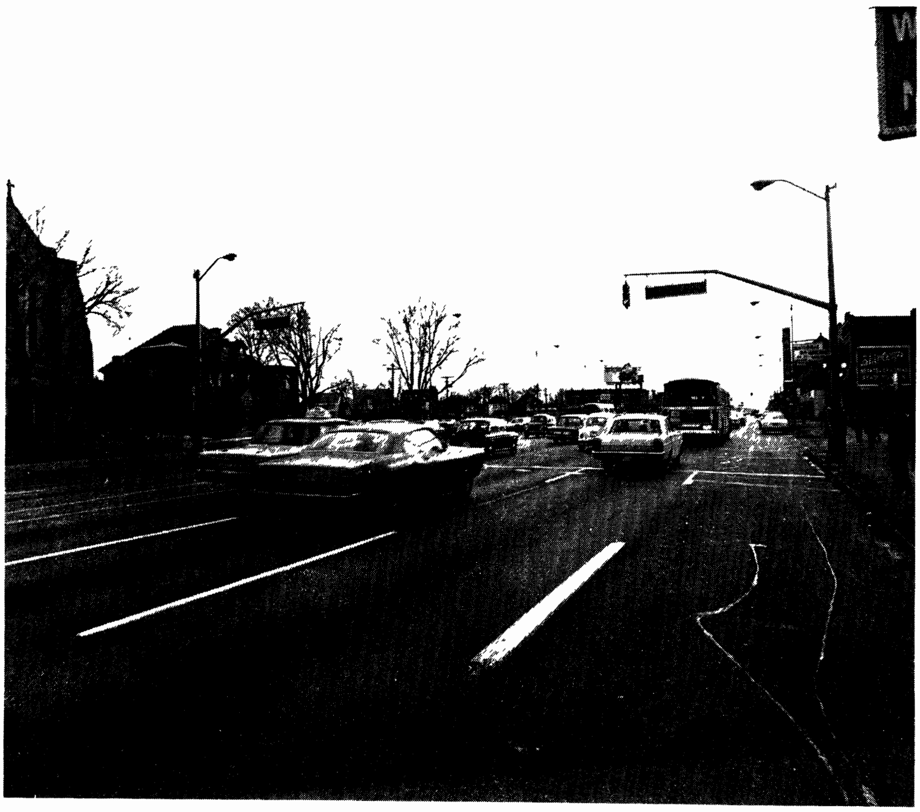


FIGURE 2-16
TYPICAL INSTALLATION WITH SIGNALS AND MAST ARM

FIGURE 2-17
TYPICAL UNSIGNALIZED LOCATION WITH SPAN WIRE

FIGURE 2-18
TYPICAL UNSIGNALIZED LOCATION WITH MAST ARMS

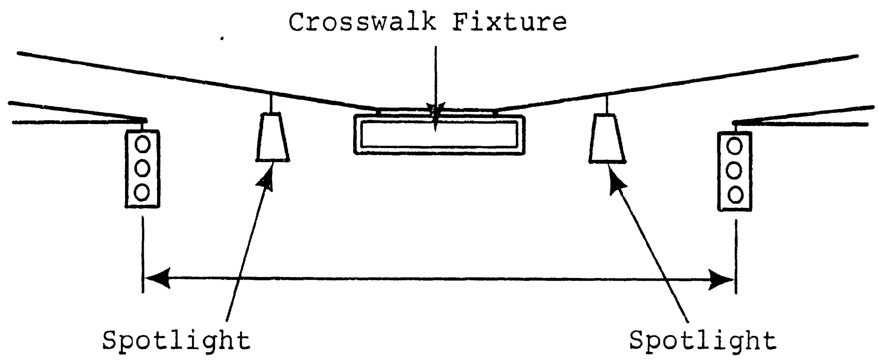


Figure 2-19
SPOTLIGHTS AND CROSSWALK FIXTURE

Amber Beacons

This installation consists of two 8" overhead amber signals directed toward approaching drivers, as shown in Figures 2-11, 2-17, 2-18, 2-20 and Plate 2-2. The Amber Beacons operate in conjunction with the Crosswalk Fixture in the dynamic mode only. Following actuation, the Beacons flash for a predetermined time period alerting the approaching driver to the traffic environment at the crosswalk.

Spotlights

These are small high-output luminaires located over the crosswalk to provide uniform extra illumination on the crosswalk, as shown in Figures 2-19 and 2-20. They make the pedestrian more readily visible to the driver at night and under low visiblity conditions. They can operate in either the dynamic or static mode.

Advance Warning Sign (See Figures 2-12, 2-22 and Plates 2-1, 2-2.)

This is a 36" x 36" yellow reflectorized sign with two flashing Amber Beacons erected at the curb in advance of the crosswalk and directed towards the approaching driver. The legend reads "Pedestrian Crossing Ahead." The driver sees this message well in advance of the crosswalk area, thus ensuring sufficient time for thought and cautious action on the part of the driver. The Beacons can operate in either the static or dynamic mode.

Photocell Detectors

These are automatic sensing devices which can detect the pedestrian's presence when he passes the detector. Light relays, one application of the photocell, were employed to detect pedestrian presence. The relay features a small long-life lamp in the projector which produces a beam of light. This beam is then focused on a photocell in the receiver which converts the "pulsed" light from the projector into electrical pulses which are then fed into the amplifier of the control unit. The amplified signal is fed into the control grid of an A.C.-operated silicon controlled rectifier in the control unit. The rectifier conducts current to hold the output relay in the energized position as long as sufficient signal is present at its grid. Upon interruption of the light beam by a pedestrian's presence, or if the projector, receiver, or control unit fail to operate properly, the signal to the silicon-controlled rectifier is removed and the control relay drops out.

It was necessary to determine the best height at which to install the Detector. The light beam from the Detector must be interrupted completely by an object before the output relay is de-energized. Therefore, it was decided that the Detector should be installed at a height corresponding to the maximum time of interception of the light beam. Thus, the height for the Detector installation was fixed at 2.5 to 3 feet above the ground. An evaluation of this device could not be made because the test installation was rendered inoperative by vandals.

FIGURE 2-20
CROSSWALK ILLUMINATED WITH SPOTLIGHTS

FIGURE 2-21
CROSSWALK ILLUMINATED WITH SPOTLIGHTS AND CROSSWALK FIXTURE

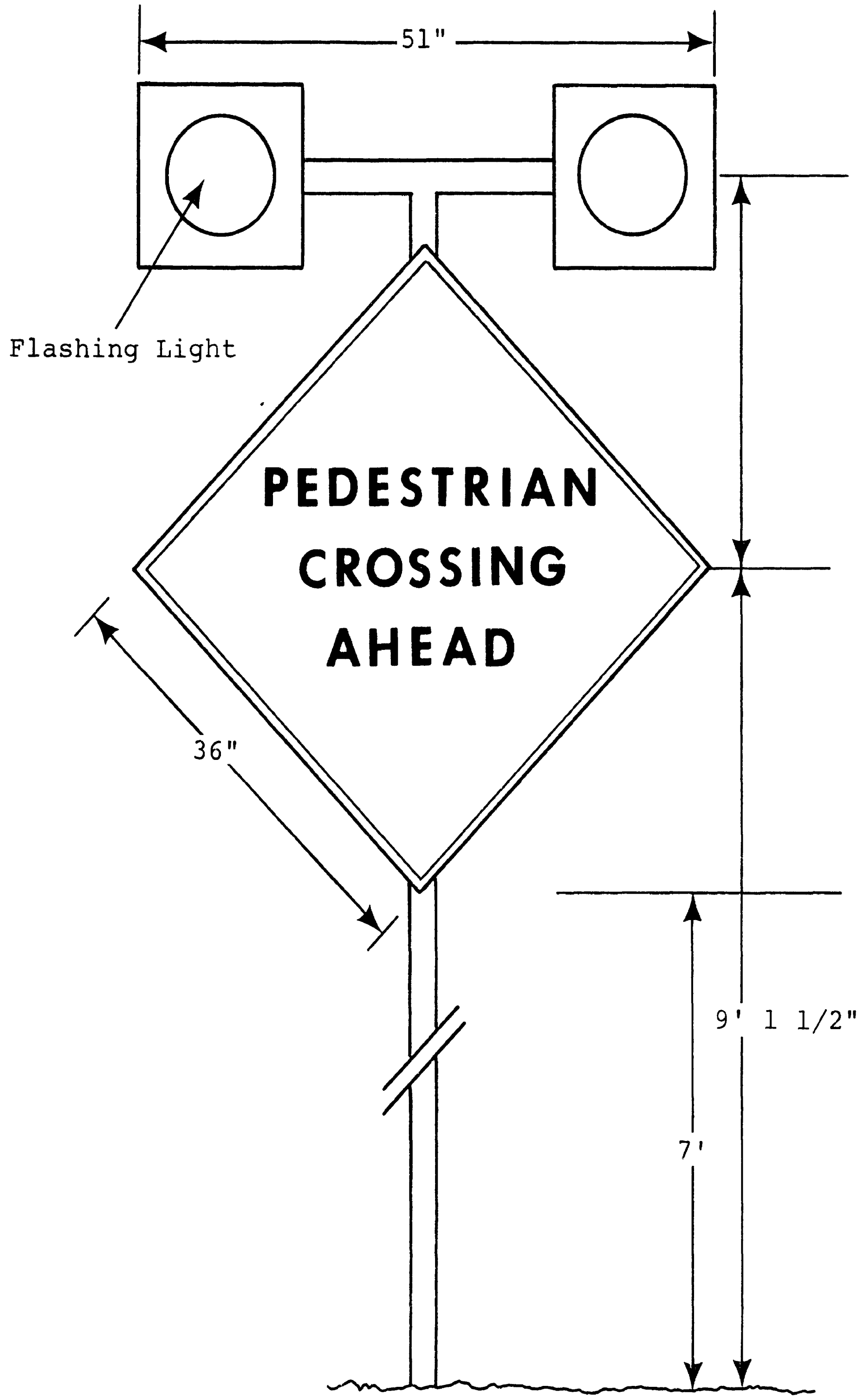


Figure 2-22

ADVANCE WARNING SIGN

Tubolite-Illuminated Pylons

These are polyethylene base translucent plastic tubes that are molded one piece, closed top and flexible. They are 4-1/4" in outside diameter, have a wall thickness of .135", are 24" long and are a Federal yellow color. With the cover plate, retaining ring, base housing, gasket, lens, lamp receptacle and other accessories, a Pylon has a net weight of 15 pounds. It is internally illuminated with a 100 volt, 6000-hour life incandescent lamp. The Pylons were installed on the median close to the curb beside the crosswalk. It was expected that the illuminated Pylons would attract the approaching driver's attention and thus increase the probability of the waiting pedestrian coming into the direct vision of the driver. However, an evaluation could not be made because the Pylons were rendered non-operational by vandals before they could be evaluated.

Vehicle Presence Detector

This is a roadside-mounted ultra-sonic detector which senses every passing vehicle and thus actuates the information system at the crosswalk. Detectors manufactured by GRS Company were used in this application.

INSTALLATIONS

Table 2-1 presents the equipment installed as part of the information system at each of the sites to be discussed in the next section. For the installation schedule, see Appendix F, Table F-1.

STUDY SITE SELECTION

The conditions which contribute to the pedestrian-vehicle conflict problem are numerous and varied. To evaluate the effect of a change in operations and to compare the operations at one location with another, it was necessary to balance the effect of as many conditions as possible. One method of doing this is the selection of study sites having many common characteristics. It was decided that the testing of the new controls and systems would be limited to sites having the following characteristics in common and still satisfying the primary goals of the study:

1. The pedestrian crossings should be located on streets of major traffic importance.
2. The crossings should generally be unsignalized or have "part-time" signals justified on the basis of pedestrian needs.
3. There should be an appreciable amount of after-dark pedestrian activity.
4. The locations should have pedestrian accident experience or conditions should indicate an accident potential.
5. Conventional pedestrian controls or protection procedures should have been tried without success or considered and rejected as not suitable.
6. Vehicular traffic on the cross street (if any) should not be important enough to require major design consideration.

TABLE 2-1

EQUIPMENT INSTALLED AT DEMONSTRATION SITES

EQUIPMENT	SITES: SIGNALIZED FIXED TIME			SIGNALIZED SEMI-ACTUATED		UNSIGNALIZED							
	Gratiot - Greiner	Yolanda - Outer Drive	Cass - Kirby	Seven Mile - Annott	Chicago - Sorrento	Merrick - Third	Woodward - Parsons	Seven Mile - Binder	Conner - Corbett	Livernois - Cambridge	Livernois - Grove	Wyoming - Westfield	West Grand Boulevard - Wildemere
Crosswalk Fixture	X	X	X			X	X	X	X	X	X	X	X
Lighted Push-Button Detector	X	X	X	X	X			X			X	X	X
Combination Push-Button Detector	X	X		X	X	X	X	X	X	X	X	X	X
Amber Beacons						X	X	X	X	X	X	X	X
Pedestrian Crossing Sign													
Advance Warning Sign						X	X		X	X	X		X
Spotlights		X					X	X	X				
Pedestrian Chains			X										
Pedestrian Information and Warning Sign													X
Vehicle Presence Detector													X

An additional method of isolating the effect of varied conditions was by selecting locations which can be paired or grouped according to their basic characteristics or functions. For this study, it was decided that the intersections selected should not only have the common characteristics described on page 34, but should also fit one of four or five basic crossing types. While other types of locations were studied, the following four were described in the study proposal and the project included at least two locations of each type.

1. Crossing controlled by part-time signals which have an appreciable amount of pedestrian traffic during the hours programmed for pedestrian-actuated operation. Most of these are located in the vicinity of schools where evening activities are frequently scheduled.

2. Crossings in areas where little regard is given to conventional crosswalks and a high degree of mid-block crossing occurs. These are usually near factories or colleges where the pedestrian traffic tends to take over the streets during certain periods.

3. Crossings which qualify for pedestrian signal protection but where conventional controls would create traffic problems exceeding the benefits to the pedestrians. These are pedestrian crossings near major intersections where an additional signal would interrupt the normal flow of traffic in such a way as to create unusual congestion with a possible increase in vehicular accidents.

4. Crossings with a high proportion of either very old or very young pedestrians who, experience has indicated, do not exercise the proper degree of caution when crossing the street. At these locations, the driver must be extra alert since he must assume a greater degree of the pedestrian safety responsibility. Since this project was limited to crossings with an appreciable amount of activity, the selected locations were those in areas with elderly pedestrian activity such as crossings near retirees residences, clubs, or other retiree-oriented facilities.

The intent was to develop a list of possible study sites based on the above criteria and from this list select 10 to 12 locations which best represented the various types and which offered the best conditions for testing the systems developed during the study. The guidelines were not intended to be so rigid as to preclude the selection of an unusual location which offered special testing opportunities.

The primary source of information concerning study locations was the Operations Division of the Department of Streets and Traffic since it receives and investigates the majority of citizen requests for traffic control improvements in Detroit. However, to insure the investigation of as many sites as possible, the study contacted other departments and agencies for additional information concerning problem locations. Other sources contacted for this additional information included the Detroit Police Department, the Detroit Public Schools, the Detroit Department of Parks and Recreation, the Traffic Safety Association of Detroit and the Automobile Club of Michigan.

The sites selected finally for the study were of two basic types:

1. Unsignalized pedestrian crossings of major thoroughfares, either mid-block or at their intersections with streets of minor traffic importance, where there was an apparent need for pedestrian improvements but where conventional controls were either unwarranted or would produce adverse results out-weighing benefits to the pedestrian.

2. At crossings with traffic-actuated or part-time signals installed primarily for pedestrian control, where experience had indicated a problem with either pedestrian failure to use and observe the pedestrian controls or driver failure to observe the vehicular controls.

Thirteen sites were selected at locations serving college students, high school and grade school students, shoppers in commercial areas, and transit users. Descriptions and sketches and photographs of the sites selected for the demonstration program are presented in Appendix C. A map showing the study locations is shown in Figure 2-23.

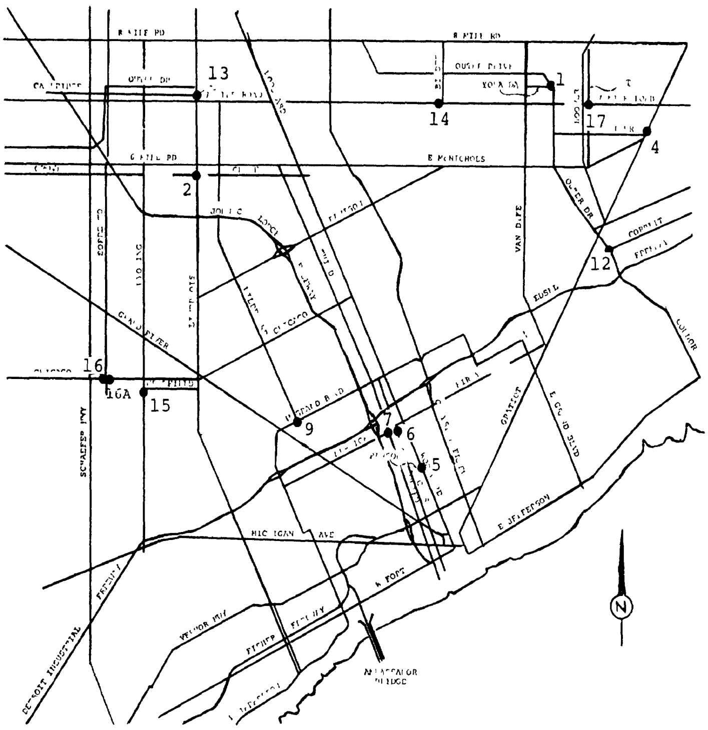


FIGURE 2-23
MAP SHOWING STUDY LOCATIONS

CHAPTER 3

"BEFORE" STUDIES

PREPARATION FOR FIELD STUDIES

The first phase of the demonstration program evaluation was to prepare a manual containing descriptions of 11 individual field studies. These studies were designed to define and measure the relevant traffic characteristics for use in the design of the operational parameters of the information systems and for subsequent comparative analysis with the evaluation study data. It is believed that this report, a July 1969 effort entitled Pedestrian Crosswalk Safety Studies, is the first comprehensive compilation of techniques of studying pedestrian behavior at crosswalks. Each of these studies was field-tested and evaluated for its effectiveness as part of the evaluation phase of the demonstration program.

The objective of the studies was to gather pertinent information on the following vehicular and pedestrian traffic characteristics: Intersection Volume, Spot Speeds, Travel Time, Gaps, Access Point Volumes, Driver Response to Crosswalk; Pedestrian Volumes, Pedestrian Personal Characteristics and Crossing Times, Pedestrian Gap Acceptance, Pedestrian Behavior at Signalized Intersections, and Visual Record (photographs). The studies were conducted Monday through Thursday during the hours specified for each study. In choosing the time for field work, care was taken to see that the prevailing weather and environmental conditions were such that they did not materially affect the normal pattern of pedestrian and vehicular traffic. If a ten-hour study was only partially completed on a given day, it was finished on another day, overlapping the study period of that day by one hour. Every effort was made to complete any study at a given site within a week. The following is a brief description of the various studies. The studies are divided into two categories, vehicular and pedestrian studies.

VEHICULAR STUDIES

Intersection Volume

Vehicles passing through the intersection during 15-minute periods were counted from 12:00 noon to 10:00 p.m. continuously. Vehicles in all lanes in both directions in the two intersecting roads were counted using hand counters. They were classified into four categories: passenger cars, small trucks (single rear axle), large trucks (two or more rear axles), and buses. All turning movements were recorded.

Spot Speeds

The purpose of the study was to determine the spot speeds of vehicles approaching the intersection along the major street by using a radar speed meter. Three studies were conducted at each intersection; the study periods were: 12:00 noon - 3:00 p.m., 4:00 - 6:00 p.m., and 7:00 - 10:00 p.m. The length of the study period was one hour or the time required to observe 50 vehicles, whichever was shorter.

Travel Time

The purpose of this study was to determine the time taken by major street vehicles to travel from a point 150 feet upstream from the crosswalk to another point 150 feet downstream. The period of study and the sample size requirements were the same as for the Spot Speed study.

Gaps

The purpose of this study was to count and measure the number and total duration of gaps exceeding six seconds between successive vehicles on the major street occurring at the crosswalk. The time of study was from 12:00 noon to 10:00 p.m. A gap counter connected to a pressure sensitive tube laid across the roadway and adjacent to the crosswalk automatically recorded the gaps between successive vehicles passing over the pressure sensitive tubes. Gaps of duration less than six seconds were not recorded by the gap counter. A gap study was conducted separately for each direction of traffic flow on the major street.

Access Point Volumes

The number of vehicles entering and leaving the major street through important driveways and other points of access and exit within 500 feet of the intersection was counted from 12:00 noon - 10:00 p.m. continuously. Vehicles were counted without classification. There were four vehicular movements to be observed for each access point or exit: In-left, In-right, Out-left, Out-right. The number of vehicles making each of these four movements was counted separately for each access point or exit.

Driver Response to Crosswalk

The study was conducted to evaluate the response of drivers to the crosswalk. Three studies were conducted at each site during the following time periods: 12:00 noon - 3:00 p.m., 4:00 p.m. - 7:00 p.m., and 8:00 p.m. - 10:00 p.m. In each time period measurements continued until 250 vehicles were observed or until the end of the study period, whichever was attained first. Four levels of vehicle slowing-down maneuvers were observed: (1) none (no slowing down), (2) deceleration without braking, (3) braking but not stopping, and (4) stopping. For a given vehicle only the greatest level of slowing down was recorded. For (1) and (2), the noticeable change from (1) to (2) alone was required; (3) and (4) were established by observing brake lights and actual stopping. The flows in the two directions of travel in the main street were observed separately. Vehicles were classified into four categories: passenger cars, small trucks (single rear axle), large trucks (two or more rear axles), and buses. For each vehicle observed, pedestrian presence at the crosswalk was observed for the following five cases: (1) none: no pedestrian on the road or curb, or approaching the curb; (2) approaching: no pedestrian on the road or curb, but one or more pedestrians approaching the curb within such a range as to be visible to the approaching driver and influence his maneuver; (3) waiting to cross: no pedestrian on the road, but one or more pedestrians waiting at the curb to cross; (4) moving toward or within the lane of the approaching vehicle; pedestrian crossing the roadway, moving toward or within the lane of the approaching vehicle; and (5) crossing past the lane of the vehicle: pedestrian crossing the roadway, but past the lane of the approaching vehicle. Each vehicle observed was free-flowing, that is, with no vehicle close enough ahead to influence its speed.

PEDESTRIAN STUDIES

Pedestrian Volumes

The volume of pedestrians crossing the major roadway within the area of influence of the intersection and the various patterns of crossing maneuver of pedestrians were observed from 12:00 noon - 9:30 p.m. The length of roadway to be observed on either side of the intersection along the major street was the lesser of: (1) the length of roadway visible from the crosswalk under study, and (2) half the distance to the next intersection (or to the next crosswalk if it occurred mid-block).

Pedestrians were observed for the following five patterns of crossing in each direction: (1) crossing in or very close to the crosswalk under study, (2) crossing in or very close to the crosswalk on the opposite side of the intersection from the crosswalk under study, (3) crossing diagonally across the road within the intersection, (4) crossing elsewhere on the same side of the intersection as the crosswalk under study, (5) crossing elsewhere on the opposite side of the intersection from the crosswalk under study. The number of pedestrians crossing the roadway by each of the above five patterns of crossing was observed for both directions of crossing the roadway.

Pedestrian Personal Characteristics and Crossing Time

The personal characteristics--party size, sex and age group--of the pedestrians and their crossing time was observed. The periods of study were between 12:00 noon - 3:00 p.m., 4:00 - 6:00 p.m., and 8:00 - 10:00 p.m. The length of the study period was such that about 100 observations were made during each study period. Age groups were identified as follows: Preschool (below 5 years), School Age (5-15 years), Young Adults (15-25 years), Adults (25-65 years), and Old People (65 and over).

Pedestrian Gap Acceptance

The number and duration of gaps between vehicles rejected and accepted by pedestrians waiting to cross the roadway were measured. Three studies were conducted at an intersection between 12:00 noon - 3:00 p.m., 5:00 - 7:00 p.m., 8:00 - 10:00 p.m. The length of the study period was such that about 100 observations were made during each study. All the pedestrian and vehicular movements observed were recorded on a 20-channel Esterline-Angus Recorder. Each pedestrian selected for observation was free-moving--that is, his evaluation and acceptance of vehicular gaps was independent of those of any other pedestrian. But if a party of pedestrians was being observed, the behavior of the members of the party in regard to evaluation and acceptance of gaps was studied as a collective, single action. The crossing maneuver of a selected pedestrian may consist of a continuous walk across the road or he may have to pause occasionally before he reaches the other curb. These different patterns of crossing were observed in detail.

Pedestrian Behavior at Signalized Intersections

Pedestrian behavior at the signalized intersections was studied for the following: time of pedestrian arrival; time of vehicle arrival; if the pedestrian pushed the button for the crossing signal, when did he do so; after pushing the button, whether the pedestrian waited for the signal; when walk signal was displayed; and if the pedestrian crossed the road without waiting for the walk signal, the pedestrian gap acceptance was studied as indicated in the previous study. Three studies were conducted at an intersection between 12:00 noon - 3:00 p.m., 5:00 - 7:00 p.m., 8:00 - 10:00 p.m. The length of the study period was such that about 100 observations were made during each study.

Visual Record

Photographs of each crosswalk site were taken from both approaches to the crosswalk during the day and at night. Thus there are four photographs for each crosswalk studied. (See Appendix C.) The photographs give the maximum possible coverage of the crosswalk and the approaching vehicles.

Table 3-1 shows the "Before" Studies conducted at each site. For the time and duration of the studies, see Appendix F, Table F-1.

ANALYSIS OF "BEFORE" STUDIES

Analysis was performed as described in Pedestrian Crosswalk Safety Studies, July 1969. The methods of treatment of the "Before" Study data are briefly described below.

Intersection Volume

The hourly frequencies of through and turning vehicular movements at the intersection were developed. Also, the frequencies of the four classes of vehicles were developed for the major street and minor street separately. The means and variances of all the above frequency distributions were computed.

Spot Speeds

The frequency distributions and the means and variances of spot speeds were developed and the 85th percentile speeds computed separately for each of the three periods of study and each of the two directions of vehicular flow.

Travel Time

The frequency distributions of travel times were developed and their means and variances computed separately for each of the three study periods and each of the two directions of travel.

Gaps

The frequency distributions of gap sizes (in seconds) were developed and their means and variances computed separately for the following two periods of study: 12:00 noon - 7:00 p.m. and 7:00 p.m. - 10:00 p.m.

TABLE 3-1

"BEFORE" STUDIES AT DEMONSTRATION SITES

"BEFORE" STUDIES	SITES												
	SIGNALIZED FIXED TIME			SIGNALIZED SEMI-ACTUATED		UNSIGNALIZED							
	Gratiot-Greiner	Yolanda-Outer Drive	Cass-Kirby	Seven Mile-Annott	Chicago-Sorrento	Merrick-Third	Woodward-Parsons	Seven Mile-Binder	Conner-Corbett	Livernois-Cambridge	Livernois-Grove	Wyoming-Westfield	West Grand Boulevard-Wildemere
Intersection Volume	X	X	X	X	X	X	X	X	X	X	X	X	X
Spot Speeds	X	X	X	X	X	X	X	X	X	X	X	X	X
Travel Time	X	X	X			X	X	X	X	X	X	X	X
Gaps						X	X	X	X	X	X	X	X
Access Point Volumes	X	X	X	X	X	X	X	X	X	X	X	X	X
Driver Response to Crosswalk			X			X	X	X	X	X	X	X	X
Pedestrian Volumes	X	X	X	X	X	X	X	X	X	X	X	X	X
Personal Characteristics and Crossing Time	X	X	X	X	X	X	X	X	X	X	X	X	X
Pedestrian Gap Acceptance						X	X	X	X	X	X	X	X
Pedestrian Behavior at Signalized Intersections	X	X		X	X								
Visual Record	X	X	X	X	X	X	X	X	X	X	X	X	X

Access Point Volumes

The hourly volume of vehicles entering and exiting at each access point was computed.

Driver Response to Crosswalk

The four levels of vehicle response (none, deceleration, braking, stopping) in relation to the pedestrian presence at various stages of crossing maneuver was summarized.

Pedestrian Volume

The number of pedestrians using various paths for crossing the road hourly in both directions was summarized.

Pedestrian Personal Characteristics and Crossing Time

The crossing time of pedestrians and their sex and age groups were summarized.

Pedestrian Gap Acceptance

The distributions of accepted and rejected gaps were developed and thus the critical gap determined. Further, the distributions of waiting time and crossing times were developed and their 85th percentiles computed.

Pedestrian Behavior at Signalized Intersection

Summaries of the following behavioral aspects were developed with reference to the pedestrian's sex and age: time differences between pedestrian's arrival at the area of influence of the crosswalk and at the curb; time he pushes the button; time he looks for walk signal; whether or not he waits until signal--if he does: when is the signal shown; if he does not: waiting time, rejected and accepted gaps in seconds; crossing time in seconds.

Visual Record

The photographs are used as part of this report.

INTERMEDIATE STUDIES

Intermediate studies were conducted immediately following the installation of the information systems but before sufficient time elapsed to enable drivers and pedestrians to stabilize their reaction to them to a habitual response pattern. It was believed that these studies would indicate the initial response of pedestrians and drivers to the installation of the information systems. Of all the sites selected for the demonstration program, the one having the highest pedestrian volume was Cass and Kirby. Hence this site was selected for a special "Intermediate" Study. The "Intermediate" Studies conducted were:

1. Vehicle Studies:

   Spot Speeds
   Travel Time

2. Pedestrian Studies:

   Pedestrian Volume
   Visual Record

For Spot Speeds and Travel Time, the required sample sizes were determined on the basis of the statistical parameters of the data observed in the "Before" Studies. The method of determining the sample size is presented in Appendix D.

Analysis of the "Intermediate" Studies

The data from the "Intermediate" Studies were reduced using the method indicated for the corresponding "Before" Studies. The results were compared to those of the "Before" Studies using standard statistical tests.

The Chi-square test at 0.05 significance level was used to compare the "Before" Study results to the "Intermediate" Study results. There was a statistically significant improvement in the desirable features of pedestrian performance at the crosswalk, especially greater relative use of the push-button detector. It was further concluded that there was no significant effect of the time of day on the use of the crosswalk by pedestrians. The seasonal effect on pedestrian flow was found to be significant.

CHAPTER 4

OPERATION OF INFORMATION SYSTEMS

Preceding the actual fieldwork on the "After" Studies, substantial efforts were made toward ensuring satisfactory operation of the information systems. The most important phases of these efforts were the design of the operational parameters of the information systems.

DESIGN OF OPERATIONAL PARAMETERS

The operational parameters for the information systems at the various sites were designed using the results of the analysis of the data obtained from the "Before" Studies. These designs were made in consultation with engineers from the Public Lighting Commission, City of Detroit and thė Department of Streets and Traffic, City of Detroit. The suitability of the design parameters was checked by field inspection of the information systems, once they were operational. The method of approach used in the design is briefly outlined below.

For the purpose of design the study sites were grouped into three categories. These were: signalized intersections, unsignalized intersections with pedestrian-actuated traffic warning devices, and unsignalized intersection with the vehicle-presence information system. Separate discussions on these three categories follow.

SIGNALIZED INTERSECTIONS

The design analyses for these sites are included in the interim report entitled Operational Time Parameters for Pedestrians and Driver Information Systems, Part II, Signalized Intersections (9). The design analysis took into consideration the three different types of operations that existed at the signalized sites. These were:

1. Mid-block crosswalk with pedestrian-actuated signals having two modes of operation:
    a. the standard pre-timed signal operation, and
    b. vehicular signal in flashing amber mode.
2. Intersections with pedestrian-actuated signals for the main street and without vehicle actuation on the cross street and having two modes of operation:
    a. the standard pre-timed signal operation, and
    b. flashing amber indication for main street vehicles, flashing red indication for the cross street vehicles.
3. Intersections with pedestrian-actuated signals for the main street and vehicle actuation on the cross street. This type of intersection operates in a semi-traffic-actuated mode.

Method of Design

The various time parameters were designed on the basis of analysis of the data from the "Before" Studies. The final recommendations, however, were influenced by field inspection and engineering judgment to ensure the maximum possible achievement of the objectives while fully satisfying the constraints. The objectives and constraints are listed below.

1. The minimum main street green phase should be long enough so that the vehicular queue will be exhausted 95% of the time (based on a random arrival model and pedestrian actuations each cycle).
2. The sum of the "WALK" period and the pedestrian clearance interval period will not be less than the 99% value of pedestrian crossing time recorded in a large sample of observations.
3. The pedestrian clearance interval will not be less than the 85% value of pedestrian crossing time recorded in a large sample of observations.
4. The "WALK" period will not be less than the average pedestrian reaction time plus the 85% time required to cross one-half of the street, and in any event never less than seven seconds.

Design of Pedestrian Phases

Duration of the Pedestrian Clearance Interval (F): The pedestrian clearance interval was based on the pedestrian crossing time. The crossing time in seconds was selected to correspond to the upper point of sharp inflection of the cumulative frequency distribution of the pedestrian crossing time. Should this value be less than the 85 percentile crossing time, the 85 percentile value was selected as F.

Duration of the Steady "WALK" Interval (W): The design value of W was the sum of the pedestrian reaction time and the time period required for the pedestrian to walk half the distance to the opposite curb. The pedestrian reaction time was selected as one second based on standard recommendations (1). The time required for the pedestrian to cross half of the crosswalk was taken as F/2, where F is the design pedestrian clearance interval determined as indicated above. Thus $W = \frac{F}{2} + 1$ subject to the constraint that it is not less than seven seconds.

Total Duration of the Pedestrian Phase (T): $T = F + W$, subject to the criterion that it is not less than the 99% pedestrian crossing time.

Design of Vehicle Phases

The signal settings were designed assuming a standard pretimed mode of operation. The green phase, therefore, was the minimum available for the main street vehicles regardless of pedestrian and/or vehicular actuations. The vehicle-actuated controller adds to the main street vehicular green all time not required by pedestrian-actuated and/or vehicle-actuated demand.

Vehicle Clearance Interval (A): The following expression gives in seconds the amber period which minimizes the "dilemma zone" for the driver (6)

$$A = \frac{D + w + L}{V} + P$$

where: D = vehicle safe stopping distance in feet

w = crosswalk length in feet

L = the length of a car

P = driver reaction time in seconds

V = approach speed of vehicles in feet per second.

V was selected as the 85th percentile spot speed. D was determined from recommendations of the American Association of State Highway Officials (7). An average car length of 20 feet and a driver reaction time of one second were assumed.

Regardless of the value of the clearance interval calculated in the design, the amber period currently used at a site was not altered. If, however, the calculated clearance interval exceeded that currently used by more than two seconds, an all red period (M) equal to the difference between the calculated and the currently used values of amber periods was introduced following the main street vehicular amber. During the all red period, neither vehicular nor pedestrian traffic was allowed to move.

Vehicular Red Interval (R): The vehicular red interval was established as the sum of the pedestrian crossing and clearance intervals and the all red period. Hence, R = F + W + M.

Vehicular Green Interval (G): Since the cycle time C was assumed to be fixed, G = C - (A + R) seconds. This was examined for the probability of exhausting the vehicular queue assuming random arrivals and pedestrian actuations each cycle.

The design vehicular volume (q) was selected as the average directional peak vehicular lane volume expressed in equivalent through passenger car units multiplied by 1.1. The equivalent through passenger car units were determined as indicated below (8).

Through passenger cars and light trucks	1.0
Left-turning passenger cars and light trucks	1.9
Right-turning passenger cars and light trucks	1.25
Through trucks and buses	2.0
Left-turning trucks and buses	2.9
Right-turning trucks and buses	2.5

The above data are used to calculate the degree of saturation

$$X = \frac{gC}{sg} \quad (4)$$

where: C = cycle time in seconds

g = effective green period = G - lost time per cycle

s = saturation flow which is the rate at which vehicles can cross the stop line during the period that a green signal is showing.

The lost time per cycle is assumed to be 10 seconds for four-way and three-way intersections and five seconds at mid-block crosswalks. The saturation flow was assumed to be 0.47 vehicles per second based on unpublished studies made in the City of Detroit as a part of the Automobile Manufacturers Association study.

The probability that the queue will be exhausted can be found in Reference (8). If this value was high enough, the signal settings calculated were satisfactory. If this value was not high enough, G and R, and consequently the pedestrian phases, were altered on the basis of engineering judgment to ensure maximum possible achievement of the objectives while staying within the constraints. The design results are summarized in Table 4-1.

UNSIGNALIZED INTERSECTIONS--PEDESTRIAN-ACTUATED

The design analysis for these sites is detailed in the report Operational Time Parameters and Driver Information Systems, Part I: Unsignalized Intersections with Pedestrian-Actuated Traffic Warning Device, March 1970 (10) and summarized here.

These sites are equipped with both devices at the crosswalks and warning devices in advance of the crosswalks. The fixtures and warning devices are lit when the pedestrian pushes a button. They remain lit only for a predetermined time period called total operation time (T seconds), unless actuated again before the end of T after the last actuation. The buzzing period or pedestrian clearance interval (B) lasts until the information system goes out, unless terminated by a new pedestrian actuation. The initial part of T, the initial interval during which the buzzer is silent, is designated as S, (T - B seconds).

Figure 4-1 presents the general mode of operation of the pedestrian and driver information system at this type of site. As shown earlier in Chapter 2, if the system has not been actuated for a time period equal to or greater than T seconds, an approaching pedestrian sees the sign "PUSH BUTTON BEFORE CROSSING." The buzzer is silent. If the pedestrian pushes the button, the pedestrian sign turns to "WATCH OUT FOR CARS," and the crosswalk fixtures are lit. The flashing beacons in the advance warning sign reading "PEDESTRIAN CROSSING" alert the approaching driver to the presence of a pedestrian at the curb or in the crosswalk. Having pushed the button, the pedestrian is expected to cross only when an acceptable gap appears in the traffic stream. The duration of the display is not based on assuming that the motorist will stop, although they may do so under many circumstances as required by state and local law.

If the pedestrian cannot leave the curb before the buzzing begins, he is expected to push the button again. When the buzzing begins, the pedestrian sign turns to "PUSH BUTTON BEFORE CROSSING." If the pedestrian does not push the button until the end of the buzzing, the information system goes off as the buzzing ceases. If, however, the pedestrian pushes the button during the buzzing, the buzzing ceases at once and the pedestrian sign turns to "WATCH OUT FOR CARS." The buzzing will again be heard after S seconds.

TABLE 4-1

RECOMMENDED DESIGN PARAMETERS FOR SIGNALIZED SITES

SITE NUMBER AND LOCATION		TOTAL CYCLE TIME (0) (SEC)	PEDESTRIAN PHASE (SEC)			VEHICLE PHASE (SEC)			OFFSET (SEC)	DEGREE OF SATURATION (X)
			STEADY "WALK" INTERVAL (W)	CLEAR-ANCE INTERVAL (F)	STEADY "DON'T WALK" INTERVAL C-(F+W)	CLEAR-ANCE INTERVAL (A)	GREEN INTERVAL (G)	RED INTERVAL (R)		
#4 Gratiot and Greiner	Off Peak	60	7.2	26.4	26.4	3.6	20.4	36.00	35	.52
	A.M. Peak	80	7.2	21.6	51.2	4.0	45.6	30.4	37	.93
	P.M. Peak	80	7.2	21.6	51.2	4.0	45.6	30.4	45	.93
#6 Cass and Kirby	Off Peak	50	9.0	15.0	26.0	3.5	20.5	26	25	.75
	A.M. Peak	70	9.8	16.1	44.1	3.5	38.5	28	63	.72
	P.M. Peak	70	9.8	16.1	44.1	3.5	38.5	28	66	.72
#1 Yolanda and Outer Drive		60	7.2	9.6	43.2	3.6	37.2	19.2	23	1.02
#16 Chicago and Sorrento		50	7.0	7.0	36.0	3.5	30.5	16.0	22	.75
#17 Seven Mile and Annott		60	7.2	10.8	42.0	3.6	36.6	19.8	39	.87

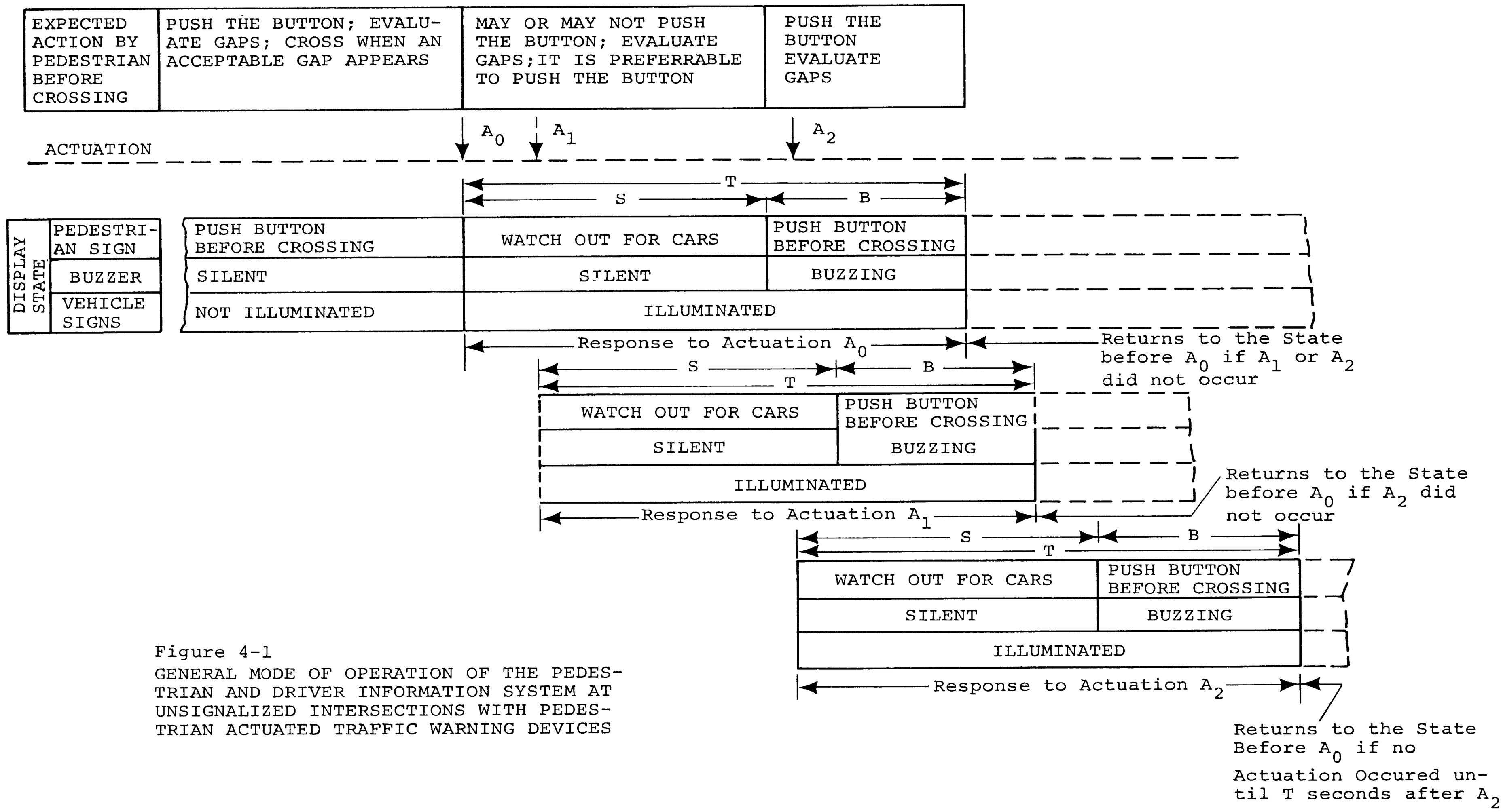


Figure 4-1
GENERAL MODE OF OPERATION OF THE PEDESTRIAN AND DRIVER INFORMATION SYSTEM AT UNSIGNALIZED INTERSECTIONS WITH PEDESTRIAN ACTUATED TRAFFIC WARNING DEVICES

Constraints

1. The total operation time (T) must not be less than the 100 percentile value of pedestrian crossing time as recorded in a large sample of observations.
2. The buzzing period (B) must not be less than the 85 percentile value of crossing time as recorded in a large sample of observations.
3. The duration of the initial interval (S) after an actuation should not be less than the 85 percentile value of waiting time and never less than 15 seconds.

Method of Design

The Duration of the Initial Interval (S Seconds) After an Actuation: It was concluded that S should be based on the time period a pedestrian may have to wait before he can cross. A pedestrian's waiting time is equal to the sum of the initial and subsequent gaps rejected by him before he accepts one. S was selected as the waiting time corresponding to the point of sharp change in curvature of the cumulative frequency plot of the waiting time, in general the 85% value. In order that the occasional pedestrian who waits quite some time does not have to push the button repeatedly, the minimum duration of the initial interval was selected to be 15 seconds.

The Buzzing Period (B Seconds): It was concluded that B should be equal to the time necessary for a slow pedestrian to cross the street. B was selected as the crossing time corresponding to the point of sharp change in curvature of the cumulative frequency plot of the crossing time. If this value was found to be less than the 85 percentile crossing time, the 85 percentile value was selected as B.

The Total Operation Time (T Seconds): T is the sum of S and B. If this sum was found to be less than the 100 percentile pedestrian crossing time, the 100 percentile value was selected as T.

In the case of streets with a median island, S, B, and T were determined independently for each side and represented with appropriate subscripts.

The design results are summarized in Table 4-2.

UNSIGNALIZED INTERSECTIONS--VEHICLE ACTUATION

There was only one site (West Grand Boulevard-Wildemere) in this category. The design analysis for this site is embodied in the report entitled Design of Operational Parameters for the Vehicle Presence Information System (11). The site sketch of the West Grand Boulevard-Wildemere intersection is given in Appendix C and Table 4-2 shows some details of the system. Because of the wide median at the center of West Grand Boulevard, pedestrians cross the roadway in two stages, accepting separate gaps in the eastbound and westbound traffic streams. The Vehicle Presence Information System provides information on westbound traffic only.

A side mounted ultra-sonic detector which senses every passing vehicle was located at a designated distance (D feet) in advance of the crosswalk. The region between the detector and the crosswalk was designated as the "Vehicle Detection Zone." Every vehicle actuation caused the pedestrian sign to display a flashing "DON'T

TABLE 4-2

RECOMMENDED DESIGN PARAMETERS FOR UNSIGNALIZED SITES

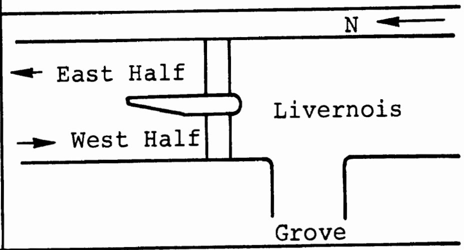
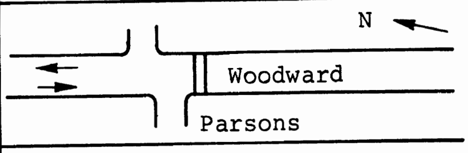
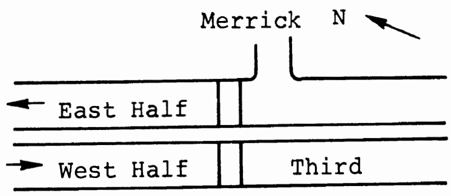
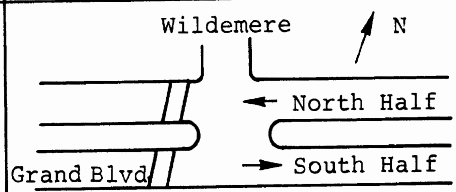
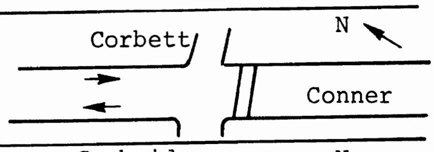
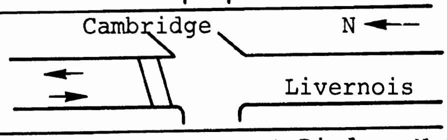
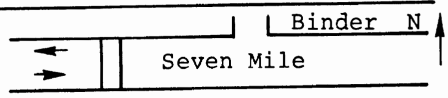
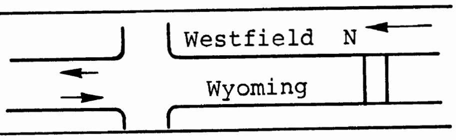
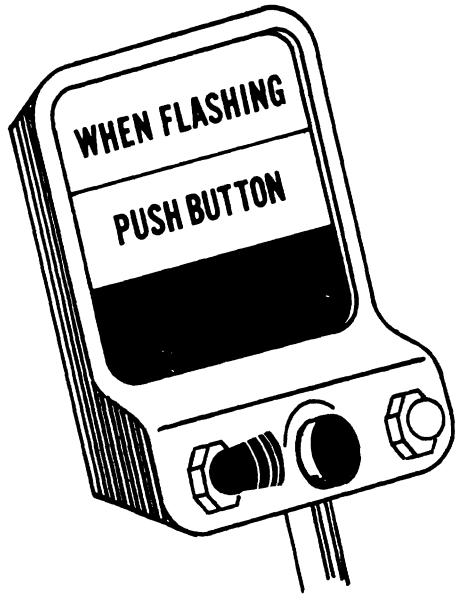
Site No. and Location		INITIAL INTERVAL (S) (Sec)	CLEARANCE INTERVAL (B) (Sec)	Site Sketch
#2 Livernois and Grove	East Half West Half	21 21	10 11	
#5 Woodward and Parsons		22	50	
#7 Third and Merrick	East Half West Half	18.5 15	14 12	
#9 West Grand Boulevard and Wildemere	North Half South Half	15 23.5	12 11	
#12 Conner and Corbett		15	15	
#13 Livernois and Cambridge		20	36	
#14 Seven Mile and Binder		15	12	
#15 Wyoming and Westfield		19	35	

PLATE 4-1. EDUCATIONAL LEAFLET. →

Traffic Controls To Assist Pedestrians

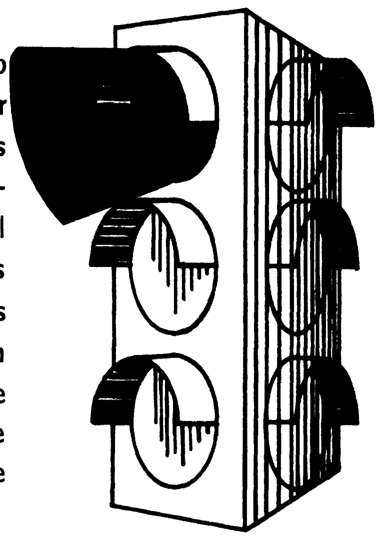


PUSH THE BUTTON –

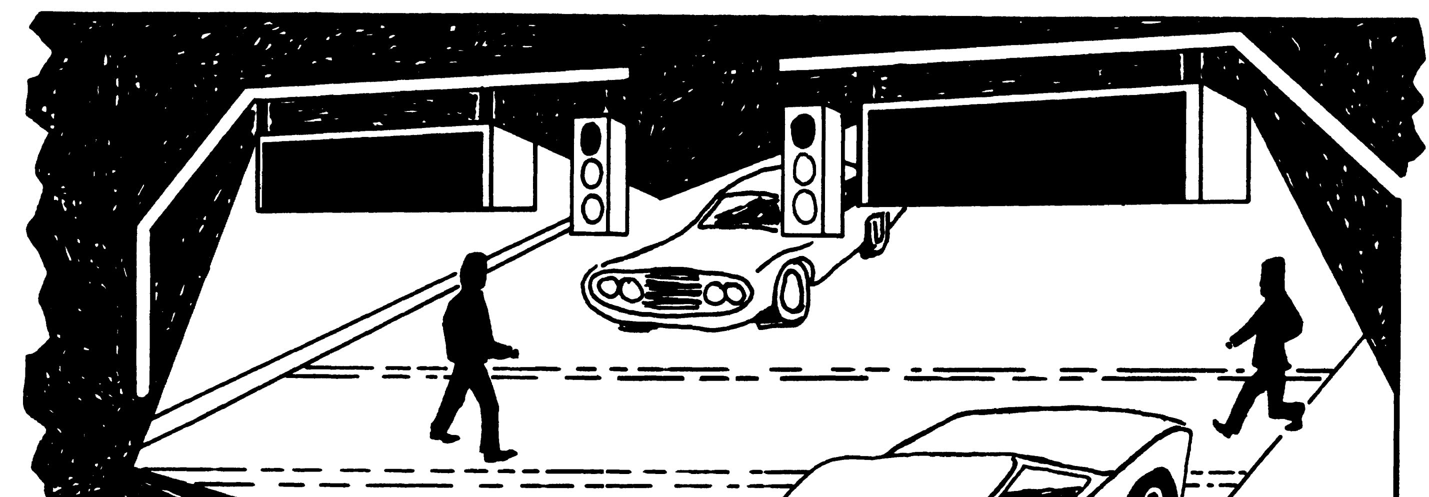
To cross the street, when the *red light* on the pedestrian control box is flashing push the button and wait until "*Walk*" appears on the pedestrian signal at the crossing. WAIT! In about one minute the signal will change to *Walk*. Whenever the signal is on *Walk* you have time to make your crossing safely. It is important to WAIT for the *Walk* signal which comes on after the *red traffic signal* tells the driver to stop.

It is wise, however, to keep alert and watch the cars. While the red traffic signal should stop them, some may unlawfully run the red light, so always be prepared to get out of their way if they don't appear to be stopping.

Note to drivers: You should always keep in mind that you are required to stop for the red traffic signal. The extra lights and signs, such as the illuminated overhead crosswalk sign, give you additional information concerning pedestrian actions and crosswalks. While your actions should be guided by the red and green traffic signal, you are also urged to take advantage of the extra lighting and be watchful for pedestrians who may be crossing when they shouldn't.



DON'T PLACE YOUR LIFE IN THE DRIVER'S HANDS. KEEP ALERT.



The Pedestrian Safety Project, approved by the Michigan Office of Highway Safety Planning, is being conducted by the Detroit Department of Streets and Traffic and the University of Michigan Highway Safety Research Institute under a Federal Grant from the Department of Transportation.

Prepared By The Traffic Safety Association Of Detroit

CROSS" message for a predetermined time period (T seconds) from the instant the actuation occurred. This time period is designated the "Vehicle Passage Interval." After T seconds the pedestrian display reverted to a steady "WATCH FOR CARS" and remained so until another vehicle actuation.

The crosswalk was also provided with pedestrian push-button detectors on the curbs. The median curb had a lighted push-button detector and the other a combination push-button detector.

The purpose of the Vehicle Presence Detector information system is to supplement the pedestrian's capability to correctly evaluate the acceptability of gaps in the traffic stream. It does not relieve the pedestrian of his responsibility to evaluate the acceptability of gaps by observing the approaching vehicles before deciding to cross. If the approaching vehicle is either too far from or too near to the crosswalk, the pedestrian has no difficulty in making the correct decision about the acceptability of the current gap. However, there is a region in advance of the crosswalk where if the pedestrian finds an approaching vehicle, he is not sure whether the gap is safe or not. This region of indecision is designated as the "Critical Zone" for the population of pedestrians.

It is apparent that the Vehicle Presence information system should detect the vehicle as it passes a selected point in the Critical Zone and warn the pedestrian that the current gap is unsafe. Selection of a detection point toward the upstream part of the Critical Zone favors the needs of the less agile and less risk-taking group of pedestrians. It favors also the situation when the current gap belongs to a fast-moving vehicle in which case the decision on the acceptability of the gap is relatively more difficult. However, fitter and more risk-taking pedestrians will tend to regard it as an undesirable restraint on their freedom and therefore lose respect for the system. To satisfy these tendencies, the detection point should be located toward the downstream part of the Critical Zone with obvious higher level of risk for the less agile and less risk-taking group of pedestrians.

Thus the two major objectives are to ensure a satisfactorily high level of safety for the less fit and less risk-taking population of pedestrians and gain the respect of the fitter and more risk-taking pedestrians. The design is based on the speed characteristics of the vehicle population and the gap acceptance or crossing time characteristics of the pedestrian population. Since the vehicle presence is to be detected at a fixed point upstream of the crosswalk, the design has to be based on a design pedestrian of selected level of crossing time or acceptable gap and a design vehicle of selected level of speed. Thus, D in feet was based on the 85% pedestrian crossing time in seconds. The value of D thus arrived at was modified by consideration of site installation problems. The duration of the interval t was designed using a procedure aimed at minimizing primarily the probability of pedestrian-vehicle conflict and secondarily the duration of false displays.

The design results were D = 495 feet and T = 13 seconds.

MONITORING OF INSTALLATIONS

Monitoring of the progress of the installation of information systems at the various sites was made by regular field inspections. This information was necessary in scheduling the "After" Studies as a need was recognized to provide sufficient time for seasoning of the system and familiarizing drivers and pedestrians with its operation.

PUBLICITY

Publicity efforts were undertaken for the proposal by the Traffic Safety Association of Detroit (TSA). Two information leaflets were designed, printed, and distributed through schools, universities and various traffic-related agencies such as the police and high school driver education classes. The leaflets are presented in Plates 2-1 and 2-2. A press release prepared by TSA was given to 35 community papers and all major radio and television stations. Other efforts were also made. Appendix E presents a Traffic Safety Association report on these efforts.

CHAPTER 5

PUBLIC RESPONSE TO DEMONSTRATION

EXPERIMENTAL DESIGN AND FIELD STUDIES

The study sites were classified into various groupings based on similar characteristic features of geometry and traffic. These groupings are represented by the sites selected for the "After" Studies. The experimental design of the "After" Studies had the goal of developing statistically significant information on the effect of the system within a reasonable time and under severe funding constraints. The plan for the studies is presented in Table 5-1. The sample size was determined based on the statistical parameters of the "Before" Study data.

Some of the "After" Studies, though similar to the "Before" Studies, needed additional or modified instructions. These were prepared and furnished to the staff that conducted the field studies. The schedule of field studies is presented in Table F-1 of Appendix 7.

The key to Table 5-1 indicates the devices used at a location. If the device was used dynamically, a capital letter is used, otherwise a lower case letter. A combination of devices displayed at a location is called a Mode and the remainder of the report will frequently use this notation.

ANALYSIS OF OPERATIONAL RESPONSES

The data on the operational characteristics of traffic, pedestrian and vehicular, before and after the installation of the information systems were analyzed by standard statistical tests. In general, a risk of concluding that there was an effect when in fact there was none was established at the five percent level. Each study deemed relevant is reported upon separately.

PEDESTRIAN PATHS

This section summarizes the results of the analysis of effect of the information systems on the pedestrian usage of the crosswalk. The effect of the information systems on this characteristic is believed to be one pertinent evaluative index of the information system. The factors that enter into the analysis are: the paths chosen by pedestrians in crossing the road, relative influence of the various modes of operations, and the effect of the time of day. The possible paths are identified as follows:

Path 1: use of the crosswalk where the information system is installed;

Path 2: use of the other crosswalk at the intersection where the information system is not installed;

Path 3: diagonally across the intersection;

Path 4: jaywalking close to path 1;

Path 5: jaywalking close to path 2.

The Chi-square test at a level of significance of 0.05 yielded the results summarized in Table 5-2.

DATE - December		1		2		3		4		7		8		9		10		11		14		15		16		17		18		21		22		23		24		25	
SITES	STUDY / TIME	Driver	Ped.	Driver	Ped.	Driver	Ped.	Driver	Ped.	Driver	Ped.	Driver	Ped.	Driver	Ped.	Driver	Ped.	Driver	Ped.	Driver	Ped.	Driver	Ped.	Driver	Ped.	Driver	Ped.	Driver	Ped.	Driver	Ped.	Driver	Ped.	Driver	Ped.	Driver	Ped.	Driver	Ped.
Conner-Corbett	Day	ABC																		A						aB						CD				Cd			
	Night	ABC						D						AB						A	A						aB	aB				CD	CD						
Seven Mile-Binder	Day																																						
	Night		A					D																															
Livernois-Cambridge	Day																																						
	Night			aB	aB									AB	AB																								
Cass-Kirby	Day																																						
	Night						A																																
West Grand Boulevard-Wildemere	Day									ABCH	ABCH																												
	Night											ABCH	ABCH																										
Chicago-Sorrento	Day							GF																															
	Night											GT																											

*Key appears on following page.

TABLE 5-1

SCHEDULE OF EVALUATION STUDIES

TABLE 5-2

EFFECT OF INFORMATION SYSTEMS ON PEDESTRIANS' CHOICE OF CROSSING PATHS

SITE NUMBER	LOCATION	MODE OF OPERATION	SIGNIFICANTLY INCREASED USE OF				
			PATH 1	PATH 2	PATH 3	PATH 4	PATH 5
1	Outer Drive-Yolanda	A	X				
6	Cass-Kirby	A	X				
12	Conner-Corbett	ABC			X	X	X
13	Livernois-Cambridge	ABC	X				
14	Seven Mile-Binder	A	X				
16	Chicago-Sorrento	Gr			X	X	X
17	Seven Mile-Annott	Gr	X				

KEY TO TABLES 5-1 AND 5-2.

A	Crosswalk Fixture (dynamic)
a	Crosswalk Fixture (static)
B	Amber Beacon (dynamic)
C	Advance Warning Sign (dynamic)
D	Spot Lights (dynamic)
d	Spot Lights (static)

E	Pylon (dynamic)
f	Pavement Markings
G	Combination Push-Button Detector
k	Pedestrian Chains
m	Pedestrian Information and Warning Signs
r	Lighted Push-Button Detector

The analysis in Table 5-2 shows that the effect of the information systems in encouraging pedestrians to use the facility correctly (use path 1) was quite significant with improved results observed at five sites.

Table 5-3 presents these same results by type of operational mode. This table shows the significant role of the dynamic crosswalk fixture (A) in encouraging pedestrians to use the facility correctly. This might be attributable to its dynamic operation, largeness, and visibility features. The failure of any of the devices to improve behavior at Conner-Corbett is disturbing and the relatively different responses at Sites #7 and #16 to the new push buttons cannot be understood.

The results of the Chi-square test by time of day are presented in Table 5-4. The results indicate a pattern of increased usage of the improved crosswalk during daylight hours and poorer performance after dark. One reason is believed to be the larger percentage of elderly pedestrians during the day and younger pedestrians during night, the former being more likely to use the improved crosswalk.

Spot Speeds

The effect of the information on the spot speed of free-moving vehicles is an index reflecting the response of drivers. The spot speeds of vehicles are known to be nearly normally distributed. The statistical tests applied here are intended to determine the effect of the information system on the means and variances of spot speeds at the various study sites.

Spot speed data are available for the following conditions:

A. In the "Before" Study, spot speeds of free-moving vehicles at the crosswalk.

B. In the "After" Study, spot speeds of free-moving vehicles 500 feet upstream of the crosswalk.

C. In the "After" Study, spot speeds of the same free-moving vehicles observed in (B) above, observed at the crosswalk.

It is safe to assume that the spot speeds of free-moving vehicles are normally distributed. The hypothesis is that there is no effect of the information system on speed performance and that the two samples being compared have identical population means. The sample size for the "Before" and "After" Studies is 50. We have therefore

$$\sigma_{\bar{A} - \bar{B}} = \sqrt{0.58} = 0.76$$

where $\bar{A}$ = the average speed recorded during the "After" Study

$\bar{B}$ = the average speed recorded during the "Before" Study.

The statistic $x = \frac{\bar{A} - \bar{B}}{\sigma_{\bar{A} - \bar{B}}}$ is approximately normal. Using a 1% level of significance, the critical region is $|x| = \frac{\bar{A} - \bar{B}}{\sigma_{\bar{A} - \bar{B}}} = 2.58$ (from normal distribution tables). So that the critical difference

TABLE 5-3

RELATIVE EFFECTIVENESS OF MODES ON CROSSING PATHS

MODES OF OPERATION	SITES SHOWING INCREASED USE OF PATH 1	SITES SHOWING INCREASED USE OF OTHER PATHS
A	Site #1: Outer Drive-Yolander Site #6: Cass-Kirby Site #14 Seven Mile-Binder	None
ABC	Site #13 Livernois-Cambridge	Site #12: Conner-Corbett
GΓ	Site #17: Seven Mile-Annott	Site #16: Chicago-Sorrento

TABLE 5-4

EFFECT OF TIME OF DAY ON USE OF CROSSWALK

SITE NUMBER	LOCATION	MODE OF OPERATION	TIME OF DAY EFFECT ON USE OF CROSSWALK: SIGNIFICANT	TIME OF DAY EFFECT ON USE OF CROSSWALK: NOT SIGNIFICANT	WHAT EFFECT
1	Outer Drive-Yolanda			X	Use of Path 1 remained predominant and no significant change was detected with time of day.
13	Livernois-Cambridge	ABC	X		12:00 noon-6:00 p.m.: Usage of Path 1 increased. 6:00 p.m.-9:30 p.m.: Usage of Paths 3, 4, 5 increased.
14	Seven Mile-Binder	A	X		12:00 noon-6:00 p.m.: Usage of Path 1 increased. 6:00 p.m.-9:30 p.m.: Usage of Paths 3, 4, 5 increased.
16	Chicago-Sorrento	GΓ	X		12:00 noon-4:00 p.m.: Usage of Path 1 increased. 6:00 p.m.-9:30 p.m.: Usage of Paths 3, 4, 5 increased.

between the average before and after speed is

$$2.58\ (\sigma_{\overline{A} - \overline{B}}) = 2.58 \times 0.76 = 2.00$$

Hence, if the absolute value of the difference between the sample means being compared exceeds 2.00, the difference is considered significant.

For tests on the variance of spot speeds, the assumption of normality for spot speeds is again made. The null hypothesis is that there is no difference between the variances of the "Before" and "After" speed distributions. If we represent the individual spot speeds in "After" and "Before" Studies by X_{Ai} and X_{Bj} and let m and n be the respective sample sizes,

$$F = \frac{(n-1) \sum_j (X_{Bj} - \overline{X}_B)^2}{(m-1) \sum_i (X_{Ai} - \overline{X}_A)^2}$$

has the F distribution with (m-1) and (n-1) degrees of freedom, if the null hypothesis is true. In the present case m = n = 50. Adopting a level of significance of five percent,the criteria for the test of the ratio of variance is 1.83 (from F distribution tables).

Results: Spot speed data at the crosswalk gathered in the "Before" and "After" studies were compared and the results are presented in Table 5-5. This test analyzes the effect of the information system and modes of operation on the spot speeds. There were no significant differences in mean spot speed observed. We conclude that the effect of the information systems on the mean spot speeds of vehicles was not significant.

The influence on the variances of spot speeds also was not significant except in two cases. In one case (Third-Merrick , Mode B Flashing Amber Beacon) the variance was significantly reduced so that the ratio of the variance from the "Before" Study to "After" Study was 2.26. This seems to indicate the potential of the Flashing Amber Beacon to stabilize the response pattern of drivers to the crosswalk. It may be mentioned that the same mode of operation at two other sites (Livernois-Cambridge and Seven Mile-Binder) also resulted in a reduction in variance, though not statistically significant. This seems to further indicate the potential of the Flashing Amber Beacon to stabilize the response pattern of drivers to the crosswalk. Other modes of operation resulted in an increase in the variance of spot speeds, although only in one instance (Conner-Corbett, southbound traffic, mode ABC: joint operation of the dynamic Crosswalk Fixture, Amber Beacon, and Advance Warning Sign) was it statistically significant. In this case, the ratio of the variances from the "After" Study and the "Before" Study was 1.96. It may be noted that of the three other cases in which the same mode was studied, two resulted in statistically insignificant increases in the variance and one in statistically insignificant decrease in the variance. It may be possible that the large, commanding display features of ABC generated differential response patterns on the part of different drivers.

TABLE 5-5

COMPARISON BETWEEN "BEFORE" AND "AFTER"
SPOT SPEED AT THE CROSSWALK

SITE NUMBER	LOCATION	MODE OF OPERATION	EFFECT OF INFORMATION SYSTEM ON			
			MEAN SPOT SPEED		VARIANCE OF SPOT SPEED	
			SIGNIFICANT	NOT SIGNIFICANT	SIGNIFICANT	NOT SIGNIFICANT
2	Livernois-Grove	ABC		X		X*
4	Gratiot-Greiner	A		X*		X*
5	Woodward-Parsons	BCD		X		X
		ABC		X		X
6	Cass-Kirby	A		X*		X
7	Third-Merrick	AC		X*		X
		B		X*	X	
		BE		X		X*
12	Conner-Corbett	ABC Southbound Traffic		X*		X*
		ABC Northbound Traffic		X*	X*	
13	Livernois-Cambridge	B		X		X
14	Seven Mile-Binder	B		X*		X
15	Grand Boulevard-Wildemere	AB		X*		X

*Result in "After" Study greater than that in "Before" Study.

Spot speed data at the crosswalk collected in the "Before" Study and spot speed at 500 feet in advance of the crosswalk collected in the "After" Study are compared and the results presented in Table 5-6.

This test analyzes the effect of the crosswalk environment on the spot speed. Only at one site (Woodward-Parsons) and for mode BCD (joint operation of Flashing Amber Beacons, dynamic Advance Warning Sign and Spotlights) was there a significant difference in mean spot speed observed. In this case the spot speed at the crosswalk was greater by 2.7 mph than 500 feet in advance of the crosswalk. For all other modes of operation the difference between the spot speeds at the crosswalk and 500 feet in advance of the crosswalk was not significant. It is concluded that the effect of the crosswalk environment on the mean spot speeds in the vicinity of the crosswalk was not significant.

The effect on the variances of spot speed was significant in two instances only. At Third-Merrick, Mode B (Flashing Amber Beacon) and Seven Mile-Binder, Mode B (Flashing Amber Beacon), the variance of spot speeds at the crosswalk was less than that at about 500 feet upstream. The ratio of the speed variance 600 feet upstream to that at the crosswalk in these two cases were respectively 2.6 and 2.8. This further supports the effect noted before that the Flashing Amber Beacons have the potential to stabilize the response pattern of drivers to the crosswalk.

The general picture that emerges from the foregoing discussion is that the information systems (except for the Flashing Amber Beacons) did not statistically significantly influence the spot speed of vehicles.

Driver Response

The driver response is evaluated in terms of the numbers of drivers who decelerated without braking, braked but did not stop, stopped, or did not respond. The Chi-square test was used to analyze the effects of the information system on this measure of performance.

Table 5-7 presents the results of the analysis. "Before" and "After" effect differences were not significant in two of the four cases. In the other two cases in which they were significant, the driver response was better before the installation than "after" at Grand Boulevard-Wildemere and at Conner-Corbett the reverse was true. This inconsistency is difficult to interpret. The tests do indicate significant differences in the relative effectiveness of the various modes of operation. The modes A, aB, AB and D seemed to be the more effective modes of operation. Day and night differences were significant in two cases and insignificant in a third case. Of the two cases in which the day and night differences were significant, in one case (Grand Boulevard-Wildemere) the day response was better than the night response, and in the other case (Conner-Corbett) the reverse was true.

Pedestrian Behavior at Signalized Intersections

The pedestrian behavior at signalized intersections was evaluated in terms of the fraction of pedestrians who actuated the push buttons or waited until the "CROSS" signal was displayed. The Chi-square test was used to analyze the effect.

TABLE 5-6

COMPARISON BETWEEN "AFTER" SPOT SPEED AT THE CROSSWALK AND 500 FEET UPSTREAM

SITE NUMBER	LOCATION	MODE OF OPERATION	EFFECT OF INFORMATION SYSTEM ON: MEAN SPOT SPEED		EFFECT OF INFORMATION SYSTEM ON: VARIANCE OF SPOT SPEED	
			SIGNIFICANT	NOT SIGNIFICANT	SIGNIFICANT	NOT SIGNIFICANT
2	Livernois-Grove	ABC		X		X
4	Gratiot-Greiner	A		X*		X
5	Woodward-Parsons	BCD	X			X*
		ABC		X		X
6	Cass-Kirby	A		X		X*
7	Third-Merrick	AC		X*		X*
		ACE		X		X
		B		X	X*	
12	Conner-Corbett	ABC		X		X
13	Livernois-Cambridge	B		X		X
14	Seven Mile-Binder	B		X	X*	
15	Grand Boulevard Wildemere	AB		X		X

*Result 500 feet in advance of the crosswalk is greater than at crosswalk.

TABLE 5-7

DRIVER STOPPING RESPONSE TO INFORMATION SYSTEMS

SITES	ARGUMENTS OF THE CHI-SQUARE TEST		SIGNIFICANT? YES	NO	WHAT EFFECT?
Grand Blvd.-Wildemere	Before vs After	# of drivers who responded vs those who did not respond	X		Greater response in "Before" study
	Day vs Night		X		Greater response during day
Connor-Corbett	Before vs After	# of drivers who did not respond; who decelerated without braking; who braked or stopped	X		More deceleration and more braking or stopping in "After" studies
	Day vs Night		X		More deceleration and more braking or stopping in night
	Mode vs Mode		X		In the ability to generate driver response, aB had the highest potential, A next, CD next, and ABC last; in the ability to generate deceleration without braking, A ranked highest, aB second, ABC third, and CD fourth; in the ability to generate braking or stopping, CD ranked highest, aB second, ABC third, A fourth
	Mode vs Mode For day vs Night		X		In the ability to generate driver response: During day AB ranked highest, CD second, and ABC third; during night aB ranked highest, CD second, and ABC third. In the ability to generate deceleration without braking: During day aB ranked highest, ABC second, and CD third; during night aB ranked highest CD second, and ABC third. In the ability to generate braking or stopping: During day CD ranked highest, aB second, ABC third; during night CD ranked highest, aB second, ABC third. Ability of ABC was better: During night than during day in generating driver response; during night than day in generating deceleration without braking or stopping. Ability of CD was better: During day than night in generating driver response; during night than day in generating deceleration without braking; during night than day in generating braking or stopping. Ability of aB was better: During night than during day in generating driver response; during night than during day in generating deceleration without braking; during night than during day in generating braking or stopping
Livernois-Cambridge	Before vs After	# of drivers who did not respond; who decelerated without braking; who braked or stopped		X	
	Day vs Night			X	
	Mode vs Mode		X		In the ability to generate driver response aB was better than AB. In the ability to generate deceleration without braking aB was better than AB. In the ability to generate braking or stopping, aB was better than AB.
Seven Mile-Binder	Before vs After	# of drivers who did not respond; who decelerated without braking; who braked or stopped		X	
	Mode vs Mode		X		In the ability to generate driver response D was better than A. In the ability to generate deceleration without braking D was better than A. In the ability to generate braking or stopping D was better than A.

Table 5-8 presents the results of the analysis. Data from one site (Cass-Kirby) showed that there was significantly more relative use of the push button by pedestrians during the day than night. This might be due to the greater visibility. All other tests shown on Table 5-9 showed no statistically significant results. This seems to indicate that the responsive push button did not have a great influence on pedestrians.

Pedestrian Behavior at Unsignalized Intersections

Pedestrian behavior at unsignalized intersections was evaluated in terms of the numbers of relative pedestrian response to the two types of detectors during day and night hours. Table 5-9 presents the results of the analysis. No differences were significant. Hence, there is no indication of any significant differential response to the detectors, whether lighted or unlighted.

TABLE 5-8

PEDESTRIAN BEHAVIOR AT SIGNALIZED INTERSECTIONS

SITES			SIGNIFICANT?		WHAT EFFECT?
			YES	NO	
Cass-Kirby	Day Vs. Night	# of Pedestrians who actuated the system; who did not actuate the system.	X		Relatively more pedestrians actuated the system during day than during night.
	Day Vs. Night	# of Pedestrians who waited until "CROSS" signal; who did not wait until "CROSS" signal.		X	
Chicago-Sorrento	Day Vs. Night	# of Pedestrians who actuated the system; who did not actuate the system.		X	
	Before Vs. After			X	
	Lighted Push-Button Detector vs. Combination Push-Button Detector			X	
	Day Vs. Night	# of Pedestrians who waited until "CROSS" signal; who did not wait until "CROSS" signal.		X	

TABLE 5-9

PEDESTRIAN BEHAVIOR AT
UNSIGNALIZED INTERSECTIONS

<table>
<tr><th rowspan="2">SITES</th><th colspan="2" rowspan="2">ARGUMENTS OF THE
CHI-SQUARE TEST</th><th colspan="2">SIGNIFICANT?</th></tr>
<tr><th>YES</th><th>NO</th></tr>
<tr><td rowspan="2">Grand Boulevard-Wildemere</td><td>Day Vs. Night</td><td rowspan="2"># of pedestrians who pushed the button; who did not push the button</td><td></td><td>X</td></tr>
<tr><td>Combination Push-Button Detector Vs. Lighted Push-Button Detector</td><td></td><td>X</td></tr>
</table>

CHAPTER 6

PEDESTRIAN AND DRIVER SUBJECT STUDY

As part of the pedestrian crosswalk study, as comprehensive an evaluation as possible by the people who are most affected by the crosswalks, the pedestrians and drivers, was desired. It was believed that stopping pedestrians and drivers, either on a voluntary basis or with the assistance of the police would be unsatisfactory because of the length of time necessary to obtain the desired information, and apprehension resulting from being flagged down by the police. Therefore, paid subjects were sought to act as pedestrians and drivers in evaluating the various sites.

Because of an electricians' strike and difficulty in installing and maintaining the crosswalk warning devices, the study was delayed several months beyond the original starting date. In June a pilot study was conducted to indicate any problems present in the questionnaire, procedure, and analysis of the data. Thirteen college students participated in the pilot study with three drivers and three pedestrians run in the day and four drivers and three pedestrians run at night. Results indicated that even if all of the critical comments on the design, placement, and operation of the warning devices were satisfied, drivers would probably not yield the right-of-way to pedestrians unless traffic signals were installed.

As a result of the pilot study, changes were made in the questionnaire and procedure to facilitate data collection and analysis. The present study reflects these changes and was conducted in December 1970.

METHOD

Subjects

Eighteen males and fourteen females, all of college age, participated in the study. Subjects were obtained by placing advertisements in the Wayne State University Part-Time Employment Office and in the campus newspaper. Subjects were paid $2.50 an hour for two to three hours of work.

Procedure

The study was conducted on two successive days with the order of both sites and modes within sites reversed the second day. Subjects were met at Wayne State and were then divided so that approximately equal numbers of people of each sex were in each group. The subjects were given instructions to read and any questions were answered. The two experimenters, both members of the Human Factors Group of the Highway Safety Research Institute, then drove the subjects to the first site. The driver subject group stopped several blocks away from each site and waited for a "go ahead" signal. While pedestrian subjects answered questions regarding the push button devices (detectors) and accompanying signs, the experimenter with the pedestrian group informed the electrician present of the desired mode of operation. Citizen Band radios were used to inform the drivers that the site was ready for approach. As the vehicle with the driver subjects approached the crosswalk, the warning devices were activated and the pedestrian subjects attempted to safely cross in front of the approaching car so that driver subjects could observe the pedestrians and make judgments based on actual conditions. The driver experimenter attempted to time his approach so that the pedestrians could cross in front of the car. Pedestrian subjects usually wore dark clothing, so the experimenter crossing the street with the pedestrians wore a light (tan) raincoat so that judgments of pedestrian visibility could be made. After all questions on the questionnaire were answered for that mode, a new mode was presented and the study was repeated. Once all modes at a site were completed, the entire group moved on to the next site.

The day and night order of presentation of modes at the three sites is presented in Table 6-1.

PEDESTRIAN SUBJECT STUDY RESULTS

Frequency of responses to each of the answers for questions A-S of the pedestrian questionnaire are presented in Tables 6-2 and 6-3 for each site. Time of study (day or night), type of detector (combination of illumination), location for observation (north, south, east, or west side of street) and rank or value of answers are given. Rank refers to whether the answer is favorable or unfavorable and is discussed later. Answers having a high frequency of response are circled. Questions A through F pertain to likelihood of use and understanding of the crosswalk. Questions G through L pertain to the unsignalized intersections and Questions M through P pertain to signalized intersections. The final four questions pertain to all sites. Results are summarized below for each question.

Question A: Pavement Markings.

Most subjects felt that the pavement markings would encourage people to use the crosswalk both during the day and at night except at Seven Mile-Binder.

Question B: Combination Push-Button-Detector.

Sixty-three of sixty-five responses indicated that the detector and accompanying signs are somewhat conspicuous to very conspicuous.

Question C: Push-Button-Detector Location.

Sixty-five of sixty-six responses indicated that the push-button is in a convenient location for operation.

Question D: Instruction Signs.

During the day subjects felt that the large sign above the detector box was somewhat likely to very likely to be read by pedestrians. However, at night, 32 of the 44 responses indicated that reading the sign was unlikely.

Question E: Push-Button-Detector Lights.

In general, pedestrians thought the change in lights in the control box was at least somewhat likely to be noticed, especially when the combination detector was present.

Question F: Understanding of Lights.

Pedestrians usually felt, however, the pedestrians would not understand the meaning of the change in lights.

Question G: Expected Driver Response.

To the important question of what the pedestrians expected the drivers to do when the push button was activated, the strongest response was to "slow down" with the next strongest response to "maintain present speed."

Question H: Reason (G).

Either the "caution" sign or previous experience led most pedestrians to respond as they did to Question G.

Question I: Driver Confusion.

Pedestrians overwhelmingly thought that drivers were confused about how to react to the warning signals.

Question J, K, and L: Buzzer Response.

Usually pedestrians were able to leave the curb before the buzzer sounded. Pedestrians thought the buzzers would direct attention to the push button during the day, but were not so inclined to think so at night. Very few subjects thought that pedestrians would understand that the push button should be reactivated.

Questions M-P: Signalized Crosswalks.

Most subjects saw the "WALK - DON'T WALK" signal before stepping off the curb, and most pedestrians waited for the "WALK" signal to come on before crossing at the signalized intersections. Most subjects who were tempted to walk before the "WALK" signal came on were tempted because traffic was light enough to permit safe crossing or because the time delay was too long.

Question Q: Feeling of Safety.

Except at Cass and Kirby, pedestrians overwhelmingly did not feel safe from vehicles while crossing the street.

Question R: Operational Parameters.

Subjects were usually able to get across the street before the warning devices went back to their non-activated condition.

Question S: Preferred Device.

Regardless of site, the best warning device was felt to be the traffic signal with accompanying "WALK - DON'T WALK" signal. No other warning device received a clear preference over any other warning device.

PEDESTRIAN SUBJECT STUDY DISCUSSION

Pavement markings and location of detector and signs at the three sites studied received the support of the pedestrian subjects. Pedestrians apparently think the large explanation sign will be read by pedestrians the first time they see it if there is adequate light to do so. This would explain the unfavorable night responses received at Seven Mile and Binder and at Conner and Corbett where illumination was very low.

At Cass and Kirby and on the west side of Conner and Corbett subjects usually thought it unlikely that pedestrians would notice the change in lights on the control box. This again may be due to high levels of surrounding illumination present at Cass and Kirby,

TABLE 6-1

ORDER OF MODE PRESENTATIONS

<u>DAY*</u> <u>Conner and Corbett</u>

1. Advance Warning Sign (C)
2. Amber Beacons (B)
3. Advance Warning Sign and Amber Beacons (BC)

<u>NIGHT*</u> <u>Conner and Corbett</u>

1. Crosswalk Fixture and Amber Beacons (AB)
2. Crosswalk Fixture, Amber Beacons, and Advance Warning Sign (ABC)
3. Crosswalk Fixture-Static, Amber Beacons, and Advance Warning Sign (aBC)--<u>only</u> crosswalk fixture is static
4. Amber Beacons and Spotlight-Static (Bd)--<u>only</u> spotlights are static

<u>NIGHT*</u> <u>Seven Mile and Binder</u>

1. Spotlights (D)
2. Crosswalk Fixture (A)
3. Amber Beacons (B)

<u>DAY</u> <u>Cass and Kirby</u>

1. Crosswalk Fixture and Traffic Signal (A)

*Order reversed on second day.

		TIME	DAY	DAY	DAY	DAY	NIGHT	NIGHT	NIGHT	NIGHT	NIGHT	NIGHT
		DETECTOR	COMB.	COMB.	ILLUM.		COMB.	COMB.	COMB.	ILLUM.	ILLUM.	
		SITE	Conner & Corbett East Side	Conner & Corbett West Side	Cass & Kirby		Conner & Corbett East Side	Conner & Corbett West Side	7 Mile & Binder North Side	7 Mile & Binder South Side	Cass & Kirby	
QUESTION	RANK	ANSWER NUMBER				TOTAL						TOTAL
A	Hi	1	5	4	6	15	7	7	4	6	9	33
	Lo	2	1	2	0	3	2	3	6	4	1	16
B	Hi	3	2	2	2	6	6	6	1	6	3	22
	Mod	4	4	4	3	11	3	4	9	3	5	24
	Lo	5	0	0	1	1	0	0	0	0	1	1
C	Hi	6	5	4	2	11	4	6	7	6	6	29
	Mod	7	1	2	3	6	5	4	3	3	4	19
	Lo	8	0	0	1	1	0	0	0	0	0	0
D	Hi	9	2	3		5	0	0	1	1		2
	Mod	10	4	2		6	1	1	1	1		4
	Lo	11	0	1		1	8	9	8	7		32
E	Hi	12	3	0	1	4	3	2	3	3	3	14
	Mod	13	3	4	3	10	6	6	6	5	3	26
	Lo	14	0	2	2	4	0	2	1	1	4	8
F	Hi	15	2	0	1	3	2	1	2	4	2	11
	Mod	16	3	3	3	9	4	5	7	3	5	24
	Lo	17	1	3	2	6	3	4	1	2	3	13

Table 6-2. Frequency of responses to each of the Pedestrian Subject Study questions. Time of study, type of detector, site, and rank or value of answer are given. Answers having a high frequency of response are circled.

		TIME	DAY	DAY				NIGHT	NIGHT				NIGHT			
		SITE	Cass & Kirby	Conner & Corbett				Cass & Kirby	Conner & Corbett				7 Mile & Binder			
			60-61	58-62	58-64	58-67		60-61	58-63	58-65	58-66	58-69	59-61	59-62	59-68	
		MODE	A	B	C	BC		A	AB	ABC	aBC	Bd	A	B	D	
RANK	QUESTION	ANSWER NUMBER					DAY TOTAL									NIGHT TOTAL
Lo	G	18		0	0	0	0		0	1	0	0	1	0	3	5
Lo		19		4	3	4	11		9	7	8	9	6	6	4	49
Hi		20		2	3	2	7		1	2	2	1	3	4	3	16
Lo	H	21		0	0	0	0		2	2	3	1	3	1	4	16
Hi		22		2	2	3	7		4	5	4	6	5	5	2	31
Hi		23		4	4	3	11		4	3	3	3	2	4	4	23
Lo	I	24		4	4	4	12		9	10	10	9	9	8	8	63
Hi		25		1	2	1	4		0	0	0	1	1	2	0	4
Mod		26		1	0	1	2		1	0	0	0	0	0	2	3
Hi	J	27		4	4	1	9		8	7	7	6	9	8	6	51
Lo		28		2	2	5	9		1	2	2	2	1	1	3	12
Hi	K	29		6	5	5	16		2	4	3	4	3	4	2	22
Lo		30		0	1	1	2		7	6	6	6	7	6	8	46
Hi	L	31		1	4	1	6		2	0	0	1	0	0	0	3
Lo		32		5	2	5	12		8	10	10	9	10	10	10	67
Hi	M	33	4					10								
Lo		34	2					0								
Hi	N	35	5					8								
Lo		36	1					2								
Lo	O	37	4					5								
Hi		38	0					4								
	P	39														
		40	1					1								
		41														
		42														
		43														
		44	4					2								
		45														
		46	2													
Hi	Q	47	4	0	0	0	4	9	2	3	3	3	4	3	3	30
Lo		48	1	6	6	6	19	0	8	7	7	7	5	7	7	48
Hi	R	49	3	2	4	2	11	10	7	3	6	9	9	8	8	60
Lo		50	2	3	2	3	10	0	2	6	2	0	0	1	1	12
	S	51	4	5	5	5	19	3	3	4	3	3	3	4	4	27
		52	3	5	5	5	18	3	4	4	4	4	4	3	3	29
		53	4	5	5	5	19	3	4	4	4	4	3	4	3	29
		54	2	1	1	1	5	2	2	2	2	2	2	2	2	16
		55	5	3	3	3	14	4	5	5	5	5	4	4	4	36
		56														
		57	4	2	3	3	12	5	3	4	4	3	3	3	4	29

Table 6-3 Frequency of response to each of the Pedestrian Subject Study questions. Time of study, site, mode of operation, and rank are given. Answers having a high frequency of response are circled.

heavy traffic, or other environmental factors. Even when the change of lights on the control box was noticed, subjects felt that it was only somewhat likely that pedestrians would understand the meaning of the change in lights.

From the subjects' responses it did not appear that the buzzers were performing the function they were expected to perform at the nonsignalized intersections.

A definite problem occurred when pedestrians began to cross the street. Despite the caution sign, which some pedestrians failed to see, subjects usually expected the drivers to slow down to permit them to cross. However, what they encountered was an unsafe situation of drivers reacting in a confused or widely varying manner with some motorists stopping or slowing, but with others paying no attention to the pedestrians or even acting hostile to the pedestrians. Only the traffic signal provided a high feeling of security on the part of the subjects and received high recommendations. The traffic signal was not a "cure all", however, since subjects were tempted to walk before the "WALK" signal came on if traffic was light enough or the delay was too long. Also, some subjects stated that they walked when the group walked and didn't notice the "WALK - DON'T WALK" signal.

The frequency and type of optional comments by pedestrian subjects, primarily to Question T, is shown in Figure 6-1. Positive comments were made regarding traffic signals, zebra stripes, and several other devices. However, pedestrians commented that the detectors were not always attention-getting and that directions and the control box displays were not satisfactory. The most frequent comment was one of lack of safety--as one subject put it: "If someone relied totally on this, he would be dead." Pedestrians felt that more devices and a better informed public were needed. Several subjects, after using the crosswalks, said they would rather cross elsewhere than use the devices.

DRIVER SUBJECT STUDY RESULTS

Results of the driver questionnaire are presented in Tables 6-4 and 6-5. Frequency of responses, based on time of study, warning device, and location are presented. Answers having a high frequency of response are circled. Results are summarized for day and then for night for each of the questions A through I.

Day Responses

Question A: Driver Attitude Toward Pedestrian at Curb.

None of the driver subjects would have stopped or braked at either of the sites, regardless of the warning devices, during the day if they had been about 200 feet from the crosswalk with a pedestrian at the curb.

Question B: Driver Attitude Toward Pedestrian in Crosswalk.

With a pedestrian approaching in the crosswalk and the driver about 200 feet from the crosswalk, four out of six drivers would have braked with the crosswalk fixture displayed at Cass and Kirby. The other two would have taken lesser action. At Conner and Corbett, regardless of mode, the driver action ranged from braking to letting up on the accelerator.

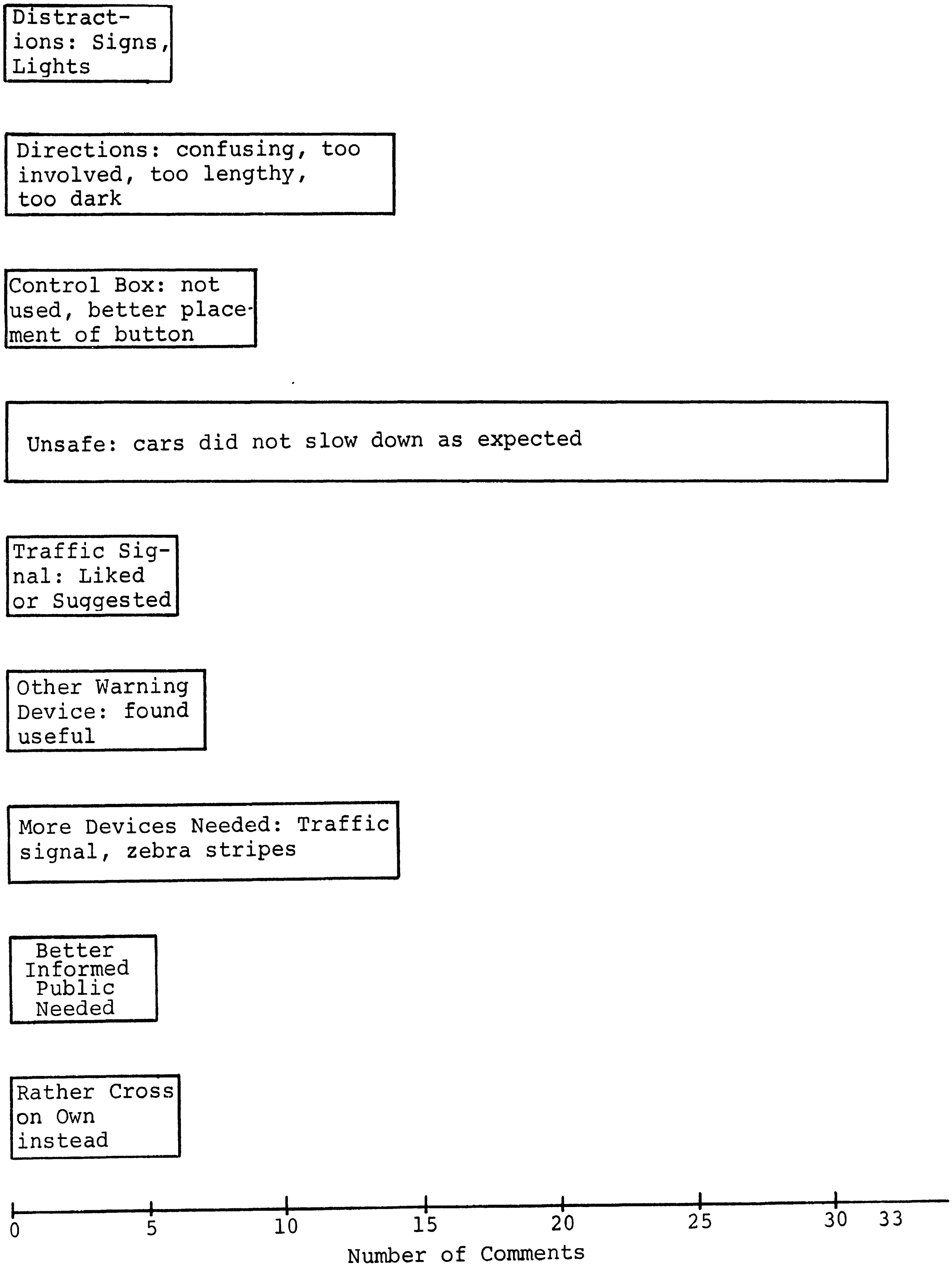


Figure 6-1

FREQUENCY OF OPTIONAL COMMENTS BY PEDESTRIAN SUBJECTS

		TIME	DAY												
		DEVICE	CROSSWALK FIXTURE					AMBER BEACONS		LIGHTED ADVANCED WARNING SIGN		UNLIGHTED ADVANCED WARNING SIGN		ZEBRA STRIPES	TRAFFIC SIGNAL
		SITE	Cass & Kirby	Conner & Corbett				Conner & Corbett		Conner & Corbett		Cass & Kirby	Conner & Corbett	Cass & Kirby	Cass & Kirby
			60-61	-	-	-		58-62	58-67	-	58-67	60-61	58-62	60-61	60-61
		OMISSIONS	1	2	2	2		2		1		2	2	1	
		MODE	A	B	C	BC	TOTAL	B	BC	C	BC	A	B	A	A
RANK	QUESTION	ANSWER NUMBER													
Lo	A	1	1	2	2	0	5								
Hi		2	3	4	4	5	16								
Hi		3	2	0	0	1	3								
Hi		4	0	0	0	0	0								
Mod		5	0	0	0	0	0								
Lo	B	6	0	0	0	0	0								
Hi		7	1	2	1	3	7								
Hi		8	1	3	4	2	10								
Hi		9	4	1	1	1	7								
Mod		10	0	0	0	0	0								
	C	11	4	1	1	1		0	0	0	1				1
		12	0	0	0	0		4	6	5	5				0
		13	0	0	0	0		0	0	0	0				0
		14	0	0	0	0		0	0	0	0				5
		15	2	3	3	3		0	0	0	0				0
Hi	D	16	3	3	3	3		4	5	2	4	0	0	1	5
Mod		17	3	1	1	1		0	1	3	2	0	2	4	1
Lo		18	0	0	0	0		0	0	1	0	0	0	1	0
Lo		19	2	0	0	0		0	2	1	3	0	0	0	0
Lo		20	0	0	0	0		0	0	0	0	0	0	1	0
Lo		21	0	1	1	0		0	0	0	0	4	3	0	0
Lo	E	22	0	0	0	0		0	0	0	0				0
Hi		23	5	3	3	3		4	6	5	6				6
Lo		24	1	1	1	1		0	0	0	0				0
Hi	F	25	4	4	4	4									
Mod		26	0	0	0	0									
Lo		27	0	0	0	0									
Hi	G	28	3	3	4	4									
Mod		29	0	0	0	0									
Lo		30	0	0	0	0									
Hi	H	31	4	2	2	2		3	3	3	3	0	0	1	4
Mod		32	2	2	2	2		1	3	1	3	3	2	4	1
Lo		33	0	0	0	0		0	0	1	0	1	2	0	0
Lo	I	34	0	1	0	0		0	0	1	0	2	1	0	2
Hi		35	5	3	4	3		3	4	4	5	2	3	5	3
Hi		36	1	0	0	1		1	1	0	0	0	0	0	1
Hi		37	0	0	0	0		0	1	0	1	0	0	0	0
Mod		38	0	0	0	0		0	0	0	0	0	0	0	1

Table 6-4 Frequency of response to each of the Driver Subject Study questions. Time of study, device, site, mode of operation, frequency of omissions to report the device operating, and rank or value of answer are given. Answers having a high frequency of response are circled.

		TIME	NIGHT																		
		DEVICE	CROSSWALK FIXTURE					AMBER BEACONS					UNLIGHTED ADVANCED WARNING SIGN			LIGHTED ADVANCED WARNING SIGN		TRAFFIC SIGNAL	ZEBRA STRIPES	SPOTLIGHTS	
		SITE	Cass & Kirby	Conner & Corbett			7 Mile & Binder	Conner & Corbett				7 Mile & Binder	Cass & Kirby	Conner & Corbett		Conner & Corbett		Cass & Kirby	Cass & Kirby	Conner & Corbett	7 Mile & Binder
			60-61	58-63	58-65	58-66	59-61	58-63	58-65	58-66	58-69	59-62	60-61	58-63	58-69	58-65	58-66	60-61	60-61	58-69	59-62
		OMISSIONS	2					1	1	1	3	2	7	6	3			1	2	2	4
		MODE	A	AB	ABC	aBC	A	AB	ABC	aBC	Bd	B	A	AB	Bd	ABC	aBC	A	A	Bd	D
RANK	QUESTION	ANSWER NUMBER																			
Lo	A	1	3	3	3	1	4				3	2									5
Hi		2	5	2	4	5	4				6	6									2
Hi		3	1	4	2	3	1				1	2									3
Hi		4	0	1	1	1	1				0	0									0
Mod		5	1	0	0	0	0				0	0									0
Lo	B	6	1	1	0	1	2				1	0									3
Hi		7	2	2	0	0	0				1	4									1
Hi		8	3	3	5	4	4				4	3									1
Hi		9	3	3	4	4	4				5	3									5
Mod		10	1	1	1	1	0				0	0									0
	C	11	7	9	8	9	9	1	0	0	0	0				1	0	0		6	6
		12	0	0	0	0	0	6	6	7	7	8				9	10	0		1	0
		13	0	0	1	1	0	0	0	0	0	0				0	0	5		0	0
		14	0	0	0	0	0	0	0	0	0	0				0	0	3		0	0
		15	0	1	1	0	1	0	0	0	0	0				0	0	0		0	0
Hi	D	16	5	4	4	4	4	5	4	5	3	2	0	0	0	7	7	6	3	1	1
Mod		17	2	4	5	6	3	1	2	2	2	4	1	0	2	2	2	2	1	4	4
Lo		18	0	1	1	2	2	0	0	0	1	0	0	0	1	3	2	0	0	0	0
Lo		19	0	0	0	0	2	0	0	0	1	0	0	0	1	0	1	0	2	3	2
Lo		20	0	1	0	0	1	1	0	0	0	3	0	0	1	2	2	1	2	2	1
Lo		21	0	1	0	0	1	0	0	0	0	0	1	4	7	0	0	0	0	0	0
Lo	E	22	0	0	0	1	0	0	0	0	0	0				1	2	0		0	0
Hi		23	8	9	7	5	6	6	6	7	6	7				7	7	9		4	3
Lo		24	0	1	3	4	4	1	0	0	1	1				2	1	0		3	3
Hi	F	25	2	2	2	4	2													1	0
Mod		26	4	7	3	5	2													2	4
Lo		27	2	1	2	1	5													2	2
Hi	G	28	2	5	4	7	3													2	3
Mod		29	4	5	2	3	5													4	2
Lo		30	1	0	1	0	1													0	2
Hi	H	31	2	4	3	4	3	1	3	3	2	2	0	0	0	5	4	5	2	1	2
Mod		32	6	5	6	4	4	5	2	3	3	3	1	1	2	1	3	3	2	5	1
Lo		33	0	1	1	2	3	1	1	1	2	3	1	3	6	3	3	1	4	1	3
Lo	I	34	4	4	5	5	3	1	1	1	0	1	1	3	6	1	2	0	4	4	3
Hi		35	3	5	4	5	4	4	5	6	7	7	0	0	0	5	4	2	2	2	1
Hi		36	1	1	2	1	2	2	1	1	0	0	1	1	2	5	5	3	2	1	1
Hi		37	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0
Mod		38	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	1

Table 6-5 Frequency of response to each of the Driver Subject Study questions. Time of study, device, site, mode of operation, frequency of omissions, and rank of answer are given. Answers having a high frequency of response are circled.

For Questions C through I frequencies for all devices at a site which might have influenced the driver are indicated.

Question C: Ability to Describe Mode Displayed.

Incorrect observations of a lower level than the mode of operation presented are critical here. No such errors were made during the day.

Question D: Attention-Getting Ability.

During the day the crosswalk fixture, amber beacons, and traffic signal all have high attention-getting ability for most people. However, the crosswalk fixture was also noted as having average attention-getting ability at Cass and Kirby and of having poor attention-getting ability because of background interference. The zebra stripes have average attention-getting ability primarily. The lighted advance warning sign had ratings ranging from high to poor attention-getting ability, but most ratings were average or better. The unlighted advance warning sign received the lowest rating for having no light.

Question E: Brightness and Contrast.

Illuminated warning devices had satisfactory brightness for most observers.

Questions F and G: Pedestrian Visibility.

Pedestrians in the crosswalk in both dark and light clothing were very visible.

Question H: Usefulness of Devices.

Observations of usefulness of devices are similar to those for attention-getting ability of devices. The traffic signal is the most highly regarded with the crosswalk fixture, amber beacons, and lighted advance warning sign usually rated as useful to very useful. Zebra stripes were felt to be useful, but the unlighted advance warning signs were rated either useful or not useful.

Question I: Responses to Devices.

All devices were about equally effective in causing driver subjects to say that they would usually let up on the accelerator when seeing any of the warning devices. A full range of action was stated, however, varying from maintaining speed to stopping. The unlighted advance warning sign was the least effective of the devices.

The following observations were made under nighttime conditions by the driver subjects.

Night Responses

Question A: Driver Attitude Toward Pedestrian at Curb.

At nighttime the crosswalk fixture and amber beacons, either alone or accompanied with other warning devices, seem to cause many drivers, although not all, to use more caution in approaching the crosswalk. Only with the crosswalk fixture "ON" would any of the drivers have braked or stopped. The spotlight by itself was least effective.

Question B: Driver Attitude Toward Pedestrian in Crosswalk.

When a pedestrian is in the crosswalk, driver behavior, as indicated by responses to this question, is quite varied. The crosswalk fixture is the only device that caused some drivers to stop. At Cass and Kirby, eight of the ten responses ranged from letting up on the accelerator to braking. At Conner and Corbett, eight or nine of the ten respondents would have placed their foot on the brake or braked to modes ABC, aBC, or Bd. Mode AB was the weakest at Conner and Corbett in slowing down traffic. At Seven Mile and Binder mode A was best, mode B was next, and mode D was last.

Question C: Ability to Describe Mode Displayed.

Most devices were observed in the correct mode of operation. Occasionally the crosswalk fixture was seen as unlighted, and once the spotlights were reported as blinking amber.

Question D: Attention-Getting Ability.

At Cass and Kirby the traffic signal and crosswalk fixture generally had high attention-getting ability. At Conner and Corbett the crosswalk fixture had average or better attention-getting ability for most drivers. Amber beacons were usually regarded as having high attention-getting ability except when paired with static spotlights. At Seven Mile and Binder mode B was questionable with three people citing location as being bad. The unlighted advance warning sign had poor attention-getting ability at Conner and Corbett because there were no lights with it. There were also more failures to see this device than any other device. The lighted advance warning sign at Conner and Corbett was usually rated as having high attention-getting ability. At Cass and Kirby the traffic signal usually had high attention-getting ability. Zebra stripes were rated from high to poor attention-getting ability at night.

Question E: Brightness and Contrast.

Illumination of all devices was usually rated as satisfactory except for spotlights and the crosswalk fixture under mode A at Seven Mile and mode aBC at Conner. Under these modes, frequencies were about equal for satisfactory brightness and not bright enough.

Questions F and G: Pedestrian Visibility.

Visibility was always higher for pedestrians wearing light clothing than for pedestrians wearing dark clothing. Modes ABC and aBC were rated highest. Modes Bd and D were rated poorly as was mode A at Seven Mile.

Question H: Usefulness of Devices.

The traffic signal and the lighted advance warning signals were useful to very useful for most subjects. The crosswalk fixture and amber beacons in combination were also seen as useful or very useful. The unlighted advance warning signal was not useful for most, nor were zebra stripes. Most other modes or devices were useful to the drivers.

Question I: Responses to Drivers.

The best device for slowing or stopping traffic was the traffic signal. The next strongest devices were lighted advance warning signals and amber beacons, with crosswalk fixtures following these two devices. The other devices are relatively ineffective in preventing most drivers from maintaining present speed.

Question J: Additional Comments.

Few additional comments were made by drivers. Two drivers noted that the unlighted advance warning signs at Cass and Kirby were very difficult to see. One driver said he had used the Cass and Kirby crosswalk and found it very helpful.

DRIVER SUBJECT STUDY DISCUSSION

The behavior of drivers at seeing pedestrians at the curb or in a crosswalk varies considerably at night from driver to driver regardless of the mode presented. Behavior is less varied and less "cautious" during the day.

Devices were usually reported as operating in the correct mode; however, 50 failures to report devices present were noted. Sixteen of these failures were for the unlighted advance warning sign at night. It is likely for some of these failures that the devices were seen but were not reported or were reported incorrectly. There were about an equal number of reports of seeing other devices at sites which were not present or were not illuminated, so subjects may have been looking so hard for some devices that they missed others. In no instance was there a failure to observe any warning device.

Most devices appear to provide satisfactory attention-getting ability; however, spotlights and unlighted advance warning signals appear to be of questionable value. Along with zebra stripes at night, each of these three devices alone fails to have much effect on the driver's behavior.

Except for modes aBC, A, Bd, and D, all at night, the illuminated devices were of satisfactory brightness. Pedestrians were very visible during the day, but at night visibility decreased somewhat, especially at Seven Mile and Binder for pedestrians in dark clothing under mode A.

Both day and night, the unlighted advance warning signals and zebra stripes were not seen as very useful. For the other devices, usually two or three devices in combination at night received better ratings than single devices except where a traffic signal was present.

GENERAL DISCUSSION

Since it is desirable to draw conclusions about each of the modes present at each of the sites, Table 6-6 provides an evaluation of devices, modes, and sites for driver and pedestrians. All ranks, except the overall ranks in Table 6-6 are approximate averages of the high, moderate and low ranks. All questions are given equal weight for this evaluation. Therefore, all ranks or evaluations are probably on the high or favorable side as far as safety is regarded, because if only one pedestrian fails to see or believe the caution sign, he may be killed. The ranks are intended

	DRIVER							PEDESTRIAN				
MODE		TIME	Hi	Mod	Lo	Device Rank	Mode Rank	Hi	Mod	Lo	Mode Rank	Overall Rank
	<u>Cass</u> and <u>Kirby</u>											
A	Crosswalk Fixture	Day	8	1		Hi	Mod	2	1	2	Mod	Mod
	Unlighted Advanced Warning Sign		3		2	Mod						
	Zebra Stripes		2	2	1	Mod						
	Traffic Signal		7			Hi						
P	Illuminated Detector							1	3		Mod	
A	Crosswalk Fixture	Night	5	4		Mod	Mod	3	1	1	Hi	Mod
	Unlighted Advanced Warning Sign		2		3	Lo						
	Zebra Stripes		2		3	Lo						
	Traffic Signal		6	1		Hi						
P	Illuminated Detector							2	3		Mod	
	<u>Conner</u> and <u>Corbett</u>											
C	Crosswalk Fixture	Day	8	1		Hi	Hi	4	1	2	Hi	Hi
	Advanced Warning Sign		6	1		Hi						
B	Crosswalk Fixture		7	1		Hi	Hi	2	1	4	Lo	Lo
	Unlighted Advanced Warning Sign		3		2	Mod						
	Amber Beacon		7			Hi						
BC	Crosswalk Fixture		8	1		Hi		1		6	Lo	Lo
	Advanced Warning Sign		5	2		Hi						
	Amber Beacons		6	1		Hi						
P	Combination Detectors							2	3		Mod	
	Sign							1	2		Mod	
	Caution Sign							2	1		Hi	
AB	Crosswalk Fixture	Night	4	5		Mod	Mod	2		5	Lo	Lo
	Amber Beacons		6	1		Hi						
	Unlighted Advanced Warning Sign		2		3	Lo						
ABC	Crosswalk Fixture		5	4		Mod	Hi	1		6	Lo	Lo
	Amber Beacons		6	1		Hi						
	Advanced Warning Sign		5	2		Hi						
aBC	Crosswalk Fixture		4	5		Mod	Hi	2		5	Lo	Lo
	Amber Beacons		6	1		Hi						
	Advanced Warning Sign		5	2		Hi						
Bd	Amber Beacons		4	3		Mod	Mod	2		5	Lo	Lo
	Unlighted Advanced Warning Sign		1	1	3	Lo						
	Spotlights		2	4	2	Mod						
P	Combination Detector							3	2		Hi	
	Instruction Sign							2		1	Mod	
	Caution Sign							3			Hi	
	<u>Seven Mile and Binder</u>	Night										
D	Spotlights		2	6	1	Mod	Mod	1	1	5	Lo	Lo
A	Crosswalk Fixture		3	5	1	Mod	Mod	2	1	4	Lo	Lo
B	Amber Beacons		5	2		Hi	Hi	3		4	Lo	Lo
P	Combination Detector							1	4		Mod	
	Illuminated Detector							1	4		Mod	
	Instruction Sign								2	1	Mod	
	Caution Sign							1	2		Mod	

Table 6-6
Evaluation by drivers and by pedestrians of each of the devices present for any given mode at a site. Each mode and each device within a mode is evaluated by rank of High (hi), moderate (mod), or low (lo). Mode "P" refers to the pedestrians devices only and is based on answers to questions A-F and H.

only as "averages" and should not be construed as providing approval for a particular device or mode.

For the driver, unlighted advance warning signs and zebra stripes receive moderate ranks during the day and low ranks at night. At night, crosswalk fixtures and spotlights receive moderate ranks regardless of site. In mode Bd, amber beacons are ranked moderate by drivers. For the driver, six modes receive high ranks and six modes receive moderate ranks.

Mode ranks are also shown for pedestrians in Table 6-6. Ranks for detectors and signs are also shown. It is immediately apparent that pedestrians do not view the crosswalks in as favorable a light as drivers do. Of the twelve modes, only the lighted advance warning sign with unlighted crosswalk signs at Conner and Corbett during the day and the crosswalk fixture with traffic signal at Cass and Kirby during the day receive high ranks. A moderate rank is given to Cass and Kirby at night. The other nine modes are ranked low.

At Cass and Kirby, both day and night, and at Seven Mile and Binder all detectors and signs receive moderate ranks. At Conner and Corbett caution signs are ranked high both day and night and instruction signs are ranked moderate both day and night. The combination detectors at Conner and Corbett are ranked moderate during the day and high at night.

The overall rank is based on the lowest mode rank given by drivers and pedestrians for that particular mode. The only mode to receive a high rank is mode C at Conner and Corbett during the day. This mode presents an unlighted crosswalk fixture and a lighted advance warning signal. The only mode receiving a moderate rank is Cass and Kirby, both day and night. All other modes receive an overall low rank because of the pedestrian evaluation.

CONCLUSIONS

From answers and comments of the subjects, it appears that drivers are usually satisfied with the crosswalk devices and pedestrians are usually not satisfied. Drivers do not expect to have to stop or slow down significantly unless there is a signal or stop sign, or a clearly legal order that they do so, such as would occur with a policeman present directing traffic. Pedestrians, on the other hand, expect traffic to slow down (despite the caution sign) if (1) a push button is installed for them to actuate, and (2) pushing the button activates driver warning devices. The only two modes which appear at all satisfactory to both drivers and pedestrians are mode C (crosswalk sign, lighted advance warning signal) during the day at Conner and Corbett and mode A (crosswalk fixture, unlighted advance warning sign, zebra stripes and traffic signal) at Cass and Kirby. Even these modes receive some low ranks by the subjects.

The conclusion of this study is that a clear danger exists for pedestrians at unsignalized crosswalks. Better informed drivers and pedestrians, and perhaps changes in the laws regarding pedestrian crosswalks are needed if pedestrians are going to cross the streets safely. Whether the devices under study are better than no devices at all is difficult to say. At least without devices the crossing pedestrian usually realizes he is placing himself in danger and acts with this in mind. This cannot always be said for pedestrians using these devices.

CHAPTER 7

EXPERT PANEL EVALUATION STUDY

As an important phase of the evaluation process, a selected group of professionals, the "expert panel," trained and experienced in traffic safety, inspected a representative group of study sites. They provided written comments in response to questions relating to various information devices and modes of operation of the systems.

The expert evaluation panel consisted of personnel with the following skills: traffic engineers, an enforcement official, a traffic safety educator, a traffic association representative and an engineering psychologist. The experts who took part in this study are listed in Table G-1, Appendix G.

The panel members were furnished extensive questionnaire sets to aid them in a comprehensive evaluation of the various aspects of the information systems. A sample questionnaire set is presented in Appendix H. Questions were designed separately for the operation of the individual information devices making up a system and for the modes of operation at the various information systems.

EVALUATION PROCEDURE

The inspection party met for an initial briefing at the Department of Streets and Traffic, City of Detroit. The evaluation procedure was reviewed and the required engineering and environmental sketches of the study sites and information systems were shown to the panel at this time. The engineers and technicians from the Public Lighting Commission, Department of Streets and Traffic, and the Highway Safety Research Institute furnished additional clarification and explanation desired by the expert panel. The schedule indicated in Table 7-1 was followed.

PANEL EVALUATION RESULTS

This section summarizes the findings obtained from the responses of the panel to the questionnaire. The presentation is divided into two parts. First, the findings on the various individual information devices are described. This is followed by the findings on the various modes of operation of the information systems. A mode of operation is made up of either the operation of a single information device or the joint operation of the combination of a few information devices.

INFORMATION DEVICES

The Lighted Push Button Detector (Γ)

Most of the members believed that the Detector was likely to be easily seen and the written message on it easily understood by the pedestrians. The effectiveness in this respect was considered to be slightly decreased after dark. It was suggested by one member that it is necessary to have a means of indicating to the pedestrian who approaches from one side what the device meant. Opinion was nearly evenly divided on whether the pedestrians would see and understand the meaning of the two small lights on the front of the Detector and whether the pedestrians would notice that the small lights on the device change when they push the button. However, the meaning of

TABLE 7-1

EXPERT PANEL MODE PRESENTATIONS

TIME / SITES	DAY	NIGHT
Cass-Kirby	A: Crosswalk Fixture (dynamic)	A: Crosswalk Fixture (dynamic)
Seven Mile-Binder		D: Spotlights (dynamic) A: Crosswalk Fixture (dynamic) B: Amber Beacons (dynamic)
Conner-Corbett	C: Advance Warning Sign (dynamic) B: Amber Beacons (dynamic) BC: Amber Beacons (dynamic) and Advance Warning Sign (dynamic)	Bd: Amber Beacons (dynamic) and Illuminated Spotlights (static) BC: Amber Beacons (dynamic) and Advance Warning Sign (dynamic) AB: Crosswalk Fixture (dynamic) and Amber Beacons (dynamic) ABC: Crosswalk Fixture (dynamic), Amber Beacons (dynamic) and Advance Warning Sign (dynamic) aBC: Illuminated Crosswalk Fixture (static), Amber Beacons (dynamic) and Advance Warning Sign (dynamic)

the change in lights, if noticed, was considered readily understandable. All the experts believed that the Detector has good promise of gaining the confidence of the pedestrians in the long run. Some members felt that the two small lights were susceptible to vandalism. Comments and suggestions by the experts indicated a preference for a larger cabinet for the Detector, brighter lights, larger instruction signs, and explanatory legends stating "red" means "STOP" and "green" means "WALK."

The Combination Push Button Detector (G)

The majority of the panel members responded quite favorably on the value of the Detector with respect to the following aspects: ability to attract the attention of the pedestrians, the probability of the pedestrian seeing the instructions on the Detector, the understandability of the instructions, and the probability of the pedestrian noticing the change in the lighted message on the Detector on activation. The visibility of the Detector was considered to be slightly less after dark than in daylight. As for the effectiveness of the buzzer, all the members felt it unlikely that when the buzzer sounded, the pedestrians still waiting would understand that they should push the button again. The responses of the members reflected strong doubt about the potential of the buzzer to accomplish its intended function. Some members suggested that the sound of the buzzer be made louder, especially in view of the high level of traffic noise. One member considered the size of the push button too large. The Detector's susceptibility to vandalism was considered very high. It was suggested that vandal-proof bolts be used for all connections.

Pedestrian Information and Warning Signs (m)

All the panel members believed that the chances of the pedestrian seeing the Signs are good. The visibility of the Sign was considered less satisfactory after dark than during the day. Illumination was suggested for night use. The letters of the legend were thought to be too small. Opinion was nearly evenly divided on whether the pedestrian would read the Signs. The responses of the members about the various features of the Signs reflected strong doubt about their effectiveness. Some members felt that there was too much information to comprehend and pedestrians would tend to disregard the Sign. One member felt that the Signs did not look like official signs. Further, the placement of the Signs was considered to be too high.

The Pavement Markings (f) and Pedestrian Chains (k)

The panel was unanimous that the designs of the Pavement Markings were appropriate in terms of alerting the drivers to the presence of the crosswalk and the pedestrians and to encouraging greater usage of the crosswalk by pedestrians, both in daytime and after dark. One expert commended the Pavement Markings as being "superior." The majority of the panel members considered the Pedestrian Chains an effective means of directing the pedestrians toward the crosswalk, both in daytime and after dark. The importance of proper maintenance of the chains was pointed out.

The Illuminated (Pedestrian-Actuated or Static) Crosswalk Fixture (A)

The experts believed that the illuminated Crosswalk Fixture was quite likely to be easily seen by the drivers, particularly after dark. However, it seemed difficult to distinguish the legend in daylight. Some members considered the design of the Crosswalk Fixture unsatisfactory and suggested a legibility distance of 500 feet and black on highway yellow design. It was the unanimous opinion of the panel that, at unsignalized sites, the additional illumination (dynamic) provided by the Crosswalk Fixture and its legend was likely to alert the approaching night driver to the presence of the crosswalk and the pedestrians. This was generally considered to be true in the case of the statically illuminated Crosswalk Fixture also. No member felt that the device would confuse or distract the driver. Most members believed it likely that the night pedestrian would think that he was being seen better by the drivers because of the illuminated Crosswalk Fixture. This might, some members felt, cause the pedestrian to use less caution in crossing the street than usual. The opinion was strong that the device would gain the confidence of the drivers and pedestrians in the long run. No serious chance of damage from vandalism was anticipated.

The Dynamic (Pedestrian-Actuated) Amber Beacons (B)

Most of the experts believed that the flashing Amber Beacons were likely to be easily seen by the approaching drivers, both day and night. However, the majority of the panel felt that the Amber Beacons were not likely to alert the approaching drivers to the crosswalk and the presence of the pedestrians. The devices, however, were not considered as confusing or distracting to drivers. One member commented that the Beacons were likely to alert the driver to the presence of the crosswalk but not to the presence of pedestrians. Another commented that the drivers would treat the Beacons like any other flashing amber light. The majority of the members considered the size, placement, and orientation of the Amber Beacons satisfactory in terms of attracting the approaching driver. One member suggested that the Beacons could be lowered and still maintain their intended purpose.

The Dynamic (Pedestrian-Actuated) Advance Warning Sign (C)

The general feeling of the panel was that approaching drivers were likely to see the activated Warning Sign easily, although one member expressed the opinion that the device did not contrast with the visual environment at Conner and Corbett. The majority of the panel believed that the Advance Warning Sign was likely to alert the approaching driver to the crosswalk and to pedestrians. It was the unanimous opinion of the panel that it was unlikely that the driver would be distracted by the Advance Warning Sign. Half of the panel members considered the design, legend and placement of the Sign as satisfactory. One member could not see the legend. Another suggested better lighting so that the legend could be read more easily. As it is, according to one expert, the legend was more legible when the flasher was off. A comment was made that the Sign was placed too close to the crossing. The opinion was nearly evenly divided on whether the Advance Warning Sign would attract vandals or withstand attempts at vandalism.

The Illuminated (Pedestrian-Actuated or Static) Spotlights (D or d)

The use of this information device was evaluated only after dark. The panel members were nearly evenly divided in their preference between dynamic and static operation of the Spotlights. The opinion was very strong that the additional dynamic illumination provided by the pedestrian-actuated Spotlights was likely to alert the approaching night driver to the presence of the crosswalk and pedestrians whom the driver would see more easily. The majority of the panel members felt it unlikely that the illumination provided by the Spotlights would confuse or distract the drivers. One member believed that the dynamic change in illumination could attract the drivers' attention. Another commented that the dynamic Spotlights were good as an illuminating device, but not very positive as a control for drivers or pedestrians. However, another member thought that the statically illuminated Spotlights did not provide additional light to the crossing. A suggestion was made that more powerful lamps might be used to make the installation more effective.

MODES OF OPERATION

The Joint Operation of the Dynamic (Pedestrian-Actuated) Crosswalk Fixture (A), Traffic Signal, Pavement Markings (f) and Pedestrian Chains (k) at a Mid-Block Crosswalk

Opinion was nearly evenly divided on the desirability of using the Crosswalk Fixture in addition to the Traffic Signal, Pavement Markings and Pedestrian Chains. One member of the panel commented that the use of the Crosswalk Fixture with the Traffic Signal would be superfluous in ordinary circumstances, but at high pedestrian volume sites with environments like at Cass and Kirby, it seemed warranted. Most of the experts held the view that the dynamically illuminated Crosswalk Fixture was likely to help reduce the rate of driver violations of the red signal, although this effect was probably less at night. The operational time parameters of the information system were considered satisfactory. The panel was unanimous that during daytime, the lit Crosswalk Fixture was unlikely to cause pedestrians to use less caution in crossing the street than they would only with the Traffic Signal; but the majority of the members felt it likely under after-dark conditions. The opinion was very strong that the information system would contribute to pedestrian safety and gain the confidence of drivers and pedestrians in the long run. Five out of six experts felt that the mode of operation of the system was satisfactory. The cumulative scores received by this mode of operation were 22 and 27 out of 30 for the day and after-dark conditions, respectively. However, one member commented that "A direct driver control in conjunction with the crosswalk sign was much more effective."

The Night Operation of the Dynamic (Pedestrian-Actuated) Spotlights (D) As a Mode of Operation of the Information System at an Unsignalized Mid-Block Crosswalk

This mode of operation was evaluated only after dark. Half of the panel members held the view that the driver would usually yield the right-of-way to pedestrians when the Spotlights were illuminated; the rest believed that the driver would rarely do so. The majority of the members were of the opinion that, if the approaching driver saw the information system going off, he would either have more difficulty in seeing pedestrians in the crosswalk and/or believe that he no longer need be concerned with pedestrians at the crosswalk. Only a few members felt that the driver would feel confused or distracted under such circumstances. The panel was unanimous that the pedestrians were quite likely to think that they were seen better by the driver because of the illuminated Spotlights. Nevertheless, the majority of the members thought it unlikely that the illuminated Spotlights would cause the pedestrians to use less caution in crossing the street after dark than they usually would. The opinion was unanimous that this mode of operation was likely to contribute to pedestrian safety at the crosswalk after dark. The majority of the members also thought that this mode of operation as a night information system was likely to gain the confidence of drivers and pedestrians. Five out of the six experts considered the mode of operation of the system satisfactory. The operational time parameters were considered satisfactory by all panel members.

The Night Operation of the Dynamic (Pedestrian-Actuated) Crosswalk Fixture (A) as a Mode of Operation of the Information System at an Unsignalized Mid-Block Crosswalk

Only one member of the panel believed that the driver would usually yield the right-of-way to pedestrians when the Crosswalk Fixture was illuminated; all the others held the view that the drivers would rarely do so. The majority of the experts were of the opinion that, if the approaching driver sees the information system going off, he would either have more difficulty in seeing the pedestrians in the crosswalk and/or believe that he is no longer required to be particularly concerned with pedestrians in the crosswalk; only one member felt that the driver would feel confused or distracted under such circumstances. The opinion was very strong that the night pedestrians were likely to think that they were seen better by the drivers because of the illuminated Crosswalk Fixture. Nevertheless, four out of the six panel members thought it likely that the illuminated Crosswalk Fixture would cause the pedestrians to use less caution in crossing the street than they usually would. The majority of the members believed that this mode of operation is likely to contribute to pedestrian safety at the crosswalk and gain the confidence of drivers and pedestrians in the long run. However, it received only moderate appreciation from the panel as evidenced by the cumulative scores of 19 1/2 received by it out of 30.

The Operation of the Dynamic Amber Beacons (B) as a Mode of Operation of the Information System at Unsignalized Crosswalks

The opinions of the panel members were very divergent on the possible responses of a daytime driver who sees the activated information system. One member believed that the driver would expect to see a pedestrian in the vicinity of the crosswalk. Another thought that the driver would feel that his driving task is made more difficult by the information displays. A third opinion was that the driver would find it easy to evaluate the meaning of the information displays. The opinion was very strong that when the Amber Beacons are illuminated, the drivers would rarely yield the right-of-way to pedestrians. The majority of the experts were of the opinion that, if the approaching driver sees the information system going off, he would believe that he is no longer required to be particularly concerned with pedestrian safety at the crosswalk. One member who did not share this view commented that the Beacons will attract attention to the location, but may not be associated with pedestrians. The majority of the members held the view that the Amber Beacons are unlikely to contribute to pedestrian safety at the crosswalk and gain the confidence of drivers and pedestrians in the long run. The Amber Beacons as a mode of operation of the information system received only less than medium appreciation from the panel as is evidenced by the cumulative scores of 7 1/2 and 10 1/2 out of 30 received by the day operation and the night operation, respectively.

The Daytime Operation of the Dynamic Advance Warning Sign (C) as a Mode of Operation of the Information System at an Unsignalized Crosswalk

The majority of the panel believed that the Advance Warning Sign is unlikely to contribute to pedestrian safety at the crosswalk and gain the confidence of drivers in the long run. It seemed to one expert that motorists would not react favorably to it. He thought the Sign is ineffective.

The Joint Operation of the Dynamic Amber Beacons (B) and Advance Warning Sign (C) as a Mode of Operation of the Information System at an Unsignalized Crosswalk

Nearly half of the panel felt that, having seen the activated information system, the driver would expect to see a pedestrian within the vicinity of the crosswalk. One member qualified this response stating it to be true if the driver saw the system go on. The rest of the panel expressed divergent opinions on this point. One member believed that the driver would find it easy to evaluate the meaning of the information displays. Another thought that the motorist would look for unusual cross traffic. The panel was unanimous that the illuminated information system is unlikely to confuse or distract the drivers. All the members believed that the night driver would rarely yield the right-of-way to the pedestrians when the information system is lit, while only two experts thought that the motorist would do so in daytime. The feeling was nearly unanimous that, if the approaching driver saw the information system go off, he would believe that he is no longer required to be particularly concerned with pedestrian safety at the crosswalk. The majority of the members held the view that the activated information system is unlikely to cause the pedestrians to use less caution in crossing the street than they would do without them. The general feeling was very strong that the joint operation of the pedestrian-actuated Amber Beacons and Advance Warning Sign as a mode of operation of the information system is unlikely to cotribute to pedestrian safety at the crosswalk and gain the confidence of drivers and pedestrians. The mode received cumulative scores of only 11 and 10 1/2 out of 30 for the daytime and after dark operations, respectively.

The Nighttime Joint Operation of the Dynamic Amber Beacons (B) and Illuminated Spotlights (d) with the Crosswalk Fixture Assumed to be Replaced by Reflectorized Static Sign at Unsignalized Crosswalks

Four of the six experts felt that having seen the activated information system, the driver would expect to see a pedestrian in the vicinity of the crosswalk. One member qualified this response stating it to be true if the driver saw the dynamic part of the information system go on. A different opinion was that the driver would look for traffic hazards. Another view was that the driver would continue to drive on through (apparently with no special reaction). All members believed that the information system was unlikely to confuse or distract the drivers. However, one expert recorded his observation that a cab driver was confused and paid little attention to the information system. Another opinion was that the information system had no effect on the driver. It was the unanimous view of the panel that, when the information system is illuminated, the drivers would rarely yield the right-of-way to pedestrians. The entire panel believed that, if the approaching driver saw the flashing Amber Beacons going off, he would believe that he is no longer required to be particularly concerned with pedestrian safety at the crosswalk. The majority of the members held the view that the activated information system is unlikely to cause pedestrians to use less caution in crossing the street after dark than they usually would, although two members considered it likely. The opinion was evenly divided on whether the information system was likely to contribute to pedestrian safety at the crosswalk after dark. Two-thirds of the panel believed that this mode of operation is unlikely to gain the confidence of drivers and pedestrians. This mode of operation received a cumulative score of only 12 out of 30.

The Nighttime Joint Operation of the Dynamic Crosswalk Fixture (A) and Amber Beacons (B) at Unsignalized Crosswalks

Two-thirds of the panel believed that, having seen the activated information system, the night driver would expect to see a pedestrian in the vicinity of the crosswalk. One of those who shared this belief also expressed the view that the drivers would find it easy to evaluate the meaning of the information display. All members thought that the information system is unlikely to confuse or distract the drivers. Two-thirds of the panel held the view that the driver would rarely yield the right-of-way to pedestrians when the information system is illuminated. Two possible responses on the part of the driver were expected if he saw the information displays going off. All members felt that the driver would believe that he is no longer required to be particularly concerned with pedestrian safety at the crosswalk. Half of the panel also considered it likely that the driver would have more difficulty in seeing pedestrians in the crosswalk. The opinion was evenly divided on whether the activated information system was likely to cause the pedestrians to use less caution in crossing the street after dark than they usually would. One member considered it unlikely because of the high speed of vehicular traffic at the site. The opinion was very strong that this mode of operation is likely to contribute to pedestrian safety at the crosswalk after dark and gain the confidence of drivers and pedestrians. The mode received a cumulative score of 20 1/2 out of 30. A suggestion was made to use a more improved (silhouette) lighting if possible.

The Nighttime Joint Operation of the Dynamic Crosswalk Fixture (A), Amber Beacons (B), and Advance Warning Sign (C) at Unsignalized Crosswalks

Two-thirds of the panel believed that, having seen the activated information system, the night driver would expect to see a pedestrian in the vicinity of the crosswalk. One of those who shared this belief and another who did not expressed the view that the drivers would find it easy to evaluate the meaning of the information displays. Another member commented that the legend on the Advance Warning Sign was too hard to read and that the Crosswalk Fixture appears small. The panel was unanimous that the illuminated information system is unlikely to confuse or distract drivers. Two-thirds of the panel believed that the driver would rarely yield the right-of-way to pedestrians when the information system is illuminated; the rest thought that the driver would usually do so. Two possible responses on the part of the driver were expected if he saw the information displays going off. All members felt that the driver would believe that he is no longer required to be particularly concerned with pedestrian safety at the crosswalk. Two-thirds of the panel also considered it likely that the driver would have more difficulty in seeing pedestrians in the crosswalk. The opinion was evenly divided on whether the activated information system was likely to cause the pedestrians to use less caution in crossing the street after dark than they usually would. The opinion was very strong that this mode of operation is likely to contribute to pedestrian safety at the crosswalk after dark and gain the confidence of drivers and pedestrians. The importance of sufficient education and publicity was pointed out by one member. The mode received a cumulative score of 21 out of 30. One member mentioned that his scoring was based on the assumption that the Advance Warning Sign can be read.

The Nighttime Joint Operation of the Illuminated (Static) Crosswalk Fixture (a) and the Dynamic Amber Beacons (B) and Advance Warning Sign (C) at Unsignalized Crosswalks

Two-thirds of the panel believed that, having seen the activated information system, the night driver would expect to see a pedestrian in the vicinity of the crosswalk. Half of those who shared this belief, and two others who did not, expressed the view that the drivers would find it easy to evaluate the meaning of the information displays. The panel was unanimous that the illuminated information system is unlikely to confuse or distract the drivers. Two-thirds of the panel believed that the driver would rarely yield the right-of-way to pedestrians when the information system is illuminated; the rest throught that the driver would usually do so. Two-thirds of the panel felt that, if the approaching dirver saw the dynamic part of the information system going off, he would believe that he is no longer required to be particularly concerned with pedestrian safety at the crosswalk. One member thought that the driver would feel confused or distracted under such circumstances. The opinion was evenly divided on whether the static or activated information system was likely to cause the pedestrians to use less caution in crossing the street after dark than they usually would. The opinion was very strong that this mode of operation was likely to contribute to pedestrian safety at the crosswalk after dark and gain the confidence of drivers and pedestrians in the long run. The mode received a cumulative score of 22 1/2 out of 30.

SUMMARY OF PANEL EVALUATION FINDINGS

The panel evaluation study questionnaire was designed to enable the experts to systematically evaluate the various aspects of the information devices and modes of operation from the viewpoints of both drivers and the pedestrians. The dynamic (pedestrian-actuated) nature of the displays and the additional illumination at the crosswalk provided by the information systems were particularly appreciated by the panel. The dynamic nature of the displays was considered effective in catching the attention of the drivers and pedestrians. It was also believed that the additional illumination would both help drivers see pedestrians better and cause pedestrians to believe it was so with the result that pedestrians, in some cases, would use less caution while crossing. The most significant adverse effect pointed out by the experts was that the Pedestrian Information and Warning Signs (m) seemed incapable of eliminating the chance of a pedestrian believing that cars would stop for him. Another major drawback was that if the approaching driver sees the information system going off, he would either have more difficulty in seeing the pedestrians and/or believe that he is no longer required to be particularly concerned with pedestrians at the crosswalk. In spite of these, the modes of operation of the information system which were dynamic in nature and illuminated the crosswalk were believed to be capable of contributing to pedestrian safety and gaining the confidence of drivers and pedestrians in the long run. The Lighted Push Button Detector (F) with its dynamic lights was considered more effective than the conventional type of push button detector. The combination Push Button Detector (G), however, received less appreciation because the potential of its buzzer to accomplish the intended function was strongly doubted. The dynamic (pedestrian-actuated) Amber Beacons (B) were evaluated as ineffective in alerting the approaching drivers to the crosswalk and the presence of the pedestrians. Appreciation for the Zebra Pavement Markings (i) and Pedestrian Chains (k) was very high. All the other information devices were commended for their ability to alert the drivers to the possible hazard at the crosswalk and/or provide additional illumination enhancing the visibility of the pedestrians.

The preferences were even between using or not using the dynamic Crosswalk Fixture (A) at signalized intersections. The potential of the Crosswalk Fixture to help reduce the rate of driver voilations of the red signal was recognized.

The night operation of the dynamic (pedestrian-actuated) Spotlights (D) as a mode of operation of the information system at an unsignalized mid-block crosswalk was highly commended for its ability to illuminate the crosswalk and make the pedestrians more visible. Furthermore, the pedestrians themselves would be conscious of their increased visibility, but would not be tempted to use less caution in crossing the street. Half of the panel members believed that the driver would usually yield the right-of-way to pedestrians when the Spotlights were illuminated.

The night operation of the dynamic (pedestrian-actuated) Crosswalk Fixture (A) as a mode of operation of the information system at an unsignalized mid-block crosswalk was evaluated as being nearly equivalent to the dynamic Spotlights with the exception that only one member of the panel believed that the driver would usually yield the right-of-way to pedestrians when the Crosswalk Fixture was illuminated.

The dynamic (pedestrian-actuated) Amber Beacons (B) as a mode of operation of the information system at unsignalized crosswalks received only less than medium appreciation from the panel. The evaluation was similar to this in the case of the daytime operation of the dynamic Advance Warning Sign (C) as a mode of operation of the information system at an unsignalized crosswalk. The joint operation of the dynamic Amber Beacons (B) and Advance Warning Sign (C) as a mode of operation of the information system at unsignalized crosswalks was also considered unlikely to contribute to pedestrian safety and gain the confidence of drivers and pedestrians. The opinion was nearly the same on the joint operation of the dynamic Amber Beacons (B) and illuminated (static) Spotlights (d) with the Crosswalk Fixture assumed to be replaced by an identical reflectorized static appropriately colored sign at unsignalized crosswalks.

The opinion was very strong that the nighttime joint operation of the dynamic Crosswalk Fixture (A) and the dynamic Amber Beacons (B) at unsignalized crosswalks was likely to contribute to pedestrian safety at the crosswalk after dark and gain the confidence of drivers and pedestrians in the long run. The evaluation was similar and still more appreciative in the case of the nighttime joint operation of the dynamic Crosswalk Fixture (A), Amber Beacons (B), and Advance Warning Sign (C) at unsignalized crosswalks. Still more favored was the night mode of operation consisting of the illuminated (static) Crosswalk Fixture (a) and dynamic Amber Beacons (B) and Advance Warning Sign (C).

In summary, analysis of the thinking of the panel seemed to indicate that the major features of the information systems valued by the experts were the dynamic nature of the displays and the illumination provided at the crosswalk.

CHAPTER 8

CONCLUSIONS AND DISCUSSION

CONCLUSIONS

This demonstration program has made a comprehensive study of one of the important problem areas of pedestrian safety. The need for an innovative approach to this problem was appreciated by experts, pedestrians and drivers. The pedestrians responded to the information systems at unsignalized intersections by making greater use of the demonstration project crosswalks. However, it was demonstrated that a clear danger still exists at these locations. Although the information systems did generate a greater awareness by drivers of the presence of pedestrians, the systems apparently did not cause either a significant change of driver behavior or an increase in pedestrian confidence about his safety in crosswalks. The pedestrian who actuated the information system expected a positive response on the part of the approaching drivers. The pedestrians seemed to soon realize this lack of motorist response as is seen from the insignificant influence of the information systems on pedestrian behavior.

The results of all the studies indicated that drivers are not significantly influenced by the information systems. It was generally demonstrated that those information systems which were dynamic in character and provided additional illumination were more appreciated by the driver. With such information devices in operation, it seems highly probable that the drivers would act with more caution in the long run.

There was a considerable difference in the effectiveness of the various devices used, particularly during different times of the day.

The problem of pedestrian safety at signalized crosswalks is clearly different from and less severe than at unsignalized crosswalks. There was a slight tendency for the improvements in the push button detector to appear useful, particularly at locations where extended delays are necessary before the "WALK" signal is displayed. The use of the Crosswalk Fixture in conjunction with a traffic signal was found to be useful for special cases.

DISCUSSION

It was concluded that Detroit drivers generally do not consider themselves obliged to yield the right-of-way to pedestrians except at signalized intersections. They take it for granted that pedestrians should take care of themselves. Thus, we have a situation where most pedestrians believe that they are able to take care of themselves and the drivers expect them to do so. A natural inference, therefore, is that the information systems should be directed mainly toward the pedestrian so that his confidence would be supplemented by a facility for rational decision making. The studies did not vindicate the value of the experimental information system in helping the pedestrian to make a safe crossing.

The factors that influence the behavioral patterns of drivers and pedestrians require closer examination. It would be expected that there is a greater variance in the behavioral pattern of the pedestrians than of drivers because of the stratified nature of the driving population. It should be a major aim of safety efforts to reduce the variance of the behavioral patterns of the pedestrians.

The driver subject and observational studies revealed that the behavior of the drivers upon seeing pedestrians at the curb or in a crosswalk varies considerably at night from driver to driver regardless of the mode presented. Behavior appears to be less varied and less "cautious" during the day. This later pattern increases the predictability of the actions of the approaching driver. With increased level of illumination at the vicinity of the crosswalk, the environment tends to resemble the daytime conditions and hence reduces the variability of the behavioral pattern of the drivers. It is therefore fitting that the responses of the experts in the panel evaluation study consistently reflected appreciation for information systems that provided additional illumination at the site. The increased predictability of the action of drivers is a helpful element in more rational decision making by pedestrians. A satisfactory level of illumination is also very important to encourage pedestrians and drivers to read the messages directed at them.

It is important that an effort be made in the design, operation and publicity of the information systems to insure a high probability of uniform evaluation by the pedestrians and the drivers. The design principles listed below are believed to be of help in achieving this objective.

First, where local "practice" effectively grants the right-of-way to drivers at all times at unsignalized crosswalks, as is the case in Detroit, the suggested design principle at difficult crossing points is: adequate static illumination at the crosswalks with suitably illuminated static information signs for the pedestrian.

Secondly, where local laws or practice grant the right-of-way to pedestrians at all times at unsignalized crosswalks, the design principle is: adequate static illumination at the crosswalk, mandatory message (dynamically illuminated by pedestrian actuation or presence) and suitably illuminated information signs for pedestrians.

APPENDICES

APPENDIX A

CROSSWALK SIGN LIGHTING INTENSITY STUDIES

Introduction

The purpose of this study was to simulate night conditions (total darkness) in a laboratory in order to make a series of observations to determine the luminosity of the "CROSSWALK" sign.

In making such observations, it was decided that the most practical and characteristic measurements were those of the light intensities at ground level.

There were two possible variations in study parameters: (1) moving the sign vertically, and (2) varying the sign itself. Both of these variations were considered in this study.

A mathematical analysis was made to determine the theoretical luminosity values for the sign and a computer program written for this purpose. The computer program was used to estimate results for the light intensity on the pavement when a sign with the same luminance is placed at a height of 18 feet above the pavement surface.

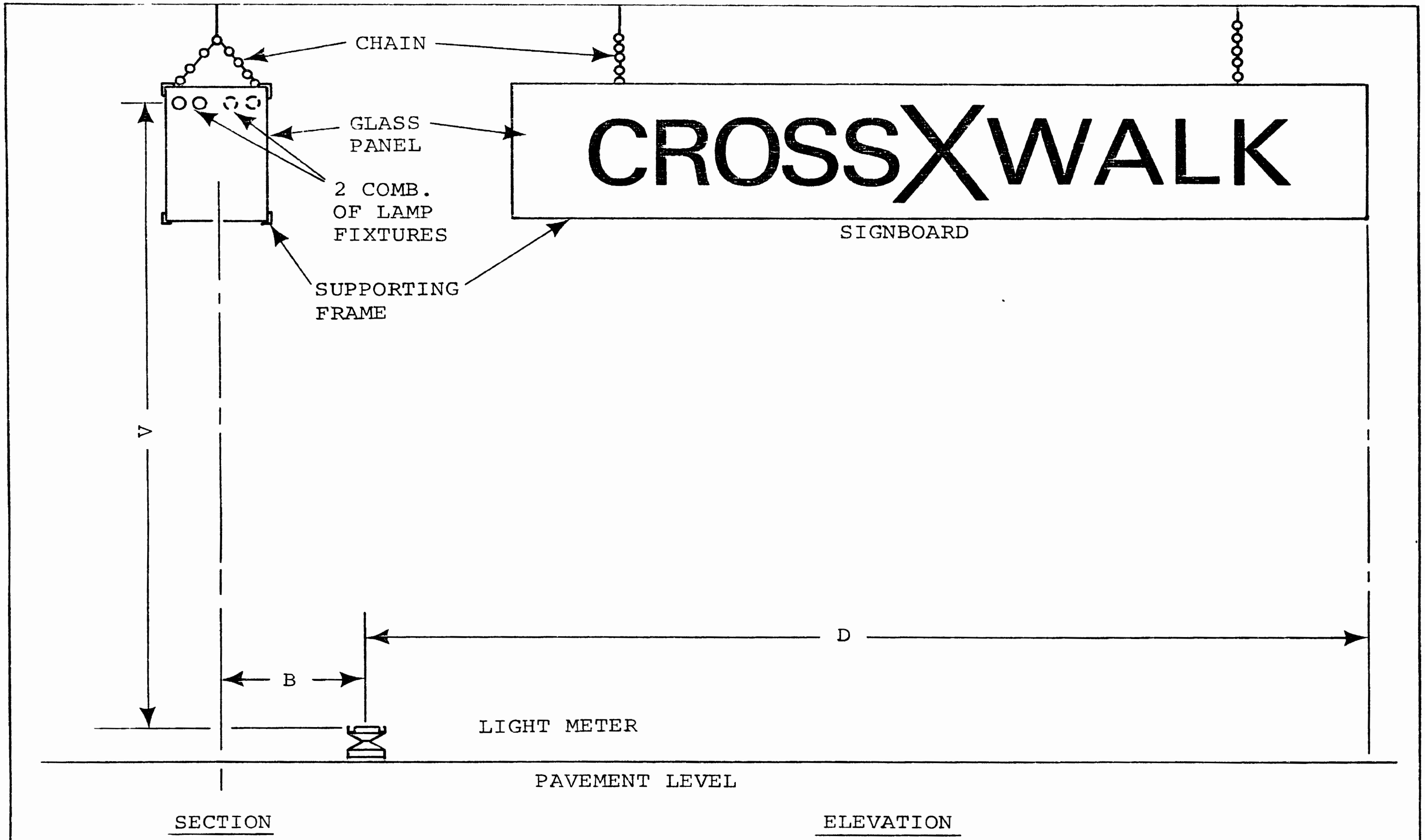
A brief account of the way in which the estimated errors were minimized is presented later in this appendix.

Equipment

The Crosswalk Sign: The sign was designed so that an eight-foot fluorescent lamp fits compactly into each of the sockets provided. The one-foot width of the sign accommodates four fluorescent lamps. The level of the lamps is approximately three feet from the lowest level of the signboard as shown in Figure A-1.

The main weight of the signboard is due to two panels of Plexiglass, three feet wide and eight and one-half feet long, bearing the word "CROSSXWALK" painted in bold black letters against an orange background. The signboard is a heavy and fragile piece of equipment, sturdy and durable if handled carefully, but dangerous if handled carelessly.

The GE Light Meter: An extremely sensitive General Electric Company low-level light meter which utilizes a photoelectric cell to determine light intensities was used as the measuring device. The meter is correct to two decimal places from zero to five foot candles, correct to one decimal place from zero to ten foot candles, and correct to one-half foot candle from zero to 20 foot candles of light intensity. This light meter was used to measure light intensities for all readings taken at various locations on the plane of study. Zero-error charts provided with the light meter were incorporated in all readings taken.



LETTERS DENOTE DISTANCES USED IN THE COMPUTER PROGRAM

FIGURE A-1
DIAGRAM OF EXPERIMENT LAYOUT

Measuring Devices: A tape measure was used in most of the experiments. In determining the nodal points for a two-foot by two-foot grid on the surface of the laboratory floor, however, it was found that a two-foot by two-foot board provided a quick and adequately accurate measurement.

Lamps: The lamps used were high-intensity eight-foot fluorescent tube lamps recommended by the manufacturer.

Measurement

Procedure: The study room was a 40-foot by 40-foot darkened room in which a strip of floor 20 feet wide along the axis of the signboard was chosen as the measuring area.

Each light intensity reading varied as a function of:

1. The locational coordinates (x,y) of the point being studied.
2. The height of the light source from the plane (v).
3. The luminosity of the source itself, which varied according to the position of the lamps in the fixture.

It was believed that for fixed values of items 2 and 3 above, the intensity of light measurement could best be presented location-wise on the plane of study by means of graphical representations. Such graphs are included in the report.

A single reading was obtained in the following manner. The location of the point in question was determined with respect to its position relative to the signboard on the plane of study. The light intensity at this point, due only to the illumination of the signboard, was measured by means of the light meter.* The value of the light intensity of the point and its location on the reference plane were recorded as one of a set of readings pertaining to a particular height of the signboard at a particular luminosity (1, 2, or 4 lamps).

Results: As a sample measure, the first stage included recognition of a significant area of measured floor surface on which the light intensity readings could be taken. Consequently, light readings were taken along the edges of the room as well as along the axis of the signboard and also perpendicular to this axis at the center of the signboard.

It was observed that it was possible to exclude an area of floor surface more than 20 feet in width, running parallel to and symmetrical with the axis of the "CROSSXWALK" signboard.

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*Illumination measurements at a point due to a single source imply simply the illumination due to the mentioned source of light at that point in an otherwise effectively darkened room (0.00 foot candles).

The graphs illustrate the next set of readings on the chosen area of the laboratory floor surface. A two-foot by two-foot grid was set up, and readings were recorded at all nodal points. It was observed that all lamps were 14 feet zero inches above the level of measure, and that the signboard was illuminated by all four lamps. The resulting tabulations for those considerations are given in Figure A-2. Contours connecting 2, 4, 6, 8, 10 and 20 foot-candle levels are shown in the figure.

An undesirable factor emerged in these readings: Light intensities greater than 20 foot candles were not measurable by the light meter. Consequently, a large patch of light immediately below the signboard was left unrecorded. This appears in Figure A-2.

The problem was solved by diminishing the light intensity of the source by removing two lamps while the position of the signboard was left intact. After the readings were taken, the experiment was repeated with the other two lamps and the additivity principle was used. The light intensity readings from this experiment are given in Figures A-3 and A-4.

In order to more accurately determine the nature of the light distribution and to completely verify the calculations which would follow, it was decided to vary the height of the lamp source. This was effected by lowering the signboard so that the lamps were at a height of eight feet above the level of the plane on which intensity measurements were made. It was necessary to be very careful at this stage. The light intensities were decidedly brighter on this plane of measurement than in the previous case. Hence, the set of readings taken for the light intensity were again made in two parts. The results of this experiment are presented in Figures A-5 and A-6.

There was, however, still a problem with this set of readings. The only two possible combinations of light were already used, and yet there was still a patch of light which exceeded 20 foot candles. The only possible way to overcome this problem was to decrease the luminosity of the source still further, until intensity measurements less than 20 foot candles could be made within this patch of light.

This was achieved in two ways: First, by darkening one lamp completely so that only one of the two lamps would illuminate the floor at a given time;* and second, by reducing the floor grid spacing to one foot by one foot in this region. Permutations of this experiment were done so that all four lamps illuminated the floor separately. Figures A-7 and A-8 present the results of these experiments.

Summary of Results

The total intensities incidental on the floor surface were measured for the two heights of the signboard, 8 and 14 feet. For each height there is a set of readings for a two-foot grid on the entire measured floor area, and a more detailed set of readings for the region of light which exceeds 20 foot candles. These results are presented in Figures A-9, A-10, A-11 and A-12.

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*This procedure was necessary because it was possible to have only two lamps at a time in the signboard.

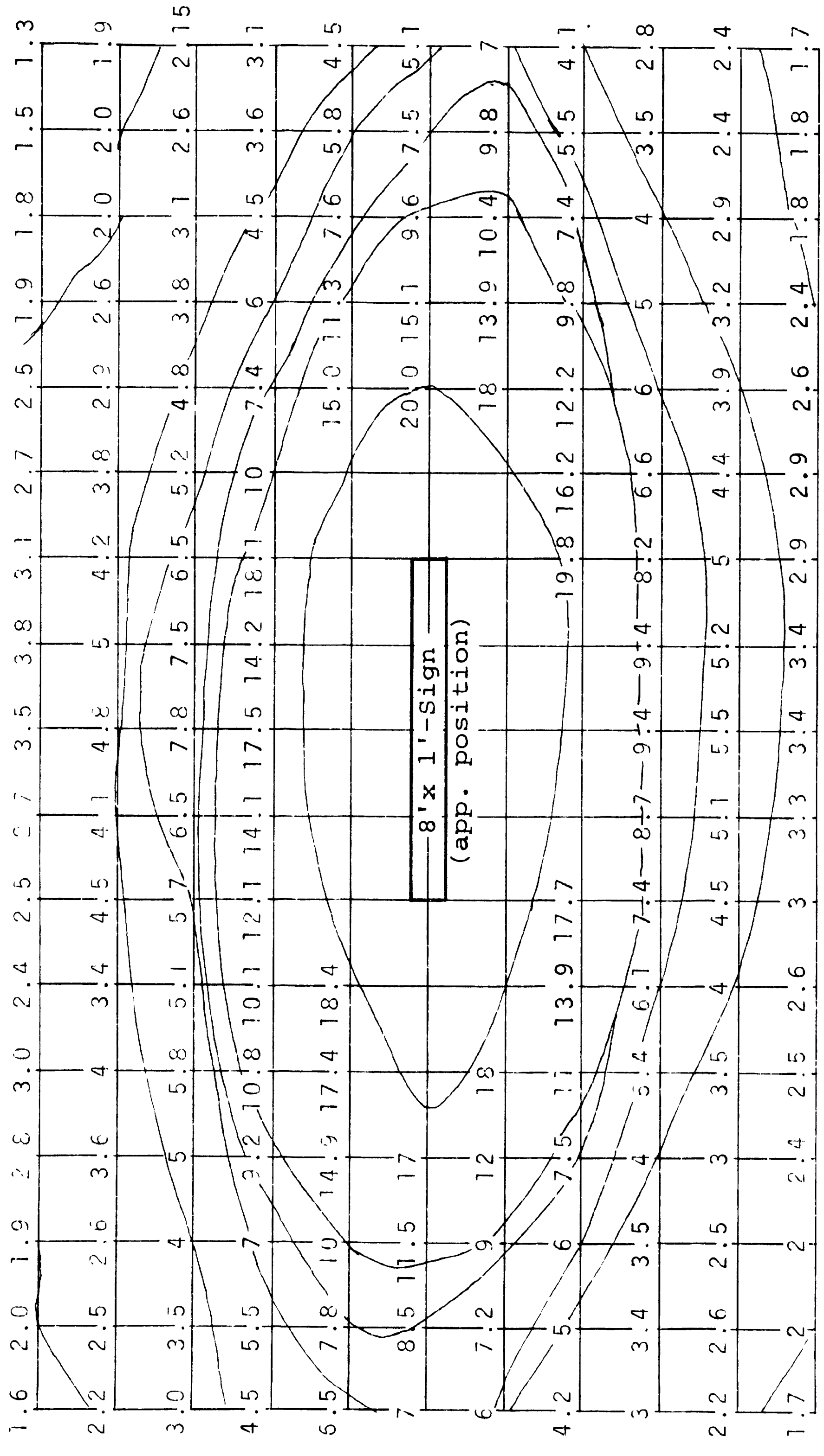


Figure A-2

LIGHT INTENSITIES SIGN: AT A HEIGHT OF 14'

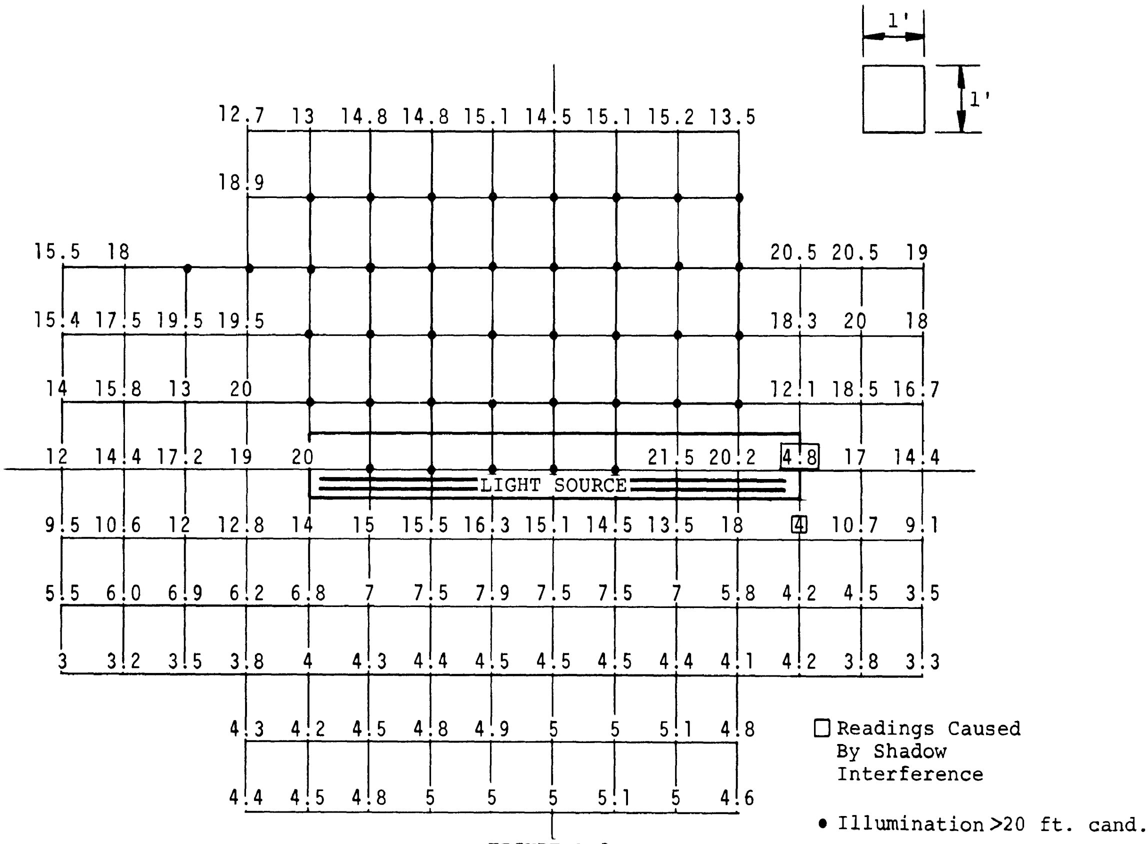


FIGURE A-3

LIGHT INTENSITIES - SIGN AT A HEIGHT OF 14 FEET: TWO LAMPS

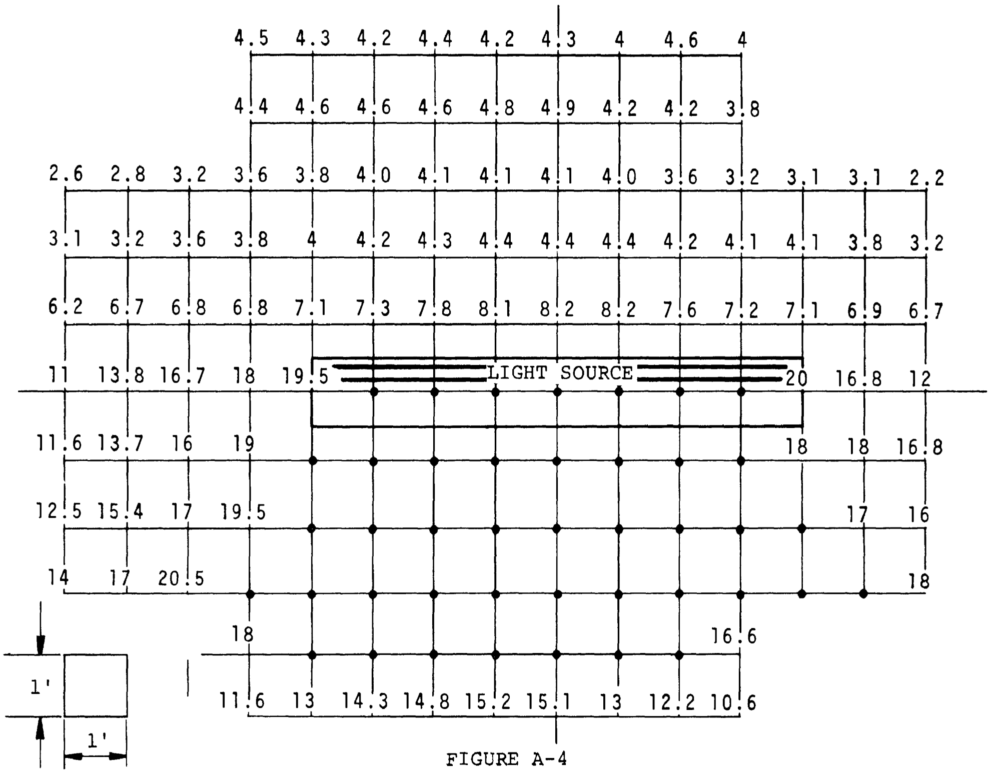


FIGURE A-4

LIGHT INTENSITIES - SIGN AT A HEIGHT OF 14 FEET: TWO LAMPS

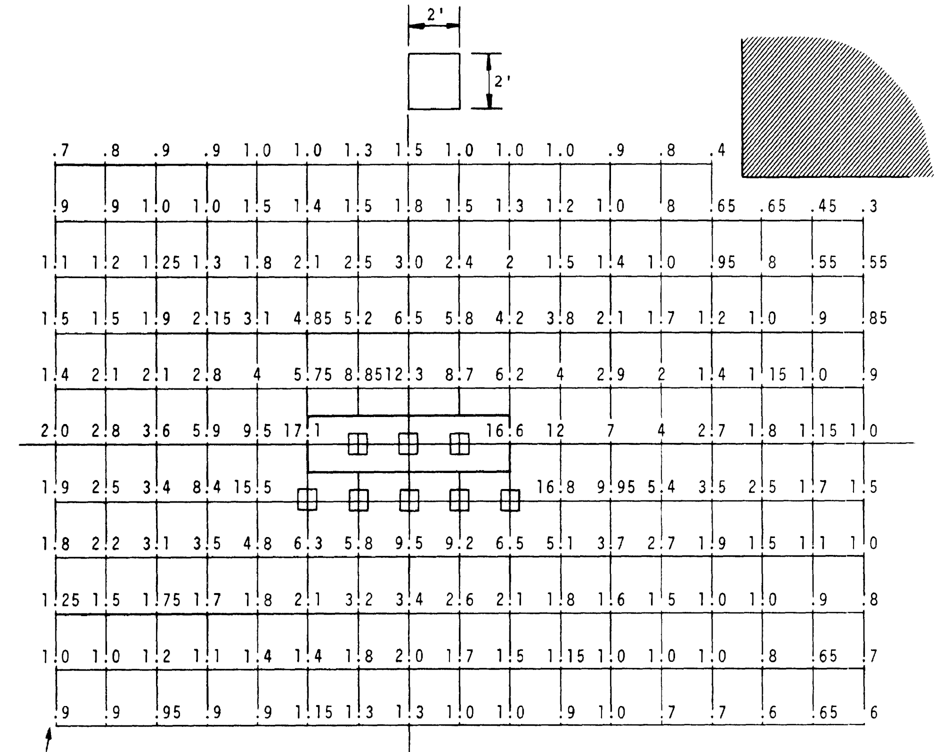


FIGURE A-5

LIGHT INTENSITIES - SIGN AT A HEIGHT OF 8 FEET: TWO LAMPS

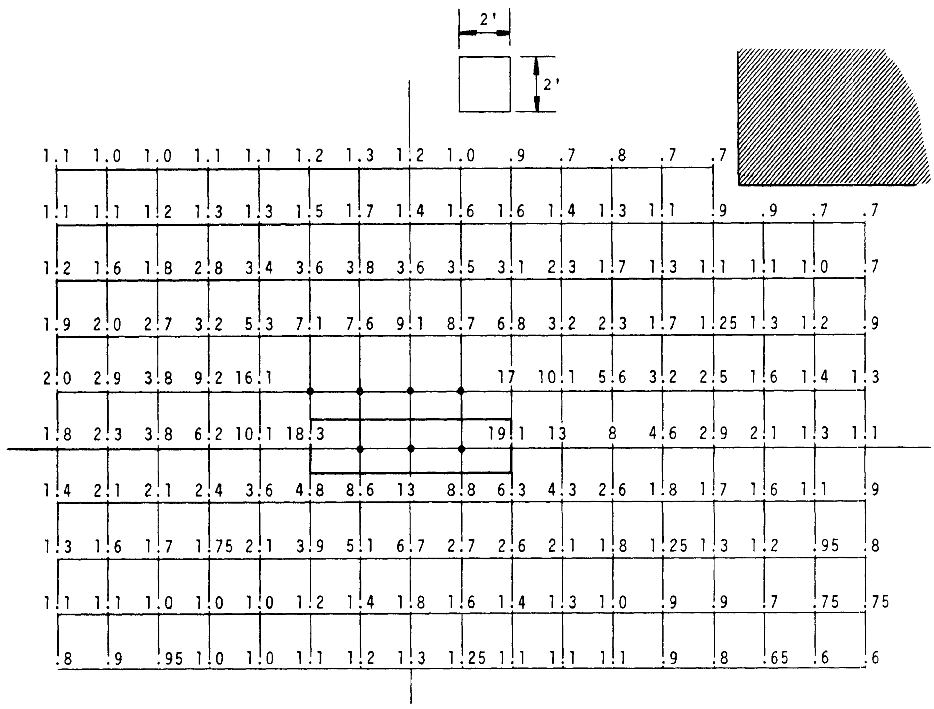


FIGURE A-6

LIGHT INTENSITIES - SIGN AT A HEIGHT OF 8 FEET: TWO LAMPS

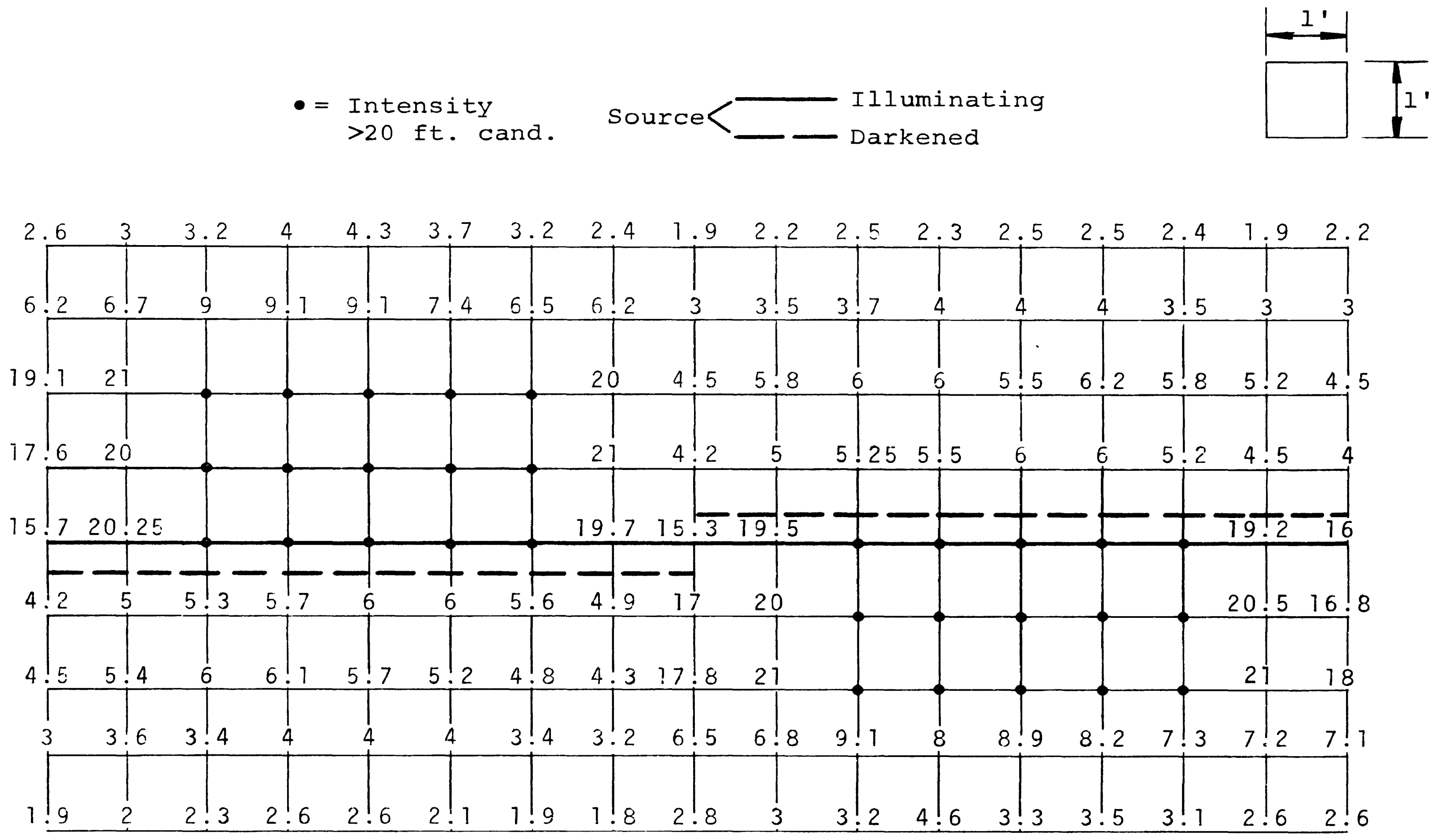


FIGURE A-7
LIGHT INTENSITIES - SIGN AT A HEIGHT OF 8 FEET: ONE LAMP

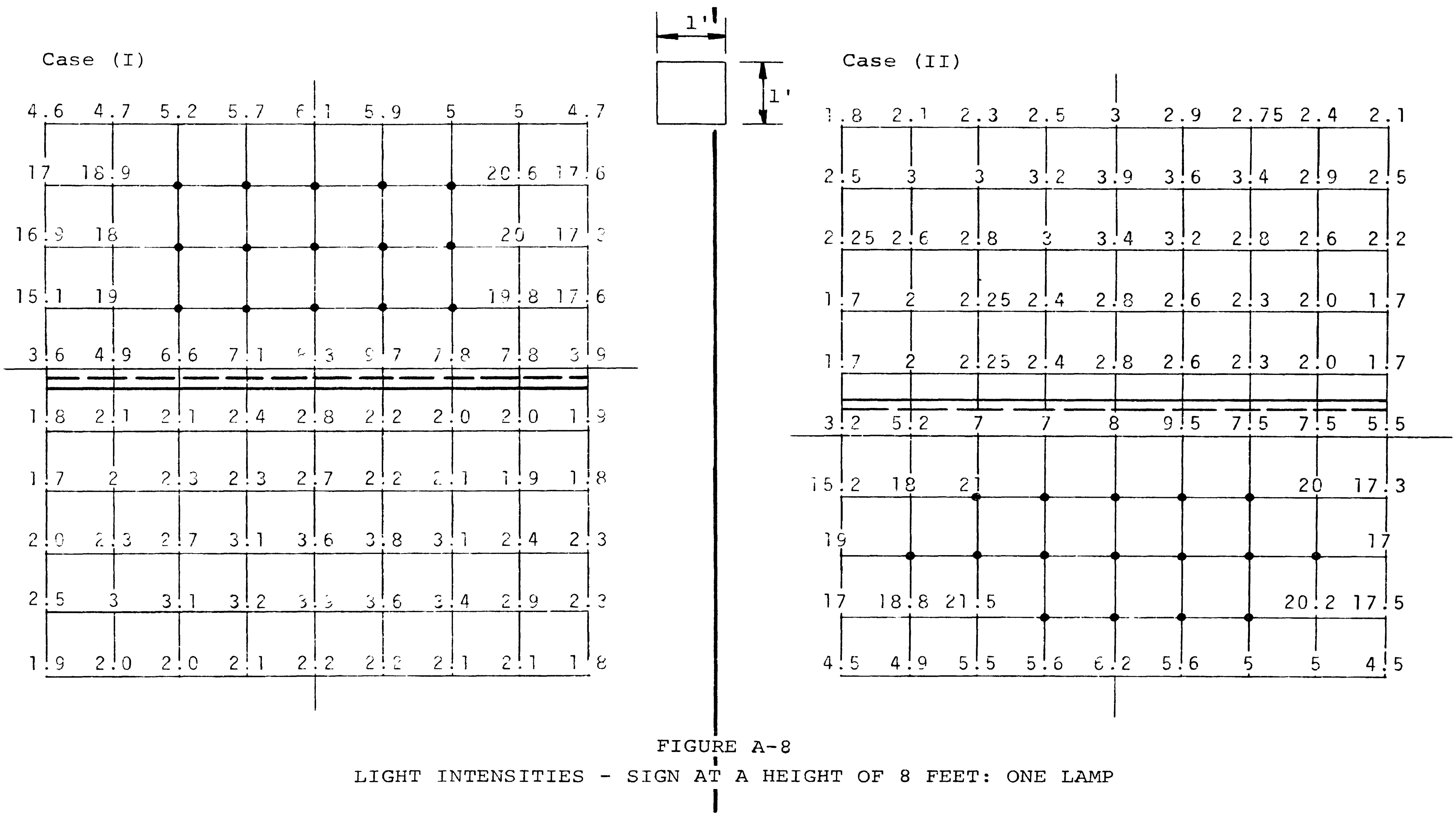


FIGURE A-8
LIGHT INTENSITIES - SIGN AT A HEIGHT OF 8 FEET: ONE LAMP

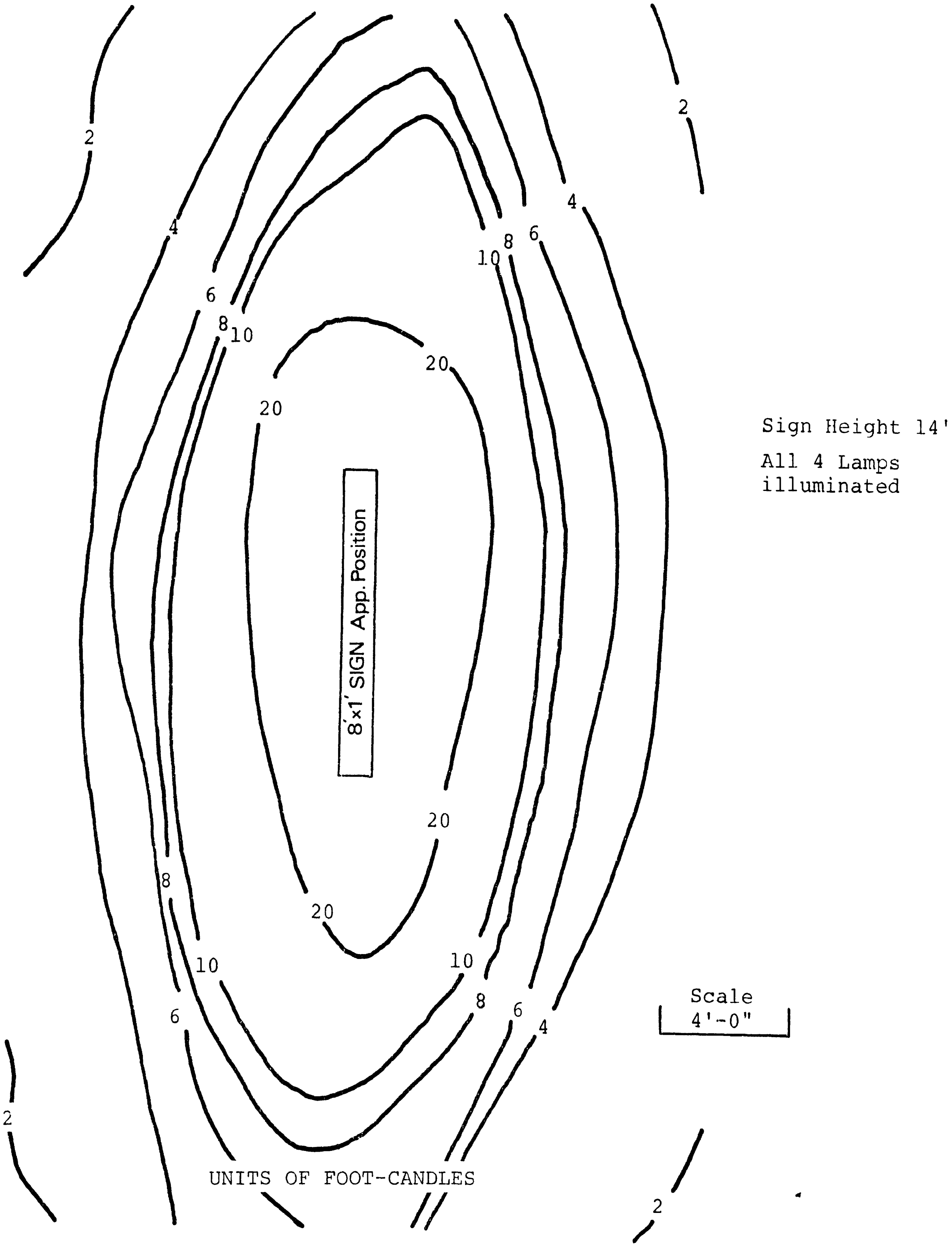


FIGURE A-9
LIGHT INTENSITY READINGS FOR LIGHT
FROM "CROSSWALK" SIGN

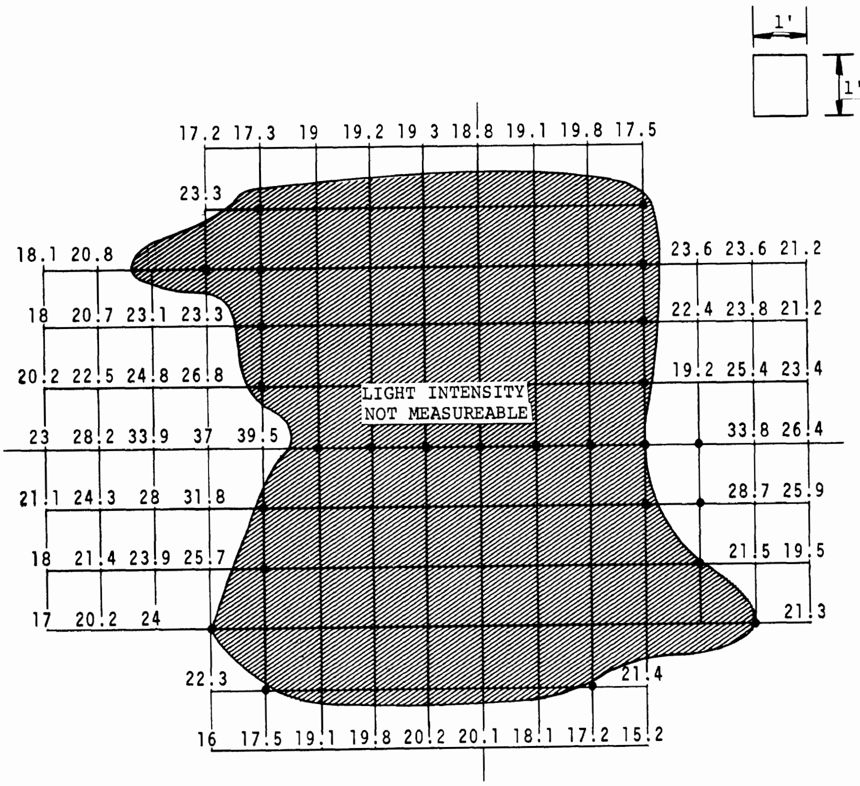


FIGURE A-10
LIGHT INTENSITIES - SIGN AT A HEIGHT OF 14 FEET:

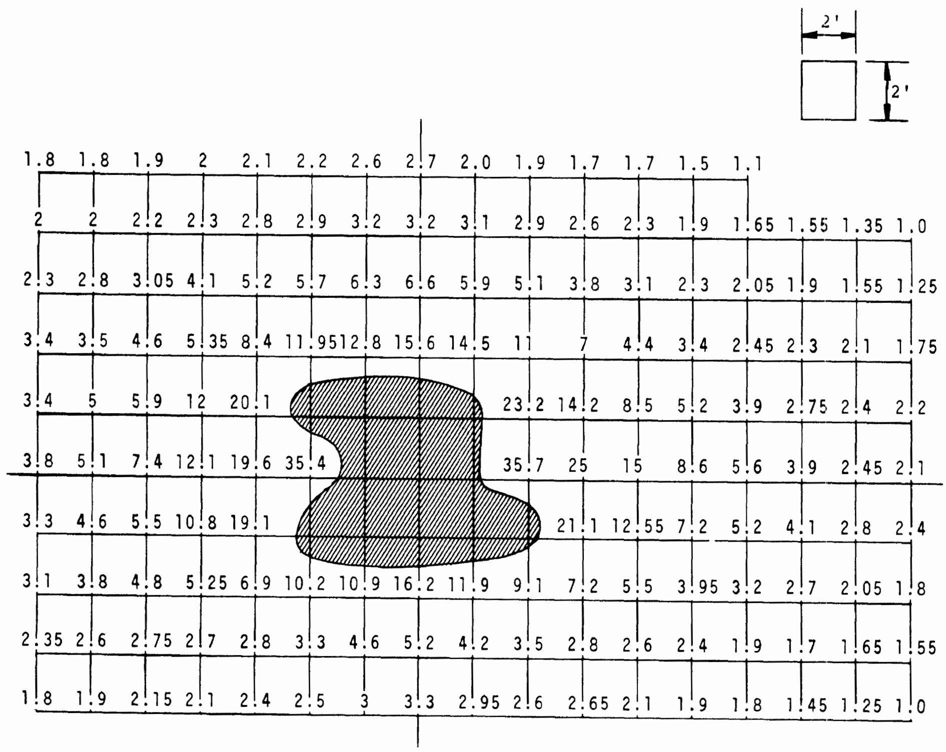


FIGURE A-11
LIGHT INTENSITIES - SIGN AT A HEIGHT OF 8 FEET

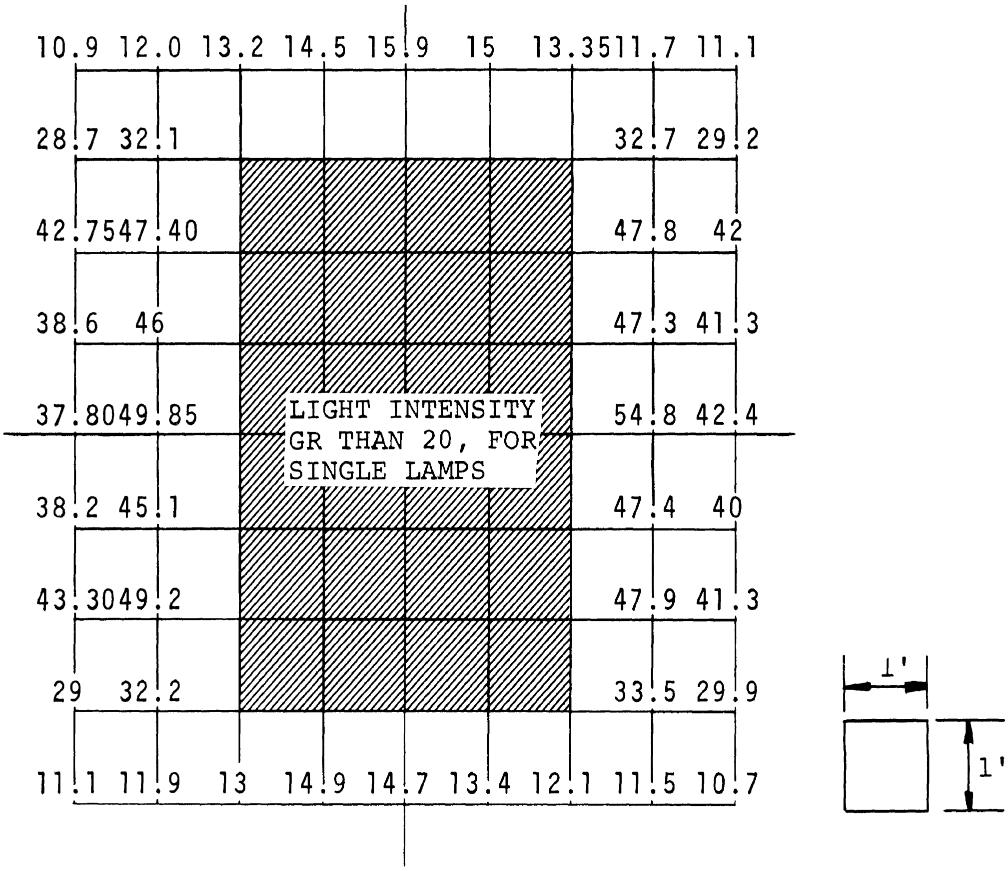


FIGURE A-12

LIGHT INTENSITIES - SIGN AT A HEIGHT OF 8 FEET

Calculation Results

The fluorescent lamps have a toroidal distribution of light (Figure A-13) given by:

R, W, b, V, M and d are in feet.

L = illumination of the source in foot candles.

E = illumination of point P in foot candles.

Plane of M, V and b is the axis of the lamp.

$$M = v^2 + b^2 \; ; \quad R = v^2 + b^2 + d^2$$

$$\text{and } E = \frac{LWV}{2\,M} \left(\frac{1}{M} \tan^{-1} \left(\frac{d}{M}\right) + \frac{d}{R^2}\right)$$

The results obtained from computer calculations are presented in Figure A-14. Predicted results are given in Figure A-15 for the recommended height of 18 feet.

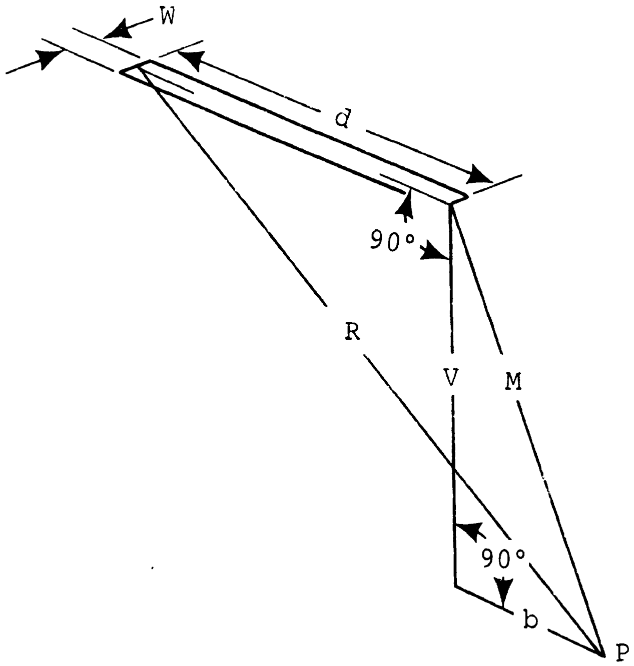


FIGURE A-13

TOROIDAL DISTRIBUTION OF LIGHT

Human Factors Evaluation

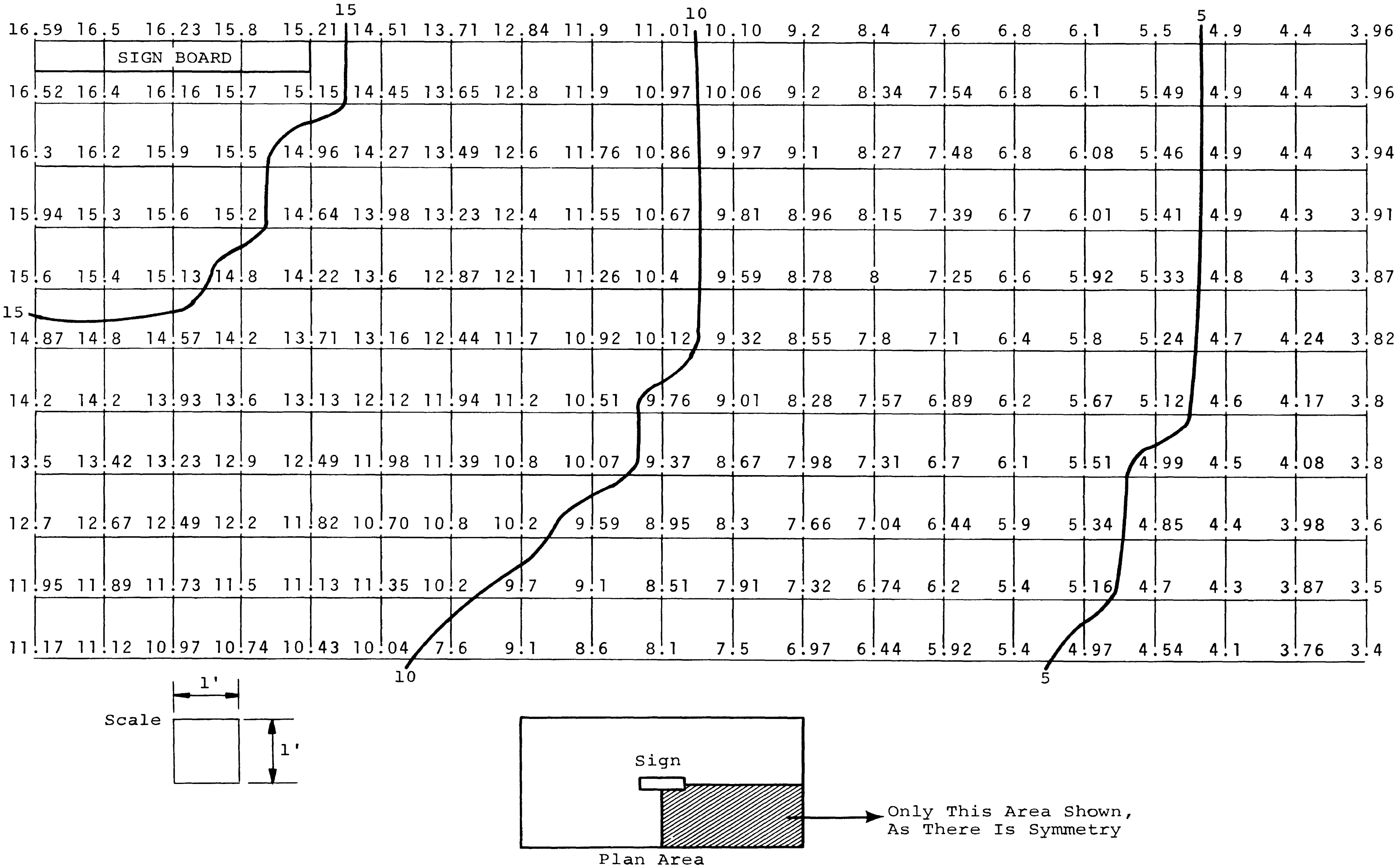
A study of the signboard from the human factors standpoint offered two suggestions for improving the signboard:

1. Edges of the sign on both sides of the display board should have been painted black so that a distinctive frame was presented. This also would have added uniformity. The sign as originally designed had only silver aluminum edges.

2. The orange color on display should have been replaced with the standard highway yellow color used on streets and highways.

FIGURE A-14

PREDICTED RESULTS: LIGHT INTENSITIES
FOR 4 LAMPS AT A HEIGHT OF 18 FEET



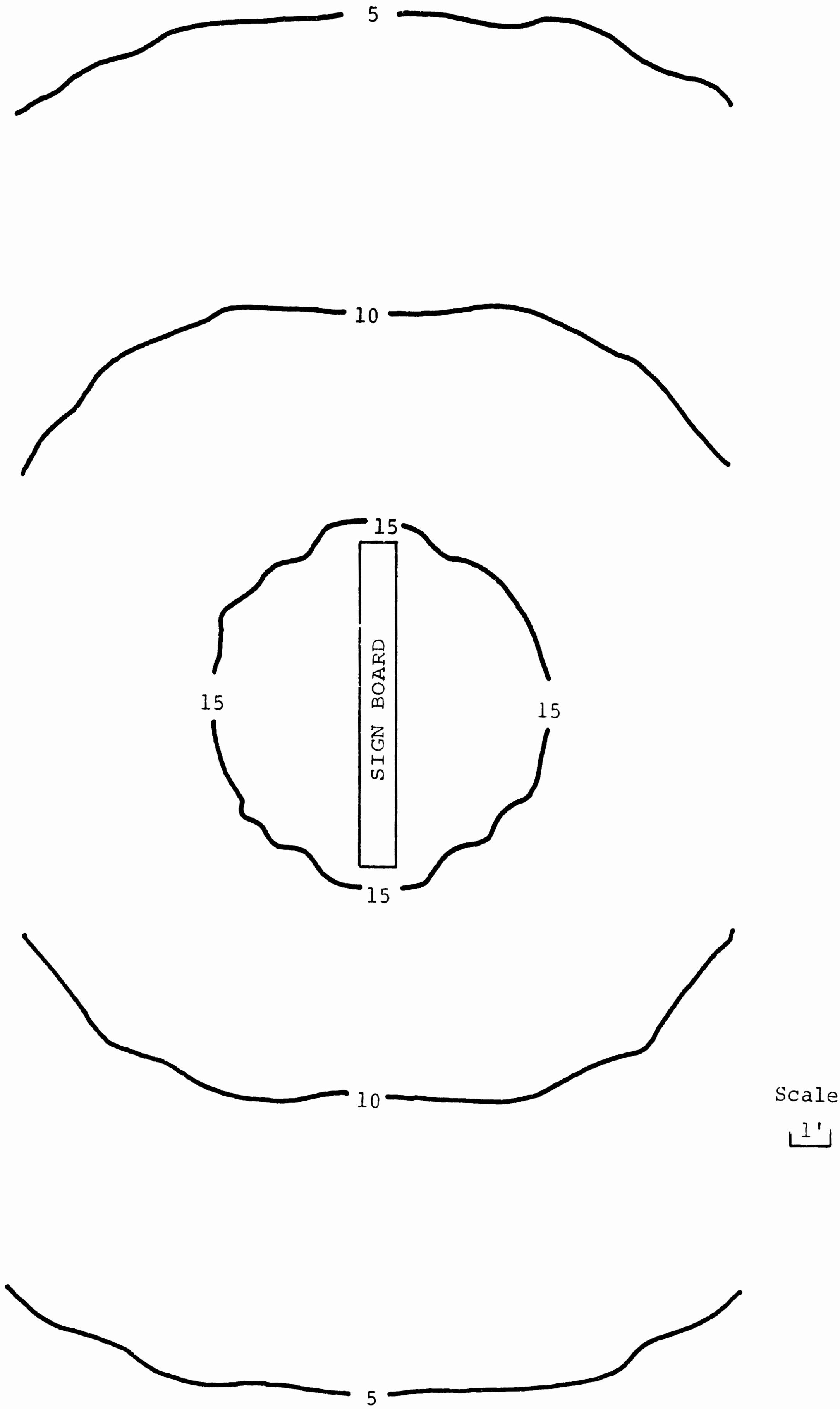


FIGURE A-15
PREDICTED RESULTS: LIGHT INTENSITIES FOR 4 LAMPS OF THE SIGNBOARD AT A HEIGHT 18' ABOVE THE PAVEMENT
(UNITS ARE IN FOOT CANDLES)

APPENDIX B

FEASIBILITY OF STROBOSCOPIC ILLUMINATION OF PEDESTRIAN CROSSWALKS

An extensive literature search on the effects of stroboscopic lights on general human perception yielded very limited information directly related to the needs of this project. Only representative reports bearing directly on intermittent illumination of the visual field are sampled here. The studies reported below were mostly concerned with intermittent stimulation and flicker adaptation.

Visual Acuity and Intermittent Illumination

Feilchenfeld investigated the relationship between visual acuity and intermittent background illumination (12). He found visual acuity to be best for flicker or flash light either at a very low rate where individual flashes could be perceived or at so high a rate that critical fusion actually took place. Visual acuity was poorest in the flash frequency ranges where the impression of flicker is most apparent. This is the very same range in which brightness enhancement is needed to maintain a level of perception of the stimulus background equivalent to that under steady illumination. Low-frequency flashes would not be suitable for purposes of this study because they do not enhance the visibility of the pedestrian on the crosswalk. Therefore, as far as visual acuity is concerned, steady illumination should be considered. This is supported by research findings of Riggs (13) and Keesy (14), who reported that flicker at shorter intervals may not improve normal visual acuity, although stabilization of the retina image may be enhanced by intermittent flashes.

The brightness of the visual field under intermittent illumination by stroboscopic light at frequencies of four to five h. appeared to remain as high as in steady light. This could be the acceptable range of flash frequency for the crosswalk lighting if it should be decided to use stroboscopic displays.

Adaptation to Intermittent Illumination

Hudson (15) compared the adaptive effect of intermittent light to that of steady light. His results did not indicate more effective adaptation with intermittent illumination.

The problems of darkness adaptation are complex and involve such factors as luminance and duration of preadapting light levels, size and location of the stimulation relative to the human eye, and light wavelength before adaptation. The luminance and duration of a flash on dark adaptation also serves as a basis for inferring the course of light adaptation. The question of adaptation to flashing illumination must be pursued further if the decision is made to use this technique of illumination.

Some Detrimental Effects of Intermittent Illumination

Irritation, visual discomfort, driving up of the alpha rhythm of the EEG, and induction of epileptic convulsions in some portions of the general population have been reported to accompany the use of intermittent illumination for visual display (16). Also, Bidwell, (17) found that brightness and color relations may appear to be reversed using a stimulus pattern shown with a homogeneous field of white light, and followed by relative darkness at a frequency of five to six cps. This approximates the stroboscopic illumination of intersections or pedestrian crosswalks. Some visual confusion in detecting objects in the visual field may be produced.

This and the report on the possibility of seizure generation under stroboscope light have led to some negative impressions on the application of stroboscopic lights to crosswalk illumination. The general problems were discussed in relation to flashing lights, which may not be as intense or severe as white strobe lights. The difficulties would be magnified if pure white lights such as those generated by a stroboscope were used.

Besides irritation and visual confusion, the negative effects of the white lights are further emphasized by the fact that the proportion of epilepsy cases in the driving-age population has been reported to be four per 1,000, which includes both drivers and pedestrians (15).

Summary

The results of this general survey do not seem to favor displays using intermittent visual stimulation, especially with stroboscopic lights. The priority for the selection and design of crosswalk illumination is believed to be as follows:

1. Steady lights.
2. Intermittent non-white lights at high frequencies.
3. Intermittent, low-frequency non-white lights ranging from four to five cps.
4. Stroboscopic lights.

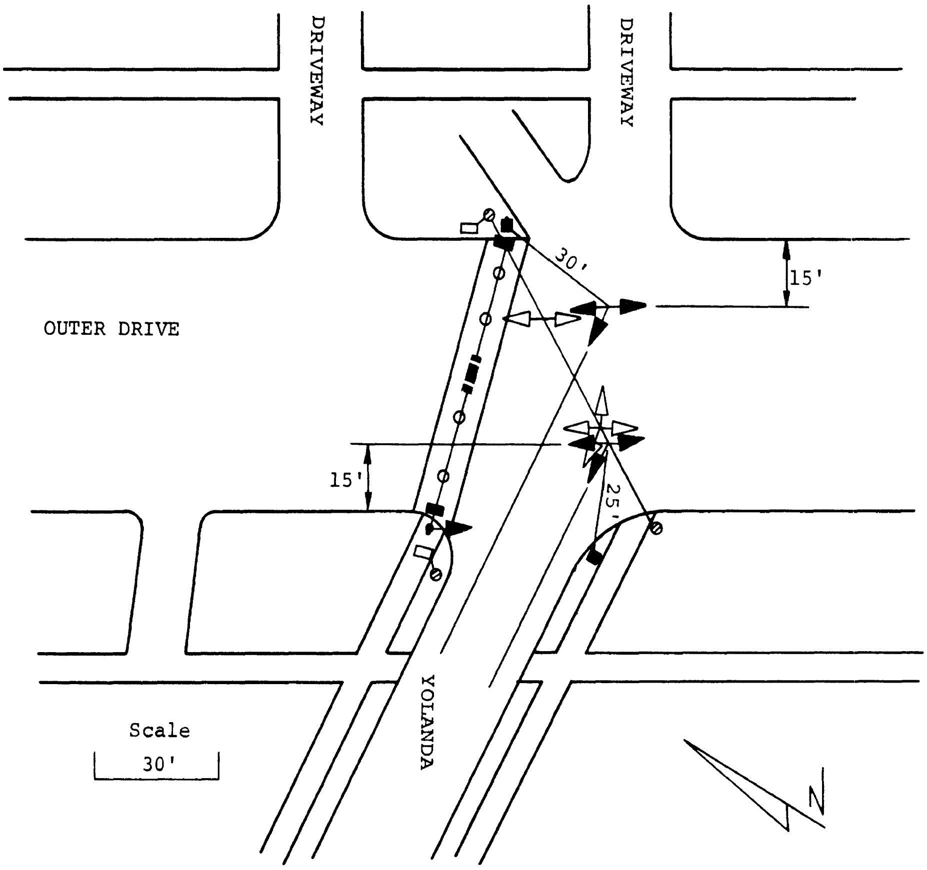
APPENDIX C

SITE DESCRIPTIONS, SKETCHES, AND PHOTOGRAPHS

This appendix presents descriptions of the sites selected for the study. The descriptions indicate the physical environment and the traffic patterns of the sites. Sketches and photographs are also presented.

Yolanda and East Outer Drive (Figure C-1)

Site Number One is located at the T-intersection of Yolanda and East Outer Drive in what is essentially a residential neighborhood. Private residences are located along the west side of Outer Drive. An apartment complex is located northeast of the intersection and the Polish Century Club is located southeast of the intersection. The north crosswalk, which was studied, is ten feet wide and has been designated as a school crossing. This crosswalk is used predominantly by local school children, neighborhood residents, and individuals who frequent the Polish Century Club. The nearest traffic signal to the pedestrian actuated part-time signal at Yolanda and Outer Drive is located approximately 1,550 feet south at Seven Mile Road. Equipment installed at this site included one crosswalk fixture with spotlights, one push-button detector, and one lighted push-button detector.

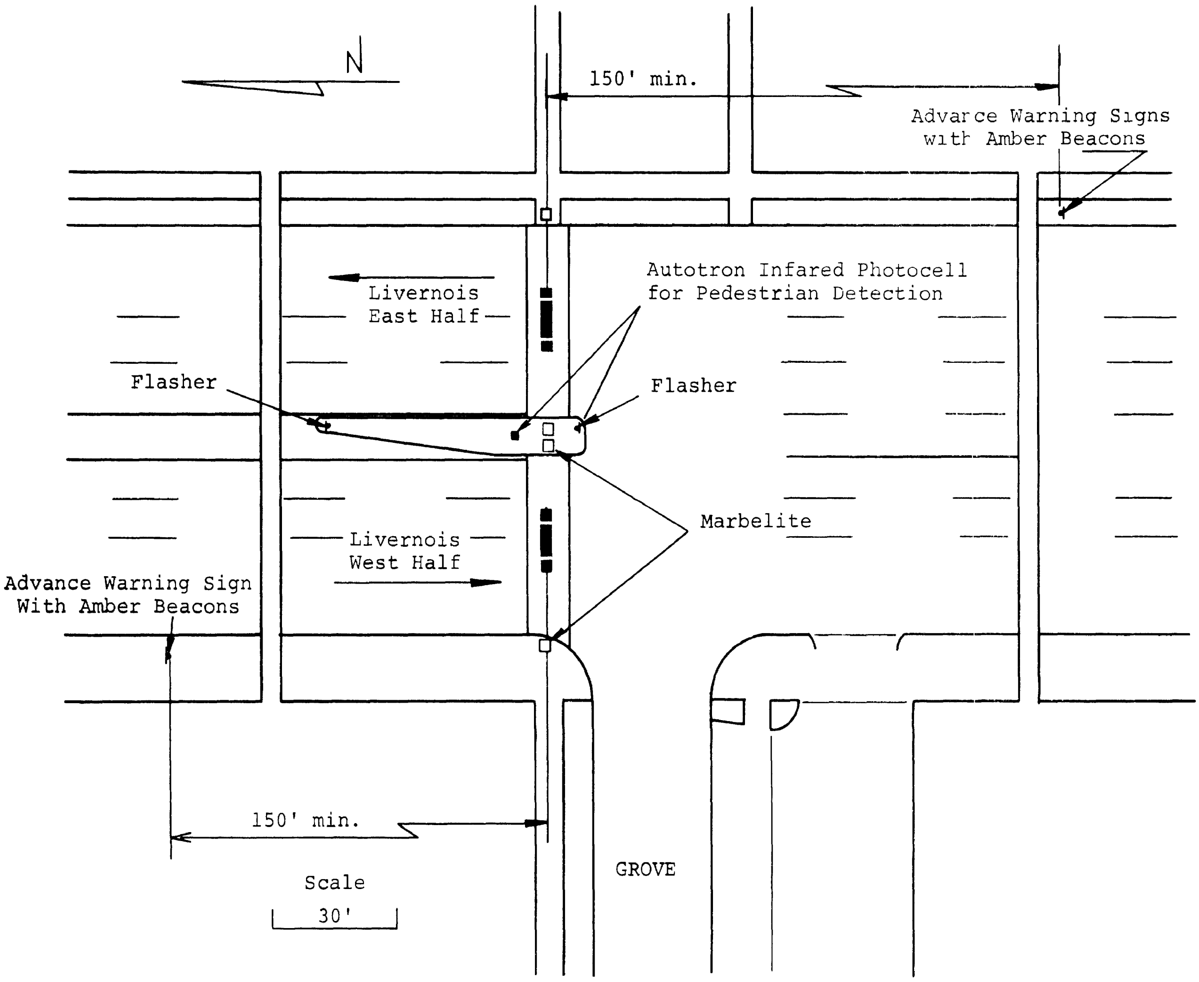


(a)

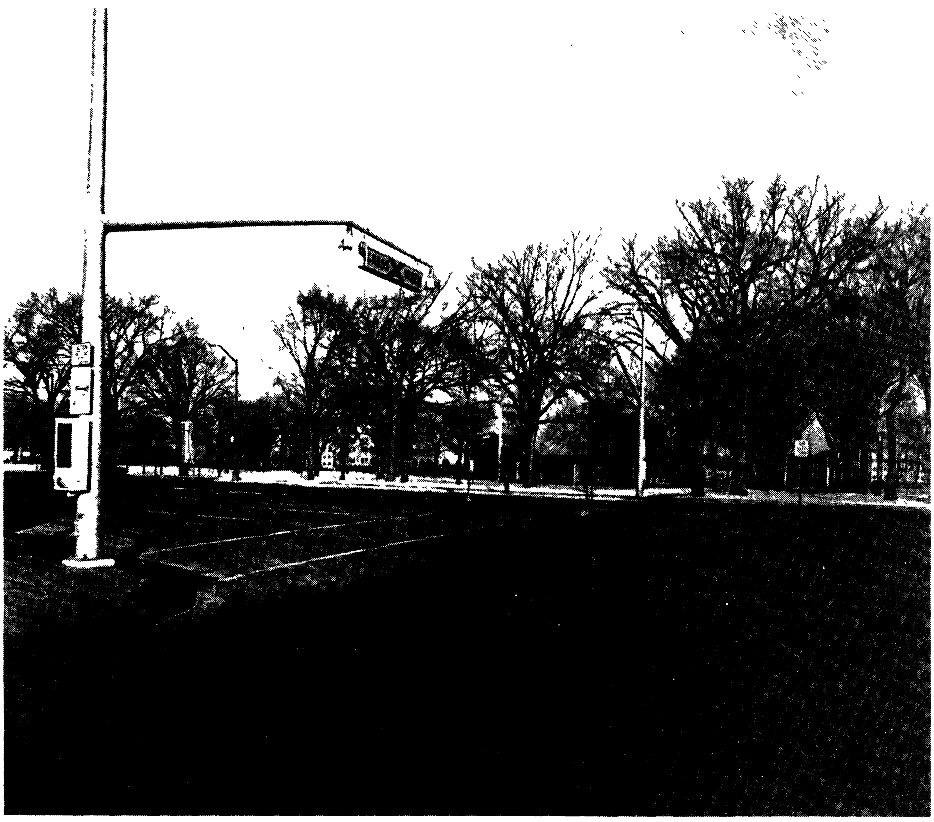
(b)
FIGURE C-1. OUTER DRIVE AND YOLANDA.
SITE NUMBER ONE.

Livernois and Grove (Figure C-2)

Site Number Two is located at the T-intersection of Livernois and Grove. The north crosswalk, which was studied, is ten feet wide, and is divided by a small concrete island located in the center lane of Livernois. The crosswalk is used almost exclusively by college students who attend the University of Detroit, as the U of D campus is located east of Livernois, and a variety of small stores, snack bars and the like are located on the west side of Livernois. The nearest traffic signals are located approximately 860 feet north at McNichols and 890 feet south at Florence. Equipment installation at this site included two crosswalk fixtures with amber beacons, two advance warning signs, two combination push button detectors and one lighted push-button detector.



(a)

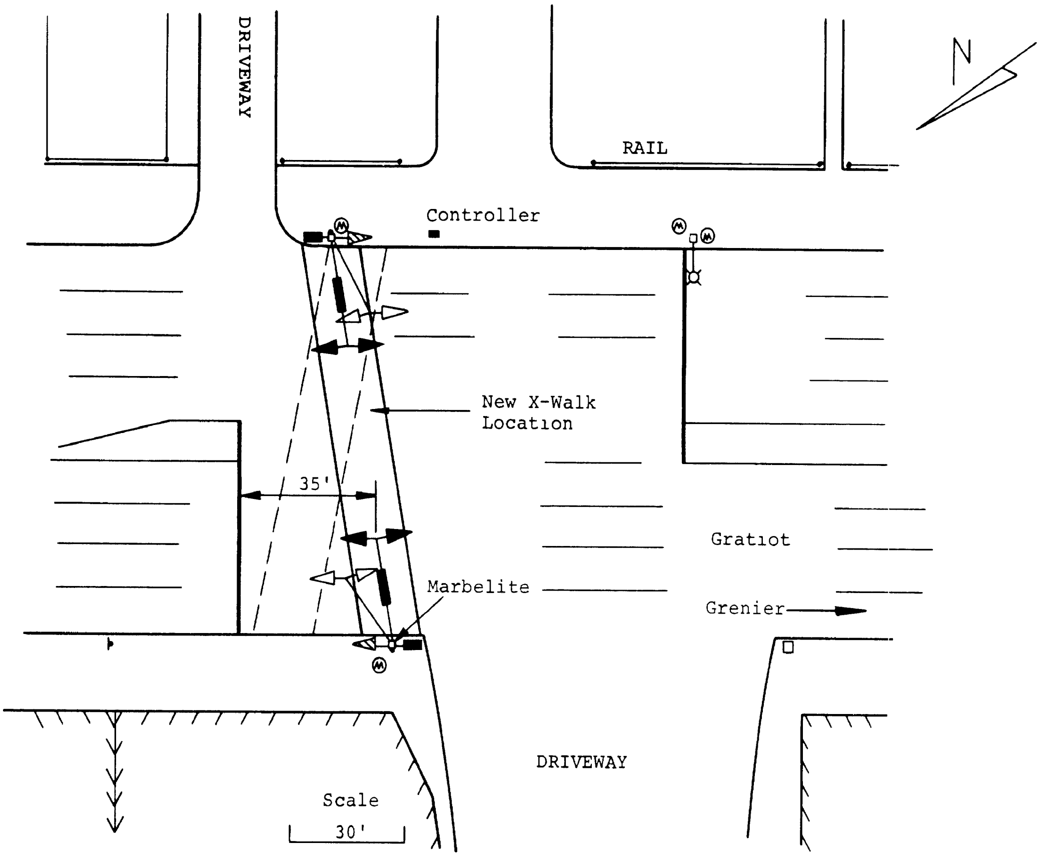


(b)

FIGURE C-2. LIVERNOIS AND GROVE
SITE NUMBER TWO.

Gratiot and Greiner (Figure C-3)

Site Number Three is a signalized pedestrian-actuated, mid-block crossing located on Gratiot between Greiner and Maple Ridge. Originally, the 15-foot wide crosswalk was at an oblique angle, southeast to southwest. This made use of the pedestrian-actuation button difficult as the button was mounted nearly 30 feet from the crosswalk. Consequently, the crosswalk was relocated east to west to situate it directly at the pedestrian-actuation button. This crosswalk has been designated as a school crossing. Assumption Catholic Church and school are located along the east side of Gratiot, while a funeral home, a bar, a bank and assorted small stores are located on the west side of Gratiot. The crosswalk is used primarily by school children, the elderly, as well as by shoppers who frequent the stores along the west side of Gratiot. The nearest traffic signals are located 2,800 feet north of the crosswalk at Seven Mile Road and 540 feet south at McNichols. Equipment installation at this site included two crosswalk fixtures and two lighted push-button detectors.

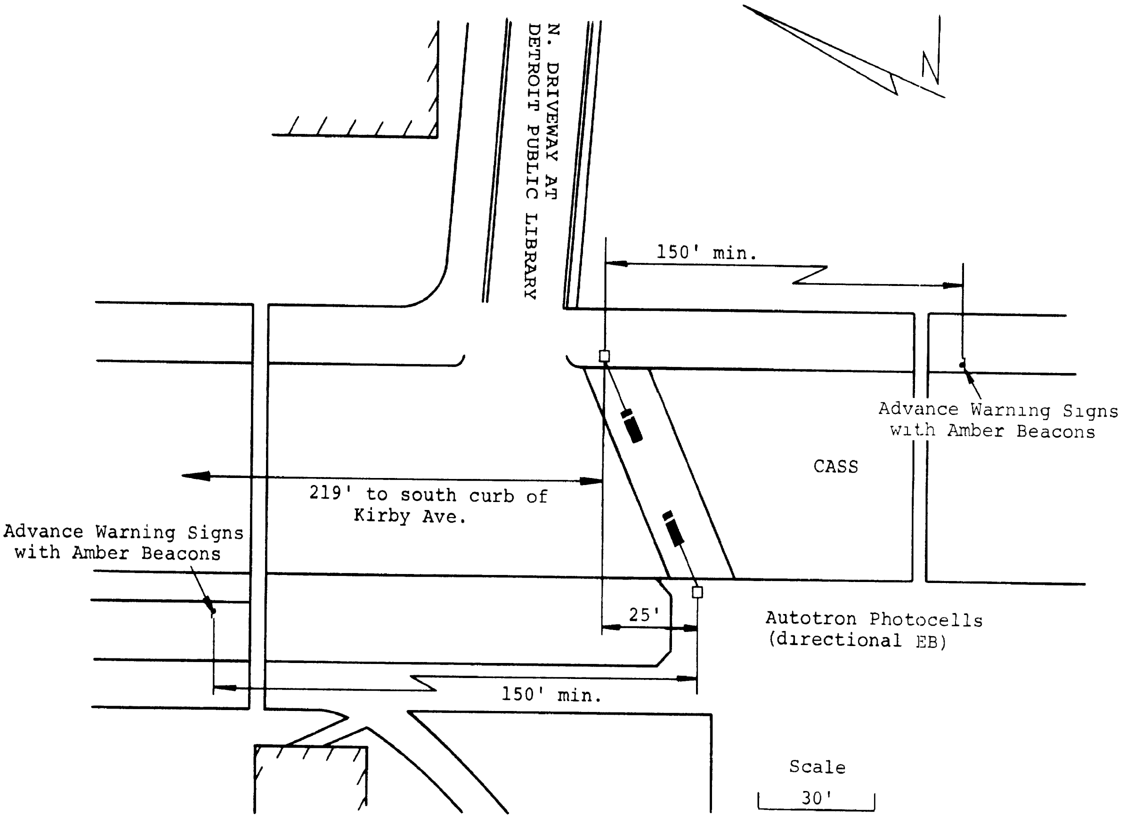


(a)

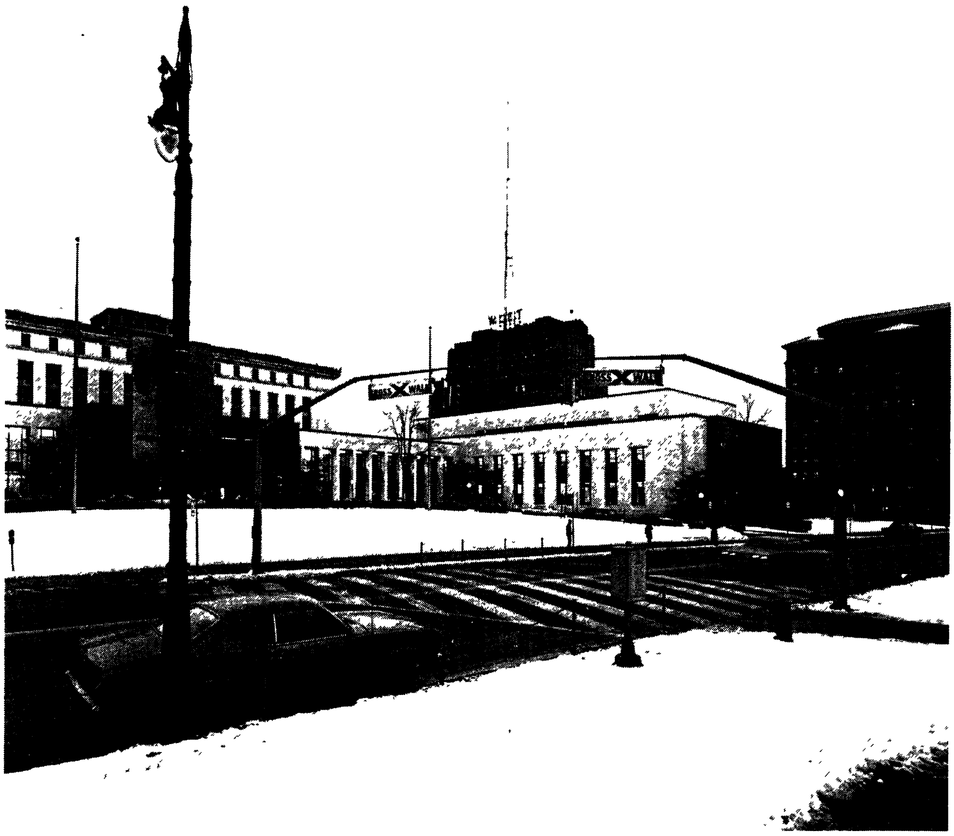
(b)
FIGURE C-3. GRATIOT AND GRENIER.
SITE NUMBER FOUR.

Cass and Kirby (Figure C-4)

Site Number Six is located on Cass approximately 260 feet south of Kirby. The crosswalk studied is 40 feet wide, crosses Cass at an oblique angle, and is painted with "zebra" or perpendicular stripes to make it distinctive. This crosswalk is located in the "heart" of the Wayne State University area with the campus situated along the west side of Cass and the Detroit Public Library located along the east side, thus it is the most heavily traveled of any crosswalk in the pedestrian project and is used almost exclusively by Wayne State students and faculty. The nearest traffic signals are located approximately 1,240 feet north at Palmer and 520 feet south at Putnam. Equipment installation included a pedestrian-actuated traffic signal, two crosswalk fixtures, one combination push-button detector, one lighted detector, and pedestrian chain.



(a)

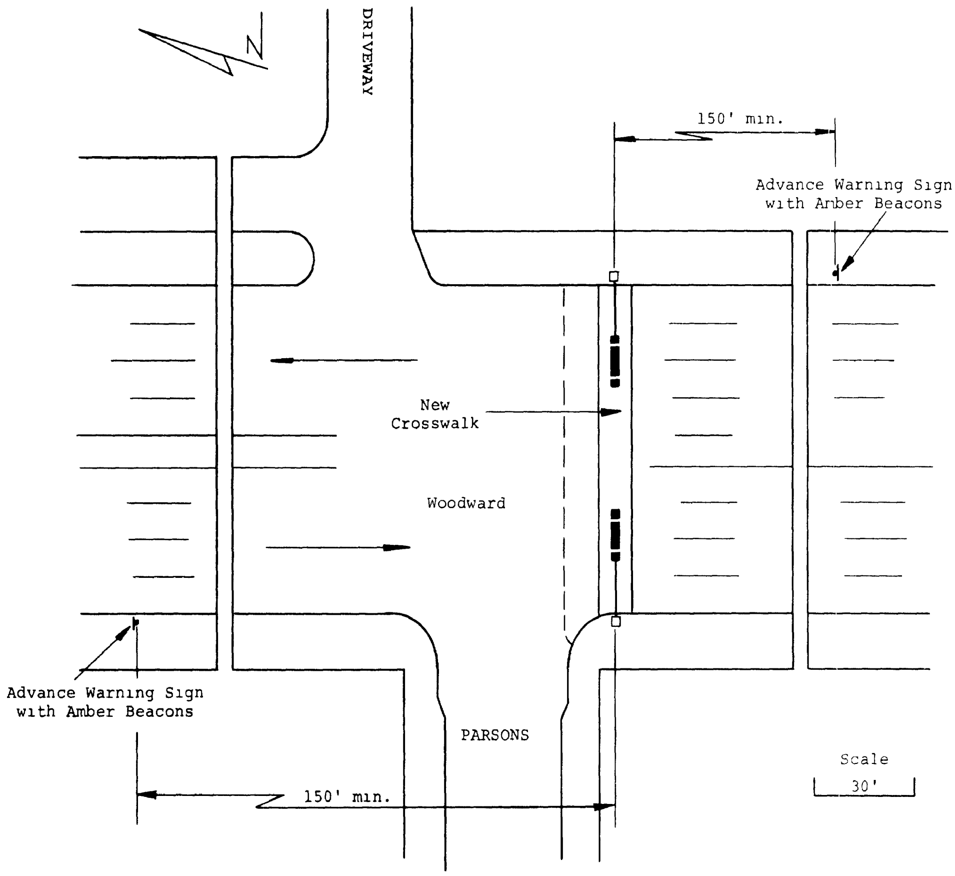


(b)

FIGURE C-4. CASS AND KIRBY.
SITE NUMBER SIX.

Woodward and Parsons (Figure C-5)

Site Number Five is located at the T-intersection of Parsons and Woodward. The crosswalk under consideration is ten feet wide and is located south of the intersection. The Detroit Bank and Trust building is located in the Professional Plaza northeast of the intersection, while the proposed expansion of the Professional Plaza will be located southeast of the intersection. This area is presently vacant. An unused three-story building is located northwest of Parsons, while a two-store Winkelman's building is located southwest of Parsons. The crosswalk is used primarily by those individuals who conduct business at the Detroit Bank and Trust building and individuals from the Medical Center area who cross in order to catch Woodward buses headed north and southbound. The closest traffic signals are located approximately 870 feet north at Alexandrine and 410 feet south at Mack and Myrtal. Equipment installation at this site included two crosswalk fixtures with amber beacons and spotlights, two advance warning signs, and two combination push-button detectors.



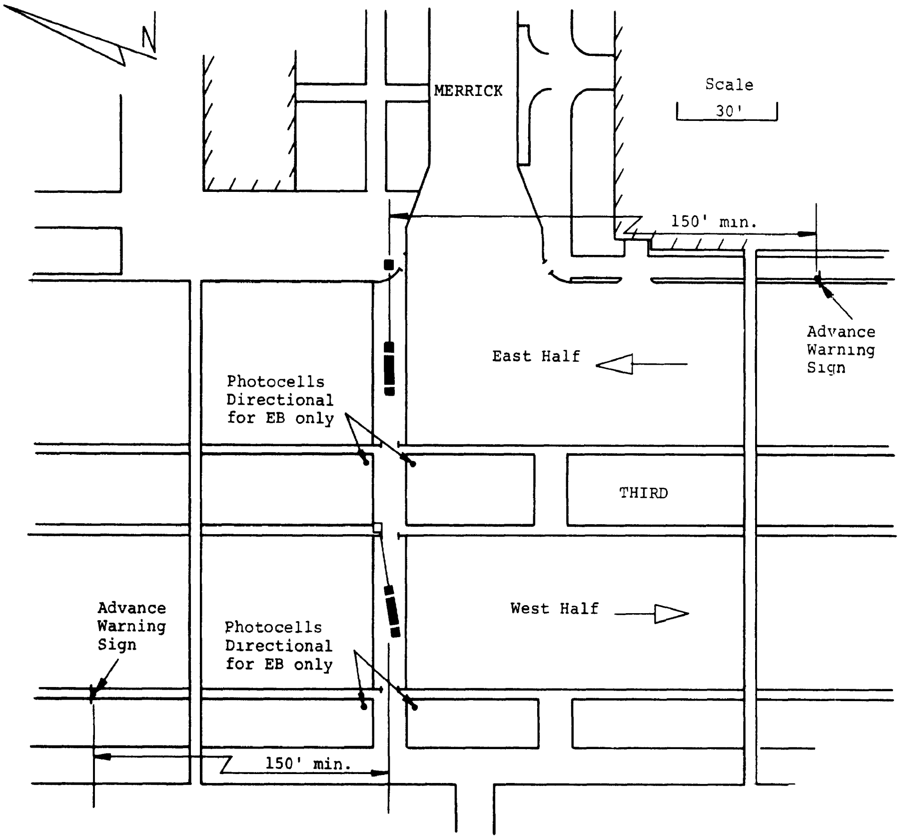
(a)

(b)

FIGURE C-5. WOODWARD AND PARSONS.
SITE NUMBER FIVE

Merrick and Third (Figure C-6)

Site Number Seven is located at the T-intersection of Third Avenue (also known as Anthony Wayne Boulevard) and Merrick. The north crosswalk was studied. It is ten feet wide, and divided by a 24-foot wide center island. It is used almost exclusively by Wayne State University students who use the parking lots and by those headed for the athletic center west of the Lodge Freeway. Various college department buildings are located east of the intersection, while Wayne State parking lots are located along the west side of Third. Traffic signals are located approximately 500 feet north of the intersection at Kirby and 880 feet south at Warren. Equipment installation at this site included two crosswalk fixtures with amber beacons, two internally-illuminated plastic posts, one advance warning sign, four combination push-button detectors and pedestrian chain. In addition to the above, an automatic pedestrian detector was installed. However, it was impossible to test this piece of equipment due to vandalism.

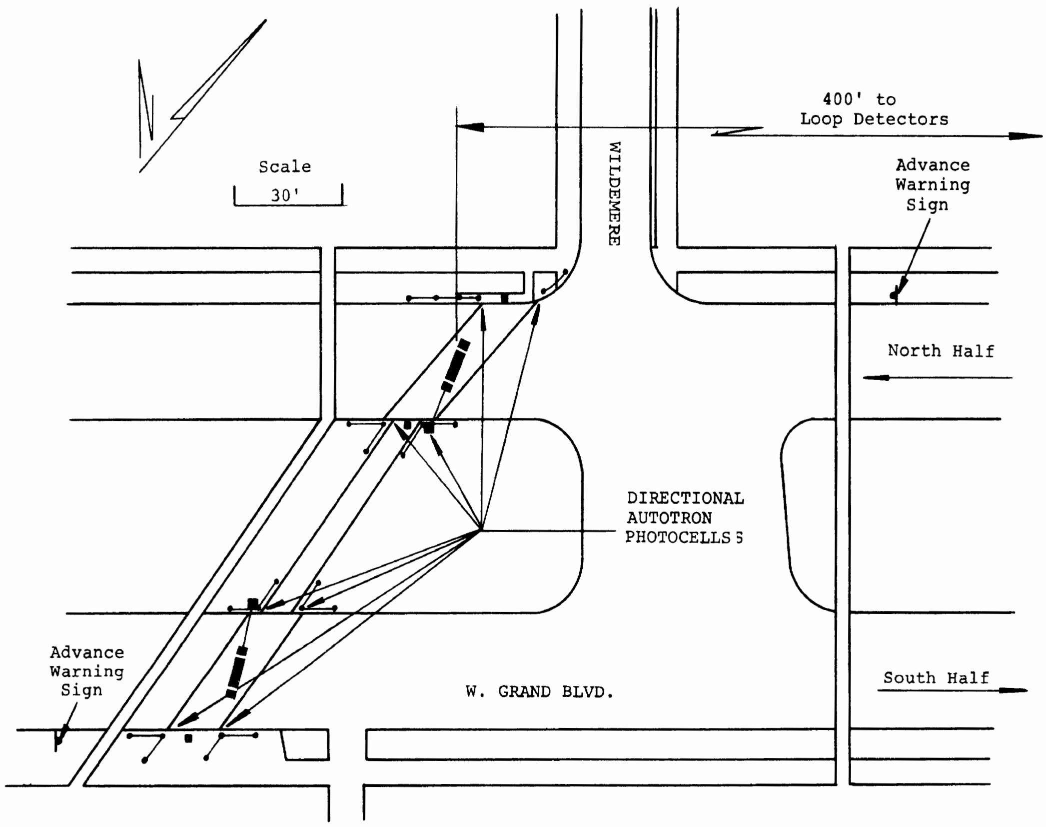


(a)

(b)
FIGURE C-6. MERRICK AND THIRD
SITE NUMBER SEVEN

West Grand Boulevard and Wildemere (Figure C-7)

Site Number Nine is located at the T-intersection of Wildemere and West Grand Boulevard. The 11-foot wide crosswalk, located west of the intersection in the northeast to southwest direction, is divided by a 50-foot boulevard, and is used primarily by Northwestern High School students and persons seeking to catch DSR buses on the boulevard. Northwestern High School and Northwestern field are located south of the intersection, while private residences and a motel are located north of the intersection. Considering the westbound traffic flow, the signals nearest the crosswalk are located approximately 870 feet east at Lawton and 930 feet west at Dexter. In the eastbound flow direction, signals are located approximately 930 feet east at Lawton and 870 feet west at Dexter. Equipment installed at this site included a vehicle presence detector on the westbound approach approximately 400 feet from the crosswalk, two crosswalk fixtures with amber beacons, two combination push-button detectors, two lighted push-button detectors and pedestrian chain.



(a)

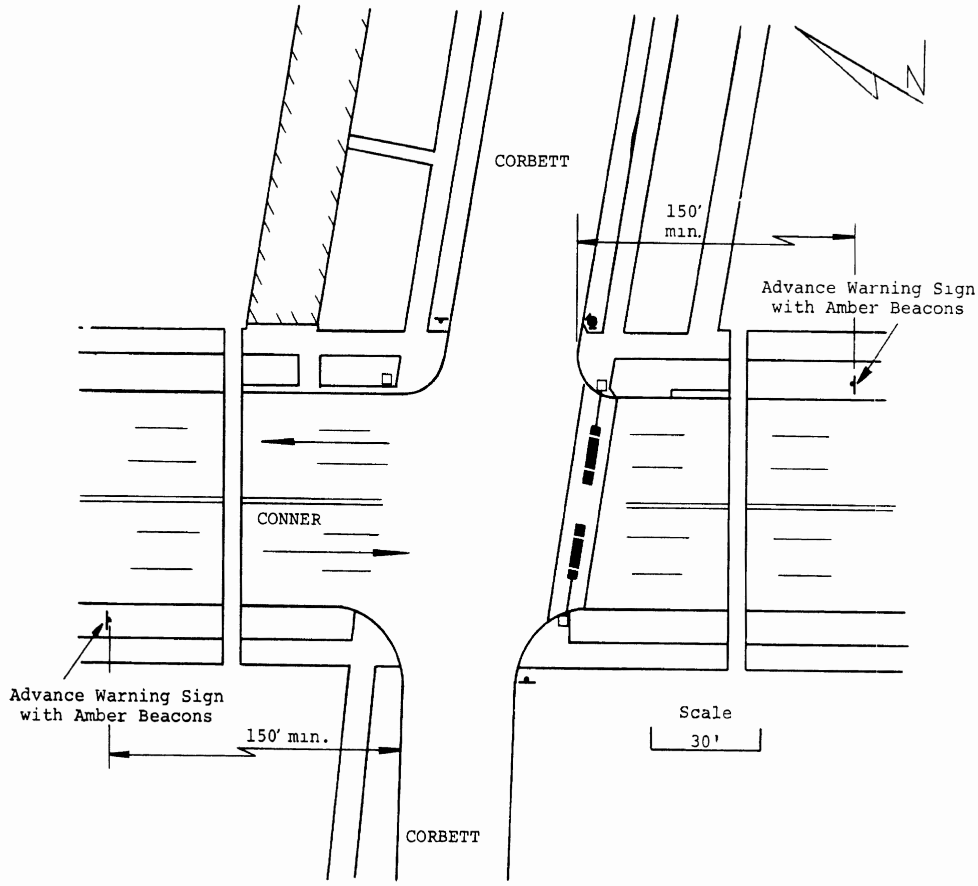
(b)

(c)

FIGURE C-7. WEST GRAND BOULEVARD AND WILDEMERE.
SITE NUMBER NINE.

Conner and Corbett (Figure C-8)

Site Number Twelve is located at the intersection of Conner and Corbett. Conner Parkway is the west leg of this intersection with a factory located one block further west. Various small shops and a bar are located northeast of the intersection. The south crosswalk which is under study is ten feet wide and is used principally by factory workers and elderly neighborhood residents who live east of the intersection. The closest traffic signals are located approximately 2,070 feet north at Gratiot and 1,500 feet south at Harper. Equipment installation included two crosswalk fixtures with amber beacons and spotlights, two advance warning signs and two combination push-button detectors.

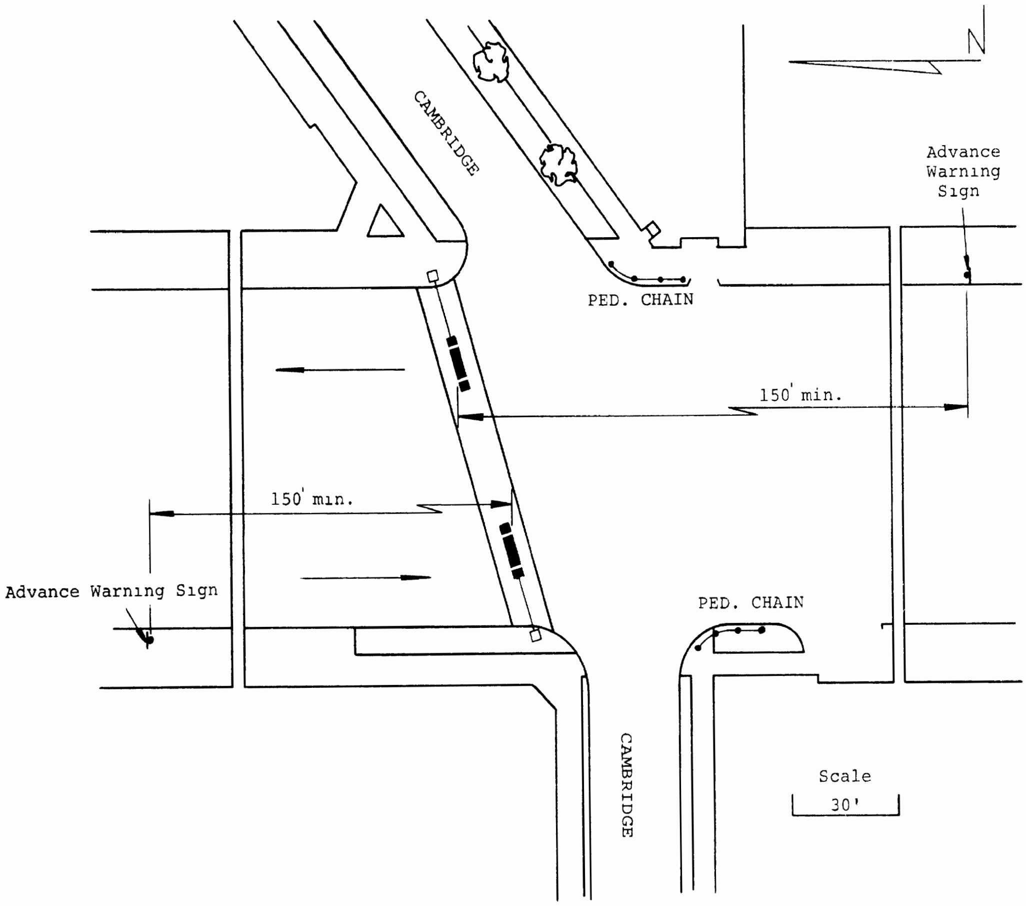


(a)

(b)
FIGURE C-8. CONNER AND CORBETT.
SITE NUMBER TWELVE.

Livernois and Cambridge (Figure C-9)

Site Number Thirteen is located at Cambridge and Livernois. Cambridge is at a 40° northeast to southwest angle east of Livernois and is perpendicular west of the intersection. Various small apparel shops line both sides of Livernois with a Michigan Bank branch and parking lot located southwest of the intersection and a parking lot located southeast of the intersection. The vast majority of pedestrians in this area are women shoppers. The ten-foot wide crosswalk is located north of the intersection at an angle of 20° north of east. This crosswalk location is almost midway between the existing traffic signals in the area that are located approximately 610 feet north at Outer Drive and 600 feet south at Seven Mile Road. Equipment installed at this site included two crosswalk fixtures with amber beacons, two combination push-button detectors and one advance warning sign.



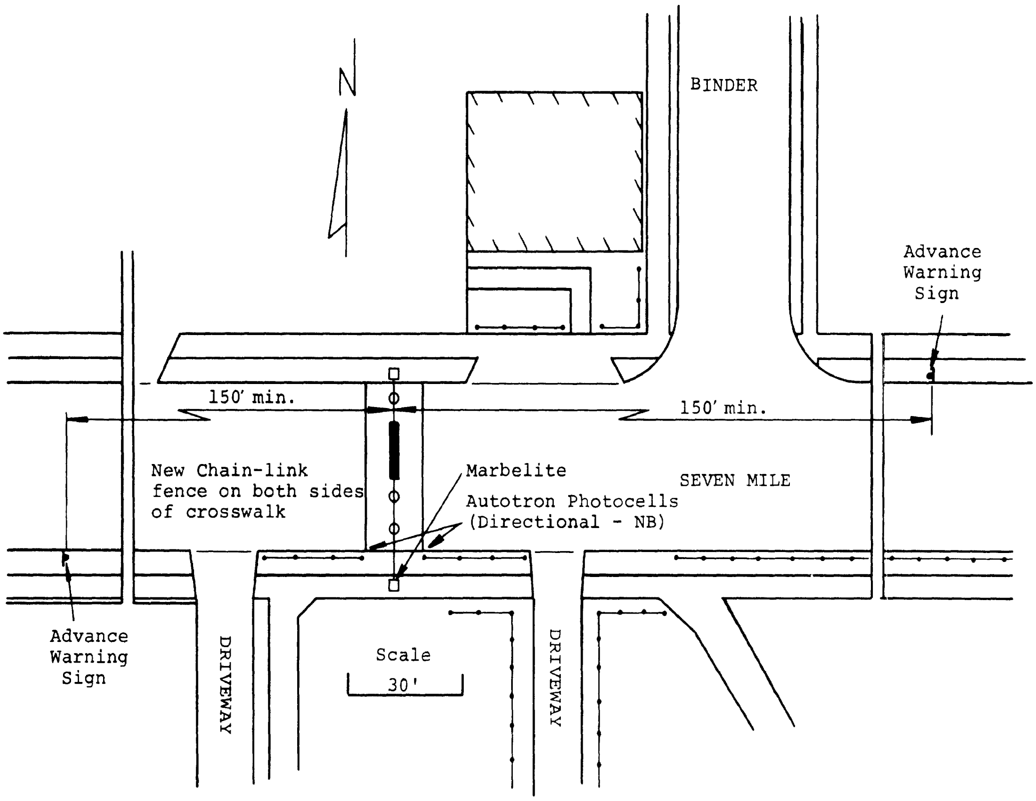
(a)

(b)

FIGURE C-9. LIVERNOIS AND CAMBRIDGE.

Seven Mile Road and Binder (Figure C-10)

Site Number Fourteen is located in the Seven Mile Road and Binder area. Pershing High School is located south of Seven Mile Road, while small snack bars, a tool and die company, a Standard Oil gas station and various vacant lots line the north side of Seven Mile Road. The ten-foot wide crosswalk is located approximately 100 feet west of the intersection and is used primarily by Pershing High School students, with some light use by local residents. The nearest traffic signals are located approximately 370 feet east at Ryan and 2,470 feet west at Conant. Equipment installed at this site included one crosswalk fixture with amber beacons and spotlights, one lighted push-button detector, and one combination push-button detector.



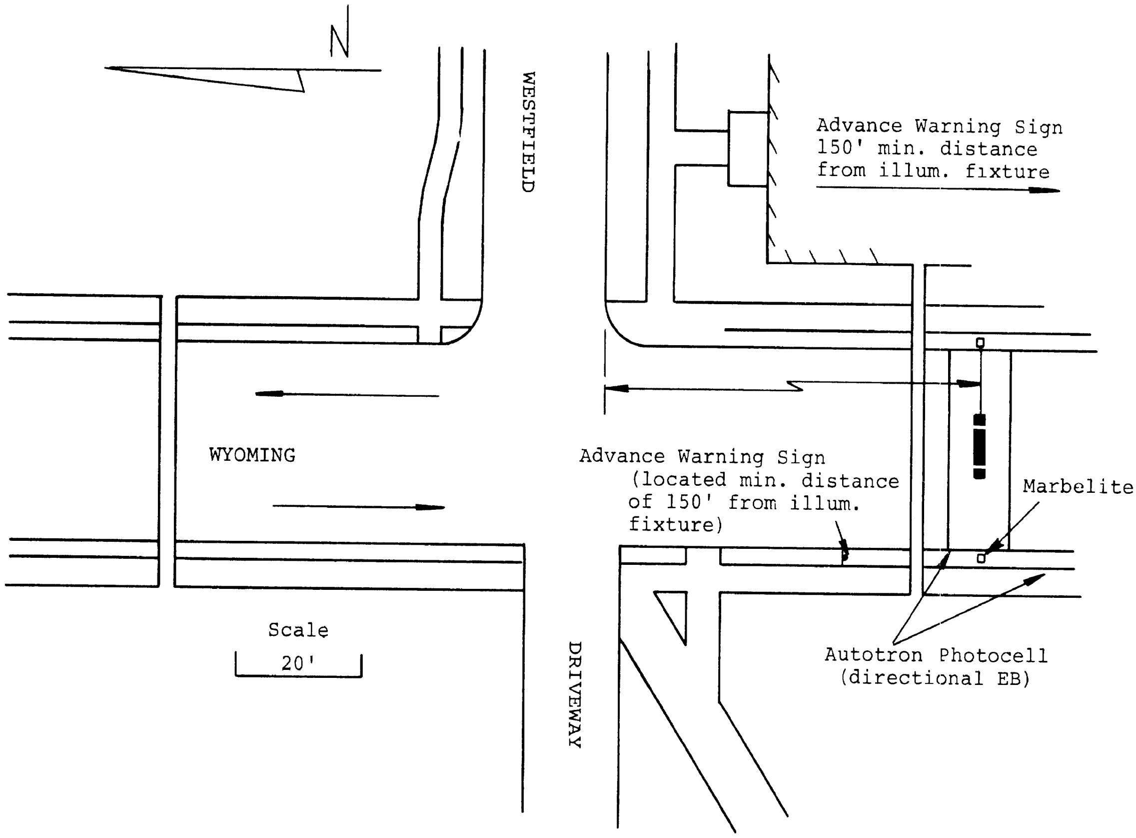
(a)

(b)

FIGURE C-10. SEVEN MILE AND BINDER.
SITE NUMBER FOURTEEN.

Wyoming and Westfield (Figure C-11)

Site Number Fifteen is a mid-block location on Wyoming between Westfield and Westpoint. The 15-foot wide crosswalk is located approximately 240 feet south of Westfield and is placed directly between the two major sidewalks leading to Mackenzie High School. The school and its field are located along the west side of Wyoming. Private residences, a funeral home, a vacant lot, two halls, an industrial plating company and a barbeque store line the east side of Wyoming in the vicinity of the crosswalk. The crosswalk is utilized almost exclusively by Mackenzie High School students with some slight use by local residents. Traffic signals are located approximately 1,020 feet north at West Chicago and 620 feet south at Oakman. Equipment installed at this site included one crosswalk fixture with amber beacons, one lighted push-button detector, one combination push-button detector and pedestrian chain.



(a)

(b)

FIGURE C-11. WYOMING AND WESTFIELD.
SITE NUMBER FIFTEEN.

Chicago and Sorrento (Figure C-12)

Site Number Sixteen is at one of the two vehicle-actuated signal locations in the City of Detroit. It is located at the intersection of West Chicago and Sorrento. A hospital and clinic are located at the southeast and northwest corners, while small stores are located northeast and southwest of the intersection. The ten-foot wide crosswalks east and west of the intersection were studied. Although the crosswalks are used by a general cross-section of the community, there are many more elderly persons than might ordinarily be expected because of the close proximity of the hospital and clinic to the crosswalks. The nearest traffic signals are located approximately 970 feet east at Meyers and 1,630 feet west at Schaefer Highway. Equipment installed at this site included two combination push-button detectors and two lighted push-button detectors.

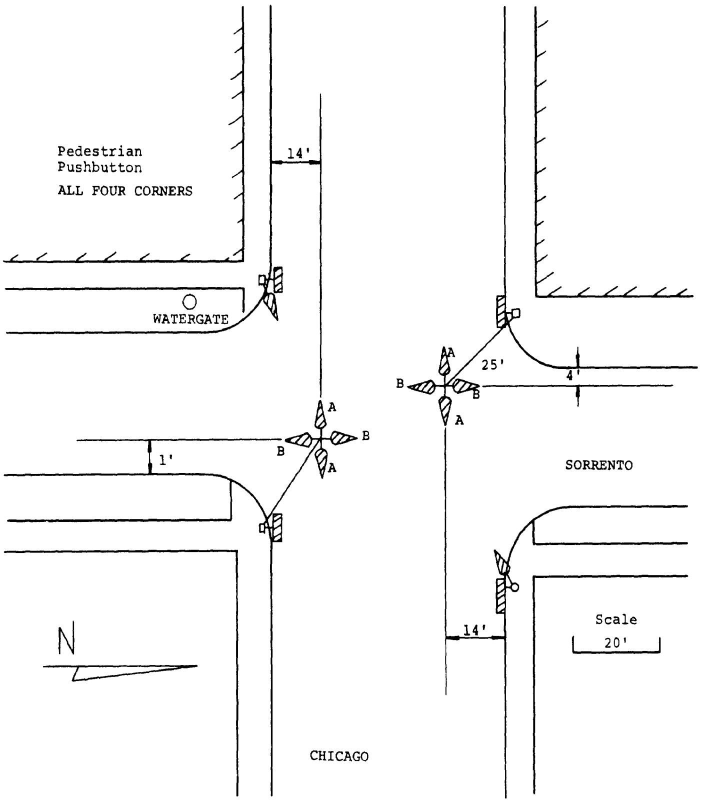


FIGURE C-12. CHICAGO AND SORRENTO
SITE NUMBER SIXTEEN.

Seven Mile Road and Annott (Figure C-13)

Site Number Seventeen is the other vehicle-actuated signal location in the City of Detroit. It is located at the T-intersection of Annott and Seven Mile Road. Osborn High School is located south of Seven Mile Road, while various small stores are located along the north side. The 15-foot wide crosswalk which was studied is used almost exclusively by Osborn students with some use by neighborhood residents. The nearest traffic signals are located 1,040 feet east at Strasburg and 640 feet west at Hoover. Equipment installed included one lighted push-button detector and one combination push-button detector.

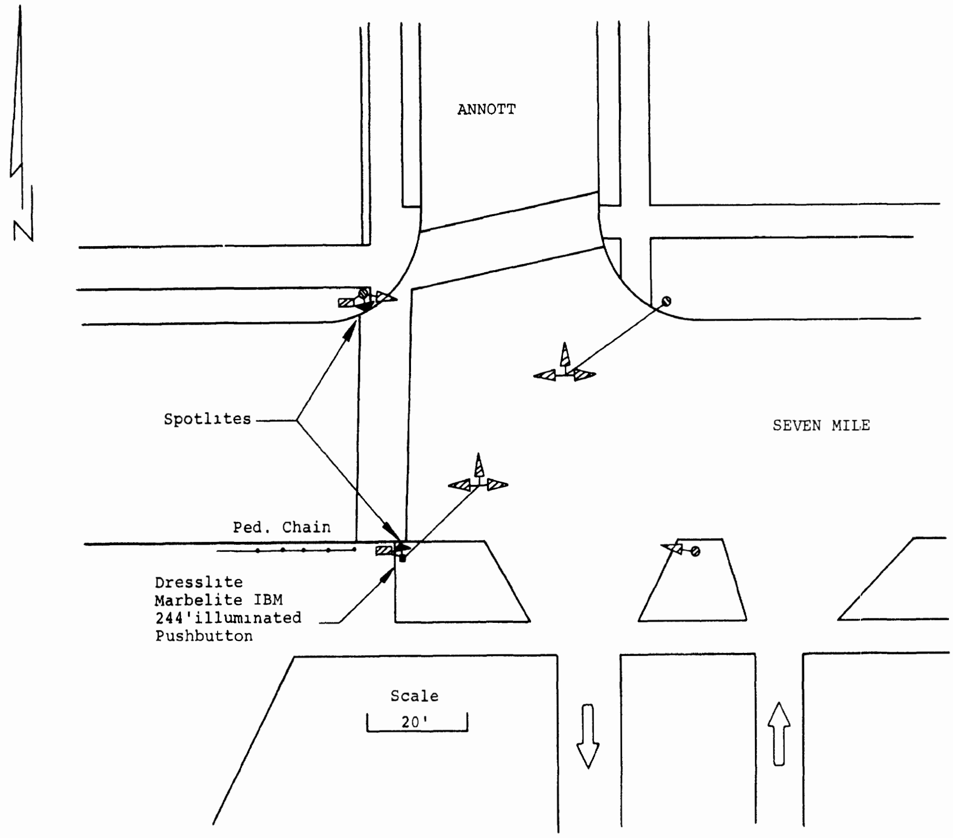


FIGURE C-13. SEVEN MILE ROAD AND ANNOTT.
SITE NUMBER SEVENTEEN.

APPENDIX D

ESTIMATION OF SAMPLE SIZES FOR THE "AFTER" STUDIES

The sample sizes for the "intermediate" studies were based on the statistical parameters of the traffic characteristics observed in the "before" studies. The Central Limit Theorem was used to estimate a sample size N with the property that, for a binomial case, if a sample size N or larger is taken, the probability will be at least 0.95 that the average sample proportion $\bar{x}$ will differ from the true proportion (p) by less than 0.1. We wish to have:

$$\Pr\{|\bar{x} - p| < 0.1\} \geq 0.95$$

$$\Pr\{-0.1 < \bar{x} - p < 0.1\} \geq 0.95$$

Now $\quad E(\bar{x}) = p, \; \sqrt{V(\bar{x})} = \sigma_{\bar{x}} = \sqrt{\frac{pq}{n}} \quad$ where

$q = 1-p$, and n = sample size, and $\sigma_{\bar{x}}$ is the standard deviation of the sample mean. On dividing both sides of the above inequality by $\sigma_{\bar{x}}$ we obtain

$$\Pr\{-0.1 \; \frac{n}{pq} < \frac{\bar{x}-p}{\sigma_{\bar{x}}} < 0.1 \; \frac{n}{pq} \geq 0.95$$

According to DeMoivre's Theorem, the probability on the left is given approximately for large n by

$$\frac{1}{\sqrt{2\pi}} \int_{-0.1\sqrt{n/pq}}^{0.1\sqrt{n/pq}} \ell^{-z^2/2} dz$$

We find from normal distribution tables that this will be at least 0.95 if

$$0.1 \sqrt{n/pq} \geq 1.96$$

or if

$$n \geq (19.6)^2 \, pq$$

Since $pq = p(1-p) \leq 1/4$ for all p between 0 and 1, n will be at least $(19.6)^2 \, pq$, no matter what p may be, if

$$n \geq (19.6)^2 (1/4) \doteq 96$$

APPENDIX E

THE PUBLIC EDUCATION PROGRAM*

The Traffic Safety Association designed, wrote, laid-out, prepared and had printed the following for the City of Detroit Pedestrian Safety Demonstration Projects:

A total of 65,000 explanatory leaflets (Plates 2-1, 2-2, and 4-1)

200 posters on cardboard stock.

20 permanent metal posters.

The Association arranged for the distribution of the leaflets and posters in the following way: The appropriate number of leaflets were distributed to 18 public and parochial elementary schools, two high schools and two universities which were adjacent to one of the pedestrian safety project installations.

The two universities were Wayne State University and the University of Detroit. The two high schools were Pershing High School and Mackenzie High School. The elementary schools were: Our Lady Queen of Heaven, Law School, Hally School, Gesu, Fleming School, Assumption Grotto, Goodale School, St. Ignatius, Pasteur School, Atkinson School, Mason School, Corpus Christi-Holy Ghost, Barton, Ephiphany, Parker School, McFarlane School, Pulaski School and St. Raymond.

The children in the elementary schools were instructed by their teachers to take the leaflet home to their parents.

In addition, the total of 200 posters were placed in business locations which were near the project installations.

Leaflets also were distributed to Detroit police officers and to high school driver education classes.

Field investigators of the Detroit Department of Streets and Traffic also distributed a total of 10,000 leaflets at the installation corners. The Department of Streets and Traffic also erected the 20 metal posters at the project installations.

All material that was prepared was distributed. The distribution was done through the Traffic Safety Association with the assistance of the Detroit Police Traffic Safety Bureau, Detroit public and parochial schools and officials at Wayne State University and the University of Detroit.

A publicity program announcing the inauguration of the study site installations was carried out. A news release was sent to all major Detroit area newspapers and given to radio and television stations. One daily newspaper carried a comprehensive story and picture. Two television stations carried the opening of the

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*Prepared by the Traffic Safety Association of Detroit.

installation at Merrick and Third. A number of radio stations broadcast news accounts of the opening.

The Detroit Police Department Television Center also prepared a five-minute video-tape program for viewing by all Detroit Police uniformed personnel. The taped program carried an explanation by the Detroit Police Department Director of Traffic William H. Polkinghorn on the action policy police should follow at these installations. Briefly, the policy was that there was to be no special or additional enforcement at the installations, but educational warning stops were directed as needed. The purpose of the tape program was primarily to apprise police of the installations and the way they operated.

APPENDIX F

SCHEDULE OF FIELD WORK

TABLE F-1

SCHEDULE OF FIELD WORK

WORK	PERIOD
"Before" Studies	Spring 1969
"Intermediate" Studies	October 1969-December 1969
Installation of Information Systems	1969 - 1970
Expert Panel Evaluation Study	December 1970
"After" Studies	Fall 1970

APPENDIX G

EXPERT PANEL MEMBERS

TABLE G-1

EXPERT PANEL MEMBERS

Lieutenant John Logan
Traffic Safety Bureau
Detroit Police Department
Number 7 Precinct
Detroit, Michigan

Mr. Donald Orne
Michigan Department of State Highways
Traffic and Safety
1st Floor, State Highways Building
Drawer K
Lansing, Michigan 48296

Mr. Gene Clinton
Wayne County Road Commission
726 City-County Building
Detroit, Michigan

Mr. Bruce Grubb
Director of Field Operations
Traffic Safety Association of Detroit
1902 Buhl Building
Detroit, Michigan 48226

Mr. H.D. Harter
Superintendent of Safety Education
Detroit Public Schools
8721 John C. Lodge Freeway
Detroit, Michigan 48202

Dr. Herbert Bauer
General Motors Research Laboratories
Mound Road at 12 Mile Road
Warren, Michigan

APPENDIX H

SAMPLE "EXPERT PANEL" QUESTIONNAIRE

HIGHWAY SAFETY RESEARCH INSTITUTE
THE UNIVERSITY OF MICHIGAN

Pedestrian Crosswalk Safety Studies

C - Panel Evaluation Study
Field Sheet No. C-1

Name...............Title..............Agency.................

Guide Lines for Evaluation of the Detection and Information System at Site....#12...Connor.and.Corbett...Day.Study..........

---

1. Inspect the site and the innovative pedestrian devices installed there.

2. Study the Information Sheet and site sketch on the following pages. The Project staff will be pleased to answer any questions you may have.

3. The sequence in which you will see and evaluate the various items (information device and/or mode of operation) at this site is indicated below:

SEQUENCE	DEVICE OR MODE EVALUATED
1	Pedestrian Information and Warning Signs
2	Combination Push Button Detector
3	Pedestrian Actuated Advance Warning Sign
4	Pedestrian Actuated Flashing Amber Beacons
5	Joint effect of the pedestrian actuated Amber Becons and Advance Warning Sign

4. Answer the questions in the attached set.

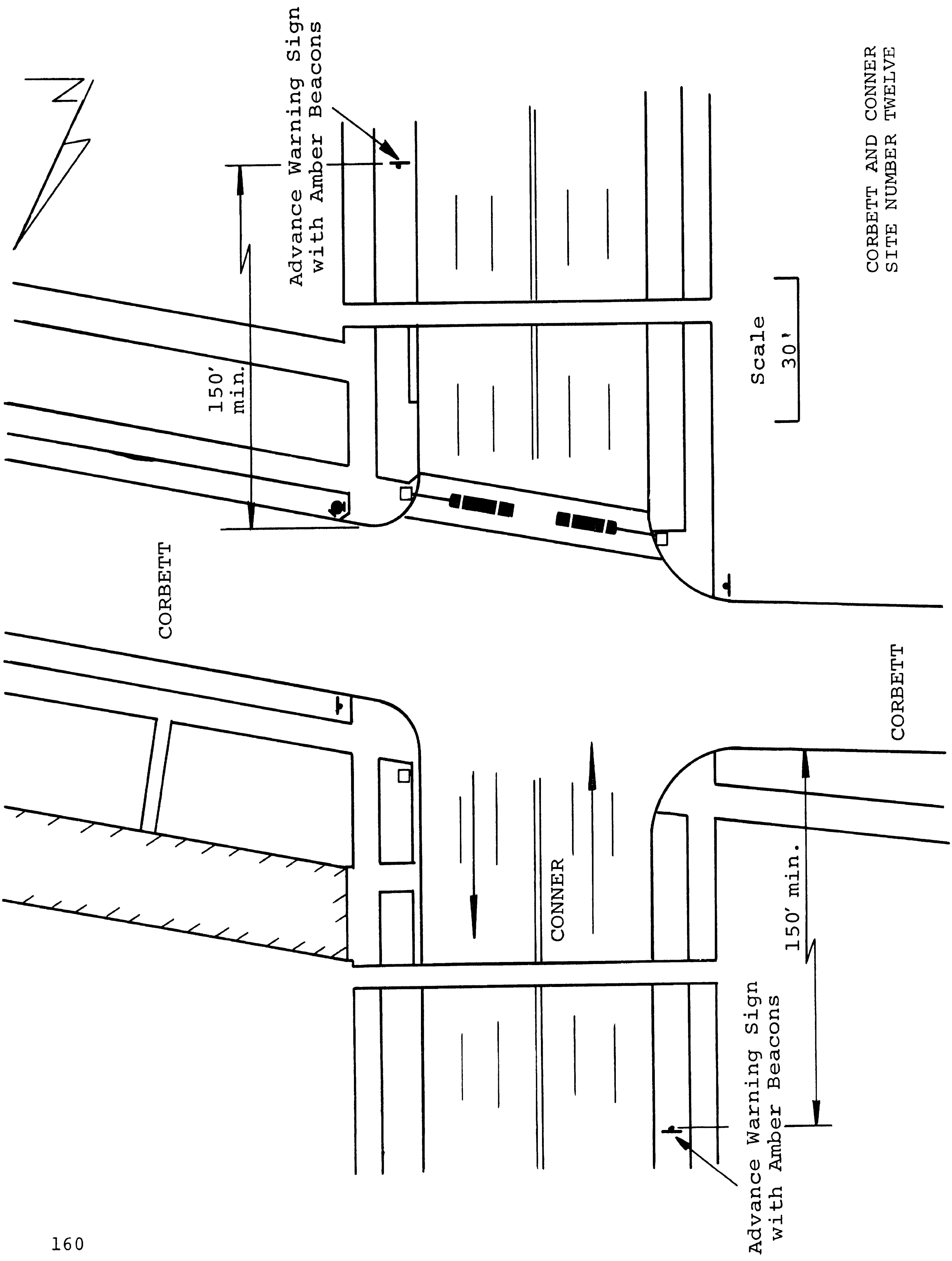
HIGHWAY SAFETY RESEARCH INSTITUTE
THE UNIVERSITY OF MICHIGAN

Pedestrian Crosswalk Safety Studies

C - Panel Evaluation Study
Field Sheet No. C-2

INFORMATION SHEET ON Conner and Corbett SITE #12

Environmental and Geometric Features	The 10-foot wide crosswalk is located south of the intersection and is used principally by workers from the factory located one block further west and elderly neighborhood residents who live east of the intersection. The closest traffic signals are located approximately 2070 feet north at Gratiot and 1500 feet south at Harper.
Vehicular Flow Characteristics Before Installation of New Devices	<table><tr><td></td><td>Passenger Cars</td><td>Trucks & Buses</td></tr><tr><td>Through</td><td>642</td><td>83</td></tr><tr><td>Right Turning</td><td>28</td><td>1</td></tr><tr><td>Left Turning</td><td>19</td><td>8</td></tr></table> 85th Percentile Spot Speed=37.16 mph 100th Percentile Spot Speed=44 mph
Pedestrian Flow Characteristics Before Installation of New Devices	Highest Hourly Pedestrian Flow: 28 <table><tr><td></td><td>85th Percentile</td><td>100th Percentile</td></tr><tr><td>Pedestrian Crossing Time (in seconds)</td><td>12</td><td>30</td></tr><tr><td>Pedestrian Waiting Time (in seconds)</td><td>14</td><td>21.5</td></tr></table>
Traffic Control and Safety Measures Before Installation of New Devices	None
Current Traffic Control, Safety Measures and Information Systems	2 Crosswalk Fixtures Spot Lights 2 Combination Push Button Detectors 1 Photo Cell Detector (Non-directional) 4 Amber Beacons 2 Advance Warning Signs TIME PARAMETERS <table><tr><td>Phases</td><td>Time in Secs.</td></tr><tr><td>Initial Interval</td><td>15</td></tr><tr><td>Clearance Interval</td><td>15</td></tr></table>


Advance Warning Sign
with Amber Beacons
150′
min.
CORBETT
Scale
30'
CORBETT AND CONNER
SITE NUMBER TWELVE
CORBETT
CONNER
150′ min.
Advance Warning Sign
with Amber Beacons

HIGHWAY SAFETY RESEARCH INSTITUTE
THE UNIVERSITY OF MICHIGAN

Pedestrian Crosswalk Safety Studies

C - Panel Evaluation Study
Field Sheet No. C-3

The following questions deal with the static Pedestrian Information and Warning Signs in the vicinity of the Combination Push Button Detector.

1. Will approaching pedestrians see the Pedestrian Information and Warning Signs? (1-12dm)

   VERY LIKELY LIKELY UNLIKELY

   Comments and Suggestions:

2. Will the pedestrians read the Information and Warning Signs? (2-12dm)

   VERY LIKELY LIKELY UNLIKELY

   Comments and Suggestions:

3. Are the legends on the Information and Warning Signs sufficiently clear, simple, and brief? (3-12dm)

   YES NO

   Comments and Suggestions:

4. Will the pedestrians understand the Information and Warning Signs? (4-12dm)

   VERY LIKELY LIKELY UNLIKELY

   Comments and Suggestions:

5. Will the Information and Warning Signs aid the pedestrian in understanding the operation of the information system? (5-12dm)

   VERY LIKELY LIKELY UNLIKELY

   Comments and Suggestions:

6. Will the Information and Warning Signs confuse or distract the pedestrians? (6-12dm)

VERY LIKELY LIKELY UNLIKELY

Comments and Suggestions:

7. Your comments on the design and placement of the Pedestrian Information and Warning Signs will be appreciated. (7-12dm)

The following questions deal with the Combination Push Button Detector.

8. Will approaching pedestrians see the Combination Push Button Detector? (8-12dG)

VERY LIKELY LIKELY UNLIKELY

Comments and Suggestions:

9. Will the pedestrians see the instructions on the Combination Push Button Detector? (9-12dG)

VERY LIKELY LIKELY UNLIKELY

Comments and Suggestions:

10. Will the pedestrians understand the instructions on the Combination Push Button Detector? (10 -12dG)

VERY LIKELY LIKELY UNLIKELY

Comments and Suggestions:

11. Will the pedestrians notice that the lighted message on the Combination Push Button Detector changes when they push the button? (11-12dG)

VERY LIKELY LIKELY UNLIKELY

Comments and Suggestions:

12. Will the pedestrians understand the meaning of the changed message on the Combination Push Button Detector? (12-12dG)

VERY LIKELY LIKELY UNLIKELY

Comments and Suggestions:

13. When the buzzer sounds, will the pedestrians still waiting understand that they should push the button again? (13-12dG)

VERY LIKELY LIKELY UNLIKELY

Comments and Suggestions:

14. Will the waiting pedestrians notice that the lighted message changes after the buzzer sounds? (14-12dG)

VERY LIKELY LIKELY UNLIKELY

Comments and Suggestions:

15. Will the pedestrians push the button again after they hear the buzzer? (15-12dG)

VERY LIKELY LIKELY UNLIKELY

Comments and Suggestions:

16. Is the interval between the pushing of the button and the buzzing: (16-12dG)

TOO LONG ABOUT RIGHT TOO SHORT

Comments and Suggestions:

17. Is the duration of the buzzing: (17-12dG)

TOO LONG ABOUT RIGHT TOO SHORT

Comments and Suggestions:

18. Is the sound of buzzing appropriate? (18-12dG)

YES NO

Comments and Suggestions:

19. If the pedestrian hears the buzzer sounding after he has begun crossing the street, he will: (Check responses you consider likely) (19-12dG)

a) Continue crossing at the same speed

b) Hurry to complete the crossing

c) Go back to the curb

d) Be confused as to what to do

Comments and Suggestions:

20. Do you believe that the Combination Push Button Detector will attract vandals? (20-12dG)

VERY LIKELY LIKELY UNLIKELY

Comments and Suggestions:

21. Will the Combination Push Button Detector withstand attempts at vandalism? (21-12dG)

YES NO

Comments and Suggestions:

22. Any other comments you wish to offer about the design, placement and operation of the Combination Push Button Detector will be appreciated. (22-12dG)

The following questions deal with the pedestrian actuated Advance Warning Sign.

23. Will the approaching drivers easily see the activated Advance Warning Sign? (23-12dC)

VERY LIKELY LIKELY UNLIKELY

Comments and Suggestions:

24. Will the Advance Warning Sign alert the approaching driver to the crosswalk and to pedestrians? (24-12dC)

VERY LIKELY LIKELY UNLIKELY

Comments and Suggestions:

25. Will the driver be distracted by the Advance Warning Sign? (25-12dC)

VERY LIKELY LIKELY UNLIKELY

Comments and Suggestions:

26. Are the design, legend and placement of the Advance Warning Sign satisfactory? (26-12dC)

YES NO

Comments and Suggestions:

27. Will the Advance Warning Sign contribute to pedestrian safety at the crosswalk? (27-12dC)

VERY LIKELY LIKELY UNLIKELY

Comments and Suggestions:

28. Will the Advance Warning Sign gain the confidence of drivers in the long run? (28-12dC)

VERY LIKELY LIKELY UNLIKELY

Comments and Suggestions:

29. Will the Advance Warning Sign attract vandals and withstand attempts at vandalism? (29-12dC)

YES NO

Comments and Suggestions:

30. Any other comments you wish to make about the Advance Warning Sign will be appreciated. (30-12dC)

The following questions deal with pedestrian actuated flashing Amber Beacons with (PLEASE ASSUME) the present Crosswalk Fixture replaced by an identical reflectorized static appropriately colored sign. This is necessary since there are no sites without a crosswalk fixture and such a sign is a logical part of the treatment of the intersection.

31. Will the flashing Amber Beacons mounted over the crosswalk be easily seen by approaching drivers? (31-12dB)

VERY LIKELY LIKELY UNLIKELY

Comments and Suggestions:

32. Will the flashing Amber Beacons alert approaching drivers to the crosswalk and the presence of the pedestrians? (32-12dB)

VERY LIKELY LIKELY UNLIKELY

Comments and Suggestions:

33. Having seen the activated information system, the driver will: (Check all possibilities you consider likely) (33-12dB)

a) Expect to see a pedestrian in the vicinity of the crosswalk

b) Feel that his driving task is made more difficult by the information displays

c) Find it easy to evaluate the meaning of the information displays

Comments and Suggestions:

34. Will the flashing Amber Beacons distract or confuse the drivers? (34-12dB)

VERY LIKELY LIKELY UNLIKELY

Comments and Suggestions:

35. Will the unlit information system hardware at this site have any effect on drivers? (35-12dB)

YES NO

Comments and Suggestions:

36. When the Amber Beacons flash will the drivers yield the right of way at the crosswalk to the pedestrians? (36-12dB)

ALWAYS USUALLY RARELY

Comments and Suggestions:

37. If the approaching driver sees the information system going off, he will: (Check all possibilities you consider likely) (37-12dB)

a) Feel confused or distracted

b) Believe that he is no longer required to be particularly concerned with pedestrian safety at the crosswalk.

Comments and Suggestions:

38. Are the size, placement and orientation of the Amber Beacons satisfactory in terms of attracting the approaching driver? (38-12dB)

YES NO

Comments and Suggestions:

39. Are the operational time parameters of the information system satisfactory? (39-12dB)

YES NO

Comments and Suggestions:

40. Will the Amber Beacons contribute to pedestrian safety at the crosswalk? (40-12dB)

VERY LIKELY LIKELY UNLIKELY

Comments and Suggestions:

41. Will the Amber Beacons gain the confidence of the drivers in the long run? (41-12dB)

VERY LIKELY LIKELY UNLIKELY

Comments and Suggestions:

42. Are the pedestrian actuated flashing Amber Beacons a satisfactory mode of operation at this site? (42-12dB)

YES NO

Comments and Suggestions:

43. Assign a numerical score on a scale of 1 (poor) to 5 (excellent) to this mode of operation. (43-12dB)

44. Any other comments you wish to make about the Amber Beacons (dynamic) as an information device and as a mode of operation of the information system at this site will be appreciated. (44-12dB)

INDICATE TO THE PRINCIPAL INVESTIGATOR THAT YOU HAVE COMPLETED YOUR RESPONSES UP TO QUESTION 44. PLEASE WAIT UNTIL THE ELECTRICIAN CHANGES THE MODE OF OPERATION OF THE SYSTEM TO THE NEXT ONE TO BE EVALUATED BEFORE CONTINUING YOUR RESPONSES.

The following questions deal with the joint operation of the pedestrian actuated Amber Beacons and Advance Warning Sign with (PLEASE ASSUME) the present crosswalk fixture replaced by an identical reflectorized static appropriately colored sign. This is necessary since there are no sites without a crosswalk fixture and such a sign is a logical part of the treatment of the intersection.

45. Having seen the activated information system, the driver will: (Check all possibilities you consider likely) (45-12dBC)

a) Expect to see a pedestrian within the vicinity of the crosswalk

b) Feel that his driving task is made more difficult by the information displays

c) Find it easy to evaluate the meaning of the information displays

Comments and Suggestions:

46. Will the illuminated information system confuse or distract the drivers? (46-12dBC)

VERY LIKELY LIKELY UNLIKELY

Comments and Suggestions:

47. Will the driver yield the right of way to pedestrians when the information system is lit? (47-12dBC)

ALWAYS USUALLY RARELY

Comments and Suggestions:

48. If the approaching driver sees the information system going off, he will: (Check all possibilities you consider likely) (48-12dBC)

a) Feel confused or distracted

b) Believe that he is no longer required to be particularly concerned with pedestrian safety at the crosswalk.

Comments and Suggestions:

49. Will the activated information system cause the pedestrians to use less caution in crossing the street than they would without them? (49-12dBC)

VERY LIKELY LIKELY UNLIKELY

Comments and Suggestions:

50. Will this mode of operation contribute to pedestrian safety at the crosswalk? (50-12dBC)

VERY LIKELY LIKELY UNLIKELY

Comments and Suggestions:

51. Will this mode of operation gain the confidence of drivers and pedestrians? (51-12dBC)

VERY LIKELY LIKELY UNLIKELY

Comments and Suggestions:

52. Do you prefer this mode of operation to pedestrian actuated Amber Beacons alone? (52-12dBC)

YES NO

To the Advance Warning Sign alone?

YES NO

Comments and Suggestions:

53. Assign a numerical score on a scale of 1 (poor) to 5 (excellent) to this mode of operation. (53-12dBC)

54. Any other comments you wish to offer about the design, placement, operational features and effectiveness of this mode of operation will be appreciated. (54-12dBC)

INDICATE TO THE PRINCIPAL INVESTIGATOR THAT YOU HAVE COMPLETED YOUR RESPONSES TO THE QUESTIONNAIRE

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